WADO

Westman Agricultural Diversification Organization

# 2021 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 the its Board of Directors, cooperating land owners, 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 climate needs.

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.

As a result of Covid-19 pandemic, which restricted public gatherings, traditional field days were not held but many videos were posted on our website https://mbdiversificationcentres.ca to share progress and results of various trials.

## 2021 Industry Partners

Agriculture and Agri-Food Canada
AIMday Sustainable Protein Summit
All Natural Nutritional Products Inc.
Avondale Seeds
Barkers Agri-Centre
BASF
Canada Malt Barley Technical Centre
Canada MB Crop Diversification Centres
Canadian Agricultural Partnership
Canadian Field Crop Research Alliance
Canterra Seeds
Ducks Unlimited Canada
General Mills
Grieg Farms
Kirkup Farms
Manitoba Agriculture & Resource Development
Manitoba Cooperator
Manitoba Crop Alliance
Manitoba Crop Variety Evaluation Team
Manitoba Pulse & Soybean Growers Assoc.
Melita Chamber of Commerce
Murphy et al.
Mustard 21
North Dakota State University
Parkland Crop Diversification Foundation
Parkland Industrial Hemp Growers
Paterson Grain
PepsiCo /Quaker
Phillex Limited
Prairie Mountain Hops
Prairies East Sustainable Ag Initiative
Pride Seeds
Pulse Genetics
Roquette Canada Ltd
Seed Manitoba
Sollio Agriculture
South East Research Farm
University of Manitoba
University of Saskatchewan
Western Ag Lab & Professional Agronomy
Western Grains Research Foundation
Western Producer

## 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 2021.

| **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 |

**Southwest Manitoba Agriculture and Resource Development 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 2021 Trial Locations

| **Cooperator -Location** | Kirkup/Snyder-Melita | Fred Greig-Reston | Brian Greig-Melita | Barkers-Melita |
|---|---|---|---|---|
| **Soil type** | Newstead Loam | Ryerson5-Loam-Coatstone Loam2-Tilston1 | Ryerson-5-Loam/ Regent-5-Loam | Lr7Sr3 (Lauder Loamy Fine Sand, Souris Loamy Fine Sand) |

**Composite drone image of the WADO main trial site at Melita on NW 27-3-27 W1 in 2021, soil type- Alexander loam.**

## WADO Staff

**Scott Chalmers** (P.Ag.) is the Diversification Specialist for Manitoba Agriculture and Resource Development in Southwest Manitoba. Scott is responsible for project development, summer staff management, data analysis and extension/communications. Scott has been working with WADO since 2007.

**Carlie Johnston** joined WADO in October 2021 as a Technician after receiving a B.Sc. from the University of Western Ontario in 2020 and an Advanced Diploma in Sustainable Food Systems from Assiniboine Community College in 2021. 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** remained with WADO through the winter to assist with sample analysis and equipment repairs and maintenance. **Erica McNish** joined WADO as a summer student attending Brandon University in the fall of 2021 and assisted with data collection as well as processing sample. **Rachelle McCannel**l (University of Saskatchewan) joined us for the third time as a summer student in 2021.

**WADO Staff 2021 (left to right): Scott Chalmers, Erica McNish, Rachelle McCannell, 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. If you have any ideas, please forward them to:

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c/o. Scott Chalmers, Manitoba Agriculture and Resource Development
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204-522-8054 (fax)
scott.chalmers@gov.mb.ca

# 2021 Weather Report and Data – Melita Area

**Table a: Season summary April 1 – October 15, 2021**

| | Actual | Normal | % of Normal |
|---|---|---|---|
| Number of Days | 198 | | |
| Growing Degree Days$_5$ | 2013 | 1699 | 118 |
| Corn Heat Units | 3233 | 2854 | 113 |
| Total Precipitation (mm) | 308 | 384 | 80 |

Source: www.gov.mb.ca/climate/SeasonalReport

**Table b: Melita 2021 Season Report by Month (Normal based on 30-year average)**

| Month | Precipitation (mm) | | Temperature °C | | Corn Heat Units | | Growing Degree Days (T >5°C) | |
|---|---|---|---|---|---|---|---|---|
| | Actual | Normal | Average | Normal | Actual | Normal | Actual | Normal |
| April | 4.3 | 20 | 4.0 | 4.6 | 168 | 74 | 34 | 24 |
| May | 43.4 | 53 | 10.5 | 11.6 | 346 | 365 | 180 | 205 |
| June | 79.2 | 101 | 19.8 | 16.8 | 643 | 583 | 427 | 351 |
| July | 34.8 | 69 | 22.1 | 19.5 | 761 | 712 | 523 | 453 |
| August | 103.8 | 78 | 18.6 | 18.5 | 638 | 659 | 426 | 415 |
| September | 5.9 | 35 | 15.7 | 12.7 | 515 | 369 | 323 | 211 |
| October (1st – 15th) | 36.3 | 31 | 11.7 | 5.6 | 163 | 116 | 101 | 40 |

Source: www.gov.mb.ca/climate/SeasonalReport

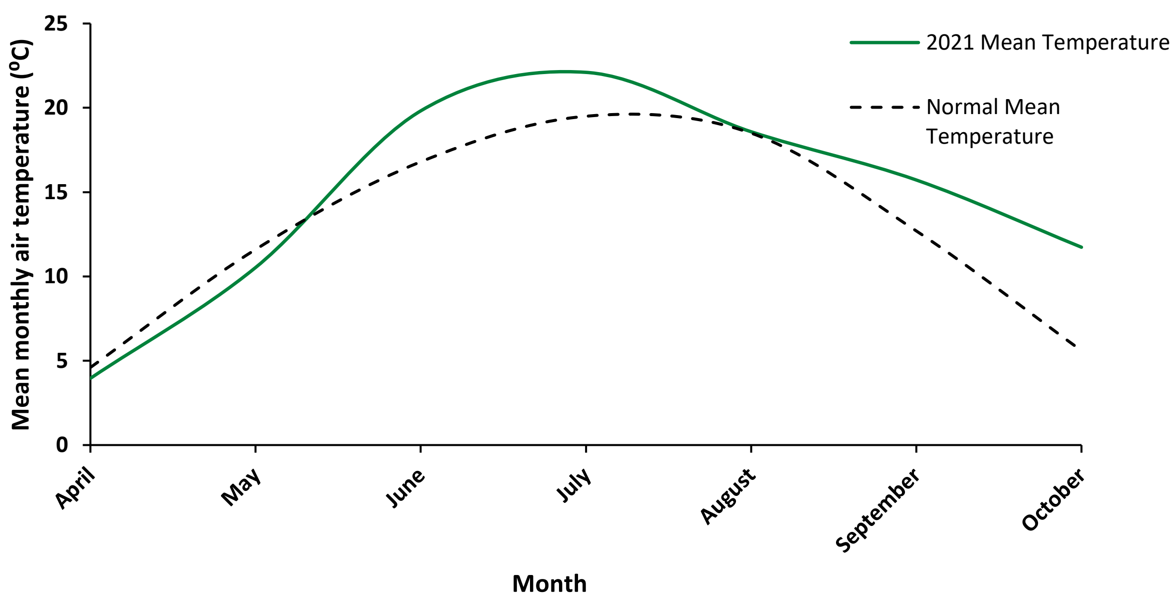


**Figure a.** Mean monthly air temperature (°C) recorded at Melita from April 1 to October 15, 2021 compared to the the normal mean monthly air temperature for Melita.

While average monthly temperature in Melita was below normal in April (4°C) and May (10.5°C), average monthly temperature rose above normal for the rest of the growing season. June average temperature was 3°C above normal, and average monthly temperature peaked in July (22.1°C). Average August temperature (18.6°C) was very close to normal, while average temperatures in September (15.7°C) and October (11.7°C) greatly exceeded normal temperatures for these months. Overall, these warmer temperatures were ideal for heat accumulation required for crop development.

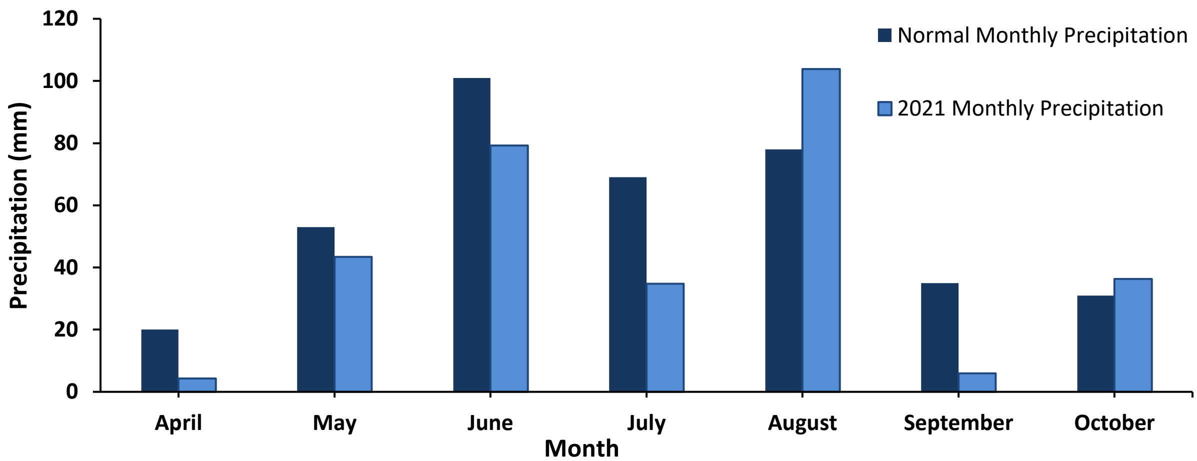


**Figure b.** Monthly precipitation (mm) recorded at Melita from April 1 to October 15, 2021 compared to the normal monthly precipitation for the region from April to October.

Overall, the 2021 growing season was drier than normal, with precipitation from April 1st to October 15th reaching only 80% of normal precipitation for the region. With little precipitation recorded in April, crop establishment was heavily reliant on existing soil moisture and the 43 mm of precipitation received in late May. Dry conditions persisted throughout early summer, as precipitation received in June (79.2 mm) and July (34.8 mm) was greatly below the 30-year normal. With 104 mm of rain falling in August, precipitation was above normal. Unfortunately, yield benefits from this precipitation were limited as much of this precipitation accumulated in late August, after the critical development stages of most crops. Litte precipitation was recorded in September (5.9 mm), while the 36 mm of precipitation accumulated from October 1st to October 15th was above normal for the region. Hail was also recorded in mid-July, damaging some cereal crop trials.

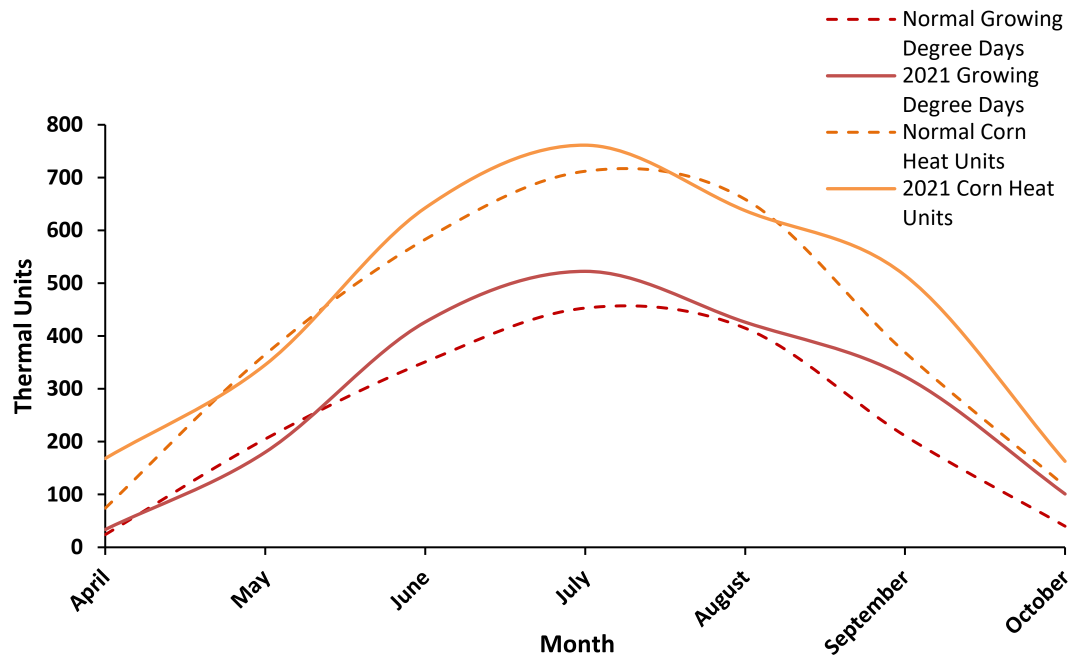


**Figure c.** 2021 Growing degree days and corn heat units accumulated in Melita compared to 30-year normal growing degree days and corn heat units for the region.

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:

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

Where, Tmin is the minimum daily temperature and Tmax 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 2021 Precipitation Map and the 2021 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

Like other organizations which host public events, WADO was limited by provincial public health orders when organizing events in 2021. In place of traditional field days, WADO was able to host a small bus tour. The bus tour hosted 25 people and toured WADO plots as well as local producer fields. WADO also participated in ten virtual events and webinars, engaging with upwards of 1300 people and communicating research information to the agriculture community. Unfortunately, the cancellation of major industry events such as the Manitoba Ag Days Tradeshow and Manitoba Crop Connect conference limited in-person engagement this year.

We would like to thank the WADO staff, Manitoba Agriculture and Resource Development employees, and those who invited WADO to speak at their virtual events for working to provide platforms for WADO to communicate with members of the agriculture industry under these restrictive conditions. The goal was to disseminate research information to producers and the Industry regardless of the method, and this goal was achieved.

## 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 1a 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. Grain corn and sunflower variety evaluation results for 2021 are available in supplemental section 25.0 and 26.0 of this report and can also be accessed at www.mbcropalliance.ca .

**Table 1a: Agronomy practices for selected MCVET crops in 2021. Yield data is published in the 2021 Seed Manitoba Guide.**

| Crop* | Pre-Emergence Burn off (rate/ac) | Soil Moisture | Seeding Date | Seeding Depth (inch.) | Fertilizer Applied (actual lb/ac) N-P-K-S-Zn | Chemistry-post emergence herbicides rate/ac | Harvest Date |
|---|---|---|---|---|---|---|---|
| Winter wheat | None | Terrible | 14-Sep-20 | 0.5 | 56 N + 38 P, 60N top dress in spring | 0.4 L Mextrol 450 | 06-Aug-21 |
| Fall rye | None | Terrible | 14-Sep-20 | 0.5 | 56 N + 38 P 60N top dress in spring | None | 16-Aug-21 |
| Barley | 400 g RT540 + Heat | Fair | 29-Apr-21 | 1.5 | 94-28-20-12-1.6 | 0.5 L Mextrol 450 | 04-Aug-21 |
| Spring wheat | 400 g RT540 + Heat | Fair | 28-Apr-21 | 1.5 | 122-28-20-12-1.6 | 0.5 L Mextrol 450, 0.5 L Roundup + 0.022 L Heat LQ desiccant | 06-Aug-21 |
| Oats | 400 g RT540 + Heat | Good | 03-May-21 | 1.5 | 122-28-20-12-1.6 | 0.5 L Mextrol, 0.5 L Roundup + 0.022 L Heat LQ desiccant | 06-Aug-21 |
| Corn | None | Good | 10-May-21 | 2 | 228-40-210-25-2 + 8 Boron + 2 Copper | 0.5 L Roundup | 06-Oct-21 |
| Sunflower | 0.08 L Authority, 0.65 L Rival | Good | 12-May-21 | 2 | 125-35-20-10-2 + 2 Boron + 4 Copper | 0.1 L Arrow + 0.5% Xact | 06-Oct-21 |
| FY RR Soybean | None | Dry | 17-May-21 | 1.25 | 16-30-21-12-2 + inoculant | 0.6 L Roundup | 15-Sep-21 |
| Conv. Soybean | 0.65 L Rival + 0.08 L Authority | Dry | 17-May-21 | 1.25 | 16-30-21-12-2 + inoculant | 0.1 L Arrow + 0.5% Xact + 0.91 L Basagran | 15-Sep-21 |
| Dry Beans | 0.65 L Rival | Dry | 17-May-21 | 1 | 87-30-21-12-2 | 0.1 L Arrow + 0.5% Xact + 0.91 L Basagran, 0.65 L Reglone desiccant + LI700 surfactant | 31-Aug-21 |
| Peas | 0.65 L Rival + 0.080 L Authority | | 28-Apr-21 | 1.5 | 12-28-20-12-1.6 + Inoculant | 17.3 g Odyssey + 0.5% v/v Merge, 0.1 L Arrow, 0.5 L Roundup + 0.022 L Heat desiccant | 12-Aug-21 |
| RR Soybean | None | Fair | 13-May-21 | 1.5 | 12-28-20-12-1.6 + inoculant | 0.6 L Roundup | 14-Sep-21 |

***All trials established on wheat stubble**

## 2.0 Comparison of Traditional and Balanced Fertility Program and Potential of New Winter Wheat Varieties

**Project duration**: 2019-2021

**Collaborators**: Ducks Unlimited, Western Ag Professional Agronomy

### *Objectives*

- To compare historical/standard "Producer Practice {100% spring}" fertility program to a balanced, "High Yield Practice {Balanced}" as determined by Western Ag Soil analysis and recommendations.

### *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, sulphur 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.

## *Materials and Methods*

This study was established at four locations, Melita, Arborg, Carberry and Roblin, Manitoba in the fall of 2020 (Table 2b). In Melita, wheat was seeded into canola stubble at a depth of 0.5" on September 14, 2020 using a 6-row dual knife seed hawk air seeder. The soil was characterized as Ryerson5Loam/Regent5Loam. No pre-emergent herbicide was necessary in 2020 at the Melita site. Post emergence weed control was done in spring to control flowering volunteer canola by application of Mextrol 450 at 0.5 L $ac^{-1}$. No fungicide application was needed at the Melita site in 2021, but Prosaro or Folicur fungicides were applied at the Arborg, Carberry and Roblin sites. The treatment structure consisted of a factorial arrangement of two fertilizer management practices and four to six winter wheat varieties in a randomized complete block design. The winter wheat varieties utilized at all sites were; Gateway, Goldrush, Elevate and Wildfire. At the Carberry site, AAC Network and W583 varieties were also incorporated into the trial. Fertilizer treatments included:

- **Producer practice**: 100 lbs of nitrogen (urea plus agrotain) per acre applied in spring and 30 lbs phosphorus banded at seeding in fall and,
- **Balanced fertility practice:** Nitrogen was applied as per Western Ag recommendations based on soil test results, and application was split with 50% N banded at seeding and the other 50% N (urea plus Agrotain) broadcasted in spring. In addition, site specific P, K, S, and micronutrient recommendations were applied.

A summary of fall soil tests conducted at Melita, Roblin, Carberry and Arborg, and fertilizer treatments for the 2020/2021 trial are presented in Table 2a. Data were analyzed using Minitab 18.1 software, and means were separated using Fisher's mean separation method at 95% confidence.

**Table 2a. Fall soil test results by site and fertilizer treatments for winter wheat in the 2020/2021 season**

| | Fall Soil Test Results (lbs ac$^{-1}$) | | | | Producer Practice Application (All N applied in Spring) | | | | Balanced Practice application Recommendations^ (50% N Applied in Fall) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Melita | Roblin | Carberry | Arborg* | Melita | Roblin | Carberry | Arborg | Melita | Roblin | Carberry | Arborg |
| N | 11 | 53 | 31 | 93 | 100 | 100 | 100 | 100 | 130 | 105 | 130 | 161 |
| P | 10 | 71 | 27 | 44 | 30 | 30 | 30 | 30 | 38 | 20 | 30 | 40 |
| K | 306 | 410 | 48 | 660 | 0 | 0 | 0 | 0 | 50 | 0 | 100 | 50 |
| S | 36 | 22 | 15 | 582 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 |
| Zn | 1.4 | 1.1 | 0.04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

* Soil sampling by Farmers Edge

^ Balanced practice application based on recommendations from the Western Ag Professional Agronomy Laboratory

**Table 2b. Site description and agronomics for each trial site in the 2020/2021 season**

| Location | Melita | Carberry | Roblin | Arborg |
|---|---|---|---|---|
| **Cooperator** | WADO | CMCDC | PCDF | PESAI |
| **Legal** | NW23-3-27W1 | South ½ of 8-11-14 W1 | NE 20-25-28 W1 | NW 16-22-2 E1 |
| **Rotation (2 yr.)** | Spring wheat – LL Canola | Soybean (2019), Canola (2020) | Barley silage (2019), Oat silage (2020) | Canola – Cereals |
| | | | | |
| **Soil Series** | Ryerson Loam | Ramada Clay Loam | Erickson clay loam | Fyala heavy clay |
| **Soil Test Done? (Y/N)** | Yes | Yes | Yes | Yes |
| | | | | |
| **Field Prep** | No till | No till | Vertical tilled | No till |
| **Stubble** | LL Canola | Canola | Oat | Canola |
| **Burn off (Date/Rate per acre/Products)** | None | 09-Sep-20: Roundup 0.67 L + Heat 29 g + Water 40 L sprayed before seeding | None | None |
| **Soil Moisture at Seeding** | Very poor | Fair | Dry | Optimal |
| | | | | |
| **Seed Date** | 14-Sep-20 | 16-Sep-20 | 18-Sep-20 | 21-Sep-20 |
| **Seed depth (Inches)** | 0.5 | 1.0 | 0.75 | 1.0 |
| **Seeder (drill/planter?)** | Knife drill | Knife drill | Disc drill | Disc drill |
| **Errors at seeding** | None | None | None | None |
| | | | | |
| **Topdressing** | 09-Apr-21 | 23-Apr-21 | 16-Apr-21 | 29-Apr-21 |
| **Herbicides (Date, Rate/ ac, Name)** | 08-Jul: 0.5 L Mextrol 450 on flowering canola | 09-Sep: 0.7 L Glyphosate, 30 g Heat<br>15-Jun: 0.12 Fitness, 0.4 L Buctril M, 0.5 L Axial | 14-Jun: 0.81 L Curtail M,<br>0.71 mL Puma | None |
| **Fungicides** | none | 08-Jul: 0.325 L Prosaro | 15-Jun: 0.202 L Folicur | 22-Jun: 0.2 L Folicur |
| **Insecticides** | 17-Jul: Coragen, aerial, grasshoppers | None | None | 28-Jun: 0.325 L Prosaro |
| | | | | |
| **Harvest Date** | 16-Aug-21 | 12-Aug-21 | 25-August-21 | 3-Aug-21 |

## *Results*

Variety use was not found to have a significant effect on wheat yield at any of the individual trial sites (Table 2c). However, over all four site years, a significant (P = 0.003) grain yield trend was observed. Across all four site years, Wildfire winter wheat produced the greatest average yield, though this yield was not significantly different from that of Elevate. AAC Network and W583 varieties were not included in multi-site analysis as these varieties were only included in the Carberry trial. Winter wheat variety significantly influenced grain protein content at the Melita, Roblin and Arborg sites in the 2020/2021 growing season. At the Melita site, protein content of Gateway (15.8%) was significantly (P < 0.001) greater than that of Elevate, Goldrush and Wildfire. At the Roblin site, Gateway winter wheat also resulted in the greatest protein content (16.7%), though this was not significantly different from that of Goldrush winter wheat (16.4%). At the Arborg site, no significant difference in protein content was observed among Wildfire (14.4%), Gateway (14.3%) or Goldrush (13.9%). Elevate resulted in the lowest average grain protein content at the Melita, Roblin, and Arborg sites, indicating a potential protein content disadvantage of this variety in Manitoba compared to the other varieties used in this trail. Protein content data was not collected for Carberry site in 2021. Protein content of Elevate was also demonstrated to be significantly (P < 0.001) lower than all other varieties when Melita, Roblin, and Arborg site data was combined (14.0%), while protein content of Gateway (15.6%) was demonstrated to be greater than all other varieties grown at these sites. Test weight significantly varied across varieties at the Melita, Roblin, and Arborg sites, as well as across varieties over all four site years. At these sites, the greatest average test weight was observed from Gateway winter wheat.

Fertilizer management practice did not have a significant influence on grain yield at the Melita, Roblin, or Carberry sites. In Arborg, winter wheat grown with a balanced fertility practice (50% N in fall) had a significantly (P = 0.034) greater average yield than winter wheat grown with the current producer fertility practice (100% N in spring). No significant effect of fertility practice on winter wheat grain protein content was observed at the Melita or Arborg sites, but winter wheat grown using current producer fertility practice at the Roblin site had greater average protein content (16.1%) than winter wheat grown using the balanced fertility practice at this site (15.7%). However, when data from all sites was combined and analyzed, no significant influence of fertility management practice on winter wheat grain yield or protein content was observed. Fertility management practice had a significant influence on grain test weight at the Melita site, the Carberry site, and over all site years, with test weight of grain grown under the producer fertility practice significantly greater than that of grain grown under a balanced fertility practice.

Significant variety and fertility practice interactions (variety x fertility) were observed when yield data from all site years was combined, but no significant interactions were observed at individual sites. Over all four site years, Wildfire winter wheat grown under producer fertility practices had the greatest average yield (4176 kg $ha^{-1}$), though this yield was not significantly different from that of Goldrush winter wheat under balanced fertility practices (3895 kg $ha^{-1}$). No significant yield differences were observed between fertility practices for Elevate or Gateway winter wheat varieties over four site years. A balanced fertility practice resulted in a greater average yield than the current producer fertility practice for Goldrush winter wheat, though the opposite was true for Wildfire winter wheat. This result may indicate that yields of some winter wheat varieties respond better to a balanced fertility practice than others. At the Melita site, Gateway winter wheat grown under balanced fertility practice resulted in the greatest average test weight (73.5 kg $hL^{-1}$), though this test weight was not significantly different from that of Elevate, Gateway, or Goldrush winter wheat grown under producer fertility practices. Protein content of winter wheat was not significantly different among variety and fertility management practice combinations (variety x fertility) at individual sites or when Melita, Roblin, and Arborg protein data was combined.

Overall, results from the 2020/2021 growing season indicate that yields of some winter wheat varieties respond better to a balanced fertility program than others. Additionally, yield results from the Arborg site demonstrate a potential yield benefit of a balanced fertility program, as wheat grown under a balanced fertility program at this site yielded significantly higher than wheat grown under a current producer fertility program. Winter wheat protein content was demonstrated to likely be more influenced by winter wheat variety than fertility management practices in the 2020/2021 growing season, as fertility management practice only had significant impact on winter wheat protein content at the Roblin site, while variety significantly influenced protein content at all sites. Test weight of harvest grain was significantly greater in wheat grown under current producer fertility practices than in wheat grown under a balanced fertility practice at two sites indicating a potential test weight benefit of applying all nitrogen in spring. Continued field study is necessary to further evaluate the performance of new winter wheat varieties under both fertility management strategies, and to effectively develop fertilizer management recommendations that winter wheat producers can implement in their production systems.

**Table 2c. Analysis of variance for average winter wheat yield (kg ha$^{-1}$), protein content (%), and test weight (kg hL$^{-1}$) at Melita, Roblin, Arborg, and Carberry, Manitoba sites for the 2020/2021 growing season.**

| | | | Location | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Melita | | | Roblin | | | Arborg | | | Carberry | | All Sites | | |
| Treatment | | | 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$^{-1}$) | Test Wt. (kg hL$^{-1}$) | Yield (kg ha$^{-1}$) | Protein* (%) | Test Wt. (kg hL$^{-1}$) |
| Variety | Elevate | 1 | 2134 | 14.1**d** | 72.1**ab** | 3862 | 14.8**c** | 60.4**c** | 3216 | 13.0**b** | 79.0**b** | 5582 | 69.1 | 3699**ab** | 14.0**c** | 70.1**b** |
| | Gateway | 2 | 1935 | 15.8**a** | 73.0**a** | 3377 | 16.7**a** | 63.3**a** | 2922 | 14.3**a** | 81.5**a** | 5582 | 70.2 | 3454**c** | 15.6**a** | 72.0**a** |
| | Goldrush | 3 | 2299 | 15.4**b** | 71.0**c** | 3428 | 16.4**a** | 62.2**b** | 3103 | 13.9**a** | 78.2**b** | 5750 | 69.6 | 3645**bc** | 15.2**b** | 70.2**b** |
| | Wildfire | 4 | 2456 | 14.9**c** | 71.3**bc** | 3661 | 15.7**b** | 59.2**d** | 2983 | 14.4**a** | 76.9**c** | 6597 | 70.0 | 3925**a** | 15.0**b** | 69.3**c** |
| | AAC Network | 5 | - | - | - | - | - | - | - | - | - | 6545 | 69.6 | - | - | - |
| | W583 | 6 | - | - | - | - | - | - | - | - | - | 5925 | 70.3 | - | - | - |
| Fertility | Balanced | 1 | **2077** | **15.1** | 71.4**b** | **3478** | 15.7**b** | 61.4 | 3167**a** | 14.1 | 78.8 | 5829 | 69.3**b** | 3628 | 15.0 | 70.2**b** |
| | 100% Spring | 2 | **2335** | **15.0** | 72.3**a** | **3686** | 16.1**a** | 61.1 | 2945**b** | 13.7 | 79.0 | 6164 | 70.3**a** | 3733 | 14.9 | 70.7**a** |
| Var x Fert | | 1,1 | 1855 | 14.3 | 71.2**cd** | 3706 | 14.5 | 60.3 | 3365 | 13.4 | 79.2 | 5334 | 68.6 | 3565**bcd** | 14.1 | 69.8 |
| | | 1,2 | 2413 | 13.9 | 72.9**ab** | 4018 | 15.0 | 60.4 | 3068 | 12.6 | 78.8 | 5831 | 69.6 | 3832**bc** | 13.9 | 70.4 |
| | | 2,1 | 1778 | 15.9 | 73.5**a** | 3106 | 16.9 | 62.9 | 3025 | 14.6 | 81.5 | 5609 | 70.0 | 3379**d** | 15.8 | 72.0 |
| | | 2,2 | 2091 | 15.7 | 72.6**abc** | 3648 | 16.5 | 63.6 | 2820 | 14.1 | 81.5 | 5555 | 70.4 | 3529**cd** | 15.5 | 72.0 |
| | | 3,1 | 2370 | 15.3 | 69.8**d** | 3575 | 15.9 | 63.1 | 3340 | 14.0 | 77.8 | 6296 | 69.3 | 3895**ab** | 15.1 | 70.0 |
| | | 3,2 | 2227 | 15.4 | 72.2**abc** | 3281 | 16.9 | 61.3 | 2866 | 13.7 | 78.7 | 5205 | 69.8 | 3395**d** | 15.3 | 70.5 |
| | | 4,1 | 2302 | 14.9 | 71.1**cd** | 3526 | 15.4 | 59.4 | 2939 | 14.4 | 76.7 | 5923 | 69.0 | 3673**bcd** | 14.9 | 69.0 |
| | | 4,2 | 2610 | 14.9 | 71.5**cd** | 3797 | 15.9 | 58.9 | 3027 | 14.4 | 77.2 | 7271 | 70.9 | 4176**a** | 15.1 | 69.7 |
| | | 5,1 | - | - | - | - | - | - | - | - | - | 5914 | 68.8 | - | - | - |
| | | 5,2 | - | - | - | - | - | - | - | - | - | 7176 | 70.4 | - | - | - |
| | | 6,1 | - | - | - | - | - | - | - | - | - | 5901 | 70.0 | - | - | - |
| | | 6,2 | - | - | - | - | - | - | - | - | - | 5948 | 70.633 | - | - | - |
| P values | Variety | | 0.082 | **<0.001** | **0.006** | 0.221 | **<0.001** | **<0.001** | 0.176 | **0.011** | **<0.001** | 0.066 | 0.113 | **0.003** | **<0.001** | **<0.001** |
| | Fertilizer | | 0.075 | 0.158 | 0.021 | 0.252 | **0.036** | 0.265 | **0.034** | 0.197 | 0.493 | 0.18 | **0.001** | 0.223 | 0.824 | **0.008** |
| | Var x Fert | | 0.353 | 0.297 | **0.035** | 0.405 | 0.115 | 0.072 | 0.248 | 0.721 | 0.533 | 0.072 | 0.482 | **0.001** | 0.181 | 0.605 |
| | CV(%) | | 15 | 1 | 1 | 12 | 3 | 1 | 8 | 5 | 1 | 12 | 1 | 11 | 3 | 1 |

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

*Does not include Carberry site

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## 3.0 Fusarium Head Blight Winter Wheat, Spring Wheat, Barley and Durum

**Project duration:** 2018-2021
**Collaborators:** Dr. Paul R. Bullock, Manasah Mkhabela –University of Manitoba

### *Objectives*

- To develop models for a more accurate prediction of Fusarium Head Blight (FHB) in wheat, barley and durum under weather conditions that prevail on the Prairies

### *Background*

Fusarium Head Blight (FHB), also known as head scab, is a devastating disease of wheat, barley and durum which is prevalent worldwide, especially in areas where weather conditions are warm and humid. The fungal disease, caused by many species including *Fusarium graminearum* Schwabe, is capable of causing significant losses in grain yield, test weight and seed germination (Steiner et al., 2017). In addition to losses in grain yield, fusarium species produce mycotoxins including Type-B trichothecenes such as deoxynivalenol (DON) or nivalenol, as well as the resorcyclic acid lactone zearalenone, which each have potential to cause serious economic losses and health risks when consumed by humans and livestock (Prandini et al. 2008; Steiner et al., 2017). There are various FHB risk prediction models currently in place but more accurate and specific ones are essential, especially for varying Prairie weather conditions. These tools are essential in providing producers with estimates of FHB risk levels and developing plans to curb the disease either through timing of fungicide application or timing of planting. Some of the available models that are currently in use include the Penn State and the Ontario DonCast models. Because of their specificity to their place of origin, very few models have been adapted to other regions which experience varying weather conditions, hence the need to develop or modify existing models to suit Prairie environmental conditions (Giroux et al. 2016). Given the severe losses in production and quality caused by FHB, the ability to accurately predict its occurrence will play a significant role in reducing year-to-year risk for producers. Therefore, modification and/or validation of the already available models is essential for accurate prediction of FHB based on weather conditions in the Canadian Prairies.

## *Materials and Methods*

Five trial sites in Alberta, Manitoba and Saskatchewan were established the 2020/2021 growing season. Winter wheat, spring wheat, durum and barley were laid out in a split plot design with 4 main plots for each crop type in a randomized complete block design of 4 replicates and 3 varieties inside each main plot (except durum – 1 variety) for a total of 10 treatments.

In fall 2020, the Melita trial was established on Ryerson5LoamRegent5Loam soil under a no till system into canola stubble. Winter wheat was seeded on September 14$^{th}$, while spring wheat, barley and durum were seeded on June 3$^{rd}$, 2021. Winter wheat was seeded at a 0.5-inch depth, while spring cereals were seeded at a 0.75-inch depth. Fertilizer was banded at seeding according to recommendations based on soil test results, with 60-35-20-10-2 (N-P-K-S-Zn) actual lbs ac$^{-1}$ fertility applied to winter wheat and 103-30-20-10-2 actual lbs ac$^{-1}$ applied to spring cereals. Winter wheat was top-dressed with 60 lbs ac$^{-1}$ actual nitrogen (via Agrotrain-treated urea) on April 9$^{th}$. Chemical weed control included 0.5 L ac$^{-1}$ Roundup and 20 ml ac$^{-1}$ Aim applied to spring wheat on June 7$^{th}$, and a spot application of 0.4 L ac$^{-1}$ MCPA Amine 500 on June 21$^{st}$. Matador (34 ml ac$^{-1}$) was applied to spring cereals on July 2$^{nd}$ for control of grasshoppers. Winter wheat was harvested August 6$^{th}$, barley and durum were harvested August 12$^{th}$, and spring wheat was harvested August 26$^{th}$.

Adhesive type spore traps were installed at 2 central spots within the plots at the beginning of anthesis (BBCH 61) to capture FHB spores. The spore traps were replaced weekly for four weeks ensuring the traps were place at the same height as the cereals in the plots. Additional data collected included plant counts, days to heading, days to maturity, harvest date, protein content, thousand kernel weight, grain moisture content at harvest, FHB score on affected head and weed pressure where necessary. Grain analysis for protein and moisture was done at WADO using IM9500 NIR grain analyzer. Data was sent to the collaborator at the University of Manitoba for analysis.

## *Results and Discussion*

As 2021 was a dry year in the Melita area, very little fusarium head blight was identified at the trial site. Additionally, yields were severely reduced due to hail which hit the trial site on July 17th.

The research trial is in its third and final year, and a summary of results from all sites will be made available upon completion of data analysis by the collaborators.

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## 4.0 PepsiCo - Quaker oats variety evaluation

**Project duration:** 2019-2021
**Collaborators**: PepsiCo/Quaker – Derek Herman, Plano TX

### *Objectives*

- To evaluate agronomic performance of 19 oat varieties under different environments in the Prairies.

### *Background*

There has been renewed interest in the production of oats as a result of their role in livestock feed as well as part of a healthy human diet. Production of oats (*Avena sativa* L.) is influenced by several factors including rainfall or precipitation, temperature, solar irradiation and soil conditions in which the crop is being grown (Sorrells and Simmons, 1992). These factors appear to impact the crop at various levels during different phenological stages. Therefore, timing of seeding is crucial in a given production area so as to synchronize seeding with the occurrence of ideal weather conditions favorable for growth and development. Oat production has been on the rise in Canada, with 4 million tons produced in 2019 (Statistics Canada, 2019). This growth has been attributed to a 15.2% increase in harvested area (to 2.9 million acres) and new higher yielding varieties available for producers across Canada. New varieties still need to be tested across different environments to allow for producers to select varieties which match their production objectives.

### *Materials and Methods*

The trial was arranged as randomized complete block design with 19 varieties replicated four times on Ryerson5LoamRegent5Loam soil in Melita. Plots were established on canola stubble under a no till system on April 29th. Plots were seeded at 1.5-inch depth using a dual knife Seedhawk air seeder. Fertilizer was banded at seeding at a rate of 120-35-20-12-1.6 actual lbs $ac^{-1}$ (N-P-K-S-Zn). Fertility application was based on soil test results and crop requirement estimates. RT540 (400 g $ac^{-1}$) and Heat (10.4 g $ac^{-1}$) were applied as pre-emergence weed control on May 4th. Mextrol 450 (0.5 L $ac^{-1}$) was applied on June 2nd for additional weed control. Matador (34 ml $ac^{-1}$) was applied for control of grasshopper populations on July 2nd, and Coragen was applied via aerial spraying on July 17th for further grasshopper control. Plots were desiccated on August 4th using Roundup (0.5 L $ac^{-1}$) and Heat LQ (22 ml $ac^{-1}$), and plots were harvested on August 6th. Data collected included days to heading, plant height at maturity, days to maturity, grain yield, lodging and disease pressure assessment (crown rust, stem rust and smut).

### Results

Significant damage occurred to plots as a result of a hail storm in late July, and yields were severely impacted. Yield data and grain samples were sent to collaborators for analysis. Result summaries are available from the project collaborators upon request.

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## 5.0 Sollio oat variety evaluation

**Project duration:** ongoing
**Collaborators:** Sollio Ltd. (QC), Christain Azar, Agr. M. Sc. Plant Breeder

### *Objectives*

- To evaluate yield potential of 30 oat varieties under varying environments in the Prairies

### *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 in meet increased oat demands (Sadras et al., 2017).

## *Materials and Methods*

The trial was established near Melita on Ryerson5Loam/Regent5Loam 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 3rd at a 1.5-inch depth using a Seedhawk dual knife opener air seeder. Fertility was banded during seeding at a rate of 112-28-20-12-1.6 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. RT540 (400 g $ac^{-1}$) and Heat (10.4 g $ac^{-1}$) were applied as pre-emergence weed control on May 4th. Mextrol 450 (0.5 L $ac^{-1}$) was applied on June 2nd for additional weed control. Matador (34 ml $ac^{-1}$) was applied for control of grasshopper populations on July 2nd, and Coragen was applied via aerial spraying on July 17th for further grasshopper control. Plots were desiccated on August 4th using Roundup (0.5 L $ac^{-1}$) and Heat LQ (22 ml $ac^{-1}$), and plots were harvested on August 6th. 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*

Plots experienced significant damage from a hail storm in late July which greatly reduced yields. Yield data and samples were sent to the collaborators for analysis. This study is aimed at variety development and results are available from the collaborator upon request.

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# 6.0 Protein content in conventional soybean varieties and comparison of their genetic potential with geo-environmental characteristics

**Project duration:** 2018-2023 (CFCRA cluster)
**Collaborators:** AAFC Ottawa - Dr. Elroy Cober

### *Objectives*

- To determine protein content differences among 20 conventional soybean varieties across seasons and locations.
- To compare the genetic potential of conventional soybean varieties with geo-environmental characteristics.

### Background

Soybeans are one of the world's most important oil and protein sources and are used for human consumption or feed for livestock in many countries. Seed quality of soybean is determined by the composition of oil, protein, fatty acids, sugars and minerals, which is affected by the genotype, the environment and how they interact (Bellaloui et al. 2015). Based on dry matter, soybeans contain approximately 40 to 50% protein, 18 to 24% oil and 18 to 26% oleic acids, sugars, amino acids, isoflavones and minerals (Akond et al., 2018; Bellaloui et al., 2020). For both food and livestock nutrition, a high and stable protein content is desirable. However, in Western Canada, protein content in soybean is low compared to that of the Eastern region as a result of lower temperatures, shorter growing season and low rainfall. Nevertheless, breeding of early maturity soybean varieties in recent years has increased the availability of short season varieties suited to Western Canada with adequate quality parameters suited for the market (Cober and Voldeng, 2012).

### *Materials and Methods*

The trial was initiated in 2018 by AAFC and ran until 2021 at ten sites across Canada. The trial was established near Melita, Manitoba and arranged as a 5 x 4 x 4 alpha lattice in a randomized complete block design with 20 treatments (conventional varieties) replicated 4 times on Alexander Loam soil (NW 27-3-27). The treatments were inoculated with granular BASF inoculant prior to seeding into wheat stubble at a depth of 1.25 inches on the 17$^{th}$ of May. Granular fertilizer was banded at seeding at a rate of 16-30-21-12-2 (N-P-K-S-Zn) actual lbs ac$^{-1}$. Chemical weed control included a burnoff application of 0.65 L ac$^{-1}$ Rival and 80 ml ac$^{-1}$ Authority on May 19$^{th}$, 100 ml ac$^{-1}$ Arrow mixed with 0.5% v/v Xact applied on June 10$^{th}$, 0.91 L ac$^{-1}$ Basagran in 20 gallons of water applied on June 14$^{th}$, and 150 ml ac$^{-1}$ Arrow mixed with 0.1% v/v Xact applied on July 8$^{th}$. Matador was applied at 34 ml ac$^{-1}$ on June 11$^{th}$ for control of grasshoppers. Roundup (0.67 L $ac^{-1}$) and Heat (20 ml $ac^{-2}$) were applied as a desiccant on September 20th. Most varieties were harvested on September 21st, with two later varieties harvested September 28th. Data collected included emergence date, plant height at maturity, days to 50% flowering, days to maturity, harvest date, moisture content at harvest, grain yield and protein content. Data and samples were sent to AAFC Ottawa for analysis.

## *Results and Discussion*

Figure 6a summarizes average seed yield and protein content by variety at various sites across the Eastern Prairies from 2018 to 2021. On average, for every 1% increase in soybean protein content, yield decreases by 53.1 kg $ha^{-1}$ in the Eastern Prairies. Detailed variety information, genomic analysis, weather information and methodology will be presented in manuscripts produced by Dr. Elroy Cober (AAFC Ottawa), with the final project summary report available in 2023 following the conclusion of the trial.

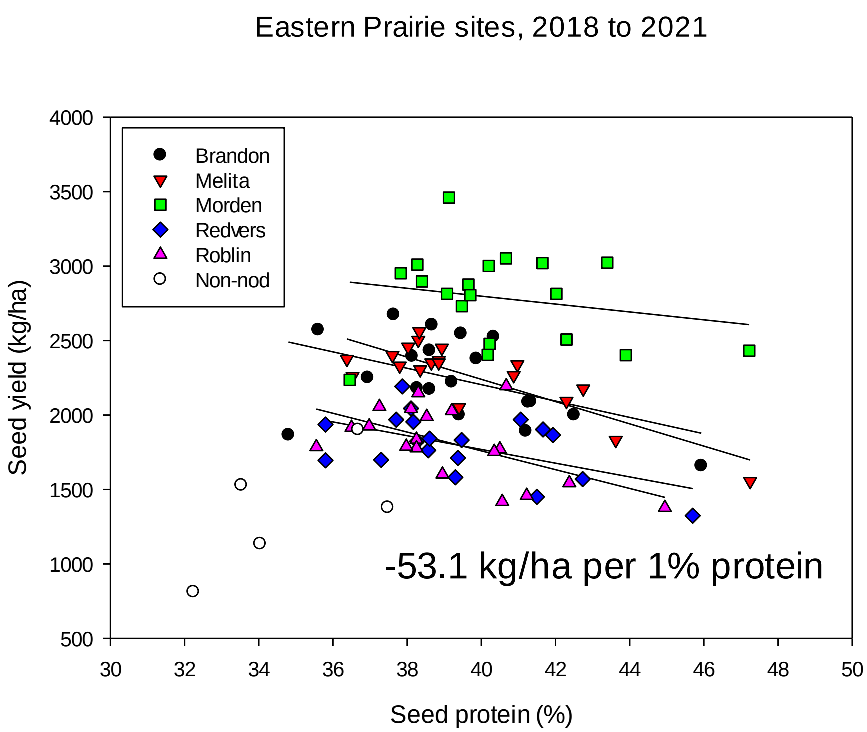


**Figure 6a.** Mean seed yield and protein for Eastern Prairie sites from 2018 to 2021.

**Soybean protein variety trial with non-nodulated treatment showing N deficiency at Melita in 2020.**

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## 7.0 Dry bean variety trial – Agriculture and Agri-food Canada

**Project duration:** 2019 - 2021
**Collaborator:** Anfu Hou Ph.D., Agriculture and Agrifood Canada, Morden MB

### *Objectives*

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

### *Background*

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

### *Materials and Methods*

The trial was established near Melita, on Alexander Loam soil (NW 27-3-27). The treatments were seeding into wheat stubble at a depth of 1.25 inches on the 17th of May. Granular fertilizer was banded at seeding at a rate of 87-30-21-12-2 (N-P-K-S-Zn) actual lbs ac$^{-1}$. Chemical weed control included a burnoff application of 0.65 L ac$^{-1}$ Rival on May 19th, 100 ml ac$^{-1}$ Arrow mixed with 0.5% v/v Xact applied on June 10th, and 0.91 L ac$^{-1}$ Basagran in 20 gallons of water applied on June 14th. Reglone (0.65 L ac$^{-1}$) and LI700 surfactant (0.25% v/v in 20 gallons of water) were applied as a desiccant on August 31st. Plots were harvested on August 31st. 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.

Photo: 2021 Bean Variety trials July 12, 2021

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## 8.0 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 is been limited.

### *Materials and Methods*

The trial was established on Alexander loam soil in Melita, Manitoba in 2021. Twelve treatments were factorially arranged in randomized complete block design with three bean types (market classes) and four inoculation strategies replicated four times. The three dry bean market classes were Navy bean (T9905), Pinto bean (Vibrant) and Black bean (Eclipse) while inoculation strategies included non-inoculated/non-fertilized (control), BOS (self-adhering peat), N-Charge (self-adhering peat) and N-Charge + Accolade (liquid growth stimulant) treatments. Seed bed preparation involved fall harrowing to spread out wheat straw from the previous crop. A burnoff herbicide application was done using a tank mix of 0.5 L $ac^{-1}$ Roundup and 0.015 L $ac^{-1}$ Aim following seeding. Seeding was done on May 26$^{th}$ at a depth of 1.25" using a 6-row dual knife Seedhawk air seeder at 100 000 seeds $ac^{-1}$ for Pinto beans and 130 000 seeds $ac^{-1}$ for Navy and Black beans. Target plant stand was 70 000 plants $ac^{-1}$ for Pinto beans and 100 000 plants $ac^{-1}$ for Navy and Black beans. Basal granular fertilizer blend was side banded during seeding at 10-30-17-9-1.7 (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 using a tank mix of Viper (0.4 L $ac^{-1}$) and 28% UAN (0.8 L $ac^{-1}$) applied with a water volume of 10 gal/ac using TeeJet® low drift spray nozzles. Plots were desiccated using a tank mix of Reglone (0.65 L $ac^{-1}$), Roundup Transorb (0.5 L $ac^{-1}$) and LI700 surfactant (0.25%, 20 gal $ac^{-1}$) using the same nozzels. 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 from 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 Carman sites, please refer to the 2021 Soybean Pulse Agronomy Lab Annual report:

[2019_2020_Annual_Report_Soybean_and_Pulse_Agronomy_Lab_MacMillan.pdf (umanitoba.ca)]

**2021 Dry bean inoculation trial in Melita**

### *Acknowledgements*

Manitoba Pulse and Soybean Growers Association, University of Manitoba.

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## 9.0 General Mills: Oat Variety Evaluation

**Project duration**: 2020 - ongoing
**Collaborators:** General Mills

### *Objectives*

- Evaluate agronomic traits of new oat varieties

### *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). With new oat varieties available, there is need to study how plant population and nitrogen application affects development and yield of oats. This information will be helpful to farmers in choosing agronomic practices which apply to their areas of production to attain higher oat yields.

### *Methods*

The General Mills trial included an advanced variety yield trial and a variety x plant population x N rate trial. These were conducted in Melita, Manitoba on Ryerson5Loam/Regent5Loam soils in 2021.

Treatments were replicated 3 times. Varieties used for the advanced variety yield trial were; ORe3542m, AAC_DOUGLAS, 2015Y3857, CDC_NORSEMAN, OT3112, ORe3541m, RUSHMORE, CDC_ARBORG, HAYDEN, WARRIOR, 2015Y3846 ALKA, CS_CAMDEN, 2017Y2693, CDC_SKYE, and CDC_ENDURE. Plots were established on canola stubble under a no till system on April 29th. Plots were seeded at 1.5-inch depth using a dual knife Seedhawk air seeder. Fertilizer was banded at seeding at a rate of 120-35-20-12-1.6 actual lbs $ac^{-1}$ (N-P-K-S-Zn). Fertility application was based on soil test results and crop requirement estimates. RT540 (400 g $ac^{-1}$) and Heat (10.4 g $ac^{-1}$) were applied as pre-emergence weed control on May 4th. Mextrol 450 (0.5 L $ac^{-1}$) was applied on June 2nd for additional weed control. Matador (34 ml $ac^{-1}$) was applied for control of grasshopper populations on July 2nd, and Coragen was applied via aerial spraying on July 17th for further grasshopper control. Plots were desiccated on August 4th using Roundup (0.5 L $ac^{-1}$) and Heat LQ (22 ml $ac^{-1}$), and plots were harvested on August 6th. 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). Yields were significantly reduced in the 2021 trial as the site was affected by a hail storm in late July. Samples were taken for quality analysis.

### *Reference list*

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# 10.0 Linseed Coop Evaluation

**Project duration:** 2018-2021

**Collaborators:** CDC Saskatchewan, Dr. Bunyamin Tar'an (flax breeder)

## 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.

## *Materials and Methods*

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. Twenty varieties were arranged in a 4 x 5 alpha lattice design and replicated three times. The Melita trial was seeded at one-inch depth on May 4$^{th}$ into wheat stubble. Fertilizer was banded during seeding at a rate of 105-28-20-12-1.6 (N-P-K-S-Zn) actual lbs ac$^{-1}$ following recommendations based on soil test results from AgVise Laboratories Inc. Chemical weed control included a burnoff application of 0.65 L ac$^{-1}$ Rival with 80 ml ac$^{-1}$ Authority on May 5$^{th}$ and additional weed control by application of 100 ml ac$^{-1}$ Arrow, Xact at 0.5%, and 0.91 L ac$^{-1}$ Basagran mixed in 20 gal of water on June 10$^{th}$. 34 ml ac$^{-1}$ Matador was applied July 8$^{th}$ for control of flea beetles. Plots were desiccated August 10$^{th}$ by application of 0.5 L ac$^{-1}$ Roundup, 0.5 L ac$^{-1}$ Reglone, 22 ml ac$^{-1}$ Heat and LI700 surfactant at 0.1%. Plots were harvested on August 26$^{th}$. 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 with experimental line FP2591 which was consistant with the entire zone for this variety (Table 10.0). Maturity for FP2591 is several days later than CDC Bethune or other check varieties. AAC Marvelous and CDC Rowland were also notably high yielding in Melita was well as the rest of zone 1. While the lowest yield for newly released varieties was 2558 kg ha$^{-1}$ for CDC Dorado (Table 10.0) which was also found to be the lowest in 2020 as well. Overall, results show a potential of high yielding experimental lines to be considered for future registration if additional tests over varying environments are consistent. Additional quality data may be available by contacting Dr. Bunyamin Tar'an at the University of Saskatchewan.

**Table 10.0 Predicted means for flax variety yield trial at Melita versus overall in Zone 1 in 2021**

| | | | | Prairie Wide | |
|---|---|---|---|---|---|
| **ENTRY** | **Melita Yield ('00 kg/ha)** | **Overall AVG Zone 1** | **Overall RANK Zone 1** | **Days to Maturity** | **Height (cm)** |
| **Checks** | | | | | |
| CDC Bethune | 15.0 | 12.0 | 11 | 92 | 49.1 |
| AAC Bright | 14.8 | 12.1 | 10 | 92 | 47.3 |
| CDC Glas | 15.4 | 12.7 | 7 | 92 | 48.6 |
| **SVPT Entries** | | | | | |
| AAC Marvelous | 16.2 | 13.4 | 2 | 95 | 49.0 |
| CDC Rowland | 16.1 | 13.2 | 4 | 98 | 48.2 |
| AAC Prairie Sunshine | 16.0 | 12.8 | 6 | 95 | 49.1 |
| CDC Dorado | 14.0 | 10.8 | 14 | 93 | 44.5 |
| CDC Kernen | 15.4 | 12.3 | 9 | 97 | 50.8 |
| **3rd Year Entries** | | | | | |
| FP2591 | 16.4 | 13.6 | 1 | 97 | 47.2 |
| FP2592 | 15.6 | 13.2 | 3 | 98 | 51.2 |
| **2nd Year Entries** | | | | | |
| FP2600 | 15.7 | 13.0 | 5 | 98 | 50.7 |
| FP2602 | 14.4 | 11.6 | 12 | 99 | 54.2 |
| FP2604 | 14.6 | 11.5 | 13 | 95 | 49.1 |
| **1st Year Entry** | | | | | |
| FP2606 | 15.3 | 12.5 | 8 | 97 | 47.0 |
| **Mean** | 15.3 | 12.5 | | 96 | 49.0 |
| **C.V. %** | 4.8 | 6.5 | | 2.6 | 4.7 |
| **LSD** | 2.91 | 1.32 | | 1.2 | 1.93 |
| **Replications** | 3 | 9 | | 9 | 10 |

## 11.0 Performance and adaptation of Quinoa varieties

**Project duration**: 2017-2021
**Collaborators**: Phillex Ltd. - Percy Phillips, WADO

### *Objectives*

- To determine yield potential and agronomic differences of seven quinoa varieties across different locations in Manitoba

### *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.

## *Materials and Methods*

A quinoa variety trial was established at locations near Melita, Roblin, Carberry and Arborg, Manitoba in 2021. Presented here are Melita's results. The trial was arranged in a randomized complete block design with seven treatments and three replicates over four site years. Varieties seeded were PHX21-01, PHX21-02, PHX21-03, PHX21-04, PHX21-05, PHX21-06 and PHX21-07. In Melita, plots were harrowed prior to seeding and were seeded with a Seedhawk dual knife air seeder on May 4th, 2021 into fair soil moisture at one-inch depth and at a seed rate of 10 lbs $ac^{-1}$. Fertility was side banded during seeding at 105-28-20-12-1.6 (N-P-K-S-Zn) actual lbs $ac^{-1}$. Post emergence weed control was done using Arrow herbicide (0.1 L $ac^{-1}$) tank mixed with X-Act adjuvant (0.5% v/v) applied to all plots on June 10th. Cygon 480EC (0.4 L $ac^{-1}$) was applied on June 28th for control of stem borer fly larvae (*Amauromyza karli* [Hendel]) before quinoa flowering. Plots were desiccated on September 20th with Roundup, Heat, and Reglone (0.67, 0.02, and 0.69 L $ac^{-1}$, respectively). Plots were harvested on September 28th (for early varieties) or October 4th for the later varieties (PHX21-05, PHX21-06 and PHX21-07). 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 11a. Means and analysis of variance for plant height, days to maturity (DTM), vigor rating, and yield of seven quinoa varieties grown in Melita, Manitoba in 2021.**

| Variety | Height (cm) | DTM (Days) | Vigor (1-9, 9 = most vigour) | Yield* (kg $ha^{-1}$) |
|---|---|---|---|---|
| PHX21-01 | 115**bc** | 118 | 7.0**a** | 769**b** |
| PHX21-02 | 125**ab** | 122 | 6.7**a** | 812**b** |
| PHX21-03 | 125**ab** | 113 | 6.7**a** | 1108**a** |
| PHX21-04 | 111**c** | 118 | 6.0**ab** | 1104**a** |
| PHX21-05 | 131**a** | 122 | 6.7**a** | 535**c** |
| PHX21-06 | 128**a** | 147 | 5.0**b** | 154**d** |
| PHX21-07 | 120**abc** | 147 | 6.3**a** | 694**bc** |
| **P value** | **0.047** | | **0.02** | **<0.001** |
| **Significant?** | **Yes** | | **Yes** | **Yes** |
| **CV (%)** | **6** | | **9** | **16** |

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 = 0.047) height differences among quinoa varieties grown in Melita in 2021, with PHX21-05 resulting in the greatest average plant height (131 cm). Average height of PHX21-02, PHX21-03, PHX21-06 and PHX21-07 plots was not significantly different from that of PHX21-05 (Table 11a). All varieties but PHX21-01 and PHX21-07 had average quinoa heights significantly greater than PHX21-04, which resulted in the lowest average plant height (111 cm). Despite significant height differences observed among quinoa varieties, no lodging was observed in any of the Melita plots. The lack of observed lodging was likely due to very dry conditions in Melita in 2021 resulting in relatively low plant height. A significant (P = 0.02) vigor rating difference was observed among quinoa varieties in 2021. The lowest vigor was observed in PHX21-06 quinoa plots (5.0), though this average vigor rating was not significantly different from that of PHX21-04 plots (6.0). Days to maturity of quinoa varieties grown at the Melita site in 2021 ranged from 147 days for PHX21-06 and PHX21-07 varieties to 113 days for PHX21-03 quinoa.

Very large yield differences were observed among quinoa varieties in 2021, with the greatest yields being observed from PHX21-03 (1108 kg $ha^{-1}$) and PHX21-04 (1104 kg $ha^{-1}$) varieties. Yields from these varieties were more than seven times greater than the average yield of the lowest yielding variety, PHX21-06 (154 kg $ha^{-1}$). Quinoa grain yield in 2021 was much lower than yields observed in 2020, likely due to extremely dry conditions and high temperatures at the trial site during quinoa flowering. Grain yields were also likely reduced due to poor emergence in variety PHX21-06 as well as 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 but wasn't able to be applied in time. High diamondback moth and lygus bug populations were also a concern in late September. Late emerging volunteer canola 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.

**Photo: Plots of quinoa photographed September 1st, 2021 near Melita, Manitoba.**

## *References*


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# 12.0 Annual Forages

***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 2021. In Melita, forages were established into canola stubble on May 31$^{st}$ at a 1.25-inch depth. Fertility was banded during seeding at a rate of 92-30-17-9-1.7 actual lbs ac$^{-1}$ (N-P-K-S-Zn). Two burnoff herbicide applications were necessary, with the landowner applying RT540 (400 g ac$^{-1}$) and Heat (10.4 g ac$^{-1}$) on May 4$^{th}$ and WADO staff applying Roundup (0.5 L ac$^{-1}$) and Aim (15 ml ac$^{-1}$) on May 26$^{th}$. Additional herbicide was necessary in many forages, with MCPA Amine (0.17 L ac$^{-1}$) applied to peas and cereals (not Millet or Sorghum) on June 17$^{th}$. Basagran (0.91 L ac$^{-1}$) was applied on Yellow Foxtail Millet and Red Proso Millet on June 17$^{th}$. MCPA Amine (0.22 L ac$^{-1}$) was applied to Sorghum-Sudangrass on June 22$^{nd}$. The use of insecticide was necessary for control of grasshoppers, with Matador (34 ml ac$^{-1}$) applied to all crops on July 2$^{nd}$ and Coragen applied via aerial spraying to all crops on July 17$^{th}$. Crops were harvested on July 28$^{th}$ at soft dough for cereals and peas, and early heading for millet and sorghum. A second cut was possible on September 24$^{th}$ due to a large rainfall in late August followed by regrowth in some crops, but these yields are not included in MCVET forage yield comparisons.

### *Results*

Dry matter yield results for each forage cut are presented in Table 12a 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 12a.** Average dry matter yield from each cut of various forage crops grown near Melita, Manitoba in 2021.

| Crop | Variety | First Cut Dry Matter Yield (tonnes $acre^{-1}$) | Second Cut Dry Matter Yield (tonnes $acre^{-1}$) | Total Dry Matter Yield (tonnes $acre^{-1}$) |
|---|---|---|---|---|
| Barley | AB Advantage | 1.87 | 0.30 | 2.44 |
| Barley | AB Cattlelac | 2.14 | 0.49 | 2.52 |
| Barley | AB Hague | 2.02 | 0.19 | 2.14 |
| Oats | CDC Arborg | 1.79 | 0.89 | 3.21 |
| Oats | CDC Haymaker | 1.01 | 0.68 | 1.86 |
| Spring Triticale | Common[1] | 1.50 | 0.37 | 2.34 |
| Peas/Barley | CDC Jasper/AB Advantage | 2.23 | 0.40 | 2.90 |
| Peas/Oats | CDC Jasper/CDC Arborg | 1.20 | 0.65 | 2.20 |
| Peas | DL Delicious | 1.56 | 0.06 | 1.62 |
| Yellow Foxtail Millet | Golden German[1] | 2.44 | 0.91 | 3.35 |
| Red Proso Millet | Cerise[1] | 2.25 | 0.27 | 2.71 |
| Sorghum-Sudangrass[2] | Common[1] | 1.72 | 0.92 | 3.21 |
| **GRAND MEAN** | | 1.81 | 0.51 | 2.54 |
| **CV %** | | 18.7 | 26 | 17 |
| **LSD (tonnes/acre) (0.05)** | | 0.58 | 0.12 | 0.39 |
| **Significant?** | | Yes | Yes | Yes |
| **Seeding Date** | | | May 31st | |
| **Harvest Date** | | July 28th | September 24th | |

[1] Due to lack of availability, common seed was used
[2] Delayed maturity sorghum-sudangrass

**Photo:** September 22nd regrowth just before harvest.

Dry conditions throughout much of the growing season followed by increased rainfall in late-August resulted in unusual regrowth following the first cut of forages. This regrowth actually allowed for a second cut to be taken in late September, though the dry matter yield from the second cut was lower than that of the first cut for all forages.

## 13.0 Barkers Grain Corn Irrigation Demonstration

**Project duration**: 2021
**Collaborators**: Canterra Seeds (PRIDE Seeds), Barkers Agri Center

### *Objectives*

- To evaluate the performance of an experimental grain corn variety compared to a traditional variety
- To evaluate the performance of grain corn varieties under irrigated or dry land conditions

### *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. However, corn is also a moisture sensitive crop and drought conditions can reduce grain yield and impact grain quality of a corn crop (Manitoba Agriculture). Irrigation of a corn crop has been shown to increase grain corn yields compared to dry land corn yields in Carberry, Manitoba, but producers in southwest Manitoba can benefit from the availability of yield data from corn grown under various irrigation conditions in the area (Abbas and Ranjan, 2016). In this demonstration, two grain corn varieties were grown under irrigated or dry land conditions to evaluate the impact of irrigation on the yield and grain quality of each variety.

### *Materials and Methods*

A grain corn irrigation demonstration was established near Melita (NW 6-4-26W1) on Mentieth loamy fine sand soil where there is access to overhead irrigation equipment on a 40-acre center pivot. Two grain corn varieties were used: A4323G2 RIB (PRIDE Seeds) and a new variety, A3979G2 RIB, recently launched by PRIDE Seeds in limited quantities. Corn was seeded into spring wheat stubble at 2-inch depth with 30-inch row spacing using a Wintersteiger Dynamic Disc planter equipped with EasyPlant software on May 10th. Prior to seeding, land was harrowed. Twelve rows of each corn variety were adjacently established in 53-meter-long plots and grown under dry land conditions. Irrigated plots were established under an irrigation pivot in the same field within a quarter mile of non-irrigated plots. Spring soil tests were performed to determine basal fertilizer application, with results indicating that most nutrient levels were low for the area (Table 13a). In the previous fall, a broadcast application of 50 actual lbs $ac^{-1}$ potassium was done using potash, though soil test results did not reflect this application. The lack of potassium in spring soil test results may have been due to dry conditions following the fall fertilizer broadcast. In spring, fertility was banded at 100-30-0 (N-P-K) actual lbs $ac^{-1}$, with an additional 25 lbs $ac^{-1}$ nitrogen and 2 lbs $ac^{-1}$ zinc applied in a chelate product. Dry land corn received additional fertility of 60 lbs $ac^{-1}$ nitrogen via broadcasted urea (treated with Agrotrain) and 2 lbs $ac^{-1}$ of each boron and copper applied via a chelate. Roundup transorb (glyphosate 540 g $L^{-1}$) was applied at 0.5 L $ac^{-1}$ on June 8th at the 3-4 leaf corn stage to control weeds. Corn was harvested October 6th by combining the four inner rows of each variety. Yield, test weight, and grain moisture at harvest (from combine) were recorded for each variety under dry land and irrigated conditions.

**Table 13a.** 2021 Spring soil test results for the demonstration site.

| Nutrient (lbs $ac^{-1}$) | | | | |
|---|---|---|---|---|
| **N** | **P** | **K** | **S** | **Zn** |
| **35** | 16 | 176 | 88 | 1 |

## *Results and Discussion*

Coming out of a dry 2020 growing season, only 42 mm of precipitation was accumulated from September 2020 – April 2021 at the demonstration site. With 28 mm of rain at the site in May, 87 mm in June, 35 mm in July and 125 mm in August, the growing season was relatively dry. The site received only 91% of normal rainfall, including 60 mm of rainfall in late August which provided minimal corn yield benefits as many varieties grown at the site had already entered the dent stage. The 2021 growing season was also very warm, with the site receiving 111% 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. While the dry land corn received more fertility than irrigated corn, the dry conditions ensured that the biggest limiting factor for corn yield in 2021 was likely water availability.

Both A4323G2 RIB corn and A3979G2 RIB corn yielded higher under irrigated conditions than under dry land conditions (Table 13b). This was expected, as 2021 conditions were very dry, and moisture was likely the major yield-limiting factor. A similar yield response to irrigation was observed in Carberry at CMCDC in 2014, where corn under irrigated conditions yielded 16% greater than corn grown on dry land conditions (Abbas and Ranjan, 2016). Irrigated corn yields may have also been limited by nutrient availability, as corn grown under dry land conditions received greater fertility than irrigated corn. Nutrient deficiency symptoms were also observed in irrigated corn.

**Table 13b.** Yield, test weight, and grain moisture at harvest for two corn varieties grown under irrigation or dry land conditions near Melita in 2021.

| | **Yield* (bu ac$^{-1}$)** | | **Test Weight (lbs Avery bu$^{-1}$)** | | **Grain Moisture** (%)** | |
|---|---|---|---|---|---|---|
| | **A4323G2 RIB** | **A3979G2 RIB** | **A4323G2 RIB** | **A3979G2 RIB** | **A4323G2 RIB** | **A3979G2 RIB** |
| **Dry land** | 121 | 129 | 60.2 | 60.1 | 18.7 | 13.0 |
| **Irrigated** | 151 | 146 | 60.8 | 60.2 | 17.8 | 15.5 |

***Yields corrected to 15% grain moisture**
****Grain moisture readings from combine during harvest**

Application of an additional 40 lbs ac$^{-1}$ nitrogen to irrigated corn would have brought the soil + applied nitrogen level to 200 lbs ac$^{-1}$, and greater yields may have been observed. The test weight of both varieties was also greater under irrigated conditions, though this difference was small. Grain moisture at harvest was greater under irrigated conditions for A3979G2 RIB corn, but the opposite was true for A4323G2 RIB corn. The difference in grain moisture responses among varieties may be due to different moisture stress responses or due to spatial variation in the field.

The A3979G2 RIB corn yielded greater than A4323G2 RIB corn under dry land conditions, but not when irrigated. Large yield differences between the varieties were not observed, and because corn was established in an unreplicated demonstration, reliable conclusions about which variety has greater yield potential in Melita cannot be drawn. Replicated grain corn variety evaluations for sites across Manitoba are presented in the Seed Manitoba 2022 Variety Selection Guide, which can be accessed at seedmb.ca or found mailed out with the Manitoba Cooperator.

A4323G2 RIB corn grown under irrigated conditions (left) compared to corn grown under dry land conditions (right) in 2021.

Road view of the grain corn irrigation demonstration near Melita in 2021 with A4323G2 RIB corn (left) and A3979G2 RIB corn (right).

## *References*

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## 14.0 Development of short season, cold tolerant, disease resistant corn inbreds

**Project duration**: 2021
**Collaborators**: Aida Kebede (AAFC Ottawa)

### *Objectives*

- Development and release of early maturing cold tolerant corn inbreds with emphasis on the 1800-2000 CHU market
- Development of corn inbreds 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 her team upon request.

## 15.0 Intercropping corn and hairy vetch

**Project duration**: 2021
**Collaborators**: WADO, Rachelle McCannell (University of Saskatchewan) B.Sc. Thesis Project

### *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.

### *Materials and Methods*

An intercrop trial with corn and hairy vetch was established near Melita, Manitoba (NW 6-4-26 W1) in 2021 on Mentieth loamy fine sand soil. Treatments consisted of corn seeded at 49 400, 64 220, or 79 040 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 1-inch depth and 9.5-inch row spacing. Fertility was applied according to soil test results (Agvise, North Dakota) and fertilizer was banded at 100-30-0-0-2 actual lbs $ac^{-1}$ (N-P-K-S-Zn) prior to seeding (Table 15a). In fall prior to seeding, 50 lbs $ac^{-1}$ actual potassium was applied in granular potash form by surface broadcast. Two lbs $ac^{-1}$ of both boron and copper were applied following seeding. Additional fertility was applied in-crop (when deficiency symptoms were observed) at 18-10-60-25 actual lbs $ac^{-1}$ (N-P-K-S) using liquid ammonium phosphate, granular potash & ammonium sulfate. Weeds were controlled at the V4 stage of corn and 4-node stage of vetch using glyphosate (540 g $L^{-1}$ a.i) applied at 0.5 L $ac^{-1}$ in a water application volume of 10 imperial gallons $acre^{-1}$.

**Table 15a.** Spring soil test results for the trial site in 2021.

| Depth (cm) | pH | OM (%) | N (ppm) | P-Olsen (ppm) | K (ppm) | Zn (ppm) | Ca (ppm) | Mg (ppm) | Na (ppm) | S (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0-15** | 8.1 | 1.6 | 14.5 | 8 | 88 | 0.49 | 3252 | 395 | 27 | 12 |
| **15-61** | 8.5 | - | 3.0 | - | - | - | - | - | - | 32 |

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, P, 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*

The presence of vetch in corn plots significantly ($P < 0.001$) reduced corn biomass, as corn with no vetch had an average biomass of 17263 kg $ha^{-1}$, while corn intercropped with vetch had an average biomass of 14250 kg $ha^{-1}$ (Figure 15a). Corn grain yield followed the same trend, with the sole corn crops resulting in an average yield of 6851 kg $ha^{-1}$ and the corn-vetch intercrops resulting in a significantly ($P < 0.001$)

lower average yield of 5666 kg $ha^{-1}$ (Table 15b). 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 similar average biomass as the monocrop corn without grain. 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 15b.** Means and analysis of variance for data collected on corn-vetch intercrops and corn monocrops grown near Melita, Manitoba in 2021.

| Factor | | Corn (Plants $ha^{-1}$) | Vetch (Plants $m^2$) | Weeds (kg $ha^{-1}$) | Corn Biomass (kg $ha^{-1}$) | Vetch Biomass (kg $ha^{-1}$) | Total Biomass (kg $ha^{-1}$) | Test Weight (kg $hL^{-1}$) | Grain Yield (kg $ha^{-1}$) | Biomass - Grain Yield (kg $ha^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|
| **System** | **(1) No Vetch** | 51400 | - | 389**a** | 17263**a** | - | 17263 | 74 | 6851**a** | 10411 |
| | **(2) Vetch** | 45932 | 27 | 96**b** | 14250**b** | 2479 | 16729 | 74 | 5666**b** | 11063 |
| **Corn rate** | **(1) 49 400** | 34449 | 29 | 458 | 15190 | 2750 | 16841 | 75 | 5423**b** | 11142 |
| **(Plants** | **(2) 64 220** | 57415 | 27 | 210 | 15748 | 2288 | 15887 | 74 | 6527**a** | 10365 |
| **per ha)** | **(3) 79 040** | 54134 | 26 | 203 | 16330 | 2400 | 17459 | 74 | 6827**a** | 10704 |
| **System x** | **1x1** | 36089 | - | 813 | 16289 | - | 16290 | 74 | 5911 | 10378 |
| **Rate** | **1x2** | 55774 | - | 303 | 17897 | - | 17897 | 75 | 7241 | 10656 |
| | **1x3** | 62336 | - | 337 | 17602 | - | 17602 | 74 | 7401 | 10201 |
| | **2x1** | 32808 | 29 | 102 | 14091 | 2750 | 16841 | 75 | 4934 | 11907 |
| | **2x2** | 59055 | 27 | 118 | 13599 | 2288 | 15887 | 74 | 5812 | 10075 |
| | **2x3** | 45932 | 26 | 70 | 15059 | 2400 | 17459 | 74 | 6252 | 11207 |
| **P value System** | | 0.494 | - | **<0.001** | **<0.001** | - | 0.344 | 0.971 | **<0.001** | 0.244 |
| **P value Rate** | | 0.061 | 0.902 | 0.238 | 0.282 | 0.209 | 0.366 | 0.935 | **<0.001** | 0.511 |
| **P Value S x R** | | 0.588 | - | 0.245 | 0.29 | - | 0.175 | 0.392 | 0.732 | 0.277 |
| **CV (%)** | | 39 | 34 | 45 | 9 | 14 | 8 | 1 | 9 | 12 |
| **R-square (%)** | | 39.9 | 27 | 69.22 | 73 | 51 | 48 | 20 | 81.2 | 55.8 |

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

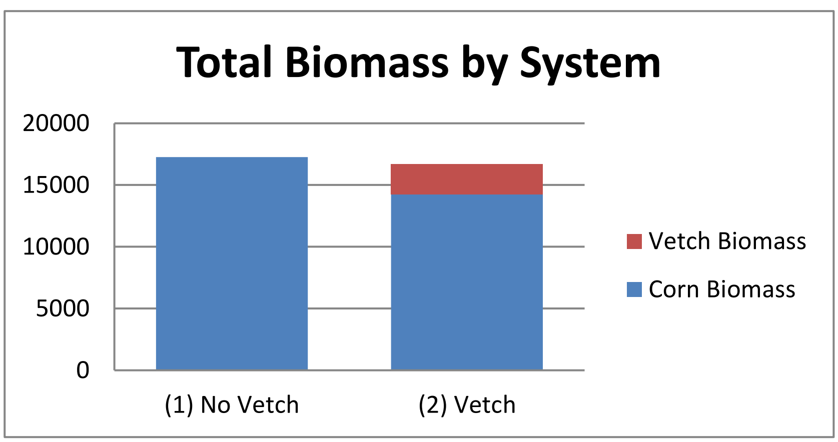


**Figure 15a.** Total corn and vetch biomass in corn monocrops or corn-vetch intercrops grown near Melita, Manitoba in 2021. Values followed by the same letter are not significantly different by Tukey's mean separation method at 95% confidence.

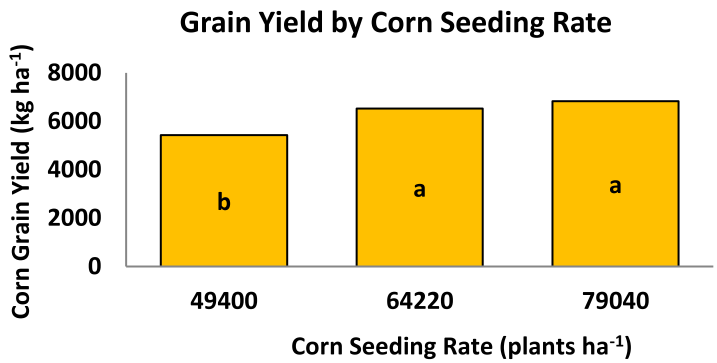


**Figure 15b.** Average grain yield of corn seeded at 49 400, 64 220, or 79 040 plants ha$^{-1}$ grown near Melita, Manitoba in 2021. Bars marked with the same letter are not significantly different by Tukey's mean separation method at 95% confidence.

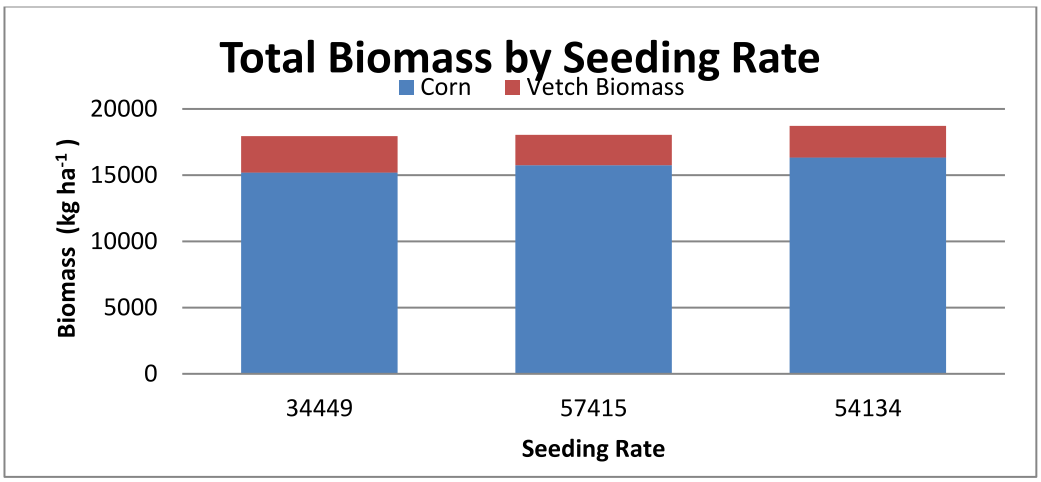


**Figure 15c.** Total corn and vetch biomass of corn-vetch intercrops with corn seeded at 49 400, 64 220, or 79 040 plants ha$^{-1}$.

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 greater than that of corn seeded at 49 400 plants ha$^{-1}$ (Figure 15b). Unexpectedly, corn seeding rate did not significantly influence corn plant population, corn biomass, or total system biomass (Figure 15c). 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. The lack of significant corn seeding rate influence on corn biomass, vetch biomass, or weed biomass is likely due to the lack of significant difference in corn population between seeding rates. If different seeding rates had produced corn stands which were significantly different, perhaps the expected effects of increased seeding rate may have been observed. Environmental conditions in Melita in 2021 were also extremely hot and dry, with the area receiving

118% of normal growing degree days while only receiving 85% of the normal rainfall during the growing season (Manitoba Agriculture – Growing season report for Melita). The absence of significant corn seeding rate influences may have also been due to hot and dry conditions reducing overall intended plant stands. Between 11 and 32% stand losses were realized between intended seed rate, and realized seed rate among treatments.

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 15d). As expected, relative feed value (RFV) and total digestible nutrients (TDN) are greatest when the whole intercrop system is grazed. The inclusion of vetch in the feed increased both crude protein (CP) and RFV compared to the monocrop feeds, indicating that vetch is adding value to the grazing system and enhances grazing systems when grain corn is harvested.

| Corn Rate (plants ha$^{-1}$) | ADF | Ca | CP | DE | Mg | Met E | NDF | Phos | Pot | RFV | TDN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Corn Only without Grain** | | | | | | | | | | | |
| **49400** | 46.05 | 0.45 | 5.14 | 2.18 | 0.33 | 1.81 | 77.20 | 0.05 | 1.27 | 64.00 | 49.44 |
| **64220** | 46.89 | 0.44 | 4.31 | 2.14 | 0.37 | 1.78 | 75.62 | 0.05 | 0.93 | 64.00 | 48.54 |
| **79040** | 49.36 | 0.48 | 4.89 | 2.02 | 0.44 | 1.68 | 76.98 | 0.05 | 1.03 | 61.00 | 45.90 |
| **Corn only Plus Grain** | | | | | | | | | | | |
| **49400** | 30.02 | 0.28 | 6.97 | 2.93 | 0.24 | 2.44 | 54.46 | 0.16 | 0.94 | 112.00 | 66.57 |
| **64220** | 28.20 | 0.23 | 7.08 | 3.02 | 0.24 | 2.51 | 48.43 | 0.19 | 0.65 | 129.00 | 68.51 |
| **79040** | 26.47 | 0.24 | 7.15 | 3.10 | 0.25 | 2.57 | 44.27 | 0.18 | 0.72 | 143.00 | 70.36 |
| **Corn Plus Grain + Vetch** | | | | | | | | | | | |
| **49400** | 21.75 | 0.26 | 9.04 | 3.32 | 0.23 | 2.76 | 36.48 | 0.23 | 0.88 | 183.00 | 75.40 |
| **64220** | 17.08 | 0.16 | 8.42 | 3.54 | 0.19 | 2.94 | 29.30 | 0.21 | 0.60 | 240.00 | 80.39 |
| **79040** | 24.37 | 0.27 | 8.92 | 3.20 | 0.24 | 2.66 | 39.89 | 0.19 | 0.90 | 163.00 | 72.60 |
| **Corn without Grain plus Vetch** | | | | | | | | | | | |
| **49400** | 44.76 | 0.59 | 9.41 | 2.24 | 0.39 | 1.86 | 69.03 | 0.12 | 1.65 | 73.00 | 50.82 |
| **64220** | 46.09 | 0.59 | 9.52 | 2.18 | 0.40 | 1.81 | 68.47 | 0.11 | 1.40 | 72.00 | 49.39 |
| **79040** | 46.82 | 0.51 | 7.73 | 2.14 | 0.41 | 1.78 | 71.66 | 0.09 | 1.39 | 68.00 | 48.61 |
| **Vetch only (inside Plot)** | | | | | | | | | | | |
| **49400** | 40.68 | 0.96 | 21.48 | 2.43 | 0.31 | 2.02 | 50.71 | 0.32 | 3.01 | 105.00 | 55.18 |
| **64220** | 41.78 | 0.99 | 19.43 | 2.38 | 0.32 | 1.98 | 50.78 | 0.27 | 2.58 | 103.00 | 54.00 |
| **79040** | 42.51 | 0.93 | 19.91 | 2.35 | 0.30 | 1.95 | 51.65 | 0.28 | 3.26 | 100.00 | 53.22 |

**Figure 15d.** Feed test results for various grazing options in a corn-vetch intercrop or corn monocrop system. Acid Detergent Fibre (ADF), Calcium (Ca), Crude Protein (CP), Digestible Energy (DE), Magnesium (Mg), Metabolizable Energy (Met E), Neutral Detergent Fibre (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. Soil was tested by treatment following the trial, but results were inconclusive as there was high spatial nutrient variability (Table 15c). Crude protein contains 6.25% nitrogen by weight (Methods of Food Analysis, 2020). When vetch is included with corn it nearly doubles the crude protein content of the total biomass. Thus, whether corn is removed from harvest or not, our calculations suggest vetch adds an additional 15.8-30.3 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 are taken into account.

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

| Factor | | N 0-6" (ppm) | N 6-24" (ppm) | N 0-24" (ppm) | P 0-6" (ppm) | Soil Organic Matter |
|---|---|---|---|---|---|---|
| **System** | **(1) No Vetch** | 3.4 | 8.6**a** | 12.0 | 7.8 | 1.5 |
| | **(2) Vetch** | 4.3 | 5.8**b** | 10.0 | 7.2 | 1.5 |
| **Corn rate (Plants per acre)** | **(1) 49400** | 4.8**a** | 6.8 | 11.6 | 6.8 | 1.5**b** |
| | **(2) 64220** | 3.1**b** | 6.2 | 9.3 | 7.6 | 1.6**a** |
| | **(3) 79040** | 3.7**ab** | 8.6 | 12.3 | 8.1 | 1.4**b** |
| **System x Rate** | **1x1** | 4.0 | 8.3 | 12.3 | 6.5 | 1.5 |
| | **1x2** | 2.8 | 6.8 | 9.5 | 7.0 | 1.6 |
| | **1x3** | 3.5 | 10.9 | 14.4 | 10.0 | 1.4 |
| | **2x1** | 5.6 | 5.3 | 10.9 | 7.0 | 1.5 |
| | **2x2** | 3.4 | 5.6 | 9.0 | 8.3 | 1.6 |
| | **2x3** | 3.9 | 6.4 | 10.3 | 6.3 | 1.5 |
| **P value System** | | 0.121 | **0.028** | 0.131 | 0.634 | 0.807 |
| **P value Rate** | | **0.05** | 0.243 | 0.148 | 0.715 | **0.006** |
| **P Value S x R** | | 0.608 | 0.52 | 0.484 | 0.305 | 0.182 |
| **CV (%)** | | 34 | 40 | 28 | 45 | 6 |
| **R-square (%)** | | 55 | 59.5 | 64.36 | 48 | 70.76 |

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

## *Conclusion*

Intercropping corn with hairy vetch was demonstrated to be a successful intercrop combination at Melita in 2021 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 four times less than in corn monocrops. Increasing seeding rate of corn was demonstrated to increase grain yield, but did not significantly affect corn plant population, corn biomass, or total system biomass. The hot, dry conditions experienced in Melita in 2021 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. 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.

**Above:** Corn and vetch growing together on June 28th. Twelve days after glyphosate application, Vetch was recovering.

**Right:** Corn in the pollination stage and vetch in the vegetative stage on July 21st.

 

**Corn harvest in corn-vetch intercrops on October 6th.** Vetch was in full flower – early pod stage with some mature seed. Some mildew was present on vetch.

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## 16.0 Pea (oat-barley-canola) intercrop evaluation

**Project duration**: 2020-ongoing
**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 so as so take advantage of biological nitrogen fixation, which saves fertilizer costs for both the current and succeeding crops in rotation. Other factors to consider when selecting intercrop combinations and densities include 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 content 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 pea-oat, pea-barley and pea-canola intercrops on yield, quality, disease and pests pressure on component crops and also understand the shift in behavior of the crops involved.

### *Materials and Methods*

The trials were conducted near Melita, Manitoba with detailed legal land description and agronomy of the site described in Table 16b. Soil sampling and testing was done in spring prior to seeding and fertilizer application was based on soil analysis results so as to meet crop requirements (Table 16a).

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 meters$^2$. Treatments were replicated four times. 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 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. Data were analyzed with Minitab (ver. 18.1) by running a GLM two-way ANOVA. A Tukey LSD test was used to compare means at 5% level of significance. P-values were derived from raw or data transformed using the Johnson method. Economic analysis was done based on operating cost, fixed cost, and labor cost assumptions established in 2020. 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 2020.

**Table 16a: 2021 Spring soil test results for Melita site**

| pH 0-6” | pH 6-24” | OM% | N 0-6" (lb ac$^{-1}$) | N 6-24" (lb ac$^{-1}$) | N-(N1+N2) | P-O (ppm) | K (ppm) |
|---|---|---|---|---|---|---|---|
| 7.1 | 8.0 | 3.1 | 15 | 4 | 19 | 3 | 210 |
| **Ca (ppm)** | **Mg (ppm)** | **S 0-6" (lb ac$^{-1}$)** | **S 6-24" (lb ac$^{-1}$)** | **Zn (ppm)** | **Salt1** | **Salt2** | **CEC (meq)** |
| 2165 | 459 | 62 | 120+ | 0.56 | 0.33 | 0.75 | 15.3 |

**Table 16b: Melita trial site description and agronomy in 2021**

| | | |
|---|---|---|
| **Location** | Melita | |
| **Legal** | NW 27-3-27 | |
| **Rotation (2 yr.)** | Glyphosate tolerant Canola, Spring Wheat | |
| **Soil Series** | Alexander Loam | |
| **Field Prep** | Harrowed | |
| **Stubble** | Spring wheat | |
| **Burnoff (Date/Rate-ac/Products)** | None | |
| **Soil Moisture at Seeding** | Fair | |
| | **Pea-Barley and Pea-Oat** | **Pea-Canola** |
| **Seed Date** | May 4, 2021 | May 7, 2021 |
| **Seed depth** | 1” | 0.75” |
| **Seeder (drill/planter?)** | Seed hawk dual knife air seeder | |
| **Fertility Applied (NPKS-lb/ac Actual)** | Granular nodulator SCG (BASF), 12-28-20-12-1.6Zn | |
| **Topdressing (Date/Rate)** | None | |
| **Herbicides (Date, Name, Rate/ac)** | June 8, MCPA Amine 500, 0.15 L $ac^{-1}$ | June 8, Odyssey 17.3g $ac^{-1}$ + Merge 0.5% v/v |
| **Fungicides** | None | |
| **Insecticides** | None | June 2, 75 mL $ac^{-1}$ Pounce (10 gal), flea beetles |
| **Desiccation Date, Product, Rate** | August 3, Roundup 0.5 L $ac^{-1}$ + Heat LQ 22 mL $ac^{-1}$ | August 10, Roundup 0.5 L $ac^{-1}$ + Heat 22 mL $ac^{-1}$ + Reglone 0.5 L $ac^{-1}$ + LI700 @ 0.1% v/v |
| **Harvest Date** | August 12, 2021 | August 16, 2021 (Canola slightly too early) |
| **GGDs actual (Seed Date>Harvest) Base 5*C** | 1305 | 1374 |
| **GGDs Normal (Seed Date>Harvest)** | 1172 | 1213 |
| **Precipitation (Actual) SD>HD** | 175 | 175 |
| **Precipitation (Normal) SD>HD** | 254 | 260 |
| | | |
| **Combine settings** | Concave clearance: 8 mm<br>Cylinder: 890 rpm<br>Fan speed: 940 rpm | Concave clearance: 12 mm<br>Cylinder: 600 rpm<br>Fan Speed: 820 rpm |
| | | |
| **Cleaning** | Spiral Separator then table cleaner<br>Barley and pea splits were hard to separate | Table cleaner |

## *Results and Discussion*

In 2021, drought conditions had significant impact on crops in the Melita area. Precipitation accumulated throughout the growing season was well below the 30-year normal precipitation for

Melita. This below average precipitation had significant impacts on crop yields, and resulted in low gross revenue of most treatments. Because gross revenue was low, net revenue of most treatments was negative.

When intercropped with oats, days to maturity for all pea crops was not significantly different (Table 16c). Oat days to maturity was significantly (P=0.008) greater than the sole oat crop in 100pea:25Oat and 100Pea:15Oat treatments. The reduced density of oat in these intercrop treatments, compared to the monocrop, may have resulted in oats having 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 reduced in intercrop treatments compared to the sole pea crop, though this decrease was only significant (P<0.001) in the 100Pea:25Oat treatment (99.5 g/500 kernels). Seed weight of oats was not significantly different across 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 (15.5% and 15.0%, respectively). This implies that intercropping oat with pea 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=0.014) reduced when pea was intercropped with oat (1.7-1.8%), compared to the sole pea crop (5.0%) (Table 16d). This implies that intercropping pea with oat could increase pea grain quality compared to a sole pea crop, perhaps because oat offers some protection to pea during crop harvest. Lodging ratings and weed pressure were not significantly different across treatments.

**Table 16c: Means and analysis of variance for Pea-Oat emergence, leaf diseases, days to maturity, seed weight, and protein content at Melita in 2021.**

| **Treatment** | **Emergence (plants m$^{-2}$)** | | **Leaf Disease*** | | **Maturity (days)** | | **Seed Weight (g/500)** | | **Protein (%)** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Description** | **Pea** | **Oat** | **Pea** | **Oat** | **Pea** | **Oat** | **Pea** | **Oat** | **Pea** | **Oat** |
| 100% Peas (check) | 53 | - | 0.43 | - | 85 | - | 106.6**a** | - | 24.9 | - |
| 100% Peas, 15% Oats | 54 | 24 | 0.48 | 1.30 | 86 | 87**a** | 101.3**ab** | 21.0 | 24.8 | 15.5**a** |
| 100% Peas, 25% Oats | 55 | 20 | 0.40 | 1.45 | 86 | 86**a** | 102.6**ab** | 20.7 | 24.5 | 15.0**a** |
| 100% Peas, 50% Oats | 59 | 44 | 0.15 | 1.50 | 85 | 85**ab** | 99.5**b** | 21.4 | 24.1 | 13.5**b** |
| 100% Oat | - | 135 | - | 1.60 | - | 83**b** | - | 19.2 | - | 12.1**c** |
| **P value** | | | 0.059 | 0.118 | 0.130 | **0.008** | **<0.001** | 0.108 | 0.225 | **<0.001** |
| **CV (%)** | | | 70 | 11 | 1 | **1** | **3** | 5 | 2 | **4** |

*Johnson transformation prior to ANOVA

**Table 16d: Means and analysis of variance for Pea-Oat lodging score, weed population, pea splits, seed diseases, root rot and aphid count at Melita in 2021.**

| Treatment Description | Lodging (1-5) | Weeds (plants $m^{-2}$) | Pea: Splits* (%) | Pea: Seed Disease (%) | Pea: Root Rot* (1-7) | Pea: Aphids (per plant) |
|---|---|---|---|---|---|---|
| 100% Peas (check) | 1.25 | 5 | 5.0**a** | 5.5 | 1.6 | 0.0 |
| 100% Peas, 15% Oats | 1.25 | 6 | 1.8**b** | 7.0 | 1.7 | 0.3 |
| 100% Peas, 25% Oats | 1.25 | 7 | 1.7**b** | 9.8 | 2.0 | 0.0 |
| 100% Peas, 50% Oats | 1.25 | 6 | 1.7**b** | 7.5 | 1.8 | 0.0 |
| 100% Oat | 1.25 | 9 | - | - | - | - |
| **P value** | **-** | 0.848 | **0.014** | 0.162 | 0.848 | 0.436 |
| **CV (%)** | n/a | 67 | **59** | 32 | 28 | n/a |

*Johnson transformation prior to ANOVA
n/a – not analyzable

As expected, there were significant (P<0.001) yield differences between pea sole crop, oat sole crop, and pea-oat intercrops (Table 16e). Pea yield in 100Pea:15Oat (22.1 bu $ac^{-1}$) and 100Pea:25Oat (19.3 bu $ac^{-1}$) was significantly lower than the sole pea crop, but greater than the 100Pea:50Oat treatment (12.2 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 other oat intercrop treatments. Though differences in partial LER were observed in each crop, there was no statistically significant difference in TLER for sole and intercrop treatments. However, none of the intercrop treatments had a total land equivalence ratio below that of the sole crops, indicating that while there may not be a statistically significant TLER increase resulting from intercropping pea with oat, TLER was not reduced by intercropping. Table 16e 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 2021, neither the sole crops nor the intercrop combinations were profitable.

**Table 16e: Mean Pea-Oat yield, land equivalence ratio and economic analysis at Melita in 2021.**

| Treatment Description | Yield (bu ac$^{-1}$) | | Land Equivalent Ratio | | | Economic Analysis | | |
|---|---|---|---|---|---|---|---|---|
| | Pea | Oat | P-LER | O-LER | T-LER | COP ($/ac) | Gross Rev ($/ac) | Net Rev ($/ac) |
| 100% Peas (check) | 35 | - | 1.00**a** | - | 1.00 | 336 | 283 | -53 |
| 100% Peas, 15% Oats | 22**b** | 31**c** | 0.65**b** | 0.44**c** | 1.09 | 348 | 299 | -49 |
| 100% Peas, 25% Oats | 19**b** | 36**bc** | 0.56**b** | 0.51**bc** | 1.08 | 363 | 293 | -70 |
| 100% Peas, 50% Oats | 12**c** | 47**b** | 0.36**c** | 0.67**b** | 1.03 | 354 | 278 | -76 |
| 100% Oat | - | 72**a** | - | 1.00**a** | 1.00 | 305 | 271 | -35 |
| **P value** | **<0.001** | **<0.001** | **<0.001** | **<0.001** | 0.307 | | | |
| **CV (%)** | **16** | **15** | **11** | **12** | 5 | | | |

When pea was intercropped with barley at various densities, no significant differences were observed in leaf disease ratings or days to maturity in either crop (Table 16f). Grain weight of pea was not significantly affected by intercropping with barley. Grain weight of barley in 100Pea:15Barley and 100Pea:25Barley treatments was significantly (P=0.003) greater than grain weight in the sole barley crop, indicating that intercropping with pea may have grain quality benefits at these barley densities. While protein content of pea was not different across treatments, barley protein content in all intercrop combinations was greater than in the barley sole crop, further demonstrating a possible grain quality benefit when barley is intercropped with pea. No significant differences were observed in lodging and weed pressure across treatments. In peas, no significant difference in pea splits, root rot, or aphid pressure was observed across treatments. Pea seed disease prevalence in the 100Pea:50Barley treatment was significantly lower than in the sole pea crop, indicating a potential disease suppression effect of barley on pea crops when intercropped at this ratio.

**Table 16f: Means and analysis of variance for Pea-Barley emergence, leaf diseases, days to maturity, seed weight and protein content at Melita in 2021.**

| Treatment Description | Actual Emergence (plants m$^{-2}$) | | Leaf Disease | | Maturity (days) | | Seed Weight (g/500) | | Protein (%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pea | Barley | Pea | Barley | Pea | Barley | Pea | Barley | Pea | Barley |
| 100% Peas (check) | 40 | - | 0.3 | - | 84 | - | 102.5 | - | 24.7 | - |
| 100% Peas, 15% Barley | 55 | 17 | 0.3 | 1.8 | 84 | 84 | 102.5 | 21.9**a** | 25.0 | 13.8**a** |
| 100% Peas, 25% Barley | 54 | 31 | 0.3 | 2.4 | 83 | 83 | 102.3 | 21.6**a** | 24.8 | 12.8**ab** |
| 100% Peas, 50% Barley | 52 | 53 | 0.3 | 2.1 | 83 | 83 | 100.1 | 20.9**b** | 25.0 | 12.0**b** |
| 100% Barley (check) | - | 122 | - | 2.0 | - | 83 | - | 19.8**b** | - | 10.7**c** |
| **P value** | | | 0.607 | 0.202 | 0.631 | 0.436 | 0.623 | **0.003** | 0.329 | **<0.001** |
| **CV (%)** | | | 40 | 18 | 1 | 1 | 3 | **3** | 1 | **4** |

**Table 16g: Means and analysis of variance for Pea-barley lodging, weed population, split peas, seed diseases, root rot and aphid count at Melita in 2021.**

| Treatment Description | Lodging (1 to 5) | Weeds (plants $m^{-2}$) | Pea: Splits (%) | Pea: Seed Disease (%) | Pea: Root Rot (1-7) | Pea: Aphids (per plant) |
|---|---|---|---|---|---|---|
| 100% Peas (check) | 1 | 6 | 4.4 | 9.3**a** | 1.6 | 0.1 |
| 100% Peas, 15% Barley | 1 | 7 | 3.7 | 9.3**a** | 1.7 | 0.2 |
| 100% Peas, 25% Barley | 1 | 8 | 4.0 | 7.5**ab** | 2.3 | 0.0 |
| 100% Peas, 50% Barley | 1 | 6 | 3.4 | 5.0**b** | 2.0 | 0.2 |
| 100% Barley (check) | 1 | 12 | - | - | - | - |
| **P value** | n/a | 0.064 | 0.267 | **0.028** | 0.382 | 0.573 |
| **CV (%)** | n/a | 39 | 16 | **24** | 30 | 159 |

n/a: not analyzable

Pea yield of the pea monocrop was greater than that of the intercropped peas, with pea yield decreasing as barley density increased (Table 16h). Barley yield followed a similar trend, as yield was greatest in the barley sole crop and declined with barley density. Barley yield in 100Pea:15Barley and 100Pea:25Barley treatments was 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. Though the TLER of each intercrop combination was greater than that of the sole pea and barley crops, this difference was not significant. 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. Based on 2020 markets, net revenue of every treatment was negative, with the greatest revenue loss in the 100Pea:50Barley treatment.

**Table 16h: Mean Pea-barley yield, Land Equivalence Ratio and economic analysis at Melita in 2021.**

| Treatment Description | Yield (bu $ac^{-1}$): Pea | Yield (bu $ac^{-1}$): Barley | Land Equivalent Ratio: P-LER | Land Equivalent Ratio: B-LER | Land Equivalent Ratio: T-LER | Economic analysis: COP ($/ac) | Economic analysis: Gross Rev ($/ac) | Economic analysis: Net Rev ($/ac) |
|---|---|---|---|---|---|---|---|---|
| 100% Peas (check) | 31**a** | - | 1.00**a** | - | 1.00 | 336 | 252 | -83 |
| 100% Peas, 15% Barley | 22**b** | 17**c** | 0.72**b** | 0.36**c** | 1.08 | 344 | 258 | -85 |
| 100% Peas, 25% Barley | 18**c** | 22**c** | 0.57**c** | 0.47**c** | 1.04 | 345 | 244 | -101 |
| 100% Peas, 50% Barley | 11**d** | 33**b** | 0.36**d** | 0.71**b** | 1.07 | 349 | 242 | -107 |
| 100% Barley (check) | - | 47**a** | - | 1.00**a** | 1.00 | 301 | 212 | -89 |
| **P Value** | **<0.001** | **<0.001** | **<0.001** | **<0.001** | 0.171 | | | |
| **CV (%)** | **9** | **12** | **6** | **12** | 4 | | | |

When pea was intercropped with canola, there was no significant difference in days to maturity or leaf disease incidence among treatments (Table 16i). Pea and canola grain weights were not significantly different across treatments. Though protein content of peas varied across treatments, the Tukey test was unable to separate means, and no statistically significant protein content difference was found. No significant lodging or weed pressure differences were observed between treatments (table 16j). In pea crops, no significant differences were observed in root rot, seed disease or aphid pressure, but the percentage of split peas was significantly (P=0.038) reduced in all intercrop combinations compared to the sole pea crop. This may indicate some mechanical protection of peas during harvest by the canola crop. 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. Additional years of study are likely required before density recommendations can be made to producers.

**Table 16i: Means and analysis of variance for pea-canola emergence, leaf diseases, days to maturity, seed weight and protein content at Melita in 2021.**

| Treatment Description | Actual Emergence (plants m$^{-2}$) | | Leaf Disease* | | Maturity (days) | | Seed Weight (g/500) | | Protein (%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pea | Canola | Pea | Canola | Pea | Canola | Pea | Canola | Pea*^ | Canola |
| 100% Peas (check) | 65 | - | 0.43 | - | 85 | - | 109.4 | - | 25.2**a** | - |
| 100% Peas, 25% Canola | 61 | 17 | 0.45 | 0.0 | 86 | 94 | 107.4 | 1.7 | 25.4**a** | 21.1 |
| 100% Peas, 50% Canola | 60 | 16 | 0.28 | 0.0 | 85 | 94 | 110.0 | 1.7 | 25.5**a** | 20.7 |
| 75% Peas, 25% Canola | 49 | 27 | 0.60 | 0.0 | 87 | 94 | 106.2 | 1.6 | 25.2**a** | 20.4 |
| 75% Peas, 50% Canola | 43 | 23 | 0..60 | 0.0 | 85 | 94 | 110.5 | 1.7 | 25.1**a** | 20.2 |
| 100% Canola (check) | - | 55 | - | 0.0 | - | 94 | - | 1.6 | - | 18.9 |
| **P value** | | | 0.294 | n/a | 0.178 | n/a | 0.178 | 0.258 | **0.05** | **<0.001** |
| **CV (%)** | | | 57 | n/a | 2 | n/a | 2 | 4 | **1** | **2** |

*Johnson transformation prior to ANOVA
n/a – not analyzable

**Table 16j: Means and analysis of variance for pea-canola lodging, weed population, split peas, seed disease, root rot and aphid count at Melita in 2021.**

| Treatment Description | Lodging (1 to 5) | Weeds (plants m$^{-2}$) | Pea: Splits (%) | Pea: Seed Disease (%) | Pea: Root Rot* (1-7) | Pea: Aphids (per plant) |
|---|---|---|---|---|---|---|
| 100% Peas (check) | 1 | 2.8 | 1.6**a** | 4.3 | 1.3 | 0.0 |
| 100% Peas, 25% Canola | 1 | 3.0 | 1.2**b** | 6.0 | 1.4 | 0.0 |
| 100% Peas, 50% Canola | 1 | 2.7 | 1.2**b** | 2.0 | 1.4 | 1.6 |
| 75% Peas, 25% Canola | 1 | 3.5 | 1.2**b** | 5.0 | 1.3 | 0.6 |
| 75% Peas, 50% Canola | 1 | 2.3 | 1.3**b** | 3.5 | 1.3 | 0.0 |
| 100% Canola (check) | 1 | 4.3 | - | - | - | - |
| **P value** | n/a | 0.227 | **0.038** | 0.07 | 0.874 | 0.544 |
| **CV (%)** | n/a | 22 | **15** | 43 | 43 | n/a |

*Johnson transformation prior to ANOVA

Pea yield was greatest in the pea sole crop and canola yield was greatest in the canola sole crop. There were no significant pea yield differences among 100Pea:25Canola, 100Pea:50Canola, and 75Pea:25Canola treatments. Among intercrop treatments, the 75Pea: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 pea with canola. Based on 2020 market prices, none of the treatments grown in this trial were profitable in 2021. The greatest revenue loss resulted from the 100Pea:50Canola treatment, while the least losses resulted from the pea sole crop and the 75Pea:50Canola treatment.

**Table 16k: Mean Pea-canola yield, Land Equivalent Ratio, and economic analysis at Melita in 2021.**

| Treatment | Yield (bu ac$^{-1}$) | | Land Equivalent Ratio | | | Economic analysis | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | COP | Gross Rev | Net Rev |
| Description | Pea | Canola | P-LER | C-LER | T-LER | $/ac | $/ac | $/ac |
| 100% Peas (check) | 37**a** | - | 1.00**a** | - | 1.00 | 336 | 305 | -30 |
| 100% Peas, 25% Canola | 32**b** | 5**d** | 0.86**b** | 0.20**d** | 1.06 | 368 | 326 | -42 |
| 100% Peas, 50% Canola | 29**bc** | 8**c** | 0.78**bc** | 0.31**c** | 1.09 | 383 | 337 | -46 |
| 75% Peas, 25% Canola | 29**bc** | 7**cd** | 0.76**bc** | 0.26**cd** | 1.02 | 359 | 316 | -43 |
| 75% Peas, 50% Canola | 26**c** | 10**b** | 0.70**c** | 0.41**b** | 1.11 | 375 | 344 | -31 |
| 100% Canola (check) | - | 25**a** | - | 1.00**a** | 1.00 | 354 | 313 | -41 |
| **P value** | **<0.001** | **<0.001** | **<0.001** | **<0.001** | **0.004** | | | |
| **CV (%)** | **9** | **9** | **8** | **9** | **4** | | | |

Though none of the intercrop combinations were demonstrated to be profitable in 2021, in some instances less revenue was lost by intercrop treatments compared to sole crops. Non-financial benefits of intercrops must also be considered, as producers would also benefit from pest and disease suppression effects of intercropping demonstrated in previous studies. Here, 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. 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. Results from this study are from one year of field research and additional years of site data would provide insight into the benefits and drawbacks of each pea intercrop combination in various weather conditions. Drought conditions in 2021 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. Therefore, this study will be conducted again in successive season and farmer recommendations will be done based on large data sets.

### *References*

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## 17.0 Advanced yield tests for Malt barley [AA Barley, AB Barley, AC Barley, AFOO 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 of 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 Ryerson5Loam/Regent5Loam soils in 2021. All the yield tests were arranged as randomized complete block design with 30 treatments (varieties) and 3 replicates for AA barley, AB barley and AC barley, and 26 treatments (varieties) and 3 replicates for AFOO barley. Due to the number of treatments and to deal with reducing variability, a serpentine layout was ideal for the trials. Barley was seeded into canola stubble at a 1.25-inch depth on May 27th and May 28th (Food barley). Fertilizer was banded at seeding at rates of 92-30-17-9-1.7 actual lbs $ac^{-1}$ (N-P-K-S-Zn) as per soil test results. Seeding errors require an additional 30 lbs $ac^{-1}$ nitrogen to be applied to AB, AC, and AFOO barley, and plots were top-dressed with Agrotrain treated urea on June 8th Pre-emergent herbicide was applied May 4th by the landowner (400 g $ac^{-1}$ RT540 and 10.4 g $ac^{-1}$ Heat) and on May 26th by WADO (0.5 L $ac^{-1}$ Roundup and 15 ml $ac^{-1}$ Aim). Mextrol 450 (0.3 L $ac^{-1}$) was applied on June 14th and July 8th. Matador (34 ml $ac^{-1}$) was applied for grasshopper control on June 14th, and Coragen was applied via aerial spraying on July 17th for additional grasshopper control. Roundup (0.5 L $ac^{-1}$) and Heat LQ (22 ml $ac^{-1}$) were applied on August 11th as a desiccant, and plots were harvested on August 16th. The trial was hit with a hail storm in late July and yields were greatly reduced due to hail damage.

## *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.**

## 18.0 Western Coop 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 trial was conducted on Ryerson5Loam/Regent5Loam soils under a no-till system at Melita in 2021. Experimental design used was a randomized complete block design with 15 treatments (varieties) replicated 3 times. Barley was seeded into canola stubble on May 27$^{th}$. Pesticide applications were identical to that of the Barley advanced yield trials (section 17.0). Plots were harvested on August 16$^{th}$. Like the barley advanced yield trials, the hulless barley co-op was hit with a hail storm in late July and yields were greatly reduced.

### *Results and Discussion*

Results from this study may be 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.

## 19.0 Evaluating Winter Heartiness of a Newly Developed Fall-Seeded Lentil Variety

***Project duration***: 2021
***Collaborators:*** Western Ag, Ducks Unlimited Canada

### *Objectives*

- To assess the winter heartiness and yield potential of a newly developed fall-seeded lentil variety, SuperCool

### *Background*

As farmers look to diversify their production systems and mitigate risks, the interest in fall-seeded pulse crops has risen. Fall-seeded crops are an effective risk management tool for producers, as they allow producers to establish a crop in the fall and avoid difficult conditions which may be experienced in the spring. Spring conditions which are too wet, cold, or dry may bring difficulties to a producer when establishing a crop in the spring, and these difficulties can be circumnavigated by already having an established crop in the field. Fall-seeded lentils have emerged as a pulse alternative to fall-seeded cereals, providing producers with more options for fall-seeded crops and allowing them to break up disease cycles and combat herbicide resistance (Lyseng, 2020). While the utility of fall-seeded lentils has been demonstrated in Alberta, the implementation of fall-seeded lentils into Manitoba production systems has been limited (Strydhorst *et al*., 2015). SuperCool, a new fall lentil variety developed by Western Ag, may have success in Manitoba as a fall-seeded pulse crop. The newly-developed variety was derived from the red lentil variety Morton, which originated in Washington state and has had some success in Alberta and Saskatchewan (Lyseng, 2020; Strydhorst *et al*., 2015). In collaboration with Western Ag and Ducks Unlimited Canada, this trial aimed to assess the winter heartiness and yield potential of SuperCool fall-seeded lentils in Melita and around the Canadian Prairies.

### *Materials and Methods*

The fall lentil trail was established near Melita, Manitoba in fall of 2020 on Ryerson5Loam/Regent5Loam soil. SuperCool lentils were seeded into canola stubble on September 14th at a one-inch depth. Soil moisture at seeding was very low. Granular fertilizer was banded at seeding at a rate of 12-25-20-12-1.6 actual lbs $ac^{-1}$.

### *Results*

Due to a cold winter with little snow cover in 2021, the fall-seeded lentils did not over-winter well. Only a few plants were able to survive. Winter survival of lentils was approximately 2% of the expected emergence, and no yields were taken from the trial. Photo taken May 25th

### *References*


Lyseng, R. (2020, April 16). Feel your pulse next winter, it might be rising. *The Western Producer*. https://www.producer.com/news/feel-your-pulse-next-winter-it-might-be-rising/

Strydhorst, S. *et al.* (2015). Adaptability and Quality of Winter Pea and Lentil in Alberta. *Agronomy Journal* **107 (6): 2431-2448.** doi:10.2134/agronj15-0092.

## 20.0 Development of improved varieties of Camelina for the Canadian Prairies

**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. In the project, we are working to continue our spring camelina breeding activities in order 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: www.dfcc.ca/camelina or by contacting Dr. Christine Eynck directly at AAFC in Saskatoon, SK.

## 21.0 Yellow Mustard (Sinapis alba) Variety Trial

**Project duration:** 2018-2023
**Collaborators:** Mustard21 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.

### *Materials and Methods*

Trials were conducted at Melita and Reston in 2021 and laid out in randomized complete block design with 11 treatments replicated 4 times at each site. Both the Melita site (Alexander Loam) and Reston site (Alexander Loam) trials were established on spring wheat stubble. Land preparation involved harrowing to evenly spread plant residues at both sites. Seeding was done on May 10$^{th}$ at the Melita site and on May 11$^{th}$ at the Reston site. At both sites, the seeding depth was one inch and fertilizer was side banded during seeding at 101-28-20-12-1.6 actual lbs ac$^{-1}$ (N-P-K-S-Zn). In-crop weed control was done by application of Assure II (0.3 L ac$^{-1}$) with Suremix (0.5%) at each site on June 8$^{th}$. Further weed control was done on June 17th at the Reston site using Arrow (120 ml $ac^{-1}$) with Xact (0.1%) due to green foxtail pressure. Three insecticide applications were required at each site for control of flea beetles, with Pounce (75 ml $ac^{-1}$) applied first, followed by two applications of Matador (34 ml $ac^{-1}$). Prior to harvesting at Melita, Roundup (0.5 L $ac^{-1}$) and Heat LQ (22 ml $ac^{-1}$) were applied as a desiccant to facilitate drying of stems and control of late weeds. Roundup (0.5 L $ac^{-1}$), Reglone (0.5 L $ac^{-1}$) and LI700 surfactant (1 L $ac^{-1}$) were applied as a desiccant at the Reston site. Reston plots were harvested on August 13th, and Melita plots were harvested on August 16th. Data collected included maturity date, plant height at maturity, days to flowering and grain yield. Completed raw data and samples were sent to the collaborator for statistical analysis and publication.

## *Results and Discussion*

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

## *References*

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

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

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

Katepa-Mupondwa, F., Gugel, R. K. and Raney, J. P. 2006. Genetic diversity for agronomic, morphological and seed quality traits in *Sinapis alba* L. (yellow mustard). Canadian Journal of Plant Science **86: 1015-1025.**

**Photo: Yellow mustard trial at the Melita site in 2021.**

## 22.0 Juncea Mustard/Oriental Mustard (*Brassica Juncea)* Variety Trial

**Project duration:** 2017-2023
**Collaborators:** Mustard21 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 2021. Thirteen varieties 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 21.0). 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 12th, and mustard at the Reston site was harvested on August 13th. Data collection objectives were similar to that of the yellow mustard trial. Data and samples were sent to cooperators for statistical analysis and publication.

### *Results and Discussion*

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

### References

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

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

## 23.1 Multi-Crop Intercrop evaluation (Pea-Oats-Canola-Wheat-Flax-Mustard) – 2021 Results

**Project duration:** 2019-2021
**Collaborators:** Manitoba Pulse & Soybean Growers Association - Daryl Domitruk, PCDF-Roblin, WADO-Melita

### Objectives

- Evaluate agronomic performance of peas in a monocrop or when intercropped with oats, canola, spring wheat, flax or mustard

### Background

Choice of an intercropping system depends on many factors including: weather, machinery available for seeding, harvesting and separation of seed, economics and compatibility of the crops involved. Many organic agriculture farmers have resorted to various intercropping systems with the aim of addressing weed and disease pressure, which often inhibits organic systems under monoculture situations (Pridham and Entz, 2007). Scientists have also been advocating for ways to counteract effects of climate change. Intercropping systems can help address climate change by exhibiting biological control of insect pests, weeds and diseases. Biological control allows for less use of synthetic chemicals, addressing the chemical resistance issues present in agriculture today. Another benefit of intercropping is improving soil health at low cost, considering residual nitrogen if a legume is included in the intercropping system. In other studies, pea-wheat intercropping systems have been shown to be efficient in the use of nitrogen due to their spatial self-regulating dynamics, which allows pea to improve its interspecific competitive ability in fields with lower soil nitrogen, and vice versa for wheat (Andersen et al., 2004 and Ghaley et al., 2005). Harnessing this nitrogen use efficiency is one way which producers can reduce synthetic nitrogen inputs and negative environmental impacts of crop production. Compared to a sole pea crop, pea-oat intercrops result in reduced pea lodging because of the support provided by oats to the pea crop (Kontturi et al., 2010). This physical support also helps reduce harvesting difficulties and can increase revenue. This study evaluated various intercrop combinations which can be utilized by producers in different areas of production.

## *Materials and Methods*

The trials were established at Melita, Reston and Roblin Manitoba in 2021. Soil tests were conducted to determine nutrient status before seeding at all sites (Table 23.1I). A randomized complete block design with 11 treatments and 4 replicates was used at each site. Fertilizer was applied according to soil test results during seeding, along with inoculant (Table 23.1I). Site description, agronomy and weather information for each trial is presented in Table 23.1II. Data collected from each site included: Counts at emergence and flowering, weed counts and biomass at flowering, grain yield, percentage of pea splits, and protein content. Disease severity data collected was for Mycosphaerella, powdery mildew, rust, sclerotinia and fusarium wilt. Data were analyzed using Minitab 18.1 software and means were separated using Fishers LSD at 95% confidence.

**Table 23.1I. Soil test results for Melita, Reston, and Roblin sites in 2021.**

| **Soil Test:** | | | | **Nutrient** | | | |
|---|---|---|---|---|---|---|---|
| **Location** | **N (lbs ac$^{-1}$)** | **P ppm** | **K Ppm** | **S (lbs ac$^{-1}$)** | **Zn ppm** | **Organic Matter (%)** | **pH** |
| Melita | 18 | 5 | 279 | 208 | 0.64 | 3.3 | 7.0 |
| Reston | 102 | 9 | 252 | 92 | 1.07 | 4.7 | 6.7 |
| Roblin | 120 | 52 | 670 | | | | |

| **Applied:** | | | **Nutrient (lbs ac$^{-1}$)** | | |
|---|---|---|---|---|---|
| **Location** | **N** | **P** | **K** | **S** | **Zn** |
| Melita | 12 | 28 | 20 | 12 | 1.6 |
| Reston | 15 | 28 | 20 | 12 | 1.6 |
| Roblin | 0 | 15 | 0 | 0 | 0 |

## *Results and Discussion*

At the Melita site, peas intercropped with canola or mustard yielded significantly ($P < 0.001$) greater than other intercrop combinations (Table 23.1a). Partial land equivalence ratio (PLER) of pea component crops followed the same trend, with peas from the pea-canola (0.54) and pea-mustard (0.51) intercrops having significantly ($P < 0.001$) greater PLERs than the other intercrop combinations. However, the only intercrop with an average TLER greater than 1 was the pea-canola intercrop. While the pea-mustard intercrop produced high pea yields, PLER of the mustard component crop was lowest. This highlights a potential competition effect of pea on mustard.

Pea yields at the Reston site followed a similar trend as the Melita site, with the pea-canola and pea-mustard intercrops resulting in the greatest pea yields (Table 23.1b). In terms of pea PLER, the pea-canola intercrop resulted in a significantly ($P < 0.001$) greater PLER than all other intercrops. The pea-flax intercrop resulted in the lowest pea yield (28 kg $ha^{-1}$) and PLER (0.07) of all intercrop combinations. The Reston pea-canola intercrop also resulted in the greatest average TLER (1.46), though this result was not significantly ($P < 0.001$) different from that of the pea-mustard (1.13) or pea-oat (1.35) intercrop. The Reston pea-flax intercrop was the only combination which did not over-yield, though the TLER from this intercrop combination was not significantly ($P < 0.001$) different from that of the pea monocrop.

**Table 23.1II. Agronomy and weather data from intercrop trial sites in Reston, Melita, and Roblin, MB in 2021.**

| Location | Reston, MB | Melita, MB | Roblin, MB |
|---|---|---|---|
| Legal Land Location | SE 11-7-27 W1 | NW 27-3-27 | NE 20-25-28 W1 |
| Soil Series | Ryerson Loam | Alexander Loam | Erickson Clay Loam |
| Previous Crop | Spring Wheat | Spring wheat | Oat silage |
| Field Preparation | Harrowed, No-till | Harrowed, No-till | Vertical tillage |
| Pre-Emergent Herbicides | May 12: 0.65 L $ac^{-1}$Rival on canola, peas, flax and mustard, Authority on peas and flax | May 10: 0.65 L $ac^{-1}$ Rival on Pea, Flax, mustard, and canola, 0.1 L $ac^{-1}$ Authority in Pea and Flax | May 26: 0.54 L $ac^{-1}$ Liberty |
| Soil Moisture at Seeding | Fair | Fair | Very poor |
| Seed Date | May 11 | May 7 | May 19 |
| Seed Depth (inch) | 1” | 0.75” | 0.75” |
| Herbicides | June 9: Basagran, Arrow, Axial, Odyssey | June 8: Basagran 0.91 L $ac^{-1}$, Arrow 0.1 L $ac^{-1}$ + Xact 0.5%, Odyessy 17.3 g $ac^{-1}$ + Merge 0.5% | None |
| Insecticides | Flea beetles – June 1: 75 ml $ac^{-1}$ Pounce, 10 gal<br>June 10: 34 ml/ac Matador | Flea beetles - June 2: 75 ml $ac^{-1}$ Pounce, 10 gal<br>Blister beetles – June 28: 0.4 L $ac^{-1}$ Cygon (15 gal $ac^{-1}$) on canola | None |
| Desiccation | August 6 – Roundup 0.5 L $ac^{-1}$ + Reglone 0.5 L $ac^{-1}$ + LI700 1 L $ac^{-1}$ | August 10 – Roundup 0.5 L $ac^{-1}$ + Heat 22 ml $ac^{-1}$ + Reglone L $ac^{-1}$ + LI700 @ 0.1% | None |
| Harvest Date | August 13, flax August 26 | August 16 (Canola slightly too early) | September 24 |
| **Combine Settings** | | | |
| Rotor | 760 | 600 (1000 for flax) | 800 |
| cleaning fan | 780 | 820 | 930 |
| rotor-concave space | 8 mm | 12 mm | 10 mm |
| **Growing Season Report (Seeding – Harvest)** | | | |
| Precipitation (mm) | 154 | 175 | 246 |
| Normal (mm) | 259 | 260 | 265 |
| Growing Degree Days | 1252 | 1374 | 1466 |
| Normal GDDs | 1248 | 1213 | 1302 |

Intercrops in Roblin displayed similar results as the Melita and Reston sites (Table 23.1c), with the pea-canola intercrop resulting in the greatest pea yield (432 kg $ha^{-1}$), though this yield was not significantly (P = 0.003) different from that of the pea-mustard intercrop (270 kg $ha^{-1}$). While analysis of variance for pea PLER of Roblin intercrops indicated a significant treatment effect (P = 0.038), Fishers LSD test was unable to separate means, indicating no significant difference between pea PLERs. The greatest TLER resulted from the pea-canola intercrop in Roblin, though this TLER was not significantly different from that of the pea-mustard, pea-oat, or pea-wheat intercrops. Like in the Reston trial, the lowest TLER resulted from the pea-flax intercrop. While TLERs observed at the Roblin site were much greater than those observed at the Reston or Melita sites, it is important to note that the pea monocrops in Roblin yielded much lower than the pea monocrops in Melita and Reston, therefore leading to greater pea partial land equivalence ratios.

Overall, pea yield at all sites was much lower than 2020 yields. However, similar trends were observed, with pea-canola and pea-mustard intercrops also consistently producing high pea yields and TLERs in 2020 as well. The flax-pea intercrop did perform much better in 2020 than in 2021, and poor performance of this intercrop combination in 2021 could be due to less accumulated precipitation in the 2021 growing season. Results from 2019, 2020, and 2021 sites will be combined and analyzed in a separate report, and may better illustrate which intercrop combinations perform best throughout both wet and dry years.

**Table 23.1a. Mean Yield and Land Equivalence Ratio (LER) of various crops grown in monocrop or intercropped (IC) with pea at Melita, MB in 2021.**

| **Crop** | **Yield (kg/ha)** | | | **LER** | | |
|---|---|---|---|---|---|---|
| | **Sole** | **Crop-IC** | **Pea-IC** | **Partial Crop-IC** | **Partial Pea-IC** | **TLER** |
| Pea | 2209 | - | - | - | - | 1.00**b** |
| Flax | 1314 | 1049 | 430**b** | 0.80 | 0.19**b** | 1.00**b** |
| Oat | 2259 | 1768 | 464**b** | 0.79 | 0.21**b** | 1.00**b** |
| Wheat | 1688 | 1171 | 618**b** | 0.69 | 0.28**b** | 0.98**b** |
| Canola | 1278 | 788 | 1195**a** | 0.63 | 0.54**a** | 1.17**a** |
| Mustard | 629 | 338 | 1118**a** | 0.54 | 0.51**a** | 1.00**b** |
| **P value** | | | **<0.001** | | **<0.001** | **<0.001** |
| **CV (%)** | | | **12** | | **11** | **5** |

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

**Table 23.1b. Mean yield and Land Equivalence Ratio (LER) of various crops grown in monocrop or intercropped (IC) with pea at Reston, MB in 2021.**

| Crop | Yield (kg/ha) | | | LER | | |
|---|---|---|---|---|---|---|
| | Sole | Crop-IC | Pea-IC | Partial Crop-IC | Partial Pea-IC | TLER |
| Pea | 415 | - | - | - | - | 1.00**cd** |
| Flax | 192 | 145 | 28**c** | 0.71 | 0.07**c** | 0.78**d** |
| Oat | 3643 | 3346 | 175**b** | 0.93 | 0.42**b** | 1.35**ab** |
| Wheat | 3198 | 2242 | 178**b** | 0.71 | 0.42**b** | 1.13**bc** |
| Canola | 1806 | 1268 | 312**a** | 0.72 | 0.75**a** | 1.46**a** |
| Mustard | 1387 | 835 | 216**ab** | 0.62 | 0.52**b** | 1.13**abc** |
| **P value** | | | **<0.001** | | **<0.001** | **<0.001** |
| **CV (%)** | | | **22** | | **19** | **13** |
| Values followed by the same letter are not significantly different by Fishers LSD method at 95% confidence. | | | | | | |

**Table 23.1c. Mean yield and Land Equivalence Ratio (LER) of various crops grown in monocrop or intercropped (IC) with pea at Roblin, MB in 2021.**

| Crop | Yield (kg/ha) | | | LER | | |
|---|---|---|---|---|---|---|
| | Sole | Crop-IC | Pea-IC | Partial Crop-IC | Partial Pea-IC | TLER |
| Pea | 274 | - | - | - | - | 1.00**b** |
| Flax | 537 | 111 | 156**b** | 0.21 | 0.60**a** | 0.81**b** |
| Oat | 1874 | 1754 | 162**b** | 0.93 | 0.61**a** | 1.55**ab** |
| Wheat | 3068 | 2184 | 163**b** | 0.72 | 0.71**a** | 1.42**ab** |
| Canola | 2000 | 1513 | 432**a** | 0.76 | 1.80**a** | 2.56**a** |
| Mustard | 1364 | 1041 | 270**ab** | 0.77 | 1.16**a** | 1.93**ab** |
| **P value** | | | **0.003** | | **0.038** | **0.004** |
| **CV (%)** | | | **36** | | **55** | **35** |
| Values followed by the same letter are not significantly different by Fishers LSD method at 95% confidence. | | | | | | |

Plant counts were conducted at emergence and at flowering to assess plant stand changes during the growing season, though plant stand change between these two stages was minimal. Average plants per square meter for the pea monocrop was adjusted prior to analysis of variance to reflect the reduced pea seeding rate in intercrop treatments. Analysis of variance of average peas per square meter revealed no significant difference between the monocrop pea stand (adjusted) and the intercrop pea stand at Melita, indicating no significant effect of intercropping on pea stand compared to monocropping (Table 23.1d). While weed biomass differences were observed between treatments, weed count was generally similar, so only weed biomass results are summarized here. In the Melita trial, average weed biomass in intercrops was greatest in the pea-mustard intercrop, though this was not significantly different than the average weed biomass of pea-oat and pea-wheat intercrops. Low weed biomass was observed in pea-flax (7 g $m^{-2}$) and pea-canola (5 g $m^{-2}$) treatments, though this biomass was not significantly different than that overserved in pea-oat intercrops (41 g $m^{-2}$). Pea grain quality was assessed by measuring the amount of split peas in a harvest grain sample as well as the protein content of harvested peas. A significant (P < 0.001) treatment effect was observed in pea split incidence at the Melita site, with the highest pea split incidence observed in pea-flax intercrops (32.2%), and the lowest in pea-oat intercrops (5.2%). Pea protein was not significantly different across pea intercrop and monocrop treatments.

No significant difference was observed in pea stand across treatments at the Reston site, indicating that intercropping had little effect on pea stand compared to monocropping (Table 23.1e). Weed biomass in Reston was lowest in the pea monocrop (1041 g $m^{-2}$), though this biomass was not significantly different from that of pea-flax, pea-oat, pea-canola, or pea-mustard intercrops. This result indicates that, like in 2020, weed biomass was not effectively reduced by intercropping in 2021. Analysis of variance on pea split incidence and pea grain protein content was not done for the Reston site in 2021, as not enough sample from some pea-flax intercrop plots was collected to measure these variables.

Like other sites, no significant treatment effect on pea stand was observed at the Roblin site. Weed biomass data was unable to be collected across all replicates in 2021 at the Roblin site, so weed biomass data is not presented here. Pea split incidence and pea grain protein content was also not measured for the Roblin site.

Overall, no consistent reduction in weed biomass was observed in intercrops compared to the pea monocrop.  Weed biomass of intercrops was significantly higher than that of the monocrop in some cases. A more consistent trend may emerge by analyzing data from all three trial years, and these results will be presented in a separate summary report.

**Table 23.1d. Mean plant stand density at flowering, weed biomass per square meter, and grain quality of monocrops and pea intercrops (IC) grown at Melita, MB in 2021.**

| **Crop** | **Final Emergence ppms** | | | **Weeds (g $m^{-2}$)^** | | **Pea splits (%/500 seeds)** | **Pea protein (% DM basis)** |
|---|---|---|---|---|---|---|---|
| | **Sole** | **Crop-IC** | **Pea-IC** | **Sole** | **Pea-IC** | | |
| Pea | 34 | - | 17 (adj.) | 17**bc** | **-** | 16.0**b** | 25.6 |
| Flax | 239 | 109 | 30 | 9 | 7**c** | 32.2**a** | 24.7 |
| Oat | 131 | 72 | 35 | 147 | 268**ab** | 5.2**c** | 25.3 |
| Wheat | 100 | 45 | 33 | 11 | 41**abc** | 17.5**b** | 25.0 |
| Canola | 37 | 20 | 32 | 12 | 5**c** | 20.3**b** | 25.5 |
| Mustard | 32 | 26 | 36 | 417 | 512**a** | 18.8**b** | 25.4 |
| **P value** | | | 0.931 | | **<0.001** | **<0.001** | 0.074 |
| **CV (%)** | | | 29 | | **11** | **15** | 2 |

Values followed by the same letter are not significantly different by Fishers LSD method at 95% confidence.
^Johnson transformation prior to ANOVA

**Table 23.1e. Mean plant stand density at flowering and weed biomass per square meter of monocrops and pea intercrops (IC) grown at Reston, MB in 2021.**

| Crop | Final Emergence ppms | | | Weeds (g m$^{-2}$)^ | |
|---|---|---|---|---|---|
| | Sole | Crop-IC | Pea-IC | Sole | Intercrop |
| Pea | 62 | - | 31 (adj) | 1041**b** | - |
| Flax | 274 | 146 | 26 | 2388 | 1870**ab** |
| Oat | 143 | 71 | 31 | 2088 | 2593**ab** |
| Wheat | 160 | 60 | 31 | 2755 | 2596**a** |
| Canola | 43 | 23 | 37 | 2660 | 1549**b** |
| Mustard | 38 | 17 | 37 | 3674 | 2490**ab** |
| **P value** | | | 0.300 | | **0.005** |
| **CV (%)** | | | 22 | | **4** |

Values followed by the same letter are not significantly different by Fishers LSD method at 95% confidence.
^Johnson transformation prior to ANOVA

**Table 23.1f. Mean plant stand density at flowering of monocrops and pea intercrops (IC) grown at Roblin, MB in 2021.**

| Crop | Final Emergence ppms | | |
|---|---|---|---|
| | Sole | Crop-IC | Pea-IC |
| Pea | 66 | - | 33 (adj.) |
| Flax | 188 | 122 | 28 |
| Oat | 122 | 94 | 38 |
| Wheat | 129 | 98 | 34 |
| Canola | 104 | 39 | 25 |
| Mustard | 53 | 25 | 31 |
| **P value** | | | 0.214 |
| **CV (%)** | | | 24 |

Though net revenue was negative in almost all intercrops, significant net revenue differences were observed at all trial locations. In Melita, the pea-wheat intercrop resulted in the greatest mean net revenue loss (-$134), though this loss was not significantly ($P < 0.001$) different from that of the pea-mustard intercrop (Table 23.1g). Mean net losses of the pea-flax, pea-oat, and pea-canola intercrops were not significantly different from that of the pea monocrop. While all intercrop combinations at this trial resulted in revenue loss, these results illustrate that of the intercrop combinations tested here, pea-flax, pea-oat, and pea-canola intercrops may be the most economically feasible.

Economic analysis of the Reston site revealed much different results, with the pea monocrop (-$260) and the pea-flax intercrop (-$292) resulting in the greatest loss in revenue (Table 23.1h). The pea-oat intercrop was the only intercrop treatment to result in positive net revenue ($49), though statistically this revenue was not different from that of the pea-wheat, pea-canola, and pea-mustard intercrops.

Net revenues of the Roblin intercrops followed a similar trend as the Reston intercrops, with the pea monocrop (-$275) and the pea-flax intercrop (-$286) resulting in the greatest revenue losses (Table 23.1i). The greatest intercrop revenue was observed in the pea-mustard intercrop ($45), though this revenue was not significantly (P < 0.001) different from that of the pea-canola intercrop ($2).

In general, pea intercrops resulted in less revenue loss than pea monocrops in 2021, though revenue generated from each intercrop treatment varied among sites. Analysis of economic results across all three years of the trial may reveal an intercrop treatment which consistently results in higher revenues than pea monocrops, and these results will be presented in a separate summary report.

**Table 23.1g. Cost of production (COP) and revenues of various crops in monocrop and in intercrop (IC) with pea grown at Melita, MB in 2021.**

| | Economics per acre | | | | | |
|---|---|---|---|---|---|---|
| | **Sole-COP** | **IC – COP** | **Mean Gross Revenue** | | **Mean Net Revenue** | |
| **Crop** | | | **Sole** | **IC** | **Sole** | **IC** |
| Pea | $303 | - | $230 | - | -$74**a** | - |
| Flax | $289 | $325 | $267 | $257 | -$23 | -$67**a** |
| Oat | $292 | $318 | $236 | $233 | -$56 | -$86**ab** |
| Wheat | $308 | $316 | $169 | $182 | -$139 | -$134**c** |
| Canola | $328 | $339 | $250 | $279 | -$77 | -$61**a** |
| Mustard | $317 | $336 | $213 | $231 | -$104 | -$105**bc** |
| **P value** | | | | | | **<0.001** |
| **CV (%)** | | | | | | **-15** |

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

**Table 23.1h. Cost of production (COP) and revenues of various crops in monocrop and in intercrop (IC) with pea grown at Reston, MB in 2021.**

| | Economics per acre | | | | | |
|---|---|---|---|---|---|---|
| | **Sole-COP** | **IC – COP** | **Mean Gross Revenue** | | **Mean Net Revenue** | |
| **Crop** | | | **Sole** | **IC** | **Sole** | **IC** |
| Pea | $303 | - | $43 | - | -$260**b** | |
| Flax | $289 | $325 | $39 | $32 | -$251 | -$292**b** |
| Oat | $292 | $318 | $380 | $367 | $89 | $49**a** |
| Wheat | $308 | $316 | $321 | $243 | $12 | -$73**a** |
| Canola | $328 | $339 | $354 | $281 | $26 | -$58**a** |
| Mustard | $317 | $336 | $470 | $305 | $153 | -$31**a** |
| **P value** | | | | | | **<0.001** |
| **CV (%)** | | | | | | **-51** |

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

**Table 23.1i. Cost of production (COP) and revenues of various crops in monocrop and in intercrop (IC) with pea grown at Roblin, MB in 2021.**

| Crop | Economics per acre | | | | | |
|---|---|---|---|---|---|---|
| | Sole-COP | IC – COP | Mean Gross Revenue | | Mean Net Revenue | |
| | | | Sole | IC | Sole | IC |
| Pea | $303 | - | $28 | - | -$275**c** | |
| Flax | $289 | $325 | $109 | $39 | -$181 | -$286**c** |
| Oat | $292 | $318 | $196 | $200 | -$96 | -$118**b** |
| Wheat | $308 | $316 | $307 | $236 | -$1 | -$80**b** |
| Canola | $328 | $339 | $392 | $342 | $64 | $2**a** |
| Mustard | $317 | $336 | $462 | $380 | $145 | $45**a** |
| **P value** | | | | | | **<0.001** |
| **CV (%)** | | | | | | **-27** |

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## 23.2 Multi-Crop Intercrop Evaluation (Pea-Oats-Canola-Wheat-Flax-Mustard) Three-Year Final Report

**Project duration**: 2019-2021

**Collaborators:** Manitoba Pulse & Soybean Growers Association - Daryl Domitruk, PCDF-Roblin, WADO-Melita

### *Objectives*

- Evaluate agronomic performance of peas in a monocrop or when intercropped with oats, canola, spring wheat, flax or mustard

### *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 flax, oat, wheat, mustard, and canola intercropped with peas near Melita, Reston, and Roblin, Manitoba from 2019 to 2021. Crop emergence, weed biomass, 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 site. Three-year average total land equivalence ratio (TLER) of all intercrop combinations except the pea-flax intercrop was above 1, indicating consistent over-yielding from each of these intercrop combinations at all sites. TLER of pea-oat and pea-canola intercrops was significantly greater than that of the sole pea crop at both the Reston and Roblin sites, while TLER of pea-wheat and pea-mustard intercrops was significantly greater than that of the sole pea crop only at the Roblin site. While no significant net revenue difference was observed among intercrops at the Melita site, net revenue of pea-oat, pea-canola, and pea-mustard intercrops was significantly greater than that of the pea sole crop at the Reston and Roblin sites. Intercropping was not demonstrated to decrease weed biomass compared to a sole pea crop at any of the trial sites, and no significant difference in pea grain protein content or split pea incidence between intercrops and pea sole crops was observed. Disease pressure was low at all sites in all trial years, so no disease incidence trends could be identified. Overall, while no weed or disease suppression effect 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.

### *Background*

Choice of an intercropping system depends on many factors including weather, machinery available for seeding, harvesting and separation of seed, economics and compatibility of the crops involved. Many organic agriculture farmers have resorted to various intercropping systems with the aim of addressing increasing weed and disease pressure, which often inhibits organic systems under monoculture situations (Pridham and Entz, 2007). Scientists have also been advocating for ways to counteract effects of climate change. Intercropping systems can help address climate change by exhibiting biological control of insect pests, weeds and diseases. Biological control allows for less use of synthetic chemicals, addressing the chemical resistance issues present in agriculture today. Another benefit of intercropping is improving soil health at low cost, considering residual nitrogen if a legume is included in the intercropping system. In other studies, pea-wheat intercropping systems have been shown to be efficient in the use of nitrogen due to their spatial self-regulating dynamics, which allows pea to improve its interspecific competitive ability in fields with lower soil nitrogen, and vice versa for wheat (Andersen et al., 2004 and Ghaley et al., 2005). Harnessing this nitrogen use efficiency is one way which producers can reduce synthetic nitrogen inputs and negative environmental impacts of crop production. Compared to a sole pea crop, pea-oat intercrops result in reduced pea lodging because of the support provided by oats to the pea crop (Kontturi et al., 2010). This physical support also helps reduce harvesting difficulties and can increase revenue. This study evaluated various intercrop combinations which can be utilized by producers in different areas of production.

### *Materials and Methods*

Trials were established in 2019, 2020, and 2021 near Melita (NW 27-3-27, Alexander Loam), Reston (SE 11-7-27, Ryerson Loam) and Roblin (NE 20-25, Erikson Clay Loam), MB. A randomized complete block design with 11 treatments and 4 replicates was used at each site. Plots sizes were 12.96$m^{-2}$ in Reston and Melita, both with 6 rows, and 8.4 $m^{-2}$ in Roblin with 5 rows, all sites at 24.13 cm row spacing. Treatments included a pea monocrop (check), monocrop treatments of flax, wheat, oats, canola, and mustard, and intercrop treatments of the later with pea. Varieties and target plant densities were as follows, pea (CDC Amarillo, 80 plants $m^{-2}$), flax (CDC Neela, 430 plants $m^{-2}$), wheat (AAFC Brandon, 250 plants $m^{-2}$), oats (CS Camden, 225 plants $m^{-2}$), canola (5545CL, 100 plants $m^{-2}$), mustard (Andante, 100 plants $m^{-2}$). Intercrops target seeding density were at 50% of each monocrop component and crops were mixed into the same row. Fields were prepared by harrowing with no tillage, and burnoff/pre-emergent herbicides were applied when necessary. Soil tests were conducted to determine nutrient status before seeding at all sites, and fertilizer was applied during seeding according to soil test results. Granular pea inoculant (SCG Nodulator, BASF) was also applied during seeding at recommended rates. Registered in-crop herbicides and insecticides were used when necessary. Reston plots were desiccated in 2020 and 2021, and Melita and Roblin plots were desiccated in all years. A detailed breakdown of pesticide use, fertilizer rates, and other agronomic information is given in interim trial reports which can be found in the 2019, 2020 and 2021 WADO annual reports. Monthly weather data for each year, as well as 30-year normal for each site, is presented in tables 23.2I, 23.2II and 23.2III below. Data collected from each site included: Counts at emergence and flowering, weed counts and biomass at flowering, grain yield, percentage of pea splits in harvest grain, and protein content of pea harvest grain. Disease severity data collected was for Mycosphaerella, powdery mildew, rust, sclerotinia and fusarium wilt. 2019, 2020 and 2021 data were combined for each site, and Minitab 18.1 software was used for statistical analysis. Only variables with all site years exhibiting homogeneity (equal variance) and normality were subject to multi-year analysis of variance. Analysis of variance was done with REML analysis using the Kenward-Roger mixed effects model. For the REML model, treatments were considered fixed effects and site years and replications were considered random effects. Site years were nested in replications and a treatment by year interaction factor was also included. Mean separation was done using the Tukey method at 90% or 95% confidence, depending on the p value determined for that factor. Net revenue for each treatment was calculated by subtracting the operating costs of each treatment from the gross revenue of the treatment. Operating costs were calculated based on assumptions of crop inputs, crop insurance, land taxes, machinery, and labor costs established in 2019. Gross revenue was calculated based on market prices established in 2019 and average treatment yield. Economic assumptions were unchanged across trial years to allow for year-to-year comparison (see Appendix 23.2).

**Table 23.2I. Accumulated precipitation and average monthly temperature for the Melita site in 2019, 2020, and 2021 compared to 30-year normal precipitation and temperature for the area.**

| Melita | | Month | | | | | |
|---|---|---|---|---|---|---|---|
| Year | | April | May | June | July | August | September |
| 2019 | Precipitation (mm) | 17 | 15 | 84 | 74 | 100 | 137 |
| | Average Temp. ($^{o}$C) | 5.4 | 9.7 | 16.9 | 19.5 | 17.6 | 13.4 |
| 2020 | Precipitation (mm) | 5 | 20 | 63 | 62 | 34 | 7 |
| | Average Temp. ($^{o}$C) | 2.2 | 11.2 | 18.2 | 20.2 | 19.0 | 12.8 |
| 2021 | Precipitation (mm) | 4 | 28 | 87 | 35 | 125 | 13 |
| | Average Temp. ($^{o}$C) | 4.0 | 10.5 | 19.2 | 21.9 | 18.8 | 15.8 |
| Normal* | Precipitation (mm) | 27.5 | 55.1 | 77.7 | 70.4 | 51.6 | 37.3 |
| | Average Temp. ($^{o}$C) | 5.3 | 11.9 | 16.8 | 19.6 | 18.9 | 12.9 |

* Environment Canada Weather, 30-year normal 1981-2010 (Pierson, MB)

**Table 23.2II. Accumulated precipitation and average monthly temperature for the Reston site in 2019, 2020, and 2021 compared to 30-year normal precipitation and temperature for the area.**

| Reston | | Month | | | | | |
|---|---|---|---|---|---|---|---|
| Year | | April | May | June | July | August | September |
| 2019 | Precipitation (mm) | 12 | 22 | 33 | 39 | 71 | 141 |
| | Average Temp. ($^oC$) | 4.8 | 8.1 | 17.4 | 19.0 | 17.1 | 15.6 |
| 2020 | Precipitation (mm) | 8 | 15 | 114 | 51 | 45 | 7 |
| | Average Temp. ($^oC$) | 1.2 | 10.5 | 17.4 | 19.7 | 18.7 | 12.5 |
| 2021 | Precipitation (mm) | 6 | 25 | 81 | 29 | 100 | 4 |
| | Average Temp. ($^oC$) | 3.5 | 9.8 | 18.8 | 21.3 | 18.1 | 14.9 |
| Normal* | Precipitation (mm) | 28.6 | 54.1 | 82.2 | 66.7 | 62.1 | 40.5 |
| | Average Temp. ($^oC$) | 4.4 | 11.5 | 16.4 | 19.2 | 18.4 | 12.2 |
| * Environment Canada Weather, 30-year normal 1981-2010 (Virden, MB) | | | | | | | |

**Table 23.2III. Accumulated precipitation and average monthly temperature for the Roblin site in 2019, 2020, and 2021 compared to 30-year normal precipitation and temperature for the area.**

| Roblin | | Month | | | | | |
|---|---|---|---|---|---|---|---|
| Year | | April | May | June | July | August | September |
| 2019 | Precipitation (mm) | 15 | 7 | 59 | 83 | 44 | 58 |
| | Average Temp. ($^oC$) | 3.1 | 8.7 | 15.2 | 17.4 | 15.0 | 11.5 |
| 2020 | Precipitation (mm) | 16 | 17 | 111 | 69 | 43 | 11 |
| | Average Temp. ($^oC$) | -1.2 | 10.0 | 15.7 | 18.5 | 17.5 | 10.3 |
| 2021 | Precipitation (mm) | 12 | 50 | 62 | 37 | 82 | 16 |
| | Average Temp. ($^oC$) | 3.2 | 9.3 | 17.7 | 20.1 | 16.6 | 13.9 |
| Normal* | Precipitation (mm) | 75.6 | 84.5 | 97.0 | 94.1 | 83.9 | 94.4 |
| | Average Temp. ($^oC$) | 6.4 | 13.3 | 18.4 | 20.8 | 19.5 | 14.8 |
| * Environment Canada Weather, 30-year normal 1981-2010 (Russell, MB) | | | | | | | |

## *Results and Discussion*

Accumulated precipitation at the Melita site was lower than the 30-year normal precipitation in 2020 and 2021, with precipitation being greater than normal in 2019. Low accumulated precipitation in 2020 and 2021 resulted in lower yields than observed in 2019, with low 2021 yields resulting in negative net revenue calculations for all intercrop combinations. Precipitation accumulated in Roblin was near 30-year normal for the area in all trial years, though crop yields were low in 2021, leading to a negative net revenue for most intercrop combinations in 2021.

At the Melita site, average pea grain yield was greatest in the pea-mustard intercrop (208 kg $ha^{-1}$), though this yield was not significantly different from that of the pea-flax, pea-wheat, or pea-canola intercrops (Table 23.2a). Pea partial land equivalence ratio followed the same trend as yield. A significant (P = 0.032) trend in total land equivalence ratio (TLER) was observed, but Tukey's mean separation method was unable to separate means. Three-year average TLER was greatest in the pea-mustard intercrop (1.20), with the pea-canola intercrop also resulting in a high average TLER (Figure 23.2a).

In Reston, three-year average pea yield was greatest in the pea-canola intercrop (398 kg $ha^{-1}$), with pea yield in the pea-mustard intercrop not significantly different from that of the pea-canola intercrop (Table 23.2b). Average pea partial LER of the Reston pea-canola intercrop (1.05) was significantly (P < 0.001) greater than all other intercrops over three years, while pea LER of the pea-flax intercrop (0.38) was significantly lower than all other intercrops. Three-year average TLER was greatest in the pea-canola intercrop (1.84), though this TLER was not significantly different from that of the pea-oat intercrop. TLER of the pea-flax intercrop was not significantly different from that of the pea sole crop, indicating no significant yield benefits from intercropping pea with flax at the Reston site.

At the Roblin site, the pea-canola intercrop resulted in the greatest average pea yield over three site years (1567 kg $ha^{-1}$), though the pea-mustard (1045 kg $ha^{-1}$) and pea-flax (929 kg $ha^{-1}$) intercrops resulted in average pea yields which were not significantly different from that of the pea-canola intercrop (Table 23.2c). Pea partial LER at Roblin followed a similar trend, with pea LER greatest in the pea-canola intercrop (1.52), and the pea-mustard intercrop pea LER (0.93) not significantly different from that of the pea-canola intercrop. Three-year average TLER was greatest in the pea-canola intercrop (2.03), though this was not significantly different from that of the pea-oat (1.25), pea-wheat (1.11), or pea-mustard (1.49) TLER. It is important to note that pea sole crop yield in 2019 was considerably low at the Roblin site, and this contributed to high pea LERs in this year. Additionally, this resulted in high TLERs, with the pea-canola intercrop resulting in an average TLER of 2.42 in 2019. The high TLERs observed in this year are likely the reason why Roblin three-year average TLERs are much greater than those observed at the Reston and Melita sites.

**Table 23.2a. Three-year mean yield and Land Equivalence Ratio of various crops grown in monocrop or intercropped with pea at Melita, MB.**

| Crop | Yield (kg ha$^{-1}$) | | | LER | | |
|---|---|---|---|---|---|---|
| | Sole | Crop-IC | Pea-IC | Partial Crop-IC | Partial Pea-IC | TLER |
| Pea | 3493 | - | - | 1.00 | - | 1.00**a** |
| Flax | 1528 | 863 | 1660**ab** | 0.58 | 0.42**ab** | 1.00**a** |
| Oat | 3557 | 2874 | 1015**b** | 0.81 | 0.29**b** | 1.10**a** |
| Wheat | 2108 | 1307 | 1623**ab** | 0.63 | 0.46**ab** | 1.09**a** |
| Canola | 1909 | 1047 | 2066**a** | 0.58 | 0.60**a** | 1.18**a** |
| Mustard | 1009 | 583 | 2208**a** | 0.58 | 0.63**a** | 1.20**a** |
| **P value** | | | **0.018** | | **0.011** | **0.032** |
| **CV (%)** | | | **9** | | **22** | **53** |

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

**Table 23.2b. Three-year mean yield and Land Equivalence Ratio of various crops grown in monocrop or intercropped with pea at Reston, MB.**

| Crop | Yield (kg ha$^{-1}$) | | | LER | | |
|---|---|---|---|---|---|---|
| | Sole | Crop-IC | Pea-IC | Partial Crop-IC | Partial Pea-IC | TLER |
| Pea | 384 | - | - | 1.00 | - | 1.00**d** |
| Flax | 1778 | 1359 | 145**b** | 0.74 | 0.38**c** | 1.13**cd** |
| Oat | 5600 | 5540 | 227**b** | 1.00 | 0.63**b** | 1.63**ab** |
| Wheat | 5038 | 3908 | 224**b** | 0.77 | 0.63**b** | 1.40**bc** |
| Canola | 3309 | 2647 | 398**a** | 0.79 | 1.05**a** | 1.84**a** |
| Mustard | 2436 | 1843 | 266**ab** | 0.74 | 0.73**b** | 1.46**bc** |
| **P value** | | | **0.007** | | **<0.001** | **<0.001** |
| **CV (%)** | | | **16** | | **23** | **33** |

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

**Table 23.2c. Three-year mean yield and Land Equivalence Ratio of various crops grown in monocrop or intercropped with pea at Roblin, MB.**

| Crop | Yield (kg ha$^{-1}$) | | | LER | | |
|---|---|---|---|---|---|---|
| | Sole | Crop-IC | Pea-IC | Partial Crop-IC | Partial Pea-IC | TLER |
| Pea | 1504 | - | - | 1.00 | - | 1.00**b** |
| Flax | 1505 | 255 | 929**ab** | 0.21 | 0.67**b** | 0.89**b** |
| Oat | 4728 | 3532 | 515**b** | 0.80 | 0.45**b** | 1.25**ab** |
| Wheat | 4019 | 2305 | 637**b** | 0.59 | 0.52**b** | 1.11**ab** |
| Canola | 3248 | 1535 | 1567**a** | 0.51 | 1.52**a** | 2.03**a** |
| Mustard | 1920 | 998 | 1045**ab** | 0.55 | 0.93**ab** | 1.49**ab** |
| **P value** | | | **0.011** | | **<0.001** | **0.020** |
| **CV (%)** | | | **26** | | **68** | **65** |

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

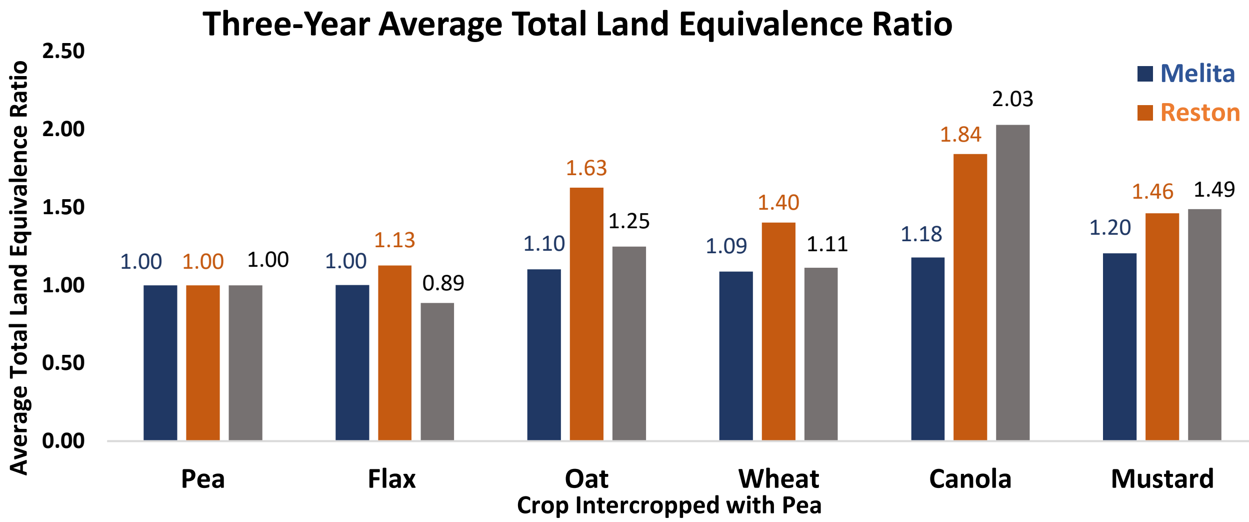


**Figure 23.2a. Three-year average total land equivalence ratio of pea intercrops grown at Melita, Reston, and Roblin sites in 2019, 2020 and 2021.**

There was no significant difference in three-year average pea plant stand observed across treatments at the Melita, Reston or Roblin sites (Tables 23.2d, e, and f). Melita and Reston sites displayed no significant difference in three-year average weed biomass among treatments. No significant difference in pea split incidence or pea protein content was observed between treatments for the Melita and Reston trials over three years. Weed biomass, pea grain protein content, and incidence of pea split data was not recorded in each year of the Roblin trial, so a three-year summary is not given here. Disease severity data is not presented here, as disease incidence was low at all sites in all trial years.

**Table 23.2d. Three-year mean plant stand density at flowering, weed biomass per square meter, and grain quality of monocrops and pea intercrops grown at Melita, MB.**

| Crop | Final Emergence ppms | | | Weeds (g $m^{-2}$)^ | | Pea splits (%/500 seeds) | Pea protein (% DM basis) |
|---|---|---|---|---|---|---|---|
| | Sole | Crop-IC | Pea-IC | Sole | Pea-IC | | |
| Pea | 67 | - | 34 (adj.) | 59 | - | 8.1 | 23.8 |
| Flax | 277 | 135 | 35 | 66 | 39 | 13.0 | 23.4 |
| Oat | 182 | 104 | 34 | 89 | 123 | 3.3 | 24.1 |
| Wheat | 178 | 83 | 35 | 12 | 36 | 9.7 | 24.0 |
| Canola | 56 | 35 | 35 | 87 | 64 | 9.5 | 23.5 |
| Mustard | 57 | 35 | 33 | 185 | 198 | 9.9 | 23.8 |
| **P value** | | | 0.973 | | 0.537 | 0.358 | 0.337 |
| **CV (%)** | | | | | 56 | 5 | 6 |

*Johnson transformation prior to ANOVA

**Table 23.2e. Three-year mean plant stand density at flowering and weed biomass per square meter, and grain quality of monocrops and pea intercrops grown at Reston, MB.**

| Crop | Final Emergence ppms | | | Weeds (g m$^{-2}$)^ | | Pea splits (%/500 seeds) | Pea protein (% DM basis) |
|---|---|---|---|---|---|---|---|
| | Sole | Crop-IC | Pea-IC | Sole | Pea-IC | | |
| Pea | 76 | - | 38 (adj.) | 930 | - | 12.9 | 24.7 |
| Flax | 375 | 181 | 35 | 672 | 731 | 7.3* | 22.8* |
| Oat | 179 | 97 | 31 | 739 | 946 | 5.0 | 24.3 |
| Wheat | 200 | 92 | 34 | 669 | 1020 | 9.1 | 23.4 |
| Canola | 56 | 30 | 36 | 475 | 448 | 9.5 | 24.3 |
| Mustard | 41 | 21 | 36 | 1325 | 842 | 9.9 | 23.9 |
| **P value** | | | 0.483 | | 0.27 | 0.139 | 0.131 |
| **CV (%)** | | | 89 | | 31 | 31 | 5 |

^Johnson transformation prior to ANOVA
*Data not recorded in 2021 due to low grain yield

**Table 23.2f. Three-year mean plant stand density at flowering of monocrops and pea intercrops grown at Roblin, MB.**

| Crop | Final Emergence ppms | | |
|---|---|---|---|
| | Sole | Crop-IC | Pea-IC |
| Pea | 63 | - | 32 (adj.) |
| Flax | 189 | 91 | 38 |
| Oat | 115 | 90 | 32 |
| Wheat | 133 | 92 | 36 |
| Canola | 70 | 28 | 40 |
| Mustard | 37 | 21 | 36 |
| **P value** | | | 0.729 |
| **CV (%)** | | | 72 |

To evaluate the economic benefits of each intercrop combination, the cost of production (COP), mean gross revenue (based on 2019 market prices), and mean net revenue (mean gross revenue – cost of production) was calculated for each intercrop and sole crop. While intercrop COP was greater than that of the sole crops, mean net revenue of the intercrops was greater than their respective sole crops at the Melita site. The opposite was true for the Reston and Roblin sites, as the mean net revenue of intercrops was lesser than that of their respective sole crop.

At the Melita site, the greatest mean net revenue was observed in the pea-mustard intercrop ($91 acre$^{-1}$), though this revenue was not significantly different from that of the pea-flax ($23 acre$^{-1}$), pea-oat ($80 acre$^{-1}$), or pea-canola ($81 acre$^{-1}$) intercrops (Table 23.2g). Mean net revenue of the Melita pea-mustard intercrop was also not significantly different from that of the pea sole crop ($60 acre$^{-1}$). The lack of significant revenue difference between intercrop treatments and the pea sole crop in Melita over three trial years indicates that intercropping pea with other crops did not have a significant economic benefit over a sole pea crop at this site.

Like the Melita site, the greatest mean net revenue was observed in the pea-mustard intercrop ($316 acre$^{-1}$) in Reston, though this revenue was not significantly different from that of the other intercrop combinations (Table 23.2h). Three-year mean net revenue of the pea-mustard, pea-canola, and pea-oat intercrops was significantly (P = 0.007) greater than that of the sole pea crop in Reston, indicating a potential economic benefit of intercropping pea with these component crops at this site.

At the Roblin site, mean net revenue of the pea-canola intercrop ($124 acre$^{-1}$) was greatest over three trial years, though this revenue was not significantly different from that of the pea-oat ($94 acre$^{-1}$), pea-wheat (-$19 acre$^{-1}$), or pea-mustard intercrops ($111 acre$^{-1}$). Pea-oat, pea-canola, and pea-mustard intercrops resulted in three-year mean net revenues significantly (P = 0.003) greater than that of the pea sole crop (-$147 acre$^{-1}$), indicating a potential economic benefit of intercropping pea with these component crops over a sole pea crop at the Roblin site (Table 23.2f).

**Table 23.2g. Cost of production (COP) and revenues of various crops in monocrop and in intercrop (IC) with pea grown at Melita, MB. Means represent three-year averages with fixed economic assumptions.**

| | Economics (per acre) | | | | | |
|---|---|---|---|---|---|---|
| | Sole-COP | IC-COP | Mean Gross Revenue | | Mean Net Revenue | |
| **Crop** | | | **Sole** | **IC** | **Sole** | **IC** |
| Pea | $303 | - | $363 | - | $60**ab** | - |
| Flax | $289 | $325 | $310 | $348 | $21 | $23**ab** |
| Oat | $292 | $318 | $363 | $398 | $71 | $80**ab** |
| Wheat | $308 | $316 | $211 | $300 | -$97 | -$16**b** |
| Canola | $328 | $339 | $374 | $420 | $46 | $81**ab** |
| Mustard | $317 | $336 | $342 | $427 | $25 | $91**a** |
| **P value** | | | | | | **0.062** |
| **CV (%)** | | | | | | **5** |
| Means followed by the same letter are not significantly different by Tukey's mean separation method at 90% confidence | | | | | | |

**Table 23.2h. Cost of production (COP) and revenues of various crops in monocrop and in intercrop (IC) with pea grown at Reston, MB. Means represent three-year averages with fixed economic assumptions.**

| Crop | Economics (per acre) | | | | | |
|---|---|---|---|---|---|---|
| | Sole-COP | IC-COP | Mean Gross Revenue | | Mean Net Revenue | |
| | | | Sole | IC | Sole | IC |
| Pea | $303 | - | $40 | - | -$263**b** | |
| Flax | $289 | $325 | $361 | $291 | $71 | -$34**ab** |
| Oat | $292 | $318 | $576 | $593 | $284 | $275**a** |
| Wheat | $308 | $316 | $505 | $415 | $197 | $99**ab** |
| Canola | $328 | $339 | $648 | $560 | $321 | $221**a** |
| Mustard | $317 | $336 | $824 | $651 | $508 | $316**a** |
| **P value** | | | | | | **0.007** |
| **CV (%)** | | | | | | **9** |

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

**Table 23.2i. Cost of production (COP) and revenues of various crops in monocrop and in intercrop (IC) with pea grown at Roblin, MB. Means represent three-year averages with fixed economic assumptions.**

| Crop | Economics (per acre) | | | | | |
|---|---|---|---|---|---|---|
| | Sole-COP | IC-COP | Mean Gross Revenue | | Mean Net Revenue | |
| | | | Sole | IC | Sole | IC |
| Pea | $303 | - | $156 | - | -$147**b** | |
| Flax | $289 | $325 | $305 | $148 | $16 | -$177**b** |
| Oat | $292 | $318 | $480 | $413 | $188 | $94**a** |
| Wheat | $308 | $316 | $403 | $297 | $94 | -$19**ab** |
| Canola | $328 | $339 | $636 | $464 | $309 | $124**a** |
| Mustard | $317 | $336 | $650 | $447 | $333 | $111**a** |
| **P value** | | | | | | **0.003** |
| **CV (%)** | | | | | | **38** |

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

## *Conclusion*

From an economic perspective, the pea-mustard, pea-canola, and pea-oat intercrops generally performed well at each site. However, at the Melita site, there was no statistically significant economic benefit of intercropping pea compared to the sole pea crop. While these fixed economic assumptions allow for the comparison of intercrops, it is important to consider that input costs and market prices are not consistent over time and the margins of both intercropping and sole crops will change over time. Land equivalence ratio allows for the comparison of intercropping and sole cropping based on land usage, as it reports the proportion of sole crop land which would be needed to produce the yields of each component crop in an intercrop system. High TLERs were generally observed in the pea-oat, pea-canola, and pea-mustard intercrops at all sites over three trial years. The pea-wheat intercrop also over-yielded over three years of trial data at all sites, while the pea-flax intercrop did not, likely due to poor flax performance in 2021. It is also important to note that land equivalence ratio is a function of sole crop performance, and ratios can be inflated when sole crops perform poorly. So, while TLERs observed at the Roblin site are much higher than those observed at the Melita or Reston sites over three years, these high ratios are likely due to poor pea sole crop performance in 2019 inflating pea partial LERs. Additionally, the expected synergistic effects of intercropping were likely less evident in 2021 due to dry conditions at the Melita and Reston sites which may have reduced over-yielding in intercrop systems due to plant stress.

It was expected that weed pressure in intercrop systems would be lower than in sole crop systems, due to intercrop components out-competing weeds. Three-year average weed biomass data showed no statistically significant difference in weed pressure between pea intercrops and pea sole crops at the Melita and Reston sites. A significant trend may be discovered in wetter years, as dry conditions in 2020 and 2021 at the Melita and Reston sites could have contributed to less overall weed growth. Disease pressure at all sites was low in all years, so any disease suppression effects of intercropping could not be observed in this trial. No significant trend in pea grain protein content or split pea incidence was identified over three years at the Melita and Reston sites, so no pea grain quality benefits of intercropping over a sole pea crop could be identified in this trial.

Overall, pea-oat, pea-canola, and pea-mustard intercrops performed well at all three sites in terms of yield and net revenue, though this performance was not always significantly better than the sole pea crop. The best intercrop choice for producers may also change as input costs and market prices fluctuate. Weather conditions at each site were varied over the three trial years, and more significant trends may have emerged if 2021 accumulated precipitation was closer to normal. Further research conducted during conditions closer to normal may identify trends in weed pressure, disease suppression, and grain quality which were not identified here.

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***Appendix 23.1:*** Summary of the total cost of production assumptions related to operating, fixed costs, labour for the various monocrop and intercrop combinations. Market price for each commodity used in gross revenue calculations and fertilizer prices assumed for fertilizer cost, in boxes below.

| **Crop System** | Pea | Flax | Oat | Wheat | Canola | Mustard | Pea-Flax | Pea-Oat | Pea-Wheat | Pea-Canola | Pea-Mustard |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Treatment No.** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| **Operating Cost** | | | | | | | | | | | |
| Seed and Treament | $ 30.25 | $ 22.80 | $ 18.13 | $ 24.00 | $ 62.50 | $ 40.00 | $ 26.53 | $ 24.19 | $ 27.13 | $ 46.38 | $ 35.13 |
| Fertilizer | $ 22.41 | $ 22.41 | $ 22.41 | $ 22.41 | $ 22.41 | $ 22.41 | $ 22.41 | $ 22.41 | $ 22.41 | $ 22.41 | $ 22.41 |
| Herbicide* | $ 22.58 | $ 25.13 | $ 15.25 | $ 36.83 | $ 20.41 | $ 28.75 | $ 28.75 | $ 21.00 | $ 18.00 | $ 22.58 | $ 28.75 |
| Fuel | $ 20.39 | $ 22.85 | $ 30.72 | $ 25.95 | $ 24.21 | $ 24.21 | $ 21.62 | $ 25.56 | $ 23.17 | $ 22.30 | $ 22.30 |
| Machinery Operating | $ 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 | $ 9.58 | $ 8.92 | $ 7.70 | $ 7.47 | $ 13.94 | $ 9.24 | $ 8.91 | $ 8.30 | $ 8.19 | $ 11.42 |
| Other** | | | | | | | $ 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 |
| inoculant cost | $ 11.00 | | | | | | $ 11.00 | $ 11.00 | $ 11.00 | $ 11.00 | $ 11.00 |
| Interest (5% for 6 months) | $ 4.41 | $ 5.29 | $ 4.89 | $ 6.26 | $ 7.41 | $ 4.15 | $ 4.85 | $ 4.65 | $ 5.34 | $ 5.91 | $ 4.28 |
| Total Operating | **$ 144.94** | **$ 133.06** | **$ 125.32** | **$ 148.15** | **$ 169.41** | **$ 158.46** | **$ 161.40** | **$ 154.72** | **$ 152.34** | **$ 175.76** | **$ 172.29** |
| | | | | | | | | | | | |
| **Fixed Cost** | | | | | | | | | | | |
| Land Investment | $ 60.44 | $ 60.44 | $ 60.44 | $ 60.44 | $ 60.44 | $ 60.44 | $ 60.44 | $ 60.44 | $ 60.44 | $ 60.44 | $ 60.44 |
| Machinery Cost | $ 66.65 | $ 66.65 | $ 66.65 | $ 66.65 | $ 66.65 | $ 66.65 | $ 66.65 | $ 66.65 | $ 66.65 | $ 66.65 | $ 66.65 |
| Storage Cost*** | $ 4.84 | $ 2.90 | $ 12.70 | $ 6.65 | $ 4.84 | $ 4.84 | $ 10.00 | $ 10.00 | $ 10.00 | $ 10.00 | $ 10.00 |
| Total Fixed | **$ 131.93** | **$ 129.99** | **$ 139.79** | **$ 133.74** | **$ 131.93** | **$ 131.93** | **$ 137.09** | **$ 137.09** | **$ 137.09** | **$ 137.09** | **$ 137.09** |
| | | | | | | | | | | | |
| **Labour Cost^** | $ 26.40 | $ 26.40 | $ 26.40 | $ 26.40 | $ 26.40 | $ 26.40 | $ 26.40 | $ 26.40 | $ 26.40 | $ 26.40 | $ 26.40 |
| | | | | | | | | | | | |
| TOTAL COST | **$ 303.27** | **$ 289.45** | **$ 291.51** | **$ 308.29** | **$ 327.74** | **$ 316.79** | **$ 324.89** | **$ 318.21** | **$ 315.83** | **$ 339.25** | **$ 335.78** |

* 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, 0.30/55 lbs for table cleaner

***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 | $ 7.00 |
| Flax | $ 12.75 |
| Oat | $ 3.75 |
| Wheat | $ 6.75 |
| Canola | $ 11.00 |
| Mustard | $ 19.00 |

| Fertilizer | $/lb |
|---|---|
| N | 0.58 |
| P | 0.54 |
| K | 0.35 |
| S | 0.42 |

## 24.1 Pea-Camelina-Mustard Intercrop (2021 Results)

**Project duration:** 2019-2021
**Collaborators:** Manitoba Pulse & Soybean Growers Association - Daryl Domitruk
Agriculture and Agri-Food Canada – Dr. Syama Chatterton, Lethbridge AB

### Objectives

- Evaluation of pea-canola, pea-camelina or pea-mustard intercrop for biological control of pea diseases and weeds
- Influence of intercropping system involving brassicas on pea grain yield, land equivalence ratio and protein content

### *Background*

Intercropping systems consisting of legume and non-legume crops can have a wide range of benefits. They add diversity to the cropping system, resulting in production stability by reducing risk of crop failure, and many studies have shown that a successful intercropping system can reduce input costs by reducing fertilizer, pesticide and herbicide requirements and thus increasing economic returns for mustard-pea or barley-pea intercrops (Malhi, 2012). An intercrop involving canola and pea has also been shown to reduce aphid populations in pea. Another benefit of intercropping is that it can result in out-yielding, whereby, the yield produced by an intercrop is greater than yield produced by component crops when grown in monocrop on the same land area. This concept has been proven in cereal-legume and oilseed-legume intercrop systems (Jetendra and Mishra, 1999). Out-yielding can be determined using various methods but the most common measurement is land equivalence ratio, which is defined as the relative land area under monocrops which is required to produce yields equivalent to intercrops. Intercropping systems involving pea and mustard are known to increase economic returns by increasing land equivalence ratio to greater than 1 in most cases (Waterer et al., 1994). Higher land equivalence ratios in intercrops may be due to weed suppression and lower susceptibility to pests and diseases, which may result in higher yields (Malhi, 2012). Weed suppression by crops such as mustard may be due to production of allelochemicals that impede growth of weeds. The purpose of this study was to determine the effect of intercropping pea with camelina or yellow mustard on yield, disease incidence, weed pressure, and grain quality.

### *Materials and Methods*

The trial was established in Reston, Manitoba (legal land location SE 11-7-27W1) on Ryerson5Loam-CoatstoneLoam2-TilsonLoam1 soil in 2019 and the same location was utilized for the 2020 and 2021 field studies. In 2019 and 2020, pea-canola intercrops were evaluated, but canola was replaced by camelina in 2021 as canola was not demonstrating pea disease suppression in previous trial years. Nine treatments were arranged in randomized complete block design with 4 replicates. Prior to seeding, land was harrowed. Seeding was done on May 11th at 1" depth into spring wheat stubble, and 0.65 L $ac^{-1}$ of Rival herbicide was applied after seeding as pre-emergence weed control**.** 100% seeding rate for Peas (cert. CDC Amarillo), mustard (Andante) and camelina (Source: AAFC Lethbridge) was 90, 100, and 400 seeds per square meter, respectively.

**Table 24.1a. Target crop density for monocrops and intercrops grown at Reston in 2021.**

| | Target density (Plants per square meter) | | |
|---|---|---|---|
| **Treatment** | **Pea** | **Mustard** | **Camelina** |
| Monocrop | 90 | 100 | 400 |
| Pea: Mustard 70:30 | 63 | 30 | - |
| Pea: Mustard 50:50 | 45 | 50 | - |
| Pea: Mustard 30:70 | 30 | 70 | - |
| Pea: Camelina 70:30 | 63 | - | 120 |
| Pea: Camelina 50:50 | 45 | - | 200 |
| Pea: Camelina 30:70 | 30 | - | 280 |

Fertilizer was banded at seeding at 15-28-20-12-1.6 actual lb $ac^{-1}$ (N-P-K-S-Zn). 0.3 L $ac^{-1}$ Assure II herbicide was applied on June 8th, and 0.12 L $ac^{-1}$ Arrow tank mixed with 0.1% Xact was used on June 17th. 0.075 L $ac^{-1}$ Pounce was applied (10 gal) on June 1st, and 0.034 L $ac^{-1}$ Matador was applied June 10th and 14th for control of flea beetles. On August 6th, Roundup and Reglone + LI700 adjuvant were applied as desiccants at rates of 0.5 L $ac^{-1}$, 0.5 L $ac^{-1}$ and 1 L $ac^{-1}$ respectively. Plots were harvested on August 13th. Data collected included plant counts at 2-3 weeks after emergence and at flowering (over two separate one-meter-long counts per plot), weed count and biomass at pod stage of peas (over two separate one-meter squared areas), disease ratings (n=20), grain yield, protein content of peas (Perkin-Elmer Inframatic 9500), and percentage of pea splits (grams per 100 gram sample) at harvest. Samples of pea plant roots were sent to the laboratory (AAFC Lethbridge, Dr. Syama Chatterton) for DNA analysis to quantify DNA copies of *Aphanomyces euteiches*, *Fusarium redolens*, *Fusarium avenaceum*, and *Fusarium solani* present in pea roots. Results of this analysis are pending and will be presented in a later report update. Visual disease assessments of overall disease severity by plot were determined on a scale of 1-7 for Fusarium root rot and Aphanomyces (1=no disease, 7=dead) and 0-9 [0=no disease, 9=dead; Xue-Wang scale (both at flower) for Mycosphaerella and Powdery Mildew (both at full pod). Data were analyzed using Minitab 18.1 software. A two-way analysis of variance was performed on all variables and Fisher's LSD mean separation method was used where analysis of variance was significant at 90% or

95% confidence intervals. Coefficient of variation (CV) was calculated using the square root of mean square error (ANOVA) divided by the grand mean of raw data.

### *Results and Discussion*

In 2021, the cropping system used had no significant effect on weed number, weed biomass, pea protein content, or disease incidence (Fusarium root rot, Aphanomyces, Powdery Mildew, or Mycosphaerella). A significant (P=0.039) trend was observed in the amount of pea splits present in harvest grain, with all pea-camelina intercrops having fewer split peas than the 70:30 and 50:50 pea-mustard intercrops (Table 24.1b). None of the intercrop treatments had average split pea incidences which were significantly different from that of the sole pea crop. Apart from some influence on split pea incidence, intercropping pea with mustard or camelina did not result in significant grain quality, weed control, or disease suppression benefits in 2021.

**Table 24.1b. Means and analysis of variance for weeds, protein content, splits % and disease ratings in pea-camelina and pea-mustard intercrops at Reston in 2021.**

| | Weeds^ | | Pea | | Disease ratings | | | |
|---|---|---|---|---|---|---|---|---|
| **Treatment** | **Biomass ($g\ m^{-2}$)** | **Weeds ($m^{-2}$)** | **Protein (%)** | **Splits (%)** | **Fusarium** | **Aphano** | **Mildew** | **Mycosphaerella** |
| Pea | 8 | 31 | 26.4 | 9.0**abc** | 2.7 | 3.0 | 0.0 | 1.0 |
| Mustard | 10 | 23 | - | - | - | - | - | - |
| Camelina | 13 | 33 | - | - | - | - | - | - |
| Pea: Mustard 70:30 | 5 | 28 | 26.5 | 9.5**ab** | 2.8 | 2.9 | 0.0 | 1.0 |
| Pea: Mustard 50:50 | 7 | 27 | 26.3 | 10.0**a** | 2.5 | 2.9 | 0.0 | 1.0 |
| Pea: Mustard 30:70 | 7 | 26 | 26.3 | 9.8**a** | 3.2 | 3.5 | 0.0 | 1.3 |
| Pea: Camelina 70:30 | 7 | 31 | 26.1 | 7.4**c** | 1.9 | 2.7 | 0.0 | 1.0 |
| Pea: Camelina 50:50 | 14 | 25 | 25.7 | 7.8**bc** | 3.1 | 3.2 | 0.0 | 1.0 |
| Pea: Camelina 30:70 | 9 | 30 | 25.6 | 7.9**bc** | 2.5 | 2.9 | 0.0 | 1.0 |
| **P value** | 0.133 | 0.686 | 0.374 | **0.039** | 0.205 | 0.516 | n/a | 0.455 |
| **CV (%)** | 58* | 34* | 3 | **14** | 25 | 19 | n/a | 18 |

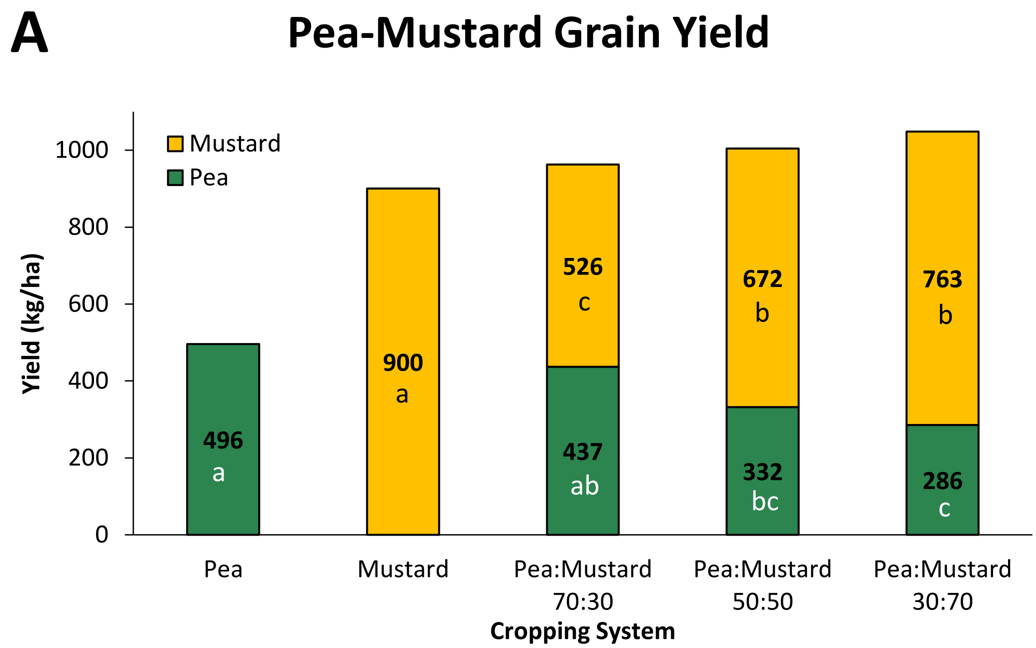
n/a – not analyzable
Means followed by the same letter are not significantly (P<0.05) different by Fishers LSD mean separation method
^Johnson transformation prior to ANOVA
*CV calculated by sqrt of standard deviation divided by grand mean* 100

**Table 24.1c. Means and analysis of variance for crop emergence counts and percentage decrease in emergence in pea, mustard and camelina at Reston in 2021.**

| | Crop Emergence Counts | | | | | |
|---|---|---|---|---|---|---|
| **Description** | **Pea at 2-3 Weeks After Emergence** | **Pea at Flower** | **Average % Decrease in Pea Emergence** | **Brassica at 2-3 Weeks After Emergence** | **Brassica at Flower** | **Average % Decrease in Brassica Emergence** |
| Pea | 57 | 59 | 3.2**b** | - | - | - |
| Mustard | - | - | - | 31 | 32 | 7.4 |
| Camelina | - | - | - | 137 | 139 | 16.6 |
| Pea: Mustard 70:30 | 43 | 45 | 4.4**b** | 11 | 11 | 12.9 |
| Pea: Mustard 50:50 | 32 | 34 | 3.0**b** | 16 | 20 | 0.0 |
| Pea: Mustard 30:70 | 27 | 22 | 18.9**a** | 23 | 23 | 7.1 |
| Pea: Camelina 70:30 | 39 | 42 | 8.3**b** | 22 | 27 | 2.8 |
| Pea: Camelina 50:50 | 30 | 33 | 1.8**b** | 52 | 48 | 13.0 |
| Pea: Camelina 30:70 | 30 | 31 | 2.5**b** | 73 | 72 | 11.9 |
| **P value** | | | **0.070*** | | | 0.751 |
| **CV (%)** | | | **131** | | | 16 |

*Significant at 90% confidence interval
Means followed by the same letter are not significantly (P<0.100) different by Fishers LSD mean separation method

Intercropping did not significantly impact the average decrease in brassica plant stand, but the average pea plant stand decrease was significantly (P=0.070) greater in the 30:70 pea-mustard intercrop than in other cropping systems (Table 24.1c). In both the 2019 and 2020 trials, no significant treatment effect on pea stand change was observed. In both years, the 50:50 and 30:70 pea-mustard intercrop treatments showed the greatest decrease in pea emergence, though this result was not statistically significant. This decrease in pea stand when intercropped with mustard at high densities may be due to competition between mustard and pea plants at these densities. Results from all three trial years will be analyzed in a separate final report, and may identify a significant pea emergence trend in pea-mustard intercrops.



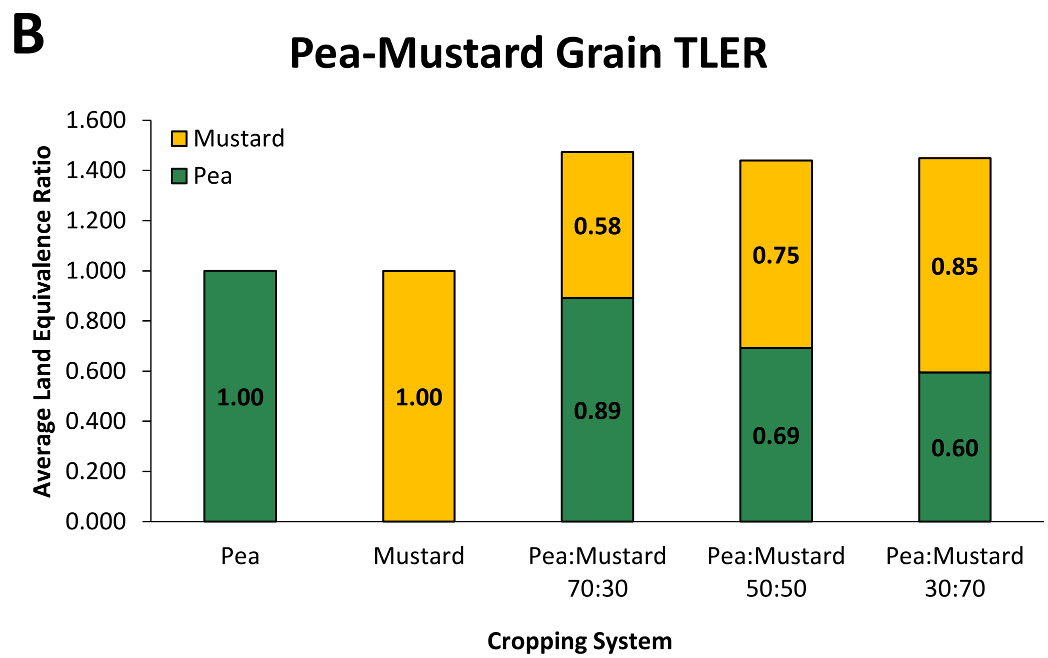




**Figure 24.1a. Grain yield (A) and land equivalence ratios (B) for pea-mustard intercrops grown at Reston, MB in 2021. Bars marked with the same letter are not significantly different by Fishers LSD method at 95% confidence.**

**Table 24.1d. Analysis of variance for yield and land equivalence ratio of pea-mustard intercrops at Reston in 2021.**

| Treatment | Pea yield (kg ha$^{-1}$) | Mustard yield (kg ha$^{-1}$) | Land Equivalence Ratio | | |
|---|---|---|---|---|---|
| | | | Pea | Mustard | Total |
| Pea | 496**a** | - | 1.00**a** | - | 1.00 |
| Mustard | - | 900**a** | - | 1.00**a** | 1.00 |
| Pea: Mustard 70:30 | 437**ab** | 526**c** | 0.89**ab** | 0.58**c** | 1.47 |
| Pea: Mustard 50:50 | 332**bc** | 672**b** | 0.69**bc** | 0.75**b** | 1.44 |
| Pea: Mustard 30:70 | 286**c** | 763**b** | 0.60**c** | 0.85**b** | 1.45 |
| **P value** | **0.039** | **<0.005** | **0.022** | **<0.005** | 0.976 |
| **CV (%)** | **22** | **13** | **19** | **12** | 16 |

Means followed by the same letter are not significantly (P<0.05) different by Fisher's LSD mean separation method.

In 2021, pea yield was greatest in the sole pea crop and mustard yield was greatest in the sole mustard crop, as expected (Table 24.1d). Pea yield from the 70:30 pea-mustard intercrop was not significantly (P=0.039) different from that of the sole pea crop, indicating minimal yield losses when decreasing pea rate and intercropping pea with mustard at 30% normal mustard density. Mustard yield from all intercrop treatments was less than that of the mustard sole crop. Partial land equivalence ratios followed the same trend as yield. Total land equivalence ratios of all intercrops were greater than that of the sole crops, though this result was not statistically significant. These results do not demonstrate a significant land equivalence ratio benefit from intercropping pea and mustard, but they do demonstrate that intercropping did not result in TLERs which were lesser than that of the sole crops. This means that while the yield of intercropped pea and mustard component crops was less than that of their respective sole crops, their combined yield exceeded the yield which was produced by pea and mustard monocrops on the same area of land.

**Table 24.1e. Analysis of variance for yield and land equivalence ratio of pea-camelina intercrops at Reston in 2021.**

| Description | Pea yield (kg ha$^{-1}$) | Camelina yield (kg ha$^{-1}$) | Land Equivalence Ratio | | |
|---|---|---|---|---|---|
| | | | Pea | Camelina | Total |
| Pea | 496**a** | - | 1.00**a** | - | 1.00 |
| Camelina | - | 803**a** | - | 1.00**a** | 1.00 |
| Pea: Camelina 70:30 | 416**ab** | 307**c** | 0.86**a** | 0.39**c** | 1.25**b** |
| Pea: Camelina 50:50 | 429**a** | 488**b** | 0.86**a** | 0.62**b** | 1.48**a** |
| Pea: Camelina 30:70 | 314**b** | 577**b** | 0.66**b** | 0.73**b** | 1.39**ab** |
| **P value** | **0.031** | **<0.005** | **0.015** | **<0.005** | **0.033** |
| **CV (%)** | **18** | **13** | **14** | **9** | **6** |

Means followed by the same letter are not significantly (P<0.05) different by Fishers LSD mean separation method.

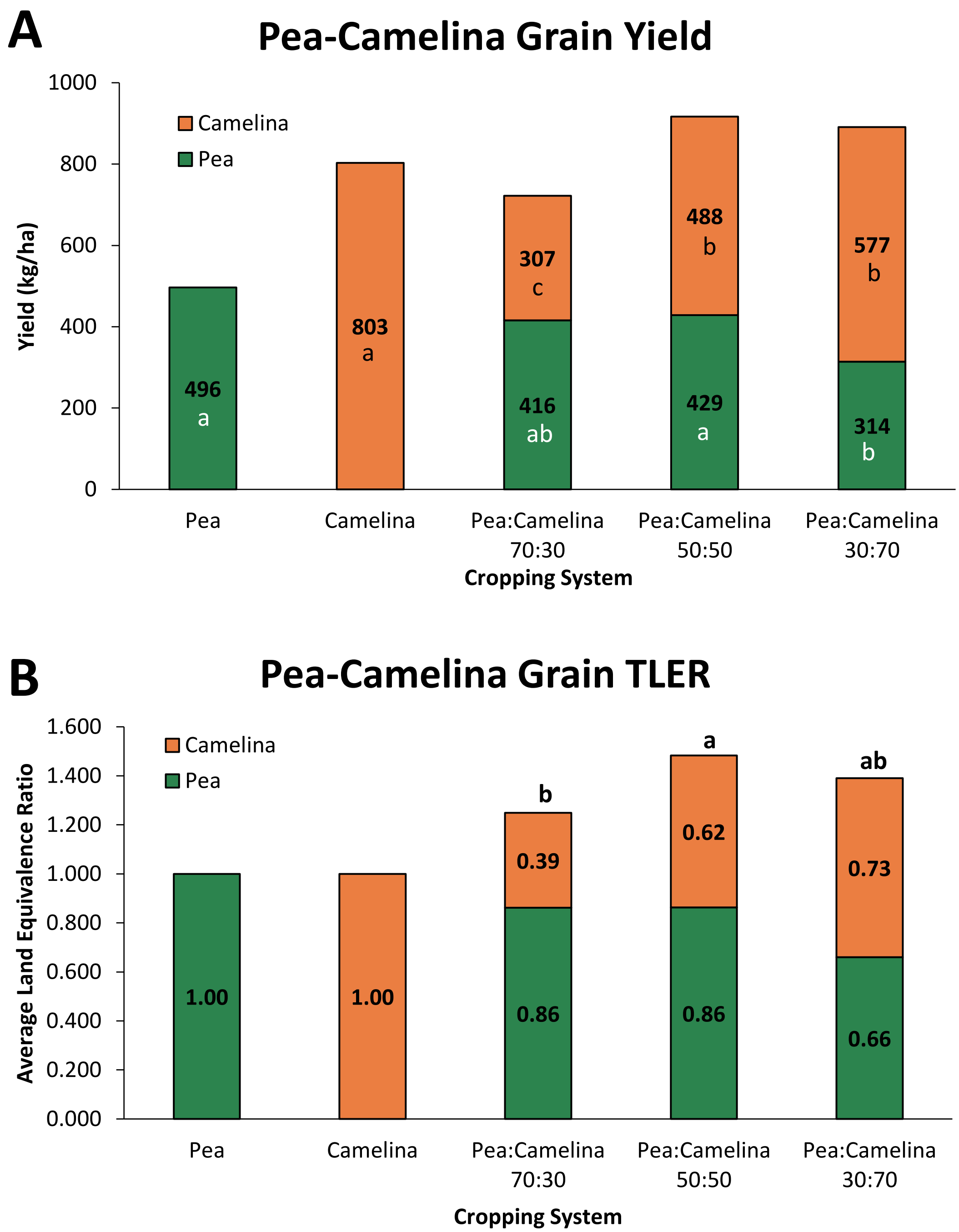



**Figure 24.1b. Grain yield (A) and land equivalence ratios (B) for pea-camelina intercrops grown at Reston, MB in 2021. Bars marked with the same letter are not significantly different by Fisher's LSD mean separation at 95% confidence.**

In 2021, pea yield in the 70:30 and 50:50 pea-camelina intercrops was not significantly (P=0.031 different from that of the sole pea crop, indicating a minimal reduction in pea yield when pea density is reduced and peas are intercropped with camelina (Table 24.1e). Alternatively, camelina yield in all intercrops was less than that of the sole camelina crop. Pea partial land equivalence ratios of 70:30 and 50:50 pea-camelina intercrops were not significantly (P=0.015) different from that of the sole pea crop. Total land equivalence ratios for all intercrop combinations were greater than that of the sole pea and camelina crops (Figure 24.1b). Average TLER of 50:50 and 30:70 pea-camelina intercrop combinations was significantly (P=0.033) greater than the average TLER of the 70:30 combination, indicating a potential benefit of higher camelina density in this intercrop combination. These results also demonstrate that total land equivalence ratios were not reduced below that of the monocrops, indicating that while the yield of intercropped pea and camelina component crops was less than their respective sole crops, their combined yield exceeded the yield which was produced by pea or camelina monocrops on the same area of land.

***Conclusions:***

In 2021, no significant effect of intercropping pea with mustard or camelina on disease incidence or weed pressure was identified based on visual ratings, however PCR quantification results are pending. Intercropping pea with mustard or camelina did not result in an increase in pea grain quality compared to the pea monocrop in 2021, though there were significantly fewer pea splits in the pea-camelina intercrop harvest grain than in the pea-mustard intercrop harvest grain. Intercropping pea with mustard or camelina was not demonstrated to have a protective effect on peas, as average pea stand decrease from 2-3 weeks after emergence to flowering was not significantly different across all treatments except the 30:70 pea-mustard intercrop, for which pea stand decrease was greatest possibly due to competition with mustard.

All intercrop combinations in both the pea-mustard and pea-camelina treatments had total land equivalence ratios greater than that of the monocrops, demonstrating the potential of pea-mustard or pea-camelina intercrops to produce greater combined yields than monocrops on the same area of land. All three years of trial data will be analyzed in a separate report, and results from that analysis will be used to form recommendations which producers can apply to their intercropping systems.

**Pea-camelina-mustard intercrop trial at Reston in 2021.**

## *References*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## 24.2 Pea-Mustard-Canola-Camelina Intercrop Trial – Three-Year Final Report

**Project duration**: 2019-2021
**Collaborators:** Manitoba Pulse & Soybean Growers Association - Daryl Domitruk
Agriculture and Agri-Food Canada – Dr. Syama Chatterton, Lethbridge AB

### *Objectives*

- Evaluation of pea-canola, pea-camelina or pea-mustard intercrop for biological control of pea diseases and weeds
- Influence of intercropping system involving brassicas on pea grain yield, land equivalence ratio and protein content


### *Abstract*

Intercropping has been demonstrated to benefit producers by reducing the need for chemical pesticides through exhibiting biological control of weed pressure, disease incidence, and grain quality and by mitigating crop failure risks through adding diversity to a system. This study aims to understand the seeding rate dynamics of intercropping peas with Brassica family crops and examine the potential effects of intercropping canola, camelina, or yellow mustard on *Aphanomyces* and *Fusarium* root rot incidence, weed pressure, grain yield, and grain quality over three consecutive years. Pea intercrops seeded at various densities were established near Reston, Manitoba in 2019 and 2020, and pea-camelina intercrops replaced pea-canola intercrops in 2021. Crop emergence, weed density and biomass, grain yield, and pea grain quality were assessed. Weed biomass was lesser in pea-mustard intercrops with high mustard density than in the pea monocrop, highlighting a potential weed suppression effect of mustard at these densities. Pea-mustard intercrops demonstrated consistent over-yielding as total land equivalence ratios were greater than 1 for all pea-mustard intercrop treatments, highlighting a potential revenue benefit of intercropping pea with mustard. Data from pea-canola intercrops did not exhibit homogeneity across growing seasons for all variables, so many variables were unable to be analyzed across both years for these intercrops. No significant land equivalence ratio or yield differences were observed between pea-canola intercrop treatments and pea monocrops. Pea grain protein content and split pea incidence of pea-canola intercrops was not significantly different from that of the pea monocrop. PCR quantification of *Aphanomyces euteiches* DNA copies present in pea roots revealed that pea-canola intercrops grown at 70% normal pea density and 30% normal canola density had significantly less *A. euteiches* DNA present in root samples than the pea monocrop, highlighting a potential disease control effect of intercropping pea with canola at these densities. PCR disease quantification data from pea-mustard and pea-camelina intercrops is not discussed here as results from the 2021 trial have not yet been finalized. All pea-camelina intercrop treatments had

greater average total land equivalence ratios than pea monocrop, and pea yields in pea-camelina intercrop treatments with peas seeded at 70% and 50% the normal seeding rate were not significantly lower than that of the pea monocrop, indicating potential economic benefits of intercropping pea with camelina. This study highlights potential weed and disease suppression benefits of intercropping peas with Brassica family crops when pea root rot pressure is high, and demonstrates the potential of these intercrops to out-yield pea monocrops. Both the pest control and yield benefits of these intercrops may be useful for pea producers looking to reduce their economic risk to pea root rots.

### *Background*

Intercropping systems consisting of legume and non-legume crops can have a wide range of benefits. They add diversity to the cropping system, resulting in production stability by reducing risk of crop failure, and many studies have shown that a successful intercropping system can reduce input costs by reducing fertilizer, pesticide and herbicide requirements and thus increasing economic returns for mustard-pea or barley-pea intercrops (Malhi, 2012). An intercrop involving canola and pea has also been shown to reduce aphid populations in pea. Another benefit of intercropping is that it can result in out-yielding, whereby, the yield produced by an intercrop is greater than yield produced by component crops when grown in monocrop on the same land area. This concept has been proven in cereal-legume and oilseed-legume intercrop systems (Jetendra and Mishra, 1999). Out-yielding can be determined using various methods but the most common measurement is land equivalence ratio, which is defined as the relative land area under monocrops which is required to produce yields equivalent to intercrops. Intercropping systems involving pea and mustard are known to increase economic returns by increasing land equivalence ratio to greater than 1 in most cases (Waterer et al., 1994). Higher land equivalence ratios in intercrops may be due to weed suppression and lower susceptibility to pests and diseases, which may result in higher yields (Malhi, 2012). Weed suppression by crops such as mustard may be due to production of allelochemicals that impede growth of weeds. The purpose of this study was to determine the effect of intercropping pea with yellow mustard, canola, or camelina on yield, disease incidence, weed pressure, and grain quality. Intercrops were grown at Reston, Manitoba in 2019, 2020, and 2021, and this report aims to understand the seed rate dynamics of pea intercropping with Brassica type family members (mustard, canola and or camelina) and their potential effect on Aphanomyces root rot over three consecutive years of trial data on the same field in rotation after four years out of pea.

### *Materials and Methods*

The trial was established in Reston, Manitoba (Legal Land Location: SE 11-7-27W1) on Ryerson5Loam-CoatstoneLoam2-TilsonLoam1 soil series where there was pea grown in rotation in 2015 with a presence of root rot. In 2019 and 2020, pea-canola and pea-mustard intercrops were evaluated, but canola was replaced by camelina in 2021 (as requested by S. Chatterton, AAFC) as camelina was demonstrating pea disease suppression in other research works. Nine treatments were arranged in randomized complete block design with 4 replicates. The 100% seeding rate for Peas (CDC Amarillo), mustard (Andante), canola (5545CL) and common camelina (AAFC Lethbridge) was 90, 100, 100, and 400 seeds per square meter, respectively. Each component crop in the intercrop treatments was grown at 30%, 50%, or 70% of the monocrop density. Agronomic details for each site year are summarized in Table 24.2II below. Weather data for Reston from May 1$^{st}$ to August 31$^{st}$ for each year is summarized in Table 24.2I. Data collected included plant counts at 2-3 weeks after emergence and at flowering (over two separate – one meter long counts per plot), weed count and biomass at pod stage of peas (over two separate – one meter squared areas), disease ratings (n=20), grain yield, protein content of peas (Perkin-Elmer Inframatic 9500), and percentage of pea splits (grams per 100 gram sample) at harvest. To quantitatively assess disease pressure, 20 random samples of pea plant roots per plot were sent to the laboratory (AAFC Lethbridge, Dr. Syama Chatterton) for DNA analysis to quantify DNA copies of *Aphanomyces euteiches*, *Fusarium redolens*, *Fusarium avenaceum*, and *Fusarium solani* present in pea roots. Results of this analysis for 2021 are pending, so they are only discussed in regards to the pea-canola intercrop. Visual disease assessment of overall disease severity by plot was determined on a scale of 1-7 for Fusarium root rot and Aphanomyces (1=no disease, 7=dead) and 0-9 (0=no disease, 9=dead; Xue-Wang scale) for Mycosphaerella and Powdery Mildew. Data were analyzed using Minitab 18.1 software. For intercrops which were grown in multiple years, data was combined and tested for normality and equal variance prior to analysis. Only variables with site years exhibiting homogeneity (equal variance) were subject to multi-year analysis of variance. Analysis of variance for multi-year data was done with REML analysis using the Kenward-Roger mixed effects model, while single year analysis was done by two-way analysis of variance (ie. Camelina treatments). For the REML model, treatments were considered fixed effects and site years and replications were considered random effects. Site years were nested in replications and a treatment by year interaction factor was also included. Mean separation was done using Fisher's LSD method at 90% or 95% confidence intervals, depending on the p value determined for that factor.

**Table 24.2l: Monthly weather data for all three site years and nearest regional 30-year normal values of average daily temperature and precipitation at the Reston trial location.**

| Year | | Month | | | | | |
|---|---|---|---|---|---|---|---|
| | | April | May | June | July | August | September |
| 2019 | Precipitation (mm) | 12.3 | 22.2 | 33.4 | 39.3 | 71.6 | 141.7 |
| | Ave. Temp. ($^oC$) | 4.8 | 8.1 | 17.4 | 19.0 | 17.1 | 15.6 |
| 2020 | Precipitation (mm) | 8.8 | 15.8 | 114.4 | 19.7 | 45.9 | 7.2 |
| | Ave. Temp. ($^oC$) | 1.2 | 10.5 | 17.4 | 51.3 | 18.7 | 12.9 |
| 2021 | Precipitation (mm) | 6.3 | 25.6 | 81.9 | 29.7 | 100.3 | 4.3 |
| | Ave. Temp. ($^oC$) | 3.5 | 9.8 | 18.8 | 21.3 | 18.1 | 14.9 |
| Normal* | Precipitation (mm) | 28.6 | 54.1 | 82.2 | 66.7 | 62.1 | 40.5 |
| | Ave. Temp. ($^oC$) | 4.4 | 11.5 | 16.4 | 19.2 | 18.4 | 12.2 |

### *Results*

## PEA-MUSTARD INTERCROP

The successes of intercropping pea with mustard were investigated over three field seasons from 2019 to 2021, and data from all three trial years was pooled and analyzed. There was no significant difference observed across treatments in terms of weed number and biomass, pea grain quality, or visual disease ratings (Table 24.2a). PCR analysis of pea roots was also done to quantify DNA copies of diseases, but 2021 data has not been received so results are not presented here. Results of the PCR analysis for individual years can be found in the 2019 and 2020 annual report. A significant (P = 0.026) trend in average pea stand decrease between two to three weeks after emergence and flowering was observed, with the 30:70 pea-mustard intercrop treatment resulting in a greater average pea stand decrease than the pea monocrop (Table 24.2b). There was also no significant difference in average pea stand decrease between the 50:50 and 30:70 pea-mustard intercrop treatments observed. Because the average pea stand decrease increases with mustard density, this decrease is likely a result of competition between mustard and pea crops. Mustard plant stand decrease, however, was not significantly affected by intercropping with pea over three years.

**Table 24.2II. Agronomic information for three years of intercrop trials grown at Reston, Manitoba.**

| | 2019 | 2020 | 2021 |
|---|---|---|---|
| **Stubble** | Flax | RR Canola | Spring Wheat |
| **Pre-emergence weed control** | 3.7 L $ha^{-1}$ Roundup transorb and 1.6 L $ha^{-1}$ Rival | 1.2 L $ha^{-1}$ Roundup transorb, 0.037 L $ha^{-1}$ Aim and 1.6 L $ha^{-1}$ Rival EC, 1.2 L $ha^{-1}$ Roundup transorb and 0.037 L $ha^{-1}$ Aim | 1.6 L $ha^{-1}$ Rival EC |
| **Seed Date** | May 17$^{th}$ | May 15$^{th}$, Reseeding may 17$^{th}$ | May 11$^{th}$ |
| **Seed depth** | 0.75" | 0.75" | 1" |
| **Fertility Applied (NPKS kg $ha^{-1}$ Actual)** | 9-39-22-8-2Zn | 11-39-22-9-2Zn | 17-31-22-13-1.8Zn |
| **Herbicides (Rate, Name, L $ac^{-1}$)** | 0.30 L $ha^{-1}$ Select + 0.5% v/v Amigo, 0.30 L $ha^{-1}$ Select + 0.5% v/v Amigo + 3.7 L $ha^{-1}$ Urea | Peas and pea-canola: 0.044 kg $ha^{-1}$ Odyssey + Merge + 0.25 L $ha^{-1}$ Mustard and pea-mustard: Arrow 0.25 L $ha^{-1}$ Arrow + XAct | 0.74 L $ha^{-1}$ Assure II, 0.30 L $ha^{-1}$ Arrow + 0.1% Xact |
| **Insecticides** | 0.18 L $ha^{-1}$ Pounce | 0.17 L $ha^{-1}$ Pounce (3 applications) | 0.19 L $ha^{-1}$ Pounce, 0.084 L $ha^{-1}$ Matador (two applications) |
| **Desiccation** | 1.2 L $ha^{-1}$ Roundup transorb, 1.6 L $ha^{-1}$ Reglone + 0.5% v/v LI700 | 1.2 L $ha^{-1}$ Roundup transorb, 1.6 L $ha^{-1}$ Reglone + 0.25% v/v LI700 | 1.2 L $ha^{-1}$ Roundup transorb,1.2 L $ha^{-1}$ Reglone + 0.25% v/v LI700 |
| **Harvest Date** | August 21$^{st}$ | August 31$^{st}$ | August 13$^{th}$ |

**Table 24.2a. Three-year average weed biomass weight, weed count, pea grain protein percentage and splits, and disease ratings for pea-mustard intercrops grown at Reston from 2019-2021.**

| Treatment | Weeds* | | Pea | | Disease ratings | | | |
|---|---|---|---|---|---|---|---|---|
| | Biomass (g $m^{-2}$) | Weeds (plants $m^{-2}$) | Protein (%) | Splits (%) | Fusarium (1-7) | Aphanomyces (1-7) | Mildew (0-9) | Mycosphaerella (0-9) |
| Pea | 151**a** | 274**a** | 24.0 | 4.8 | 3.1 | 3.1 | 0.8 | 1.7 |
| Mustard | 94**ab** | 241**b** | - | - | - | - | - | - |
| Pea: Mustard **70:30** | 81**c** | 262**ab** | 23.7 | 5.2 | 3.5 | 3.2 | 0.9 | 1.7 |
| Pea: Mustard **50:50** | 87**bc** | 183**b** | 23.4 | 5.3 | 3.2 | 3.1 | 0.8 | 1.5 |
| Pea: Mustard **30:70** | 90**bc** | 178**b** | 23.7 | 5.7 | 3.2 | 3.4 | 1.0 | 1.6 |
| **P value** | **0.057** | **0.069** | 0.529 | 0.327 | 0.809 | 0.553 | 0.606 | 0.776 |
| **CV (%)** | **100** | **71** | 4 | 7 | 35 | 31 | 6 | 9 |

* Johnson transformation prior to ANOVA, Fisher's LSD analyzed at 90% CI

**Table 24.2b. Three-year average plants per meter (at 2-3 weeks after emergence and at flower) and average decrease in plant stand between these stages for pea-mustard intercrops grown at Reston from 2019–2021.**

| Treatment | Pea | | | Mustard | | |
|---|---|---|---|---|---|---|
| | Plants per sq. meter (2-3 WAE) | Plants per sq. meter (flower) | Average % Decrease in Plant stand | Plants per sq. meter (2-3 WAE) | Plants per sq. meter (flower) | Average % Decrease in Plant stand |
| Pea | 74 | 77 | 6**b** | - | - | - |
| Mustard | - | - | - | 48 | 48 | 6 |
| Pea: Mustard **70:30** | 54 | 48 | 11**b** | 18 | 18 | 8 |
| Pea: Mustard **50:50** | 37 | 31 | 14**ab** | 24 | 27 | 3 |
| Pea: Mustard **30:70** | 29 | 22 | 23**a** | 34 | 37 | 7 |
| **P value** | | | **0.026** | | | 0.574 |
| **CV (%)** | | | **89** | | | 100 |

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

Equal variances were not observed across all three years for pea yield, pea land equivalence ratio, and total land equivalence ratio. Therefore, 2020 pea land equivalence ratio and total land equivalence ratio, and 2019 pea yield were removed from multi-year analysis prior to ANOVA and mean separation. A significant trend in mustard yield was observed across all three trial years, with the mustard monocrop having a greater yield than all intercrop combinations (Table 24.2c). Mustard yield in the 50:50 pea-mustard intercrop treatment was not significantly different from that of the 70:30 or 30:70 pea-mustard intercrops. Mustard land equivalence ratio followed a similar trend, however average land equivalence ratio of the 30:70 pea-mustard intercrop treatment was not significantly different from that of the mustard monocrop. This suggests that even though mustard density was decreased in the 30:70 pea-mustard intercrop, the intercrop produced yields similar to that of the monocrop on the same area of land. While no significant trend was observed in pea yield, pea land equivalence ratio was significantly (P<0.005) greater in the pea monocrop and 70:30 pea-mustard intercrop than in the other intercrop combinations. Like the mustard intercrop, seeding peas at 70% of the monocrop density did not result in a significant land equivalence ratio decrease compared to the monocrop. No significant difference in total land equivalence ratio was observed across intercrop treatments.

**Table 24.2c. Average grain yield and land equivalence ratios for 2019, 2020, and 2021 trials and three-year average for pea-mustard intercrops grown at Reston.**

| Year | Treatment | Yield (kg ha$^{-1}$) | | Land Equivalence Ratio | | |
|---|---|---|---|---|---|---|
| | | Pea | Mustard | Pea | Mustard* | Total |
| **2019** | Pea | 1144 | - | 1 | - | - |
| | Mustard | - | 931 | - | 1 | - |
| | Pea: Mustard **70:30** | 987 | 714 | 0.87 | 0.77 | 1.65 |
| | Pea: Mustard **50:50** | 655 | 774 | 0.59 | 0.83 | 1.42 |
| | Pea: Mustard **30:70** | 509 | 849 | 0.45 | 0.91 | 1.36 |
| **2020** | Pea | 311 | - | 1 | - | - |
| | Mustard | - | 1735 | - | 1 | - |
| | Pea: Mustard **70:30** | 283 | 1550 | 1.09 | 0.93 | 2.02 |
| | Pea: Mustard **50:50** | 376 | 1660 | 1.51 | 0.98 | 2.49 |
| | Pea: Mustard **30:70** | 232 | 1595 | 1.02 | 0.94 | 1.96 |
| **2021** | Pea | 496 | - | 1 | - | - |
| | Mustard | - | 900 | - | 1 | - |
| | Pea: Mustard **70:30** | 437 | 526 | 0.89 | 0.58 | 1.47 |
| | Pea: Mustard **50:50** | 332 | 672 | 0.69 | 0.75 | 1.44 |
| | Pea: Mustard **30:70** | 286 | 763 | 0.60 | 0.85 | 1.45 |
| **3-Year Mean **** | Pea | 650 | - | 1**a** | - | - |
| | Mustard | - | 1188**a** | - | 1**a** | - |
| | Pea: Mustard **70:30** | 569 | 930**c** | 0.95**a** | 0.76**c** | 1.71 |
| | Pea: Mustard **50:50** | 455 | 1036**bc** | 0.93**b** | 0.86**bc** | 1.78 |
| | Pea: Mustard **30:70** | 342 | 1069**b** | 0.69**b** | 0.90**ab** | 1.59 |
| | **P value** | 0.401^ | **0.001** | **<0.005^** | **0.051** | 0.245^ |
| | **CV (%)** | 56 | **7** | **87** | **49** | 77 |
| ****Years analyzed with Equal Variances** | | 2020, 2021 | **All 3 years** | **2019, 2021** | **All 3 years** | 2019, 2021 |

Means followed by the same letter are not significantly different under Fisher's LSD mean separation method at a 95% confidence interval.
*Means followed by the same letter are not significantly different under Fishers mean separation method at a 90% confidence interval.
^ANOVA included only two years of site data to achieve equal variance

Overall, while no major weed pressure, disease pressure, or pea grain quality differences were seen between pea monocrops, mustard monocrops, and pea-mustard intercrops, a significant trend in pea stand decrease was observed. Though pea stand decrease from emergence to flower in only the 30:70

pea-mustard intercrop was significantly higher than that of the pea monocrop, this difference highlights the potential of the mustard crop to compete with the pea crop at high mustard densities. The potential of pea-mustard intercrops to over-yield was demonstrated in all three years of the trial, with land equivalence ratios of pea-mustard intercrops when either component crop was seeded at 70% monocrop density shown to be not significantly different from that of their respective monocrops. Additionally, throughout all three trial years, the total land equivalence ratios of all intercrop treatments were greater than that of the monocrops. Though the economics of intercrops compared to monocrops was not analyzed in this trial, the consistent over-yielding of pea-mustard intercrops illustrates the potential economic benefits of intercropping to pea producers when the influence of pea root disease pressure is high.

### PEA-CANOLA RESULTS

Pea-canola intercrops were grown at Reston in 2019 and 2020. When data from both years was combined, unequal variances across trial years were found for weed biomass, weed number, visual disease rating, pea yield, pea land equivalence ratio, and total land equivalence ratio data. Data from these variables was not homogenous, therefore these results were not analyzed as a combined analysis and will not be discussed. There was no significant treatment effect on pea grain protein content or split pea incidence across both site years. The average decrease in pea and canola plant stand between 2-3 weeks after emergence and flowering stages was also not significantly different across treatments. No significant trends in grain yields or land equivalence ratios between monocrops and intercrops were observed across both years of trial data.

PCR quantification of *Aphanomyces euteiches* DNA copies in root samples revealed that the 70:30 pea-canola intercrop treatment had significantly (P = 0.081) lower *A. euteiches* incidence in pea roots than the 30:70 pea-canola intercrop and the pea monocrop. This reduced Aphanomyces incidence at the 70:30 pea-canola intercrop ratio could demonstrate the potential of canola to suppress pea root disease when intercropped with pea at this density. However, reduced root disease compared to the control could also be a result of reduced pea spatial density, rather than a result of disease suppression by the canola plant. This effect could be further investigated by including monocrop treatments with reduced seeding rates in the trial design, and comparing disease incidence in reduced-density monocrops with that of the intercrop treatments. It is also possible that in high density pea stands *A. euteiches* may be infecting pea by root-to-root transmission as Pfender et al (1983) found in greenhouse experiments.

**Table 24.2d. Two-year average weed biomass weight, weed count, pea grain protein percentage and split pea incidence, and disease ratings for pea-canola intercrops grown at Reston from 2019-2020.**

| | Weeds* | | Pea | | Disease ratings | | | |
|---|---|---|---|---|---|---|---|---|
| **Treatment** | **Biomass ($g\ m^{-2}$)** | **Weeds (plants $m^{-2}$)** | **Protein (%)** | **Splits (%)** | **Fusarium (1-7)** | **Aphanomyces (1-7)** | **Mildew (0-9)** | **Mycosphaerella (0-9)** |
| Pea | 222**a** | 396**a** | 22.7 | 2.8 | 3.4 | 3.2 | 1.2 | 2.0 |
| Canola | 120**b** | 236**c** | - | - | - | - | - | - |
| Pea: Canola **70:30** | 107**b** | 334**ab** | 22.5 | 2.9 | 3.6 | 3.3 | 1.4 | 1.9 |
| Pea: Canola **50:50** | 100**b** | 269**bc** | 22.4 | 2.6 | 3.5 | 2.9 | 1.6 | 1.7 |
| Pea: Canola **30:70** | 107**b** | 270**bc** | 22.3 | 2.8 | 3.6 | 3.5 | 1.6 | 1.7 |
| **P value** | **0.001** | **0.033** | 0.804 | 0.970 | 0.842 | 0.412 | 0.494 | 0.613 |
| **CV (%)** | **15** | **15** | 13 | 51 | 9 | 9 | 6 | 8 |

* Johnson transformation prior to ANOVA
Means followed by the same letter are not significantly different by Fisher's LSD mean separation a 95% confidence interval.

**Table 24.2e. Two-year average plants per meter (at 2-3 weeks after emergence and at flower) and average decrease in plant stand between these stages for pea-canola intercrops grown at Reston in 2019 and 2020.**

| | Pea | | | Canola | | |
|---|---|---|---|---|---|---|
| **Treatment** | **Plants per meter (2-3 WAE)** | **Plants per meter (flower)** | **Average % Decrease in Plant stand** | **Plants per meter (2-3 WAE)** | **Plants per meter (flower)** | **Average % Decrease in Plant stand** |
| Pea | 83 | 86 | 7 | - | - | - |
| Canola | - | - | - | 66 | 68 | 4 |
| Pea: Canola **70:30** | 55 | 45 | 18 | 18 | 19 | 5 |
| Pea: Canola **50:50** | 40 | 37 | 14 | 33 | 31 | 7 |
| Pea: Canola **30:70** | 29 | 19 | 29 | 46 | 42 | 12 |
| **P value** | | | 0.404 | | | 0.749 |
| **CV (%)** | | | 74 | | | 87 |

**Table 24.2f. Two-year averages for *Aphanomyces euteiches*, *Fusarium redolens*, *Fusarium avenaceum*, and *Fusarium solani* incidence in pea roots collected from pea-canola intercrops at Reston.**

| | PCR Results | | | |
|---|---|---|---|---|
| **Treatment** | ***A. euteiches**** **(DNA copies $\mu L^{-1}$)** | ***F. redolens*** **(DNA copies $\mu L^{-1}$)** | ***F. avenaceum*** **(DNA copies $\mu L^{-1}$)** | ***F. solani*** **(DNA copies $\mu L^{-1}$)** |
| Pea | 206.8**ab** | 10.6 | 6.6 | 21.5 |
| Canola | - | - | - | - |
| Pea: Canola **70:30** | 141.0**c** | 6.7 | 6.2 | 18.6 |
| Pea: Canola **50:50** | 164.0**bc** | 6.7 | 1.4 | 16.4 |
| Pea: Canola **30:70** | 236.1**a** | 10.8 | 2.6 | 19.2 |
| **P value** | **0.081** | 0.466 | 0.499 | 0.890 |
| **CV (%)** | **33** | 36 | 18 | 33 |

*Means followed by the same letter are not significantly different by Fishers mean separation method at a 90% confidence interval.

**Table 24.2g. Grain yield and land equivalence ratios from 2019 and 2020 growing seasons and two-year average grain yield and land equivalence ratios for pea-canola intercrops grown at Reston.**

| | | Yield (kg ha$^{-1}$) | | Land Equivalence Ratio | | |
|---|---|---|---|---|---|---|
| **Year** | **Treatment** | **Pea** | **Canola** | **Pea** | **Canola** | **Total** |
| **2019** | Pea | 1144 | - | 1.00 | - | 1.00 |
| | Canola | - | 1742 | - | 1.00 | 1.00 |
| | Pea: Canola **70:30** | 977 | 1201 | 0.88 | 0.70 | 1.58 |
| | Pea: Canola **50:50** | 840 | 1394 | 0.76 | 0.81 | 1.56 |
| | Pea: Canola **30:70** | 525 | 1670 | 0.46 | 0.97 | 1.43 |
| **2020** | Pea | 311 | - | 1.00 | - | 1.00 |
| | Canola | - | 2367 | - | 1.00 | 1.00 |
| | Pea: Canola **70:30** | 520 | 2361 | 2.19 | 1.08 | 3.27 |
| | Pea: Canola **50:50** | 469 | 2397 | 1.76 | 1.13 | 2.89 |
| | Pea: Canola **30:70** | 336 | 2493 | 1.32 | 1.16 | 2.47 |
| **2-Year Mean** | Pea | 727 | - | 1.00 | - | - |
| | Canola | - | 2055 | - | 1.00 | - |
| | Pea: Canola **70:30** | 749 | 1781 | 1.53 | 0.89 | 2.42 |
| | Pea: Canola **50:50** | 654 | 1896 | 1.26 | 0.97 | 2.23 |
| | Pea: Canola **30:70** | 430 | 2082 | 0.89 | 1.06 | 1.95 |
| **P value** | | 0.454 | 0.374 | 0.486 | 0.613 | 1 |
| **CV (%)** | | 11 | 13 | 23 | 30 | 6 |

Overall, because few results from this trial were statistically significant when analyzed over both trial years, further investigation of pea-canola intercrops is necessary before recommendations can be made to producers. However, reduced *A. euteiches* incidence in one of the intercrop treatments highlights a possible root disease suppression effect of canola on pea, and this effect could be further investigated in future intercrop seeding rate studies.

## PEA-CAMELINA INTERCROP

In the 2021 field season, the pea-canola intercrop was replaced with a pea-camelina intercrop as minimal disease control was achieved by the pea-canola intercrop in previous field seasons. Intercropping pea with camelina had no significant effect on weed number or biomass, disease ratings, or pea grain quality compared to monocrops (Table 24.2h). However, pea splits were less prevalent in pea grain from all camelina intercrops than in pea- mustard intercrops at 50:50 and 30:70 ratios. Decrease in pea or camelina stand was not significantly affected by intercropping (Table 24.2i).

Significant differences between pea-camelina intercrops and monocrops were observed in terms of yield and land equivalence ratios (Table 24.2j). Pea yield in the 70:30 and 50:50 pea-camelina intercrops was not significantly (P=0.031) different from that of the sole pea crop, indicating a minimal reduction in pea yield when pea density is reduced and peas are intercropped with camelina. Alternatively, camelina yield in all intercrops was less than that of the sole camelina crop. Pea partial land equivalence ratios of 70:30 and 50:50 pea-camelina intercrops were not significantly (P=0.015) different from that of the sole pea crop. Total land equivalence ratios for all intercrop combinations were greater than that of the sole pea and camelina crops. Average TLERs of 50:50 and 30:70 pea-camelina intercrop combinations were significantly (P=0.033) greater than the average TLER of the 70:30 combination, indicating a potential benefit of higher camelina density in this intercrop combination. These results also demonstrate that total land equivalence ratios were not reduced below that of the monocrops, indicating that while the yield of intercropped pea and camelina component crops was less than their respective sole crops, their combined yield exceeded the yield which was produced by pea or camelina monocrops on the same area of land.

A more detailed discussion of results from the pea-camelina intercrops can be found in the Pea-Mustard-Camelina 2021 trial report (Section 24.1).

**Table 24.2h. Mean weed pressure, disease, and pea grain quality for pea-camelina intercrops grown at Melita in 2021.**

| | Weeds^ | | Pea | | Disease ratings | | | |
|---|---|---|---|---|---|---|---|---|
| **Treatment** | **Biomass g $m^{-2}$** | **Weeds $m^{-2}$** | **Protein (%)** | **Splits (%)** | **Fusarium (1-7)** | **Aphano. (1-7)** | **Mildew (0-9)** | **Myco. (0-9)** |
| Pea | 8 | 32 | 26.4 | 9.0 | 2.7 | 3.0 | 0.0 | 1.0 |
| Camelina | 13 | 34 | - | - | - | - | - | - |
| Pea: Camelina 70:30 | 7 | 31 | 26.1 | 7.4 | 1.9 | 2.7 | 0.0 | 1.0 |
| Pea: Camelina 50:50 | 14 | 25 | 25.7 | 7.8 | 3.1 | 3.2 | 0.0 | 1.0 |
| Pea: Camelina 30:70 | 9 | 30 | 25.6 | 7.9 | 2.5 | 2.9 | 0.0 | 1.0 |
| **P value** | 0.250 | 0.698 | 0.345 | 0.435 | 0.133 | 0.715 | n/a | n/a |
| **CV (%)** | 4 | 2 | 3 | 17 | 24 | 19 | n/a | n/a |

n/a – not analyzable
Means followed by the same letter are not significantly (P<0.05) different by Fishers LSD mean separation method
^Johnson transformation prior to ANOVA, CV was calculated by sqrt of standard deviation divided by grand mean* 100

**Table 24.2i. Mean Pea and Camelina plant stand for pea-camelina intercrops grown at Melita in 2021.**

| Description | Crop Emergence Counts | | | | | |
|---|---|---|---|---|---|---|
| | Pea at 2-3 Weeks After Emergence | Pea at Flower | Average % Decrease in Pea Emergence | Brassica at 2-3 Weeks After Emergence | Brassica at Flower | Average % Decrease in Brassica Emergence |
| Pea | 57 | 59 | 3.2 | - | - | - |
| Camelina | - | - | - | 137 | 139 | 16.6 |
| Pea: Camelina 70:30 | 39 | 42 | 8.3 | 22 | 27 | 2.8 |
| Pea: Camelina 50:50 | 30 | 33 | 1.8 | 52 | 48 | 13.0 |
| Pea: Camelina 30:70 | 30 | 31 | 2.5 | 73 | 72 | 11.9 |
| **P value** | | | 0.612 | | | 0.469 |
| **CV (%)** | | | 162 | | | 110 |

**Table 24.2j. Mean yield and land equivalence ratios for pea-camelina intercrops grown at Melita in 2021.**

| Description | Pea yield (kg ha$^{-1}$) | Camelina yield (kg ha$^{-1}$) | Land Equivalence Ratio | | |
|---|---|---|---|---|---|
| | | | Pea | Camelina | Total |
| Pea | 496**a** | - | 1.00**a** | - | 1.00 |
| Camelina | - | 803**a** | - | 1.00**a** | 1.00 |
| Pea: Camelina 70:30 | 416**ab** | 307**c** | 0.86**a** | 0.39**c** | 1.25**b** |
| Pea: Camelina 50:50 | 429**a** | 488**b** | 0.86**a** | 0.62**b** | 1.48**a** |
| Pea: Camelina 30:70 | 314**b** | 577**b** | 0.66**b** | 0.73**b** | 1.39**ab** |
| **P value** | **0.031** | **<0.005** | **0.015** | **<0.005** | **0.033** |
| **CV (%)** | **18** | **13** | **14** | **9** | **6** |

Means followed by the same letter are not significantly (P<0.05) different by Fisher's LSD mean separation method.

### *References*


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## 25.0 Grain Corn Hybrid Trials 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. The Manitoba Corn Committee publishes the annual results with all the yearly data in their brochure, which is available by calling the MCA office. The 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.

## 26.0 Confectionary and Oil Sunflower variety trial in Manitoba

**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). 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 Table1a of this report. Results for the 2021 sunflower variety trials can be found in the 2021 Manitoba Seed Guide or on the MCA website.

## 27.0 Faba Bean Row Spacing

***Project duration***: 2021
***Collaborators:*** WADO

### *Objectives*

- To examine the effects of establishing faba beans with a planter at various row spacings compared to the traditional air-seeding method

### *Background*

For faba bean crop establishment, the current best practice is seeding the crop using an air seeder. While this method is accessible to many producers, seeding faba beans with an air seeder poses some difficulties to producers. Faba beans can often cause air seeder blockages due to their large size, resulting in seeding delays. Additionally, air seeding faba beans often leads to clumping of seeds and an uneven plant stand due to a variety of factors related to air seeder design and function. The use of a singulating planter, rather than an air seeder, to establish a faba bean crop may help avoid these production issues and theoretically reduce other crop stressors such as diseases, water use, and intraspecific competition. Planters allow a producer to better place seed, reducing seed clumping issues and seed input costs, and they reduce blockage issues often faced when using air seeders. Here, a trial was established using faba beans planted at various row spacings or seeded with an air seeder at narrow widths commonly used by producers to examine the effect of crop establishment method on faba bean crops based on various agronomic responses.

### *Materials and Methods*

A trial was established into spring wheat stubble at Melita, Manitoba (NW 27-3-27) on Ryerson Loam soil. Field was harrowed prior to seeding. Treatments were arranged in blocks with and replicated four times. Target seed density was 45 plants per meter squared, assuming seed weight of 386 g/1000 seeds, 2% mortality and 99% germination rate. Variety used was 'Snow Bird'. Faba bean plots were established using an air seeder or a planter at various row spacings. Air-seeded plots were established using a SeedHawk dual-knife opener air seeder with 9.5-inch row spacing. Planted plots were established using a Wintersteiger Dynamic Disc (EasyPlant software, Juniper Systems) vacuum planter with a soybean plate and row spacing adjusted to 15, 20, or 30 inches. Row cleaners were removed as straw was found to pile up between cleaners. Seed was pre-inoculated with BASF peat inoculant for faba beans (Nodulator FB Peat – BASF) at recommended rates prior to seeding. Fertility was banded at 16-30-21-12-2 (N-P-K-S-Zn) lbs $ac^{-1}$ prior to establishing seed establishment with a Seedhawk dual-knife opener.

Basagran (0.91 L ac$^{-1}$) was applied on June 14th, and Arrow (0.125 L ac$^{-1}$) mixed with X-act adjuvant (0.75%) was applied on June 22nd for weed control. A spot herbicide spray was done using 150 ml ac$^{-1}$ Arrow mixed with 0.1% Xact on July 8th for additional weed control. Matador (34 ml ac$^{-1}$) insecticide was applied on June 24th for control of blister beetles. Data collected included: Emergence counts, crop height, days to flowering, pod height, leaf disease ratings, weed counts, lodging ratings, days to maturity, yield, seed size (grams per 500 seeds) and diseased seeds per 100 seeds. Plots were harvested September 8th. Data were analyzed using Minitab 18.1 software and means were separated using Fisher's LSD method at 95% confidence.

### *Results*

Faba bean yield was significantly influenced by crop establishment method, with air-seeded plots (narrowest row spacing) resulting in the greatest average yield (1536 kg ha$^{-1}$). Treatments which were established using a planter had yields significantly lower than that of the air-seeded treatment, with the lowest average yield (1007 kg ha$^{-1}$) resulting from faba beans seeded with 30" row spacing (Table 27a). Row spacing was not observed to significantly affect plant stand density, crop height, days to flowering, pod height, leaf disease, weed pressure, lodging, days to maturity, seed size or seed disease incidence in faba bean plots. It was expected that row spacing would affect weed pressure, disease pressure, and seed size as faba bean density changed, though these effects were not observed. Weed and disease pressure was low in 2021, as conditions were extremely dry, and perhaps significant weed and disease pressure trends would emerge in wetter conditions. Seed size may also be influenced by row spacing in wetter years.

**Table 27a. Averages and analysis of variance for agronomic factors of faba beans established by air seeder (9.5" row spacing) or planter (15, 20, or 30" row spacing) at Melita, Manitoba in 2021. *Weeds data was trandformed with Johnson transformation prior to analysis**

| Row Spacing | Emergence (Plants per m²) | Crop Height (cm) | Days to Flowering | Pod Height (cm) | Leaf Disease (1-9) | Weeds* Per meter² | Lodging (1-5) | Days to Maturity | Seed Size (g/500) | Diseased Seeds (#/100) |
|---|---|---|---|---|---|---|---|---|---|---|
| **9.5"** | 39 | 57 | 47 | 34 | 2 | 87 | 1 | 84 | 167 | 31 |
| **15"** | 32 | 61 | 49 | 34 | 2 | 115 | 1 | 86 | 158 | 38 |
| **20"** | 33 | 65 | 48 | 36 | 2 | 96 | 1 | 83 | 164 | 35 |
| **30"** | 27 | 61 | 49 | 38 | 2 | 293 | 1 | 85 | 165 | 42 |
| **P Value** | 0.186 | 0.132 | 0.295 | 0.191 | 0.783 | 0.052 | n/a | 0.37 | 0.127 | 0.051 |
| **CV (%)** | 22 | 7 | 2 | 7 | 19 | 83 | n/a | 2 | 3 | 13 |

**Photos: Faba bean row spacing at narrow row air seeded width at 9.5” compared to planted row spacing width of 15”, 20”, and 30”, respectively left to right. Photo taken July 12, 2021, near Melita, MB.**

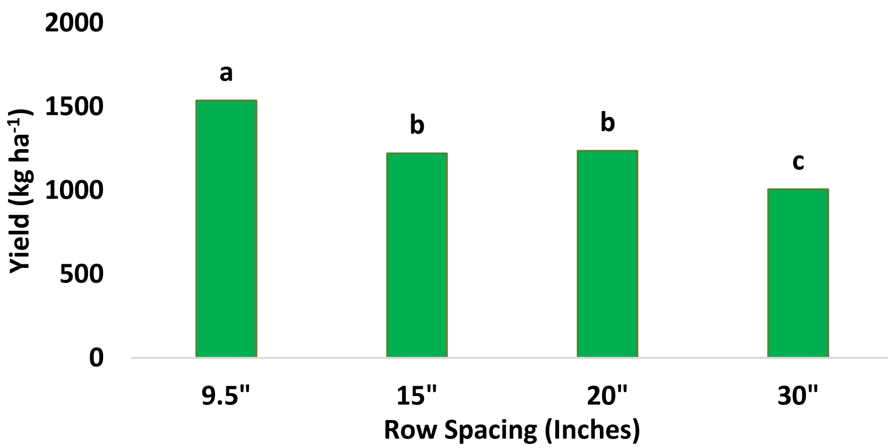


**Figure 27a. Average yield of Faba Beans established by air-seeder (9.5” row spacing) or planter (15, 20, or 30” row spacing) at Melita, MB in 2021.**

Overall, results from 2021 show that air seeding faba beans is still best practice, as air-seeded plots resulted in the greatest yield (Figure 27a). Trial repetition in wetter years may identify weed pressure, disease pressure, and seed size trends which were not identified here, and may demonstrate the theorized benefits of planting faba beans.

## 28.0 – Determining Optimum Target Plant Stands for Spring Cereal Crops

***Collaborators:*** Anne Kirk, Manitoba Agriculture, James Frey, Nirmal Hari, Haider Abbas, Manitoba Agriculture Diversification Centres

### *Objectives*

- Determine if target plant stand recommendations should be adjusted for spring wheat, oat, and barley
- Determine if optimum plant stands differ for individual varieties
- Assist producers with determining target plant stand and seeding rate for newer spring cereal varieties

### *Background*

Yield of spring cereals is impacted by many agronomic practices, but starts with variety selection, seeding date, target plant stand, and the seeding rate needed to achieve those plant stands. Optimum plant population is determined by factors including crop management practices and growing conditions. Manitoba Agriculture currently recommends target plant stands of 23-28 plants/ft$^2$ for spring wheat, 18-23 plants/ft$^2$ for oat, and 22-25 plants/ft$^2$ for barley. With the introduction of semi-dwarf and higher yielding cultivars, target plant stands may need to be adjusted to maximize profitability. Pervious research has shown that optimum plant populations can differ by both crop type and variety. In a North Dakota study, Mehring et al. (2016) found that optimum seeding rates for spring wheat ranged from 14 to 46 plants/ft$^2$ depending on the characteristics of the variety.

### *Materials and Methods*

- Locations: Arborg, Carberry, Melita, and Roblin
- Year: 2021
- Experimental Design: Randomized complete block design with factorial treatments and replicated three times
- Treatments: Two cultivars of spring wheat, oat, and barley planted at six seeding rates. Target plant populations were 9, 15, 21, 27, 33, and 39 plants/ft$^2$. See Table 28a for a complete treatment list.
    - Experiments were separated by crop type
    - Seeding rates were calculated based on thousand kernel weight and assumed 15% seedling mortality
- Data Collection: Plant stand, mortality, heads per plant, and yield.
    - Carberry oat plots had poor emergence and were terminated.
    - Melita had hail on July 17. It is estimated that the hail resulted in 20% yield loss in the wheat, and 30% yield loss in the barley and oats

**Table 28a.** Crop types, varieties, and target plant stands studied.

| Crop Type | Variety | Target Plant Stand (pl/ft$^2$) |
|---|---|---|
| Spring Wheat | AAC Brandon | 9, 15, 21, 27, 33, 39 |
| | Faller | 9, 15, 21, 27, 33, 39 |
| Oat | CS Camden | 9, 15, 21, 27, 33, 39 |
| | Summit | 9, 15, 21, 27, 33, 39 |
| Barley | AAC Connect | 9, 15, 21, 27, 33, 39 |
| | CDC Austenson | 9, 15, 21, 27, 33, 39 |

**Table 28b.** Agronomic information

| | Arborg | Carberry | Melita | Roblin |
|---|---|---|---|---|
| Soil Series | Peguis Clay | Wellwood Loam | Waskada Loam | Erickson Loamy Clay |
| **Wheat** | | | | |
| Seeding Date | 07-May | 3-May | 4-May | 6-May |
| Fertility (lb/ac) | | | | |
| Residual | 93 N, 44 P | 12 N, 4 P, 158 ppm K, 12 S | 10 N, 14 P, 364 K, 90 S | 93 N, 46 ppm P, 709 ppm K |
| Applied | 60 N, 20 P | 78 N, 34 P, 15 K | 105 N, 28 P, 20 K, 12 S | 96 N, 15 P |
| Harvest Date | 17-Aug | 13-Aug | 4-Aug | 31-Aug |
| **Oat** | | | | |
| Seeding Date | 10-May | - | 6-May | 4-May |
| Fertility (lb/ac) | | | | |
| Residual | 93 N, 44 P | - | 10 N, 14 P, 364 K, 90 S | 162 N, 41 ppm P, 703 ppm K |
| Applied | 60 N, 20 P | - | 112 N, 28 P, 20 K, 12 S | 10 N, 15 P |
| Harvest Date | 18-Aug | - | 6-Aug | 15-Sep |
| **Barley** | | | | |
| Seeding Date | 10-May | 30-Apr | 4-May | 6-May |
| Fertility (lb/ac) | | | | |
| Residual | 93 N, 44 P | 12 N, 4 P, 158 ppm K, 12 S | 10 N, 14 P, 364 K, 90 S | 93 N, 46 ppm P, 709 ppm K |
| Applied | 60 N, 20 P | 78 N, 34 P, 15 K | 105 N, 28 P, 20 K, 12 S | 31 N, 15 P |
| Harvest Date | 18-Aug | 13-Aug | 4-Aug | 8-Sep |

**Table 28c.** Monthly and growing season (May 1 - September 30) summaries. Data from Manitoba Agriculture Growing Season Report web43.gov.mb.ca/climate/SeasonalReport.aspx

| | May | June | July | August | September | Growing Season |
|---|---|---|---|---|---|---|
| **Arborg** | | | | | | |
| Precipitation (mm) | 19 | 39 | 11 | 116 | 34 | 221 |
| % of Normal precipitation[1] | 36 | 51 | 20 | 147 | 71 | 69 |
| Growing degree days (GDD) | 163 | 412 | 502 | 397 | 291 | 1767 |
| % of Normal GDD[1] | 80 | 122 | 116 | 103 | 153 | 114 |
| **Carberry** | | | | | | |
| Precipitation (mm) | 36 | 74 | 12 | 111 | 8 | 243 |
| Normal precipitation[1] | 75 | 106 | 17 | 158 | 16 | 79 |
| Growing degree days (GDD) | 156 | 419 | 496 | 389 | 308 | 1770 |
| Normal GDD[1] | 85 | 125 | 117 | 100 | 161 | 116 |
| **Melita** | | | | | | |
| Precipitation (mm) | 28 | 87 | 35 | 125 | 13 | 289 |
| Normal precipitation[1] | 52 | 86 | 51 | 160 | 38 | 86 |
| Growing degree days (GDD) | 108 | 426 | 522 | 426 | 323 | 1878 |
| Normal GDD[1] | 88 | 121 | 115 | 103 | 153 | 115 |
| **Roblin** | | | | | | |
| Precipitation (mm) | 50 | 62 | 37 | 82 | 16 | 249 |
| Normal precipitation[1] | 111 | 84 | 52 | 148 | 31 | 83 |
| Growing degree days (GDD) | 148 | 380 | 467 | 360 | 266 | 1623 |
| Normal GDD[1] | 86 | 121 | 119 | 102 | 163 | 116 |

[1]Based on 30-year averages

All sites had lower than normal precipitation over the entire growing season. Arborg had very low precipitation throughout May, June, and July, which resulted in short plants, few tillers, and low yields overall. Low precipitation was especially evident at all sites in July, where Arborg and Carberry had 20 and 17% or normal precipitation, respectively, and Melita and Roblin has 51 and 52% of normal precipitation, respectively. July was warmer than normal at all locations, and the warm and dry conditions affected plant growth and development.

## *Results and Discussion*

### Plant Stand

Stand establishment increased as seeding rate increased at most site years. There was no significant difference in plant stand between seeding rate treatments for wheat at Roblin, results will not be shown for this site as a range of plant populations were not established. At many locations plant stands were lower than the target. The exception was Arborg where plant stands ranged from 18-57, 12-47, and 25-35 plants/ft$^2$ in the barley, oat, and wheat plots, respectively (Table 28d).

**Table 28d.** Plant stand (plants/ft$^2$) for barley, oat, and wheat at the Arborg (Arb), Carberry (Car), Melita (Mel), and Roblin (Rob) locations. Barley varieties are CDC Austenson (A) and AAC Connect (B), oat varieties are CS Camden (A) and Summit (B), and wheat varieties are AAC Brandon (A) and Faller (B). Least significant difference (LSD) values are shown for sites where there is a significant difference (Pr<0.05) between treatments. At sites with significant differences between treatments, means within the same site year followed by the same letter within a column are not significantly different.

| | **Barley** | | | | **Oat** | | | **Wheat** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Arb | Car | Mel | Rob | Arb | Mel | Rob | Arb | Car | Mel | Rob |
| | plants/ft$^2$ | | | | | | | | | | |
| **Variety** | | | | | | | | | | | |
| A | 40 | 15 | 16.3b | 18 | 33 | 17a | 12 | 29 | 19 | 14 | 11 |
| B | 43 | 14 | 17.8a | 18 | 29 | 13b | 10 | 31 | 21 | 14 | 13 |
| *LSD* | - | - | *1.3* | - | - | *2* | - | - | - | - | - |
| **Target Plant Population (pl/ft$^2$)** | | | | | | | | | | | |
| 9 | 18e | 6d | 7f | 8c | 12e | 6f | 6f | 25d | 9e | 6d | 11 |
| 15 | 36d | 10cd | 12e | 14b | 23d | 10e | 9ef | 27cd | 15d | 10c | 12 |
| 21 | 40cd | 13bc | 15d | 17b | 29cd | 14d | 10de | 30bc | 20c | 13b | 11 |
| 27 | 47bc | 14b | 19c | 21a | 34bc | 16c | 12cd | 33ab | 23bc | 16b | 17 |
| 33 | 53ab | 19ab | 23b | 23a | 40b | 21b | 14bc | 33ab | 26b | 19a | 11 |
| 39 | 57a | 24a | 28a | 23a | 47a | 24a | 16a | 35a | 30a | 19a | 9 |
| *LSD* | *9* | *5* | *2* | *3* | *7* | *3* | *3* | *5* | *3* | *3* | - |

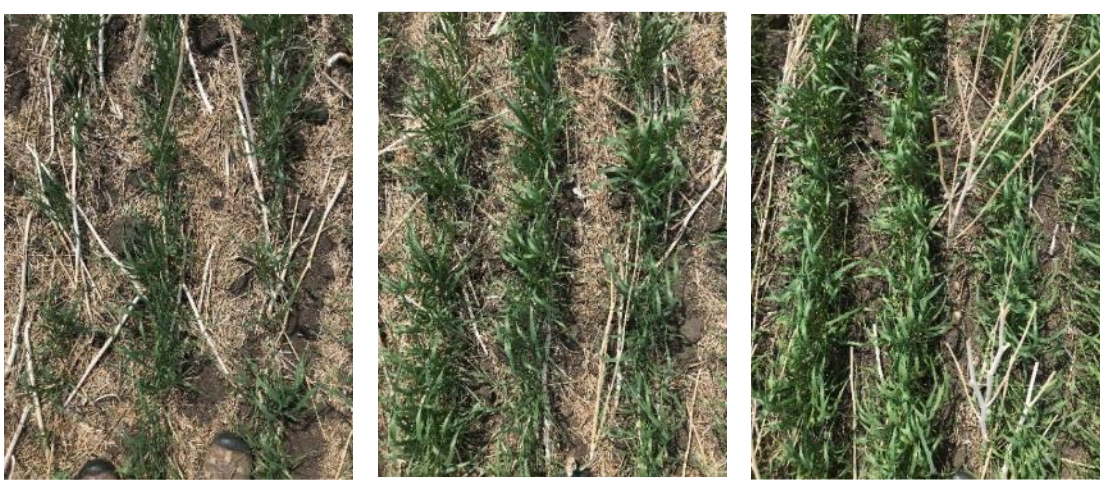

**Figure 28a**. AAC Brandon wheat planted at target plant stands of 9, 21, and 33 plants/ft$^2$ at Melita in 2021.

<u>Heading</u>

Cereals can compensate for lower plant populations by increasing tillering. Research in which spring wheat plants were given ample room found that stems per plant ranged from 19 to 44 depending on the variety (Wiersma 2014). While cereal cultivars have differing abilities to tiller, at the majority of sites there was no difference in heads per plant between cultivars (Table 28e). The actual number of spikes or panicles present at maturity depends on the number of tillers produced and the number that survive to maturity. The effect of drought stress on yield components depends on the timing of drought stress, and early season drought stress reduces yield potential through tiller death (Duggan et al. 2000). This is evident in the results from the Arborg location, where heads per plant were low across all crop types and treatments.

Heads per plant decreased as seeding rate increased, which demonstrates the ability of cereal crops to compensate for reduced plant populations by increasing tillering (Table 28e). There was no significant difference in heads per plant at target plant populations ranging from 21-39 plants/ft$^2$ at five out of the eight sites where there were significant differences in heads per plant.

**Table 28e.** Heads per plant for barley, oat, and wheat at the Arborg, Carberry, Melita, and Roblin locations. Barley varieties are CDC Austenson (A) and AAC Connect (B), oat varieties are CS Camden (A) and Summit (B), and wheat varieties are AAC Brandon (A) and Faller (B). Least significant difference (LSD) values are shown for sites where there is a significant difference (Pr<0.05) between treatments. At sites with significant differences between treatments, means within the same site year followed by the same letter within a column are not significantly different. Roblin wheat data is not shown due to high coefficients of variation.

| | **Barley** | | | **Oat** | | | **Wheat** | | |
|---|---|---|---|---|---|---|---|---|---|
| | Arborg | Carberry | Roblin | Arborg | Melita | Roblin | Arborg | Carberry | Melita |
| | ---------- Heads/plant ---------- | | | | | | | | |
| **Variety** | | | | | | | | | |
| A | 0.8 | 6.0 | 6.8 | 0.77 | 1.7b | 6.03 | 1.1 | 5.8 | 2.7 |
| B | 0.8 | 5.7 | 6.7 | 0.89 | 2.2a | 6.74 | 1.2 | 5.9 | 2.8 |
| *LSD* | - | - | - | - | *0.2* | - | - | - | - |
| **Target Plant Population (pl/ft$^2$)** | | | | | | | | | |
| 9 | 1.5a | 6.5ab | 10.2a | 1.2a | 3.2a | 7.8 | 1.8a | 6.7a | 4.3a |
| 15 | 0.9b | 6.8a | 7.9b | 0.7b | 2.2b | 6.7 | 1.3b | 5.9b | 3.1b |
| 21 | 0.7c | 5.1c | 7.2b | 0.8b | 1.8bc | 6.9 | 1.2b | 5.8b | 2.6bc |
| 27 | 0.6c | 5.5c | 5.7c | 0.9b | 1.7cd | 6.0 | 0.9c | 5.6b | 2.3c |
| 33 | 0.6c | 5.7bc | 4.5c | 0.8b | 1.4d | 5.8 | 0.9c | 5.5b | 2.0c |
| 39 | 0.5c | 5.3c | 4.9c | 0.7b | 1.4d | 5.1 | 0.8c | 5.8b | 2.2c |
| *LSD* | *0.2* | *0.9* | *1.4* | *0.3* | *0.4* | - | *0.3* | *0.8* | *0.7* |

Yield

*Wheat*

There were significant yield differences between the wheat varieties at the three locations where yields are reported, with AAC Brandon yielding significantly higher than Faller at two sites (Table 28f). Yields were generally low at Arborg and Carberry due to drought conditions, with Carberry yields being further reduced as a result of hail.

When averaged across cultivars, there were no differences in wheat yield across plant densities at Melita. At the Carberry location yields increased as plant stand increased, with the highest yields being reported at target plant densities of 27 to 39 plants/ft$^2$ (Table 28f, Figure 28b). At Arborg, the 9 plants/ft$^2$ treatment had the lowest yield overall, with 33 plants/ft$^2$ yielding the highest (Table 28f, Figure 28b). Actual plant populations ranged from 9 to 30 plants/ft2 at Carberry, 6 to 19 plants/ft2 at Melita, and 25-35 plants/ft2 at Arborg. Figure 28c shows yield plotted against plant stand, giving context to the results. There was no interaction between seeding rate and cultivar, both cultivars responded similarly to increased seeding rates (data not shown).

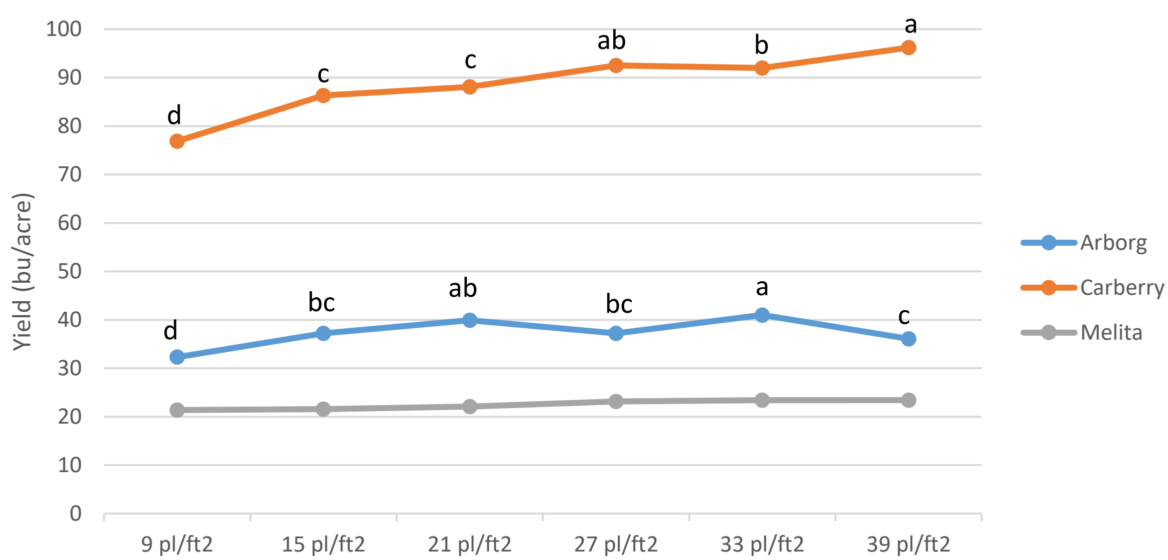


**Figure 28b.** Wheat yield (bu/acre) at six target plant densities at Arborg, Carberry and Melita. Statistically significant differences are shown by letters above the line. Treatments within the same site with the same letter are not significantly different (P<0.05).

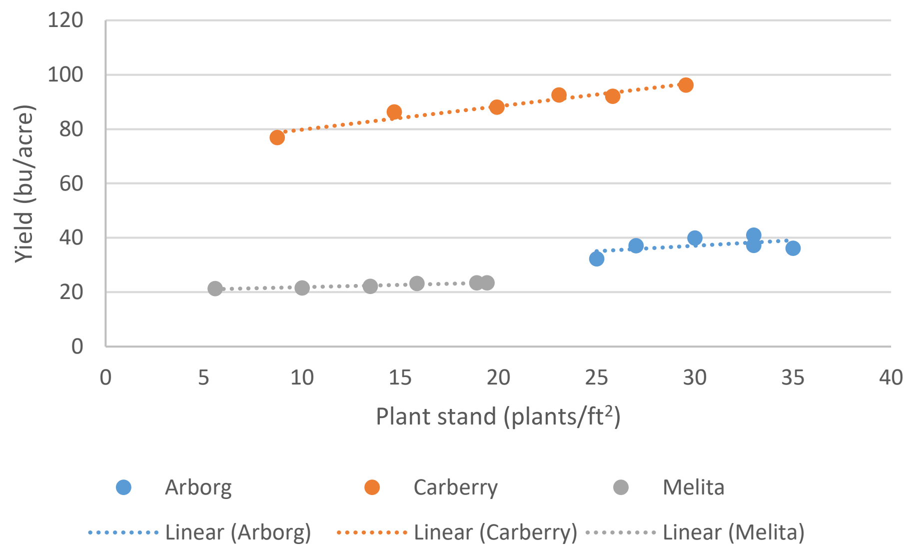


**Figure 28c.** Wheat yield (bu/acre) plotted against actual plant density (plants/$ft^2$) at Arborg, Carberry and Melita. Statistically significant differences for plant stand and yield can be found in Tables 4 and 6, respectively.

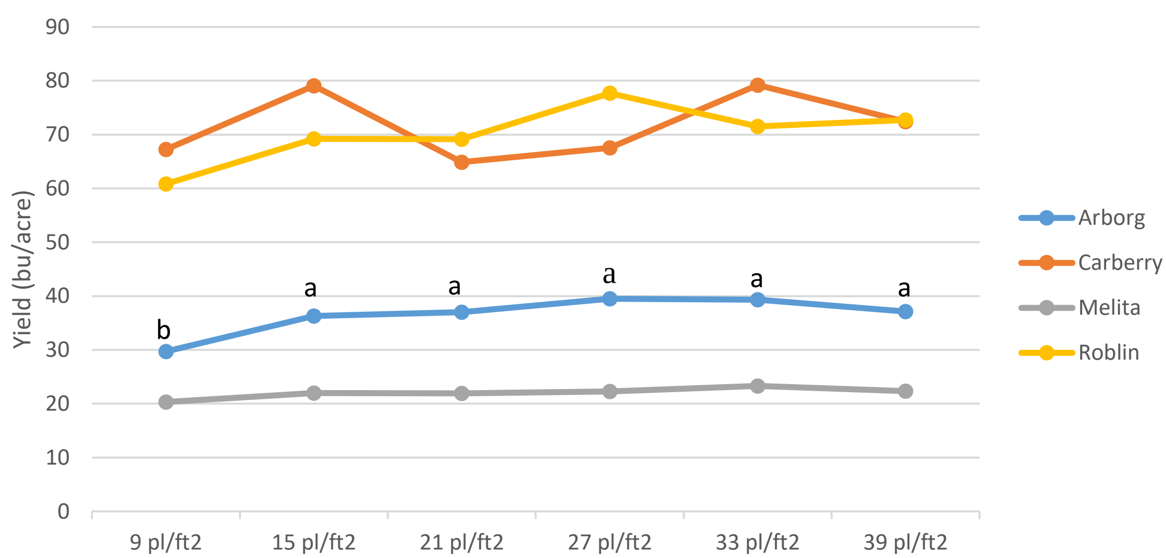


**Figure 28d.** Barley yield (bu/acre) at six target plant densities at Arborg, Carberry, Melita, and Roblin. Statistically significant differences are shown by letters above the line. Treatments within the same site with the same letter are not significantly different (P<0.05).

*Barley*

There were no significant yield differences between barley varieties at three of four locations. At Arborg, CDC Austenson yielded significantly higher than AAC Connect (Table 28f). When averaged across cultivars, there were no significant yield differences between target plant stands at three of the four locations. There were only significant yield differences between target plant densities at Arborg, with the 9 plants/ft$^2$ treatment yielding significantly lower than the higher target plant densities (Figure 28d and Table 28f). Actual plant populations ranged from 6 to 28 plants/ft$^2$ at Carberry, Melita, and Roblin, and 18 to 57 plants/ft$^2$ at Arborg (Table 28d). Figure 28e shows yield plotted against plant stand, giving context to the results and highlighting the higher plant populations at Arborg. There was no interaction between plant density and cultivar, both cultivars responded similarly to increased seeding rates (data not sown).

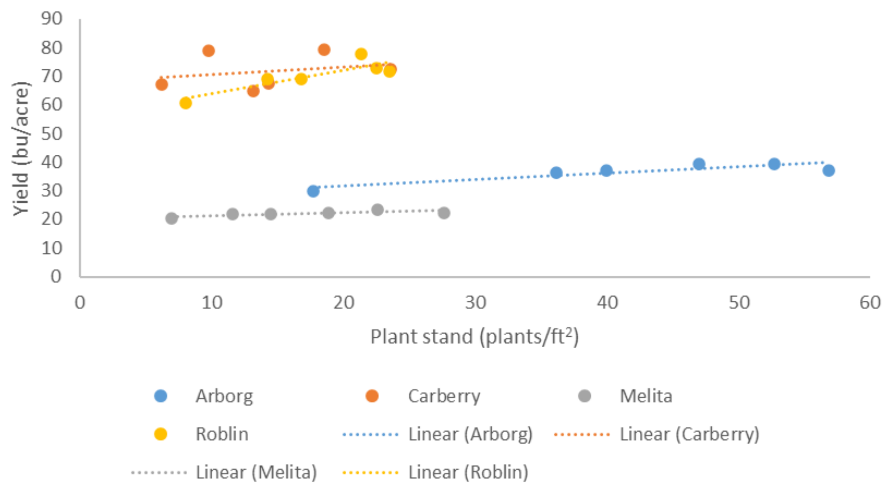


**Figure 28e.** Barley yield (bu/acre) plotted against actual plant density (plants/ft$^2$) at Arborg, Carberry Melita, and Roblin. Statistically significant differences for plant stand and yield can be found in Tables 33d and 33f, respectively.

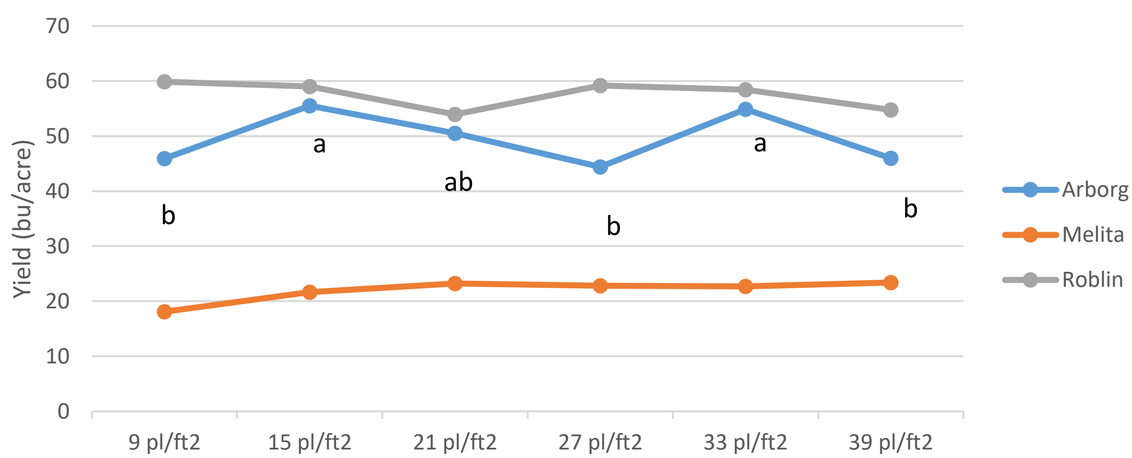


**Figure 28f.** Oat yield (bu/acre) at six target plant densities at Arborg, Melita, and Roblin. Statistically significant differences are shown by letters below the line. Treatments within the same site with the same letter are not significantly different (P<0.05).

*Oat*

There was a significant yield difference between the two oat varieties at two of the three locations, with CS Camden yielding higher than Summit in both cases (Table 28f). Averaged across cultivars, there was no difference in oat yield across the range of target plant densities at two of the three locations. There were significant yield differences across target plant densities at the Arborg location, but no consistent trend (Figure 28f). Oat yield plotted against plant stand is shown in Figure 28g. There was no interaction between plant density and cultivar, both cultivars responded similarly to increased seeding rates (data not shown).

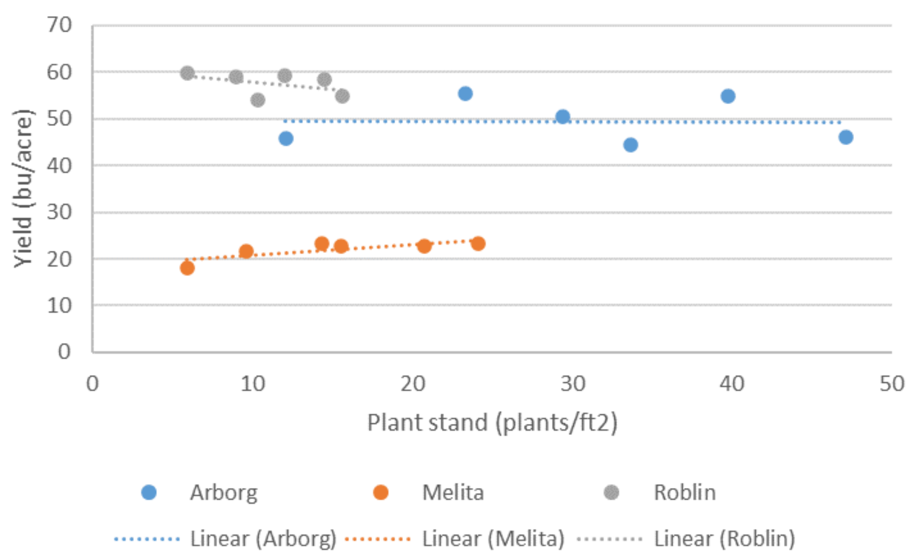


**Figure 28g.** Oat yield (bu/acre) plotted against actual plant density (plants/ft$^2$) at Arborg, Melita, and Roblin. Statistically significant differences for plant stand and yield can be found in Tables 4 and 6, respectively.

This study is a continuation of a research project that took place at Arborg, Carberry, Melita, and Roblin in 2017 and 2018. The oat and barley sites in 2017 and 2018 showed similar yields across a range of plant stands, indicating that the current recommended target plant populations for barley and oat are sufficient. At the wheat sites in 2017 and 2018 there was a general trend of higher yields with increased plant stands, but no significant difference in yields between target plant stands of 21 to 39 plants/ft$^2$ at four of the five sites.

The 2021 results are similar, in that there were no significant yield differences across the range of plant densities at most sites. There was a general trend of higher yields with higher plant stands at the wheat, barley, and one of the oat sites, although the data indicates that these trends should be taken with caution. There were no significant difference in yields between target plant stands of 21 to 39 plants/ft$^2$ at nine out of the 10 sites. At all sites, both varieties tested responded similarly to each target plant stand, indicating that similar seeding rate recommendations could be made for both varieties of each crop type studied.

**Table 28f.** Yield (bushels/acre) for barley, oat, and wheat at the Arborg, Carberry, Melita, and Roblin locations. Barley varieties are CDC Austenson (A) and AAC Connect (B), oat varieties are CS Camden (A) and Summit (B), and wheat varieties are AAC Brandon (A) and Faller (B). Least significant difference (LSD) values are shown for sites where there is a significant difference (Pr<0.05) between treatments. At sites with significant differences between treatments, means within the same site year followed by the same letter within a column are not significantly different.

| | **Barley** | | | | **Oat** | | | **Wheat** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Arborg | Carberry | Melita | Roblin | Arborg | Melita | Roblin | Arborg | Carberry | Melita |
| | Yield (bu/acre) | | | | | | | | | |
| **Variety** | | | | | | | | | | |
| A | 38.5a | 73.9 | 22.0 | 70.9 | 53.8a | 21.1 | 86.9a | 38.3a | 84.9b | 23.6a |
| B | 34.4b | 69.5 | 22.1 | 69.5 | 45.3b | 22.8 | 28.1b | 36.3b | 92.4a | 21.4b |
| *LSD* | *2.3* | - | - | - | *4.1* | - | *4* | *2.0* | *2.7* | *0.9* |
| **Target Plant Population (pl/ft$^2$)** | | | | | | | | | | |
| 9 | 29.7b | 67.2 | 20.3 | 60.8 | 45.9b | 18.1 | 59.9 | 32.3d | 76.9d | 21.4 |
| 15 | 36.3a | 79.1 | 22.0 | 69.2 | 55.5a | 21.6 | 59.0 | 37.2bc | 86.3c | 21.6 |
| 21 | 37.0a | 64.9 | 21.9 | 69.1 | 50.5ab | 23.2 | 53.9 | 39.9ab | 88.1bc | 22.1 |
| 27 | 39.5a | 67.5 | 22.3 | 77.7 | 44.4b | 22.8 | 59.2 | 37.2bc | 92.5ab | 23.2 |
| 33 | 39.3a | 79.2 | 23.3 | 71.5 | 54.9a | 22.7 | 58.4 | 41.0a | 92.0b | 23.4 |
| 39 | 37.1a | 72.4 | 22.4 | 72.7 | 46.0b | 23.4 | 54.8 | 36.1c | 96.2a | 23.4 |
| *LSD* | *4* | - | - | - | *7* | - | - | *3.5* | *4.7* | - |

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Wiersma, J. 2014. Optimum seeding rates for diverse HRSW varieties. 2014 Research Report. Northwest Research and Outreach Centre, NDSU, Crookston. Available online: https://smallgrains.org/wp-content/uploads/formidable/46/2014OptimumSeedingRateHRSWWiersma.pdf

## 29.0 Optimizing Nitrogen and Phosphorus Management for Dry Bean in Southwestern Manitoba

***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 optimized to the region. Particularly, 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 (NW 27-3-27) in 2021 on Alexander Loam soil. Black bean (Blackstrap) and pinto bean (Windbreaker) trials were separately arranged in randomized complete block design with twelve treatments replicated four times (Table 29a). Beans were seeded using a Seedhawk dual knife opener air seeder at 1.5-inch depth. 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. Volunteer canola was controlled by application of Viper (0.4 L ac$^{-1}$) mixed with 28% UAN (0.8 L ac$^{-1}$). Plots were desiccated using Reglone (0.65 L ac$^{-1}$), Roundup (0.5 L ac$^{-1}$), and LI700 surfactant (0.25%), and harvested ten days later. 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, vigour rating, greenness score, chlorophyll meter and NDVI readings, nodulation score, lodging ratings, plant height, grain yield, and grain moisture at harvest.

**Table 29a.** Treatments used in dry bean nitrogen and phosphorus trials established near Melita in 2021.

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

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

### *Phosphorus Trial*

A dry bean phosphorus rate trial was established adjacent to the nitrogen dry bean trials near Melita (NW 27-3-27). Black bean (Blackstrap) and pinto bean (Windbreaker) trials were separately arranged in randomized complete block design with eight treatments replicated four times (Table 29a). 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. Nitrogen was side-banded as urea at 3 lb $ac^{-1}$ actual nitrogen. Weed control and desiccation protocol was identical to that of the nitrogen trials. 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), vigour ratings, lodging ratings, plant height, grain yield, and grain moisture at harvest.

### *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, nitrogen trials produced visual differences among beans which received different amounts of nitrogen fertilizer (see photo). Dry beans which received more nitrogen were generally greener and exhibited greater vigour.

**Photo: Dry bean nitrogen trial established near Melita in 2021.**

### *References*

Manitoba Pulse and Soybean Growers. 2020. Dry bean acres in Manitoba https://www.manitobapulse.ca/2016/12/dry-bean-acres-in-manitoba/

Manitoba Pulse and Soybean growers. 2022. Dry bean production – Crop Nutrition. https://www.manitobapulse.ca/production/dry-bean-production/crop-nutrition/

## 30.0 Prairie Mountain Hops

**Collaborator:** Randy and Lyn Tye

Hops (*Humulus lupulus* L.) are viny plants that have flowering structures called cones (loosely termed the "hops" of the plant) which are used as a bittering and aroma flavor additive to beer and have been used for centuries as a natural preservative. The crop attracts many insect pests and diseases, thereby requiring effective integrated pest management in order to achieve high yield and quality. Knowledge of biology and environmental conditions in which hops thrive is essential for enacting effective pest management.

WADO continued their partnership with Prairie Mountain Hops (PMH) farm in 2021, providing advice on various management aspects including fertility management, pest management, scouting, and various other tasks. PMH is located several miles south of Boissevain, MB. It was established in 2017 with 2.5 acres of plants (approx. 2500 plants). In 2019, PMH increased its production area by more than 100% to 5.5 acres (5500 plants) and still plans to meet a target of 15 acres in the near future. The operation grows many different varieties of hops, many of which go on to be sold to Manitoba-based microbreweries. Hop production requires very high input costs, including labor and pesticide costs, but high returns following successful crop management are assured due to high market demands for locally-produced hops.

In 2021 the drought was of concern for the crop performance, despite irrigating from water sources that provide some relief, it was certainly a difficult year for all farmers. Little to no Powdery mildew disease was present in 2021 but the two-spotted spider mite did make an appearance in July.

Variety details and more information about the Prairie Mountain Hops operation can be found on the PMH website at: prairiemountainhops.ca

## 31.0 WADO Urban Orchard Establishment Demonstration

***Collaborators:*** Tim Gompf - West Souris River Conservation District, Town of Melita

In 2011, WADO committed to establishing an Urban Orchard in the town of Melita. The town council approved the project with a 10-year commitment as long as the land be maintained by WADO at all times to the council's satisfaction. The orchard is located between 55 Walter Thomas Drive and 49 Walter Thomas Drive.

WADO purchased three trees of multiple varieties of each haskap, saskatoon, and dwarf sour cherry from Prairie plant Systems in Saskatoon, SK. Trees were planted temporarily in 2011 and cared for by Scott Chalmers, then transplanted into plastic rows on town property in 2012. Drip line irrigation was installed and grass was planted between the trees.

Three trees of each of the following haskap, saskatoon, and dwarf sour cherry varieties were established:

| Haskap | Saskatoon | Dwarf Sour Cherry |
|---|---|---|
| ▪ Tundra | ▪ Martin | ▪ SK Carmine Jewel |
| ▪ Borealis | ▪ Thiessen | ▪ Romeo |
| ▪ Indigo Yum | ▪ Smoky | ▪ Juliet |
| ▪ Indigo Gem | ▪ JB30 | ▪ Cupid |
| ▪ Berry Blue | ▪ Honeywood | ▪ Valentine |
| | | ▪ Crimson Passion |

This location has several advantages for this project, including lot size, location in an undeveloped area, and it being clearly visible near a busy intersection. Additionally, a drainage ditch and a north shelter of trees is located on the site and acts as a protection of the orchard from the elements.

2021 was the first year that any major fruit production was noticed, with the cherries doing especially well this season. It was difficult to determine the extend of haskap berry production, as it was unclear whether berry growth was poor or if bushes experienced extensive bird damage. The saskatoon bushes haven't thrived at this location and were also subjected to extensive bird damage when fruit was produced. The orchard will remain at this location and WADO hopes to see continued fruit growth in going forward.

Photo: Orchard with (from left to right) Saskatoons, Haskap, and Cherry. Top photo: Cherry variety 'SK Carmine Jewel'

## 32.0 Buckwheat Rutin Production Field Scale Trial – Melita 2021

### *Establishment*

Seeding took place May 31st on the legal land location of NW 27-3-27W1 into spring wheat stubble using no-till methods. By this time risk of frost was past. A pre-seed burnoff using Roundup transorb (glyphosate 540 g a.i./L) applied at 0.5L/ac and Aim (carfentrazone 240 g/L) applied at 15 ml/ac as a tank mix with water applied at 10 imp. gallons per acre was sprayed to control weeds. Approximately three acres of 'Mancan' buckwheat was seeded using a Seedhawk dual knife drill. Seeding rate was targeted at 185 plants per meter. Given the low germination rate of the seed at 75%, thousand seed weight of 30.23 g, and an estimated mortality of 15%, seeding rate was determined to be 71.6 lbs/ac. Seed was placed 1.25" depth and fertilizer was sideband at a rate of 80N-30P-17K-9S-1.7 Zn lb/ac actual sourced from UAN and a granular blend of MAP, ammonium sulfate and zinc sulfate. Soil test results showed 34N, 9P, 477K, 120S, and 1.3Zn lbs/ac existing nutrients, therefore total nutrients (soil plus applied in lbs/ac) available to the crop was 114N, 39P, 494K, 129S, 3Zn.

An in-crop application of Arrow (clethodim) herbicide was applied at 125 ml/ac plus X-act adjuvant (0.75% v.v) at 10 gal/ac water volume on June 8th. The buckwheat appeared to be quite free of broadleaf weeds, including volunteer canola. Volunteer wheat seedlings were controlled with this herbicide application.

The crop was quick to emerge, with emergence occurring in less than several days and established rows present in two weeks.

### *Data Collection*

Prior to the cutting process, data was collected including emergence counts at the seedling stage and flower stage in the same locations over 9 random field locations. Other data included days to 50% flower and days to 100% flower, wet and dry biomass, and partitions of weights in regards to stem over, leaf and flowers, on those same respective locations. Biomass measurements will provide an understanding of the potential yield from flowers, leaves, and stems of the buckwheat plant.

| | Mean Plant Stand (plants $m^{-2}$) | | Flower Date | | Biomass (kg ) | | Total Dry Yield | Percent of Sample | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Seedling** | **Flower** | **50%** | **100%** | **Wet** | **Dry** | **Kg $ha^{-1}$** | **Leaf** | **Flowers** | **Stems** |
| **Mean** | 217 | 205 | 08-Jul | 12-Jul | 3.1 | 0.376 | 3756 | 42% | 2% | 55% |
| **St. Dev.** | 42 | 27 | 0 | 0 | 0.4 | 0.063 | 63 | 1% | 0.3% | 2% |

Emergence was 16% greater than the targeted rate of 185 plants $m^{-1}$. This was likely due to a lower rate of mortality than estimated. Interestingly, leaf material was 42% of the total dry weight biomass, whereas only 2% accounted for the flower material, the remaining 55% was stem material. A thick stand was present that competed well against weeds and produced ample leaf growth.

### *Seasonal Weather Data*

Seeding date to 50% flower stage (cutting time) was 42 days, and seeding date to harvest date was 66 days. In that time, 91 mm of rainfall accumulated to supplement the crop's needs, in addition to the fair moisture reserve prior to seeding, though these conditions were below the normal 30-year average. Approximately 622 growing degree days (GDD) was required from seeding until the cutting stage. Melita experienced above average temperatures compared to the 30-year normal. It is possible that two crops in one year would be easily achievable if the plant material could be removed from the field right after the first cut, with either seeding or regrowth to follow.

| Month | Precipitation (Actual mm) | 30-year Normal Precipitation (mm) | Average Temperature (°C) | 30-year Normal Average Temperature (°C) | Accumulated GGD | 30-Year Normal GGD (30 yr) |
|---|---|---|---|---|---|---|
| Apr | 4 | 29 | 4.0 | 5.3 | 33 | 24 |
| May | 28 | 53 | 10.5 | 11.9 | 180 | 205 |
| June | 87 | 101 | 19.2 | 16.8 | 426 | 351 |
| July | 35 | 69 | 21.8 | 19.6 | 522 | 453 |
| Aug | 125 | 78 | 18.7 | 18.9 | 426 | 415 |
| Sept | 13 | 35 | 15.8 | 12.9 | 323 | 211 |
| Oct | 37 | 30 | 8.2 | 5.1 | 124 | 40 |
| Total | 329 | 395 | - | - | 1877 | 1635 |

Weather source is the Melita Environment Canada station.

First fall frost was on October 16 at -1.6°C, nearly a month past the normal first frost date of Sept $18^{th}$ (50% risk).

### *Cutting Process*

The crop had grown on minimal but timely moisture. The crop had really not been under stress, but appeared somewhat wilted, with leaves leathery due to the heat of the day. The plants had been three days into flower, with perhaps another week to reach full flower potential, however lower leaves were showing signs of yellowing and senescence (see photos). Cutting of the buckwheat began on July 12 after 1:00 pm. That morning, WADO staff sampled several areas within the crop for biomass indexing. Three days before cutting, a ½" rain fell, followed by 0.5/10" the night before. Conditions on cutting day were arid, 28-30 $^{o}$C, and sunny with winds at 25km/hr gusting to 37 km/hr. The week following cutting was also hot and dry, with temperatures in the mid to high 30s.

Cutting was done using a HW300 New Holland 16' haybine. This haybine consists of a crop bar that leans the crop just prior to cutting, a spring finger reel for reaping over a standard knife for cutting. The crop auger diverts the buckwheat into the chevron style crimper (conditioner) with a gap set to 1/4" between two rollers, which kinks and cracks the stems but retains most of the leaves intact. Baffles divert the crop into a 4-foot-wide windrow for drying. The rpm speed of the engine was reduced, which in turn reduced the speed of the reel. We felt at normal rpm speeds the reel was shredding leaves of the stem and thus by reducing the speed, we reduced the shedding, keeping more leaves intact on the stem which in turn may lead to easier windrow pickup during the baling process. It was estimated to take 25 minutes to complete cutting over the given area (2.2 acres). Cutting height was about 6" above ground level. After seeding, rocks were rolled with a 16" diameter land roller filled with water. This rolling enabled lower cutting heights with the haybine and prevented potential damage to the knife.

Some leaves fell outside the windrow due to the vigorous shredding by the reel, but this was minimal. The majority of the leaves fell into the stems within the windrow. It is suspected that if raking is required to flip the windrow to assist with the drying process, some leaves will be lost to the ground. It was hoped with the hot, dry weather that the windrow will quickly dry without spoiling. Stems were rather succulent and were snapping in half during the conditioning process, few were actually being kinked and left intact. Perhaps if the crop was left longer, there would be more fibers in the stems to keep them intact. In addition, the flowering process was on the early side, and given the availability of soil moisture at the time, there could have been some more growth time available. However, with the bottom leaves senescing, it was deemed that the crop had reached it peak biomass point. It was estimated that, under the current drying conditions, the buckwheat would take several days to dry sufficiently. Handfuls of stems were "soaking wet" and there was risk of spoilage unless conditions assisted or windrow is raked (flipped).

**Seeding day. May 31st.**

**Complete emergence of rows. June 15th.**

**Cutting day. July 12th.**

**Crop height was ideal, shading of the ground competed with weeds and conserved moisture. July 12th. Approximately**

**Self Propelled Haybine. July 12th. Crop was easy to cut.**

**Many loose leaves on the windrow detached from stems.**

**Kinking of stems during the conditioning process.**

**Stems are very succulent. They break easily by the haybine conditioner. Stems appeared not to be greatly influenced by the conditioner in terms of improved condition for dry down.**

## *Raking*

Raking of buckwheat occurred soon after cutting to assist with the drying process due to the succulent nature of the buckwheat stems. Raking only takes a few minutes an acre to accomplish as this process goes quickly. Unfortunately, the crimper did not sufficiently compress stems to reduce drying time, and raking was required to let the windrow breath out moisture and prevent molding. Raking was done during warm and dry spells to enable quicker drying. Raking was accomplished using a standard 2-wheel rake on a 3-point hitch attachment. This raking method enabled the row to be flipped and agitated to assist with natural drying. The later raking events resulted in more leaf loss, with the most loss just before baling when three rows were raked into one (to assist the baler with pickup).

In hindsight, perhaps a different crimper system on the haybine would have crimped stems more effectively, resulting in better drying of the succulent plant. A somewhat smoother roller conditioner that wouldn't break stems may be more effective, though this may have to be a custom-built item. https://bdrollers.com/the-crusher-hay-conditioning-rollers-product-information/

In addition, perhaps using a mower-conditioner or discbine would have been more gentle on leaves during the cutting process, reducing leaf loss which occurred with the haybine reel.

Raking events:

July 14 & July 16 – Crop was drying on top but was fairly wet below, perhaps starting to create heat. Maybe 15% drier than when cut.

July 21 – Perhaps half of the stem moisture had evaporated. Leaves were dry, green-brown but somewhat leathery. Some slightly molding under the windrow.

July 27 – Windrow was turned again to further assist with drying.

August 5 – Three rows raked into one to help with baling pickup. Stems were dry and brown, brittle.

### *Baling*

Baling was accomplished August 5$^{th}$. Technically baling was possible July 30, but the farmer was not able to make it in time due to his son's wedding. An attempt was made August 4$^{th}$ but the farmer said he could not pickup the thin brittle swath effectively. Raking rows together was required in order to accumulate enough crop to be picked up effectively.

A Vermeer 605M baler was used pulled by a McCormick MTX135 T3 tractor. This baler is traditionally used for grass, alfalfa and greenfeed cereal crops, and makes a hardcore bale. It is able to use both traditional string or net wrap. Feeding of the buckwheat row was cumbersome as the pickup fingers ran vigorously upward, flinging material into the intake and against opposing bars that help direct material into the belt-roller system. The action of this process breaks and grinds the brittle buckwheat stems and leaf material, leading to significant losses on the ground.

Bale yield was terrible due to losses during both the pickup and bale making processes. In addition, as the bale was kicked out the back, losses occurred on the sides of the bale where there was no net wrap as buckwheat material was too small to hold together.

### *Final Conclusions*

1. The approach to cutting and baling of buckwheat in this manner needs revision.
2. Wider placement of windrow after crimping to assist with drying, rather than narrow row may be beneficial.
3. Raking leads to greater leaf loss the later in the operation it occurs.
4. Timing cutting later in plant development may allow for greater stem fibre development and lead to more sturdy stems for pickup and bale formation.
5. Choice of a less aggressive baler pickup system and/or reducing engine RPM of the PTO system may reduce breakage of stems when feeding into baler.
6. The net wrap system appeared to work well and would have been superior to traditional string wrap, however the vigorous action of the baling process reduced the length of straw thus reduced the lateral integrity of the bale.
7. We had abnormally warm and dry conditions after cutting, therefore normal years would have likely lead to moldy windrows and poor dry down.

### *Ideas and Recommendations*

1. Use of some sort of fresh harvest system, perhaps stripper header combined with some sort of press system which would produce a fresh juice and cake that could be further refined at a later time and place, may be beneficial.

2. Would ensiling buckwheat (piling wet in anaerobic conditions) preserve the rutin and quercetin content? This would allow piles to be stored and hauled over the fall and winter seasons, potentially helping pack the product better for shipping.
3. Smoother roller system to preserve stem length and increase stem crushing to better assist dry down. The current roller system cut the stems more than it crimped and kept stems intact. Another option after cutting is using a Pronovost Macertator 6620 (Agland Manufacturing, Quebec). https://pronovost.qc.ca/en/agricultural-products/macerator/macerator-6620 Not sure if any units exist in operation in Manitoba, despite it being originally invented and manufactured here in the early 90s. It was designed to reduce drying time in alfalfa and potentially improve feed value through better digestion. It acts with two round-etched rollers that move at slightly different speeds to slightly etch stems and process the material in a more delicate way. This is said to improve drying time according to a PAMI report. https://pami.ca/pdfs/reports_research_updates/(4e)%20Mowers%20and%20Mower-Conditioners/715.PDF
4. Use of Tartary buckwheat, which may have less succulent stems, leading to quicker drying time.
5. Higher seeding rates may produce thinner stems, resulting in faster drying time.
6. Potentially use a combine as a primary processor with swath pickup to field-process dry leaves from succulent stems (without running the cleaning fan in the combine). This may allow the stems to move over the sieve, separating stems from the leaf material which would fall. This may be very bulky and potentially cause plugging in the elevator and auger systems. A tow along convey and carry system may be needed to bypass the elevator system in the combine. With hemp, for example, green succulent stems are often fed into a combine to harvest the damp seed which is then put into bins with aeration.
7. There is a possibility that the plant could be cut multiple times in a season so as long as it is cut early enough, high enough, and soil moisture is present to allow for regrowth potential.
8. Perhaps the best recommendation would be that a new company called ChangeAg, a hemp CBD processor in Newton, MB (just east of Portage la Prairie), uses a stripper header mounted on a Claas forage harvester, that strips the leaves and collects them in bulk. Then, from my personal communication with a hemp industry expert, they compress the material into an airtight bale and freeze it for later processing. https://www.changeag.com/contact Perhaps they would be willing to be a partner in production, along with their producers. Here is a video from Youtube: https://www.youtube.com/watch?v=w7vosO86FD8

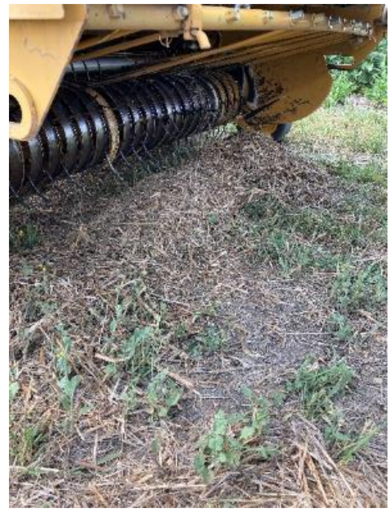
### *Photos of Raking and Baling Process*

**Moulding of the stems and leaves under the windrow despite dry windy weather. July 21. This occurred despite being raked twice prior.**

**Raking July 21**

**July 21. Raking flipped the windrow over to improve drying overall. Minimal leaf loss at this stage. Some stems still rather damp and green. Leaves have turned brown.**


Baling process August 5th.



Note the pickup fingers and the deflector bars above them. Combined they “chopped” the material during the baling process.

Some side spillage, but the net wrap worked well overall.

Plenty of material left in the field due to the baler over-processing the brittle material.

WADO

Westman Agricultural
Diversification Organization Inc.

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