WADO

Westman Agricultural Diversification Organization

# 2018 ANNUAL REPORT

## Contents

## 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 the Fed/Prov. Canada/Manitoba Diversification Centres (CMCDC) based in Carberry and Portage la Prairie. WADO owes its success to the excellent cooperation and participation we receive from the WADO 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 Growing Forward (GF) 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 to these organizations.

## 2018 Industry Partners

Agriculture and Agri-Food Canada
Avondale Seeds
Barkers Agri-Centre
BASE France
BASF
Canada MB Crop Diversification Centre
Canadian Agricultural Partnership
Canadian Hemp Trade Alliance
Canola Council of Canada
Composites Innovation Centre
Ducks Unlimited Canada
Flax Council of Canada
Gowan Agro Canada
Hemp Genetics International
Indian Head Research Foundation
La Coop Fédérée
Manitoba Agriculture
Manitoba Canola Growers Association
Manitoba Corn Growers Association
Manitoba Crop Variety Evaluation Team
Manitoba Pulse & Soybean Growers Assoc.
Monarch Homestead
Mustard 21
National Sunflower Association of Canada
NorQuin
Parkland Crop Diversification Foundation
Parkland Industrial Hemp Growers
Paterson Grain
Pepsico /Quaker
Phillex
Prairie Agricultural Machinery Institute
Prairie Mountain Hops
Prairies East Sustainable Ag Initiative
Reston School
Saskatchewan Canola Development Commission
Seed Manitoba
South East Research Farm
University of Alberta
University of Manitoba
University of Saskatchewan (CDC)
Western Feed Grains Development Cooperative

## 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 2018.

| Board member | Location |
|---|---|
| Gary Barker-Chairman | Melita |
| Brooks White | Pierson |
| Ryan Martens | Boissevain |
| Kevin Beernaert | Hartney |
| Kevin Routledge | Hamiota |
| John Finnie | Kenton |
| Allan McKenzie | Nesbitt |
| Patrick Johnson | Killarney |
| Neil Galbraith | Minnedosa |

**Southwest Manitoba Agriculture staff** members are also part of the WADO board: Lionel Kaskiw – Souris, Amir Farooq – Hamiota, as well as Scott Chalmers.

**Board Advisor**: Elmer Kaskiw – Shoal Lake

## Farmer Co-operators 2018 Trial Locations

Dwayne Swanson – Melita

Brooks White - Lyleton

Barker Farms - Elva

## WADO Staff

**Scott Chalmers** (P.Ag.) is the Diversification Specialist for Manitoba Agriculture 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.

**Justice Zhanda** (Agrologist in Training) joined Manitoba Agriculture from the University of Manitoba in 2018 as a Technician assigned to WADO. He is responsible for field operations, plot management and data collection.

Jessie Mayes from Pierson and Scott Boulton from Reston were summer students for 2018. Chantal Elliott remained with us through the winter to assist with sample analysis and equipment repairs and maintenance due to the absence of a Crop Technician. At the end of summer, Jessie returned to McGill University in Montreal to continue with her studies while Scott Boulton started his program at Assiniboine Community College in Brandon. Leanne Mayes is our full time Research Associate.

WADO Staff 2018 (left to right): Jessie Mayes, Justice Zhanda, Scott Boulton, Scott Chalmers, Leanne Mayes and Chantal Elliott

## Got An Idea?

The Westman Agricultural Diversification Organization continually looks for project ideas, value-added ideas, and producer production concerns. If you have any ideas, please forward them to:

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c/o Scott Chalmers Manitoba Agriculture
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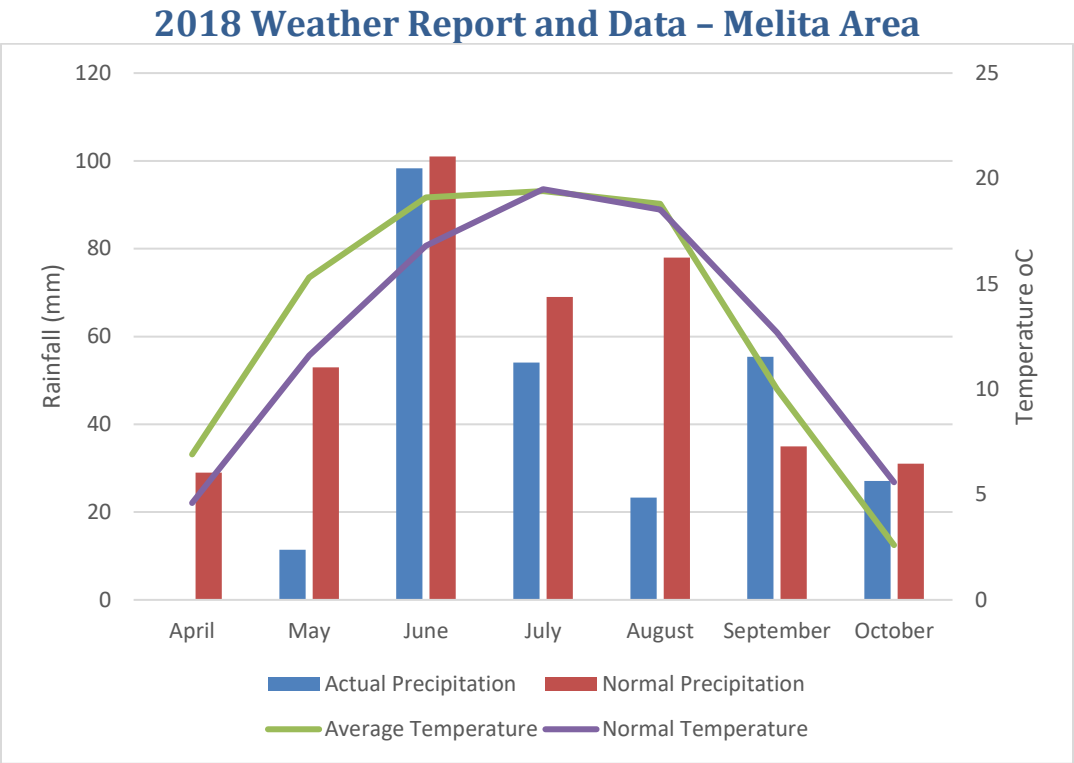


**Figure 1:** Monthly air temperature and precipitation report for Melita 2018 and normals based on 30-year averages from April to October

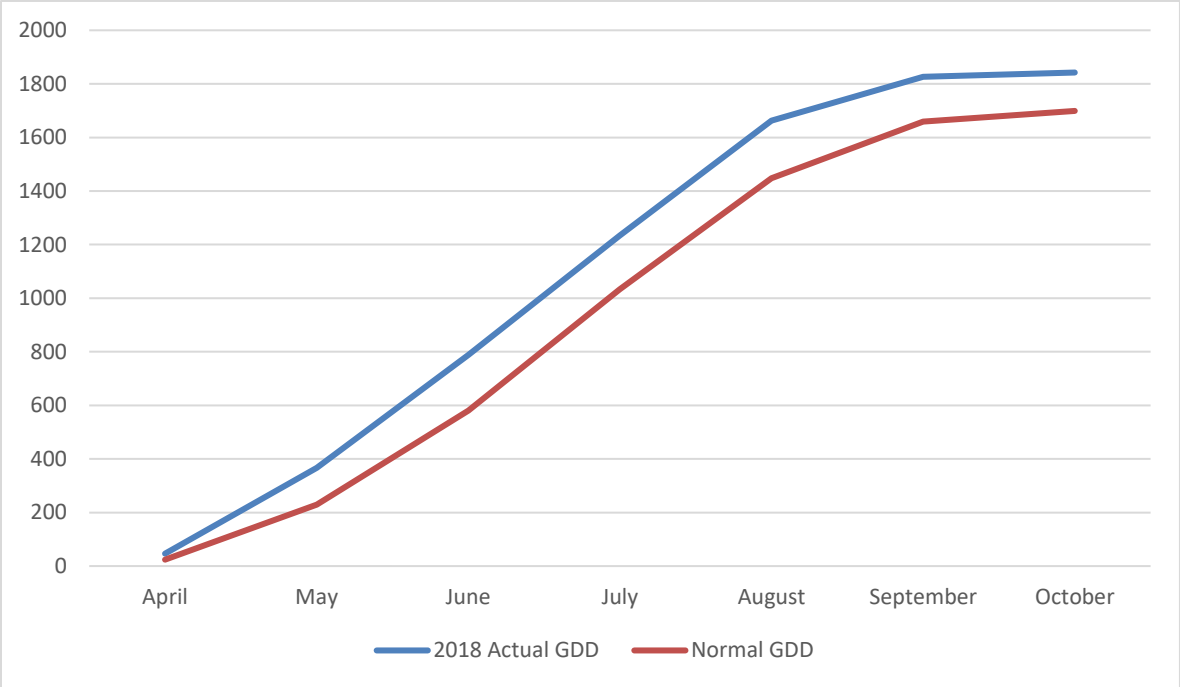


**Figure 2:** Monthly accumulated actual and normals (30-year average) CHU and GDD for Melita in 2018

**Table 1**: Melita 2018 Season Report by Month (normals based on 30-year average)

| Month | Precipitation (mm) | | Temperature °C | | Corn Heat Units | | Growing Degree Days (>5°C) | |
|---|---|---|---|---|---|---|---|---|
| | Actual | Normal | Average | Normal | Actual | Normal | Actual | Normal |
| April | 0.2 | 29 | 6.9 | 4.6 | 120 | 78 | 46.4 | 24 |
| May | 11.4 | 53 | 15.3 | 11.59 | 511.7 | 365 | 320 | 205 |
| June | 98.3 | 101 | 19.1 | 16.8 | 669.1 | 583 | 422.1 | 351 |
| July | 54.1 | 69 | 19.4 | 19.49 | 692.3 | 712 | 445.2 | 453 |
| August | 23.3 | 78 | 18.8 | 18.52 | 615.4 | 659 | 429 | 415 |
| September | 55.4 | 35 | 10 | 12.69 | 274.5 | 369 | 164 | 211 |
| October | 27.1 | 31 | 2.6 | 5.58 | 74.9 | 116 | 15.6 | 40 |

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

**Table 2:** Season summary April 15 – October 31, 2018

| | Actual | Normal | % of Normal |
|---|---|---|---|
| Number of Days | 200 | | |
| Growing Degree Days | 1842 | 1702 | 108 |
| Corn Heat Units | 2958 | 2880 | 103 |
| Total Precipitation (mm) | 269 | 390 | 69 |

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

Growing degree days (GDD) are calculated as follows:

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

Base temperature vary 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 minimum 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 crops like corn and beans that require heat for proper growth. The formula for CHU is illustrated below:

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

Where: 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 2018 Precipitation Map and the 2018 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

WADO attended Ag Days at The Keystone Center in Brandon, MB on January 22 – 24. Manitoba's Diversification Centres managed a booth showcasing new farming opportunities and possibilities. Over 45,000 people were in attendance.

This year Manitoba Pulse Growers Association hosted their annual SMART day with WADO's annual field day. On July 17 approximately 85 people joined us for lunch and tour of our main plot site NE of Melita. Our annual Field Day is the main way that WADO communicates its activities and we were encouraged to see the participation from producers, fellow researchers and industry partners. On July 18, the Southwest weed supervisors held their annual field bus tour and stopped by the plots as well, with 30 in attendance.

The main site showcased many of our variety trials including: wheat, oats, barley, soybeans, peas, narrow row beans, quinoa, flax, hemp, canola and *Brassica juncea*. Also at this site were several trials that were part of the University of Manitoba's research on soybeans and WADO's own research projects on intercropping pea-canola, flax-soybean, corn-hairy vetch and hemp relay with legumes. We would like to thank the Manitoba Pulse and Soybean Growers Association, WADO staff, Manitoba Agriculture employees and the guest speakers who made it all happen.


Scott Chalmers participated as a speaker at the following events:

- Crop Connect-Victoria Inn, Winnipeg MB, February 14-15, 2018; attendance 400
- BASE Speaking Tour – France: Maisonsel sur Brie, Angers, Quincieux, Feb 18-25, 2018; attendance 400
- WADO Annual Field Day – Melita MB, July 17, 2018; attendance 85
- Southwest Weed Supervisors Bus Tour – Melita MB, July 19, 2018; attendance 30
- MARA Pea-Canola Intercrop Field Tour - Roblin MB, July 27, 2018; attendance 23
- Intercropping Workshop– Keystone Center, Brandon MB, November 14, 2018. ; attendance 154
- Canadian Hemp Trade Alliance Annual Convention – Delta Hotel, Winnipeg MB Nov 21, 2018; attendance 100

## Understanding 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, split-split plot design 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 R-squared. 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).

R-squared is the coefficient of determination and is a value of how "sound" the data really is. In regression models such as ANOVA it is determined by a value that approaches the value of 1, which represents perfect data in a straight line. In most plot research, R-squared varies between 0.80 and 0.99 indicating good data.

Grand mean/mean of means 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 has been analyzed by statistical software from either Agrobase Gen II version 16.2.1, or Minitab 18 software. Coefficient of variation and least significant difference at the 0.05 level of significance was 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.

## 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 purpose the MCVET variety evaluations is to grow of 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 created, combined, and summarized in the "Seed Manitoba" guide. Hard copies can be found at most MAFRI 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 3 summarizes the WADO grown MCVET trial 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.

**Table 3:** Agronomy practices for selected MCVET crops in 2018. Yield data is published in the Seed Manitoba Guide.

| Crop | Stubble | Pre-Emergent Burnoff (rate per ac) | Soil Moisture | Seed Date | Seed Depth | Fertility Applied (lbs/ac) | Chemistry (per ac) | Harvest Date |
|---|---|---|---|---|---|---|---|---|
| Winter Wheat | LL Canola | Roundup 0.75 L, Heat 15 g | Excellent | 13-Sep-17 | 0.5" | 120-40-0-0 | Mextrol 0.3L, Achieve 0.2L, Mextrol 0.5L, turbocharge 1% | 07-Aug |
| Winter Rye | LL Canola | Roundup 0.75 L, Heat 15 g | Excellent | 13-Sep-17 | 0.5" | 120-40-0-0 | Mextrol 0.3L, Achieve 0.2L, Mextrol 0.5L, turbocharge 1% | 07-Aug |
| Barley | RR Soybean | None | Good | 02-May-18 | 0.75" | 115-35-24-9 | Achieve 0.2L, Mextrol 0.5L | 07-Aug |
| Spring Wheat | RR Soybean | None | Good | 02-May-18 | 0.75" | 115-35-24-9 | Achieve 0.2L, Mextrol 0.5L | 14-Aug |
| Durum | RR Soybean | None | Good | 03-May-18 | 0.75" | 115-35-24-9 | Achieve 0.2L, Mextrol 0.5L | 13-Aug |
| Oat | RR Soybean | None | Good | 02-May-18 | 0.75" | 115-35-24-9 | Mextrol 0.5L | 08-Aug |
| Pea | RR Soybean | Roundup 0.75 L | Good | 01-May-18 | 1.5" | 15-35-24-9; Granular Nodulator | Assure II 0.2L w/ Merge 1%, Odyessey 17.3g, Merge 0.5% | 07-Aug |
| Lentil | RR Soybean | Roundup 0.75 L | Good | 08-May-18 | 1" | 15-35-24-9; Granular Nodulator | Assure II 0.2L w/ Merge 1%, Arrow 0.15L, Xact 0.5% | 09-Aug |
| RR Soybean | RR Soybean | Roundup 0.75 L | fair | 10-May-18 | 1.5" | 15-35-24-9; Granular Nodulator | Roundup 0.67L x 2 applications | 28-Sep |
| Conventional Soybean | RR Soybean | Roundup 0.75 L | fair | 10-May-18 | 1.5" | 15-35-24-9; Granular Nodulator | Sulfentrazone 0.1L , Roundup 0.75L, Arrow 0.15L, Xact; 0.5%, Basagran 0.9L, Arrow 0.15L+Xact 0.5% | 27-Sep |
| Narrow Row Bean | RR Soybean | Roundup 0.75 L | Poor | 23-May-18 | 1.5" | 89-35-24-9 | Basagran 0.9L + Arrow 0.15L, Xact 0.5%v/v | 30-Aug |
| Sunflower | RR Corn, Vetch | Sulfentrazone 0.1L | Poor | 16-May-18 | 2" | 125-48-31-16 | Pounce 0.158L, Roundup 0.5L; Muster 8g, Assure II 0.3L, Suremix 0.5%v/v; Assert 0.54L+pH adj. 25 g/2 gal, Muster 12g + Superspreader 0.2%v/v | 22-Oct |

# Winter annual control through alternative pre- and post-seed herbicide weed management

**Project duration**: 2014-2017

**Collaborators**: Linda M. Hall- Agriculture and Agri-Food Canada

### *Objectives*

To develop recommendations for new herbicide products and mixtures for winter annual weeds.

In this project, we examined crop tolerance and weed control with several pre-emergent and residual soil applied herbicides (group 14 and 15) and compared in-crop herbicides for efficacy and yield response of winter wheat.

### *Materials and Methods*

We conducted two experiments to test the effectiveness of pre-emergent soil applied and foliar herbicides in 2014 at Lethbridge, in 2015 at Edmonton, St. Albert, Melita and Lethbridge and in 2016 in Melita totalling 6 site years. Limited data from the 2016 sites at Melita were collected due to salinity effects on spring growth and seed yield. Peas (cv. Thunderbird yellow peas or a locally adapted variety) were seeded at 85 seeds $m^{-2}$ following a pre-seed weed control with glyphosate. No in-crop weed control was used. Peas were harvested when mature, keeping a stubble height of 10 cm or greater.

Winter wheat (cv. Flourish) seed was treated with Raxil MD fungicide at 300 ml 100 $kg^{-1}$ seed, and with Stress Shield insecticide at 40 ml 100 $kg^{-1}$ seed. It was sown at 450 seeds $m^{-2}$ on the optimal September seeding date using no-till seeders with 20-23 cm row spacing. Seeding depth was 2-3 cm under good conditions or as deep as 5 cm if soil was dry. The N was banded 3-5 cm to the side and 3-5 cm below the seed during the seeding operation. Phosphate was placed in-furrow with the seed at the time of seeding at 30 kg $ha^{-1}$. Fungicides and insecticides were applied as necessary.

All herbicides were applied at 100 L $ha^{-1}$ water, using a backpack sprayer with low-drift nozzles (Melita), 3-point hitch R&D sprayer with flat fan nozzles (Edmonton), or bicycle sprayer with flat fan nozzles (Lethbridge). Pre-plant herbicides were applied no earlier than 2 days prior to seeding. For trial 2.1.2: In-crop herbicides were applied in the fall at 3-4 leaf stage or in the spring prior at stem elongation (Table 2).

### *2.1.1 Testing the effectiveness of pre-emergent soil applied herbicides*

Herbicide treatments are detailed in Table 1. Experimental design was a split plot design with 4 replications (12 treatments): main plot: pre-seeding tank mix partner, sub-plot: pyroxasulfone rate.

**Table 1: Herbicide treatments 2.1.1**

| Herbicide | Trade name | Formulation concentration | Application timing | Rate (g ai $ha^{-1}$) |
|---|---|---|---|---|
| Untreated control | n/a | n/a | Pre-plant | n/a |
| Untreated control | n/a | n/a | Pre-plant | n/a |
| pyroxasulfone | F6180 | 85% WG | Pre-plant | 100 |
| pyroxasulfone | F6180 | 85% WG | Pre-plant | 150 |
| pyroxasulfone + carfentrazone + glyphosate | F6180 + Aim + Credit | 85% WG + 240g $L^{-1}$ + 356g $L^{-1}$ | Pre-plant | 100 + 9 + 440 |
| pyroxasulfone + carfentrazone+ glyphosate | F6180 + Aim + Credit | 85% WG + 240g $L^{-1}$ + 356g $L^{-1}$ | Pre-plant | 150 + 9 + 440 |
| pyroxasulfone + glyphosate | F6180 + Roundup | 85% WG + 540g $L^{-1}$ | Pre-plant | 100 + 440 |
| pyroxasulfone + glyphosate | F6180 + Roundup | 85% WG + 540g $L^{-1}$ | Pre-plant | 150 + 440 |
| pyroxasulfone + flumioxazin | F6180 + Valterra | 85% WG + 51% WG | Pre-plant | 100 + 107 |
| pyroxasulfone + flumioxazin | F6180 + Valterra | 85% WG + 51% WG | Pre-plant | 150 + 107 |
| pyroxasulfone + saflufenacil + glyphosate | F6180 + Heat | 85% WG + 70% WG + 540g $L^{-1}$ | Pre-plant | 100 + 50 + 440 |
| pyroxasulfone + saflufenacil + glyphosate | F6180 + Heat | 85% WG + 70% WG + 540g $L^{-1}$ | Pre-plant | 150 + 50 + 440 |

### *2.1.2 Testing the effectiveness of herbicides applied in-crop in winter wheat*

Herbicide treatments are detailed in Table 2. Experimental design was a randomized complete block design with four treatments and 4 replications.

**Table 2: Herbicide treatments 2.1.2**

| Herbicide | Trade name | Formulation concentration | Application timing | Rate (g ai $ha^{-1}$) |
|---|---|---|---|---|
| Untreated control | n/a | n/a | n/a | n/a |
| Florasulam + MCPA ester | Frontline XL | 4g $L^{-1}$ + 280g $L^{-1}$ | 3-4L in fall | 355 |
| Halauxifen-methyl/florasulam + pyroxsulam + MCPA ester | Paradigm + Simplicity + MPCA ester | 400g $kg^{-1}$ + 30g $L^{-1}$ + 500g $L^{-1}$ | Spring; tillering | 10 + 15 + 280 |
| Halauxifen-methyl/fluroxypyr + MCPA ester | Pixxaro A + Pixxarro B | 266.25g $L^{-1}$ + 600g $L^{-1}$ | Spring; tillering | 82 + 350 |
| Pyrasulfatole + bromoxynil | Infinity | 247.5g $L^{-1}$ | Spring; tillering | 202 |
| Thifensulfuron/ tribenuron + MCPA ester | Refine + MCPA ester | 50% SG + 600g $L^{-1}$ | Spring; tillering | 15 + 280 |

### *Data Collection*

Similar assessments were conducted for 2.1.1 and 2.1.2. Visual crop tolerance and herbicide efficacy assessments were conducted 1 and 2 weeks after application and in early spring 2 weeks after recommencement of growth. In-crop treatments: 1 and 2 weeks after spraying. Crop stand density was assessed at 2 and 4 weeks after fall emergence and in early spring by counting winter wheat plants in 50 cm lengths of rows 2 and 3, 2 m from the front of the plots, and from rows 4 and 5, 2 meters from the rear of the plots. At anthesis, crop and weed biomass in the same marked rows was measured by clipping plants at a 2 cm height. Crop yield was assessed by whole plot harvest using a Wintersteiger combine. Seed was dried uniformly, and then weighed.

### *Results, discussion and conclusions*

All sites were successfully grown, with the exception of the 2016 Melita site which was affected by salinity after overwintering, limiting usage of the data.

### *2.1.1 Testing the effectiveness of pre-emergent soil applied herbicides*

Weed control assessed visually in the spring following application was variable between sites, probably because of edaphic and climatic factors. As previously stated, soil active pre-emergent herbicides are subject to significant influence of soil organic matter (Group 15 pyroxasulfone) and soil moisture (Group 14 products) for activity.

Weed control was difficult to assess visually at most locations due to a lack of weeds at the time of application (Table A). The following spring, saflufenacil + glyphosate, applied with low and high rates of pyroxasulfone, provided the highest % of weed control (rated visually), averaging 96%. Other treatments ranged from 42 to 86% control. On average, treatments that included the higher rate of pyroxasulfone had 17% better weed control in the spring than the lower rate.

Weed biomass at winter wheat anthesis was reduced by some pre-seeding herbicide treatments. It was most reduced by saflufenacil + glyphosate treatments, which were 72% and 73% lower with low/high pyroxasulfone rates than the unsprayed checks (Table B). As the pyroxasulfone rate was increased from low to high, the weed biomass was decreased an average of 31% when averaged over all treatments, averaged across all sites.

Crop survival between fall and spring varied by location: 2015/16 St. Albert (65%), 2015/16 Edmonton (87%), 2015/16 Melita (93%), and 2016/17 Melita (47%). Survival of the herbicide treated plots averaged 6% lower than the unsprayed checks at the above 4 locations (data not shown). No visual winter wheat crop injury was evident at any sites or timings (data not shown). The winter wheat density 4 WAA of treated plots entering the winter was similar to or slightly lower than the unsprayed checks (92-103%) (Table C). Treatments containing the high rate of pyroxasulfone averaged 5% lower crop density 4WAA than the low rate.

Spring crop densities were highest in the unsprayed plots (Table D). Carfentrazone + glyphosate at low/high pyroxasulfone rates averaged 95 and 96% of the checks, while crop densities were lowest in the saflufenacil + glyphosate treatment with a high pyroxasulfone rate (86%). As the pyroxasulfone rate in herbicide mixtures increased, the spring crop density was not affected when averaged over all treatments.

Winter wheat biomass, sampled at anthesis, was increased somewhat by herbicide treatments (Table E). Carfentrazone + glyphosate, applied with pyroxasulfone at low and high rates, increased crop biomass by 13 and 9%, more than other treatments. All treatments had crop biomass greater than or similar to the checks. On average, the higher rate of pyroxasulfone in tank mixtures did not affect winter wheat biomass more than the lower rate.

Winter wheat seed yields increased 5-13% by herbicide treatments (Table F) averaged across all sites. Carfentrazone+ glyphosate, in combination with pyroxasulfone resulted in the highest seed yields. As

the pyroxasulfone rate was increased from the low to high rate in herbicide tank mixes, the yield was not affected when averaged over all treatments.

While there was some evidence of residual effects on winter wheat emergence and winter survival, better weed control by residual herbicides resulted in lower weed biomass, high crop biomass and increased yield.

### *2.1.2 Testing the effectiveness of herbicides applied in-crop in winter wheat*

#### *In-crop 2.1.2 Results*

Weed control was difficult to assess visually at most locations due to a lack of weeds at the time of application (data not shown). It should be noted that there were two different times of application: Frontline XL, applied in the fall at the 3-4 leaf stage, and all others applied in the spring at winter wheat tillering stage.

Weed control assessed 2 weeks after the spring application ranged from 75% (Refine SG, MCPA ester) to 95% (Frontline XL fall application) (Table G).

Weed biomass levels were low, averaging only 0.2% to 4% of the crop biomass (Tables H, I). Weed biomass reductions by herbicide at crop anthesis ranged from 60% (Infinity) to 95% (Paradigm, Simplicity, MCPA ester), compared to the unsprayed check (Table H). Weed control at Lethbridge was not as effective as other sites.

Fall application of Frontline XL did not significantly affect spring survival, with crop densities 2% higher than the untreated checks (Table J). Crop tolerance 2 weeks after the spring application was excellent (Table K).

Crop biomass was marginally improved 2-5% by the herbicide treatments (Table L). The low weed densities, even in the unsprayed checks, were responsible for the minor impact of weed competition affecting the crop. At maturity, herbicide treatments averaged 100% to 108% of the check's seed yields. The Paradigm, Simplicity, MCPA ester tank mix had the highest seed yields (Table M).

Table A. Effect of preseeding herbicide mixtures with varying rates of pyroxasulfone on weed control the following spring after application.

| Treatment | Pyroxa-sulfone gai ha$^{-1}$ | 2014/15 Lethbridge % | SE | 2015/16 St. Albert % | SE | 2015/16 Edmonton % | SE | mean % | SE |
|---|---|---|---|---|---|---|---|---|---|
| Unsprayed | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unsprayed | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pyroxasulfone | 100 | 29 | 15 | 71 | 7 | 28 | 14 | 42 | 9 |
| Pyroxasulfone | 150 | 67 | 8 | 78 | 10 | 84 | 4 | 76 | 4 |
| Carfentrazone + Glyphosate | 100 | 82 | 9 | 78 | 10 | 89 | 5 | 83 | 4 |
| Carfentrazone + Glyphosate | 150 | 87 | 11 | 89 | 2 | 83 | 4 | 86 | 4 |
| Glyphosate | 100 | 72 | 12 | 79 | 7 | 66 | 22 | 72 | 8 |
| Glyphosate | 150 | 85 | 8 | 73 | 8 | 81 | 5 | 79 | 4 |
| Flumioxazin | 100 | 56 | 24 | 64 | 21 | 82 | 11 | 68 | 10 |
| Flumioxazin | 150 | 74 | 4 | 81 | 7 | 96 | 1 | 84 | 4 |
| Saflufenacil + Glyphosate | 100 | 97 | 2 | 95 | 2 | 98 | 1 | 96 | 1 |
| Saflufenacil + Glyphosate | 150 | 96 | 2 | 97 | 1 | 97 | 2 | 96 | 1 |

Table B. Effect of preseeding herbicide mixtures with varying rates of pyroxasulfone on dry weed biomass at crop anthesis.

| Treatment | Pyroxa-sulfone gai ha$^{-1}$ | 2014/15 Lethbridge g m$^{-2}$ | SE | 2015/16 St. Albert g m$^{-2}$ | SE | 2015/16 Edmonton g m$^{-2}$ | SE | 2015/16 Melita g m$^{-2}$ | SE | 2015/16 Lethbridge g m$^{-2}$ | SE | mean g m$^{-2}$ | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unsprayed | 0 | 98 | 43 | 79 | 53 | 50 | 20 | 11 | 4 | 204 | 72 | 88 | 23 |
| Unsprayed | 0 | 67 | 27 | 31 | 17 | 66 | 23 | 19 | 11 | 95 | 17 | 55 | 10 |
| Pyroxasulfone | 100 | 59 | 25 | 49 | 29 | 48 | 26 | 5 | 2 | 135 | 81 | 59 | 19 |
| Pyroxasulfone | 150 | 18 | 6 | 32 | 15 | 11 | 6 | 7 | 4 | 138 | 48 | 41 | 15 |
| Carfentrazone + Glyphosate | 100 | 19 | 12 | 95 | 73 | 0 | 0 | 0 | 0 | 124 | 49 | 48 | 20 |
| Carfentrazone + Glyphosate | 150 | 9 | 7 | 15 | 9 | 9 | 5 | 1 | 1 | 95 | 56 | 25 | 13 |
| Glyphosate | 100 | 24 | 8 | 4 | 3 | 3 | 2 | 0 | 0 | 138 | 52 | 34 | 15 |
| Glyphosate | 150 | 19 | 9 | 17 | 9 | 16 | 10 | 1 | 0 | 95 | 42 | 29 | 11 |
| Flumioxazin | 100 | 24 | 13 | 0 | 0 | 0 | 0 | 3 | 2 | 202 | 107 | 47 | 28 |
| Flumioxazin | 150 | 14 | 5 | 2 | 2 | 0 | 0 | 14 | 9 | 114 | 77 | 30 | 18 |
| Saflufenacil + Glyphosate | 100 | 4 | 2 | 12 | 12 | 0 | 0 | 0 | 0 | 84 | 25 | 20 | 9 |
| Saflufenacil + Glyphosate | 150 | 6 | 5 | 3 | 2 | 0 | 0 | 2 | 2 | 83 | 48 | 19 | 11 |

Table C. Effect of preseeding herbicide mixtures with varying rates of pyroxasulfone on winter wheat 4 WAA crop density.

| Treatment | Pyroxa-sulfone gai ha$^{-1}$ | 2015/16 St. Albert g m$^{-2}$ | SE | 2015/16 Edmonton g m$^{-2}$ | SE | 2015/16 Melita g m$^{-2}$ | SE | 2016/17 Melita g m$^{-2}$ | SE | mean g m$^{-2}$ | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Unsprayed | 0 | 202 | 29 | 232 | 30 | 220 | 10 | 232 | 10 | 222 | 10 |
| Unsprayed | 0 | 224 | 10 | 221 | 20 | 228 | 9 | 237 | 8 | 228 | 6 |
| Pyroxasulfone | 100 | 219 | 14 | 231 | 11 | 235 | 5 | 226 | 6 | 228 | 5 |
| Pyroxasulfone | 150 | 211 | 15 | 243 | 15 | 242 | 8 | 202 | 11 | 224 | 7 |
| Carfentrazone + Glyphosate | 100 | 221 | 11 | 234 | 18 | 252 | 7 | 222 | 9 | 232 | 6 |
| Carfentrazone + Glyphosate | 150 | 201 | 3 | 211 | 26 | 244 | 6 | 192 | 10 | 212 | 8 |
| Glyphosate | 100 | 216 | 9 | 215 | 14 | 243 | 5 | 212 | 12 | 222 | 6 |
| Glyphosate | 150 | 186 | 15 | 224 | 7 | 226 | 6 | 192 | 24 | 207 | 8 |
| Flumioxazin | 100 | 196 | 23 | 241 | 28 | 243 | 14 | 193 | 9 | 218 | 11 |
| Flumioxazin | 150 | 213 | 15 | 232 | 19 | 234 | 14 | 183 | 13 | 215 | 9 |
| Saflufenacil + Glyphosate | 100 | 232 | 7 | 213 | 17 | 226 | 4 | 221 | 19 | 223 | 6 |
| Saflufenacil + Glyphosate | 150 | 179 | 14 | 253 | 25 | 232 | 7 | 190 | 26 | 214 | 12 |

Table D. Effect of preseeding herbicide mixtures with varying rates of pyroxasulfone on winter wheat spring crop density.

| Treatment | Pyroxa-sulfone | 2014/15 Lethbridge | | 2015/16 St. Albert | | 2015/16 Edmonton | | 2015/16 Melita | | 2015/16 Lethbridge | | 2016/17 Melita | | mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | gai ha$^{-1}$ | pl m$^{-2}$ | SE | pl m$^{-2}$ | SE | pl m$^{-2}$ | SE | pl m$^{-2}$ | SE | pl m$^{-2}$ | SE | pl m$^{-2}$ | SE | pl m$^{-2}$ | SE |
| Unsprayed | 0 | 432 | 31 | 151 | 25 | 193 | 11 | 209 | 5 | 192 | 21 | 135 | 30 | 219 | 22 |
| Unsprayed | 0 | 376 | 16 | 144 | 14 | 198 | 9 | 226 | 8 | 201 | 22 | 152 | 10 | 216 | 17 |
| Pyroxasulfone | 100 | 364 | 36 | 141 | 9 | 223 | 21 | 218 | 14 | 168 | 7 | 95 | 14 | 201 | 19 |
| Pyroxasulfone | 150 | 400 | 34 | 126 | 23 | 194 | 7 | 225 | 10 | 183 | 12 | 82 | 13 | 202 | 22 |
| Carfentrazone + Glyphosate | 100 | 364 | 44 | 153 | 17 | 220 | 13 | 224 | 14 | 210 | 7 | 64 | 16 | 206 | 20 |
| Carfentrazone + Glyphosate | 150 | 367 | 22 | 152 | 13 | 201 | 3 | 223 | 10 | 196 | 18 | 106 | 18 | 208 | 18 |
| Glyphosate | 100 | 364 | 23 | 127 | 6 | 194 | 17 | 223 | 8 | 199 | 19 | 96 | 12 | 201 | 19 |
| Glyphosate | 150 | 389 | 27 | 99 | 9 | 191 | 15 | 211 | 6 | 221 | 7 | 87 | 13 | 200 | 21 |
| Flumioxazin | 100 | 352 | 30 | 136 | 29 | 183 | 9 | 220 | 5 | 202 | 8 | 95 | 25 | 198 | 18 |
| Flumioxazin | 150 | 337 | 41 | 150 | 19 | 197 | 12 | 217 | 7 | 194 | 18 | 76 | 18 | 195 | 18 |
| Saflufenacil + Glyphosate | 100 | 391 | 36 | 143 | 11 | 206 | 17 | 212 | 11 | 201 | 8 | 120 | 27 | 212 | 20 |
| Saflufenacil + Glyphosate | 150 | 365 | 18 | 105 | 9 | 193 | 21 | 220 | 5 | 168 | 11 | 76 | 24 | 188 | 20 |

Table E. Effect of preseeding herbicide mixtures with varying rates of pyroxasulfone on dry winter wheat biomass at anthesis.

| Treatment | Pyroxa-sulfone | 2014/15 Lethbridge | | 2015/16 St. Albert | | 2015/16 Edmonton | | 2015/16 Melita | | 2015/16 Lethbridge | | mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | gai ha$^{-1}$ | g m$^{-2}$ | SE | g m$^{-2}$ | SE | g m$^{-2}$ | SE | g m$^{-2}$ | SE | g m$^{-2}$ | SE | g m$^{-2}$ | SE |
| Unsprayed | 0 | 1,678 | 24 | 659 | 93 | 732 | 15 | 1,964 | 95 | 1,236 | 70 | 1,254 | 121 |
| Unsprayed | 0 | 1,686 | 113 | 689 | 34 | 561 | 65 | 2,059 | 74 | 1,437 | 97 | 1,287 | 136 |
| Pyroxasulfone | 100 | 1,861 | 204 | 661 | 17 | 695 | 28 | 1,999 | 71 | 1,408 | 34 | 1,325 | 135 |
| Pyroxasulfone | 150 | 2,052 | 86 | 713 | 79 | 725 | 37 | 1,849 | 28 | 1,276 | 139 | 1,323 | 132 |
| Carfentrazone + Glyphosate | 100 | 2,178 | 160 | 700 | 59 | 699 | 23 | 1,980 | 112 | 1,594 | 111 | 1,430 | 149 |
| Carfentrazone + Glyphosate | 150 | 2,220 | 145 | 748 | 48 | 634 | 102 | 1,832 | 98 | 1,507 | 62 | 1,388 | 146 |
| Glyphosate | 100 | 2,161 | 143 | 689 | 22 | 694 | 38 | 1,983 | 50 | 1,403 | 112 | 1,386 | 146 |
| Glyphosate | 150 | 2,067 | 30 | 489 | 45 | 753 | 16 | 1,981 | 42 | 1,283 | 74 | 1,315 | 147 |
| Flumioxazin | 100 | 1,946 | 93 | 655 | 42 | 778 | 49 | 1,975 | 66 | 1,379 | 28 | 1,347 | 130 |
| Flumioxazin | 150 | 1,846 | 97 | 632 | 101 | 764 | 16 | 1,921 | 22 | 1,144 | 85 | 1,261 | 126 |
| Saflufenacil + Glyphosate | 100 | 2,124 | 120 | 683 | 81 | 719 | 23 | 1,924 | 112 | 1,386 | 74 | 1,367 | 141 |
| Saflufenacil + Glyphosate | 150 | 2,172 | 33 | 636 | 77 | 752 | 40 | 2,048 | 49 | 1,183 | 95 | 1,358 | 149 |

Table F. Effect of preseeding herbicide mixtures with varying rates of pyroxasulfone on winter wheat seed yield.

| Treatment | Pyroxa-sulfone | 2014/15 Lethbridge | | 2015/16 St. Albert | | 2015/16 Edmonton | | 2015/16 Melita | | 2015/16 Lethbridge | | mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | gai ha$^{-1}$ | kg ha$^{-1}$ | SE | kg ha$^{-1}$ | SE | kg ha$^{-1}$ | SE | kg ha$^{-1}$ | SE | kg ha$^{-1}$ | SE | kg ha$^{-1}$ | SE |
| Unsprayed | 0 | 4,753 | 231 | 4,870 | 514 | 5,023 | 204 | 6,301 | 509 | 3,653 | 365 | 4,920 | 247 |
| Unsprayed | 0 | 5,240 | 367 | 5,000 | 574 | 4,904 | 304 | 5,938 | 572 | 4,039 | 459 | 5,024 | 233 |
| Pyroxasulfone | 100 | 5,580 | 512 | 5,151 | 83 | 5,080 | 164 | 6,173 | 482 | 4,206 | 467 | 5,238 | 213 |
| Pyroxasulfone | 150 | 5,919 | 272 | 5,466 | 564 | 5,502 | 338 | 6,515 | 326 | 3,579 | 244 | 5,396 | 269 |
| Carfentrazone + Glyphosate | 100 | 6,094 | 359 | 5,610 | 352 | 5,520 | 205 | 6,453 | 200 | 4,399 | 213 | 5,615 | 194 |
| Carfentrazone + Glyphosate | 150 | 6,933 | 372 | 5,595 | 260 | 5,531 | 195 | 6,620 | 509 | 4,564 | 295 | 5,848 | 238 |
| Glyphosate | 100 | 5,283 | 429 | 5,951 | 426 | 5,039 | 353 | 6,700 | 237 | 4,265 | 156 | 5,421 | 231 |
| Glyphosate | 150 | 6,023 | 110 | 4,902 | 204 | 4,965 | 216 | 6,734 | 54 | 3,843 | 81 | 5,293 | 236 |
| Flumioxazin | 100 | 4,903 | 400 | 5,690 | 330 | 5,097 | 122 | 6,944 | 188 | 3,918 | 286 | 5,310 | 255 |
| Flumioxazin | 150 | 5,334 | 371 | 5,088 | 259 | 5,304 | 185 | 6,640 | 356 | 3,616 | 153 | 5,196 | 247 |
| Saflufenacil + Glyphosate | 100 | 5,423 | 342 | 5,615 | 151 | 5,247 | 202 | 6,693 | 447 | 3,835 | 30 | 5,363 | 237 |
| Saflufenacil + Glyphosate | 150 | 6,223 | 234 | 5,321 | 667 | 5,563 | 438 | 6,832 | 184 | 3,732 | 63 | 5,534 | 284 |

Table G. Effect of incrop herbicide mixtures on weed control 2 WAA.

| Treatment | 2015/16 St. Albert % | SE | 2015/16 Edmonton % | SE | mean % | SE |
|---|---|---|---|---|---|---|
| Untreated | 0 | 0 | 0 | 0 | 0 | 0 |
| Frontline XL | 95 | 0 | 96 | 1 | 95 | 0 |
| Paradigm, Simplicity, MCPA ester | 93 | 3 | 84 | 2 | 88 | 2 |
| Pixxaro A, Pixxaro B | 75 | 4 | 86 | 2 | 81 | 3 |
| Infinity | 94 | 1 | 93 | 2 | 94 | 1 |
| Refine SG, MCPA ester | 68 | 4 | 83 | 2 | 75 | 4 |

Table H. Effect of incrop herbicide mixtures on dry weed biomass at crop anthesis.

| Treatment | 2015/16 St. Albert $g\ m^{-2}$ | SE | 2015/16 Edmonton $g\ m^{-2}$ | SE | 2015/16 Melita $g\ m^{-2}$ | SE | 2015/16 Lethbridge $g\ m^{-2}$ | SE | mean $g\ m^{-2}$ | SE |
|---|---|---|---|---|---|---|---|---|---|---|
| Untreated | 66 | 9 | 73 | 19 | 3 | 1 | 18 | 7 | 40 | 9 |
| Frontline XL | 4 | 4 | 0 | 0 | 6 | 2 | 19 | 15 | 7 | 4 |
| Paradigm, Simplicity, MCPA ester | 0 | 0 | 0 | 0 | 2 | 1 | 8 | 3 | 2 | 1 |
| Pixxaro A, Pixxaro B | 0 | 0 | 0 | 0 | 3 | 2 | 12 | 4 | 4 | 2 |
| Infinity | 1 | 1 | 43 | 23 | 3 | 1 | 16 | 6 | 16 | 7 |
| Refine SG, MCPA ester | 8 | 4 | 0 | 0 | 3 | 1 | 15 | 11 | 6 | 3 |

Table I. Effect of incrop herbicide mixtures on dry winter wheat biomass at anthesis.

| Treatment | 2015/16 St. Albert $g\ m^{-2}$ | SE | 2015/16 Edmonton $g\ m^{-2}$ | SE | 2015/16 Melita $g\ m^{-2}$ | SE | 2015/16 Lethbridge $g\ m^{-2}$ | SE | mean $g\ m^{-2}$ | SE |
|---|---|---|---|---|---|---|---|---|---|---|
| Untreated | 678 | 70 | 624 | 47 | 1,844 | 47 | 697 | 71 | 961 | 135 |
| Frontline XL | 769 | 22 | 761 | 52 | 1,809 | 45 | 694 | 104 | 1,008 | 123 |
| Paradigm, Simplicity, MCPA ester | 740 | 74 | 693 | 24 | 1,857 | 99 | 754 | 27 | 1,011 | 129 |
| Pixxaro A, Pixxaro B | 715 | 42 | 724 | 25 | 1,778 | 106 | 694 | 48 | 978 | 123 |
| Infinity | 675 | 13 | 678 | 49 | 1,914 | 83 | 693 | 42 | 990 | 140 |
| Refine SG, MCPA ester | 633 | 50 | 757 | 32 | 1,915 | 96 | 611 | 41 | 1,002 | 150 |

Table J. Effect of incrop herbicide mixtures on winter wheat spring crop density.

| Treatment | 2015/16 St. Albert $pl\ m^{-2}$ | SE | 2015/16 Edmonton $pl\ m^{-2}$ | SE | 2015/16 Melita $pl\ m^{-2}$ | SE | 2015/16 Lethbridge $pl\ m^{-2}$ | SE | mean $pl\ m^{-2}$ | SE |
|---|---|---|---|---|---|---|---|---|---|---|
| Untreated | 163 | 31 | 192 | 5 | 228 | 13 | 132 | 22 | 162 | 14 |
| Frontline XL | 158 | 21 | 204 | 10 | 216 | 6 | 135 | 15 | 166 | 12 |
| Paradigm, Simplicity, MCPA ester | 167 | 25 | 214 | 33 | 230 | 10 | 145 | 25 | 175 | 17 |
| Pixxaro A, Pixxaro B | 163 | 18 | 213 | 22 | 217 | 8 | 152 | 12 | 176 | 12 |
| Infinity | 164 | 26 | 203 | 13 | 228 | 11 | 137 | 19 | 168 | 13 |
| Refine SG, MCPA ester | 147 | 36 | 196 | 9 | 232 | 16 | 127 | 31 | 157 | 17 |

Table K. Effect of incrop herbicide mixtures on crop tolerance 2 WAA.

| Treatment | 2015/16 St. Albert % injury | SE | 2015/16 Edmonton % injury | SE | 2015/16 Melita % injury | SE | mean % injury | SE |
|---|---|---|---|---|---|---|---|---|
| Untreated | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Frontline XL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Paradigm, Simplicity, MCPA ester | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 0 |
| Pixxaro A, Pixxaro B | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| Infinity | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 0 |
| Refine SG, MCPA ester | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table L. Effect of incrop herbicide mixtures on dry winter wheat biomass at anthesis.

| Treatment | 2015/16 St. Albert | | 2015/16 Edmonton | | 2015/16 Melita | | 2015/16 Lethbridge | | mean | |
|---|---|---|---|---|---|---|---|---|---|---|
| | g m$^{-2}$ | SE | g m$^{-2}$ | SE | g m$^{-2}$ | SE | g m$^{-2}$ | SE | g m$^{-2}$ | SE |
| Untreated | 678 | 70 | 624 | 47 | 1,844 | 47 | 697 | 71 | 961 | 135 |
| Frontline XL | 769 | 22 | 761 | 52 | 1,809 | 45 | 694 | 104 | 1,008 | 123 |
| Paradigm, Simplicity, MCPA ester | 740 | 74 | 693 | 24 | 1,857 | 99 | 754 | 27 | 1,011 | 129 |
| Pixxaro A, Pixxaro B | 715 | 42 | 724 | 25 | 1,778 | 106 | 694 | 48 | 978 | 123 |
| Infinity | 675 | 13 | 678 | 49 | 1,914 | 83 | 693 | 42 | 990 | 140 |
| Refine SG, MCPA ester | 633 | 50 | 757 | 32 | 1,915 | 96 | 611 | 41 | 1,002 | 150 |

Table M. Effect of incrop herbicide mixtures on winter wheat seed yield.

| Treatment | 2015/16 St. Albert | | 2015/16 Edmonton | | 2015/16 Melita | | 2015/16 Lethbridge | | mean | |
|---|---|---|---|---|---|---|---|---|---|---|
| | kg ha$^{-1}$ | SE | kg ha$^{-1}$ | SE | kg ha$^{-1}$ | SE | kg ha$^{-1}$ | SE | kg ha$^{-1}$ | SE |
| Untreated | 4,731 | 309 | 4,503 | 363 | 6,801 | 191 | 3,912 | 303 | 4,987 | 311 |
| Frontline XL | 5,055 | 263 | 5,027 | 337 | 6,989 | 73 | 4,076 | 496 | 5,287 | 311 |
| Paradigm, Simplicity, MCPA ester | 5,505 | 262 | 4,983 | 261 | 7,079 | 58 | 4,014 | 338 | 5,395 | 308 |
| Pixxaro A, Pixxaro B | 5,401 | 402 | 4,948 | 237 | 6,665 | 123 | 3,729 | 134 | 5,186 | 293 |
| Infinity | 4,562 | 301 | 5,032 | 310 | 6,882 | 89 | 3,564 | 120 | 5,010 | 327 |
| Refine SG, MCPA ester | 5,087 | 181 | 5,273 | 351 | 6,692 | 117 | 3,490 | 20 | 5,136 | 307 |

## *Conclusion*

Group 14 herbicides, applied in combination with group 15 pyroxasulfone generally increased yield in winter wheat by 5-13%. Slight residual effects on winter wheat emergence and winter survival was noted but better weed control by residual herbicides compensated for stand reductions and increased winter wheat yield. No crop tolerance concerns were identified but because the trials were relatively weed free, treatments were not consistently different from untreated controls. This suggests that weed populations should be assessed in winter wheat and that this crop may not require any herbicide application where winter annual weeds are not a concern.

# Mitigating herbicide residual activity on fall stand establishment

**Project duration**: 2014-2017

**Collaborators**: Linda M. Hall-Agriculture and Agri-Food Canada

## *Objectives*

The objective of this experiment was to assess residual effects on winter wheat, and compare imidazolinone herbicides with alternative Group 14 and 15 herbicides.

## *Materials and Methods*

Field trials were conducted twice, over two years at each of three sites: Edmonton, AB (black soil zone); Lethbridge, AB (brown soil zone); Melita, MB (black soil zone). Trials were initiated in 2015 at Edmonton, St. Albert, Melita (Newstead), Melita (Stanton), and Lethbridge; in 2016 at Melita and Lethbridge. Soil was sampled and analyzed to generate fertility recommendations for nitrogen banded alongside peas or winter wheat at seeding. Following a glyphosate application, peas (cv. Thunderbird) were seeded at 85 seeds $m^{-2}$ in early May. Herbicide treatments were applied either pre-seed or in-crop to the peas as appropriate (Table 1). Following pea harvest, glyphosate was applied to reduce the impact of weeds. In early September, winter wheat cv. Flourish was sown into the pea stubble at 400 seeds $m^{-2}$ into 8.5 m long rows, in plots 6-8 rows wide with 20-30 cm row spacing.

The effects of residual herbicides were assessed by visual efficacy of weed control on endemic weeds (0-100%); visual crop tolerance assessments (0-100%) 1, 2 and 4 weeks after fall emergence and 2 weeks after recommencement of growth in spring; winter wheat stand establishment 2 and 4 weeks after fall planting (plants $m^{-2}$), based on 1 meter x 1 row from the front and rear of each plot; winter wheat stand in early spring (plants $m^{-2}$) using the same sampling area described above; winter wheat and weed biomass production at anthesis (g dry $m^{-2}$), and winter wheat seed yield (kg $ha^{-1}$) following direct combining the entire plot with a Wintersteiger combine. Experiments were designed as randomized complete blocks with seven treatments and four replicates.

**Table 1. Herbicide treatments applied to peas**

| Herbicide | Trade name | Rate (g ai $ha^{-1}$) | Application timing | Adjuvant | Adjuvant rate L $ha^{-1}$ |
|---|---|---|---|---|---|
| Untreated control | n/a | n/a | n/a | n/a | n/a |
| Pyroxasulfone | | 150 | Pre-seed | None | n/a |
| Pyroxasulfone + sulfentrazone | | 150 + 140 | Pre-seed | None | n/a |
| Sulfentrazone (LR[a]) | Authority | 140 | Pre-seed | None | |
| Imazethapyr (LR) | Pursuit 240 | 50 | In-crop | Agsurf or Agral 90 | 0.25 |
| Imazethapyr/imazamox (LR) | Odyssey | 30 | In-crop | Merge | 0.5 |
| Imazamox + Bentazon (LR) | Viper | 20 + 427 | In-crop | BASF UAN 28% | 2.0 |

LR[a]= label rate for pea

## *Results and Discussion*

Trials were successfully conducted with the exception of Melita's site (2016) where soil salinity limited the usefulness of winter wheat yield data collected the following spring.

Residual herbicides applied to peas showed no significant crop tolerance concerns when assessed visually in spring (Table 2). Crop density four 4 weeks after emergence was similar in all treatments compared to the unsprayed check (Table 3). On average, winter wheat plant density was not reduced by herbicide treatment (Table 4) and winter wheat biomass at anthesis was not affected (Table 5). The herbicide treatments averaged 5-7% higher seed yields than the unsprayed check (Table 6).
Trials conducted over 6 site years provide no support for the concerns of agronomist and growers over the effects of residual herbicides applied to peas on winter wheat stands or crop yields. However, it should be noted that soil residual effects depend on weather and edaphic factors and under dry or highly acidic soil conditions, these results may not reflect effects in different locations.

**Table 2.** Effect of residual herbicide mixtures on winter wheat crop tolerance in the spring.

| | | 2015/16 | | 2015/16 | | 2015/16 | | 2016/17 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | St. Albert | | Edmonton | | Melita S. | | Melita LJ's | | All sites | |
| Treatment | Timing | % injury | SE | % injury | SE | % injury | SE | % injury | SE | % injury | SE |
| Untreated | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 | 0.0 |
| Pyroxasulfone | PREPRE | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 2 | 1.0 | 0.7 |
| Authority | PREPRE | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0.7 | 0.7 |
| Pyroxasulfone/Authority | PREPRE | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0.1 | 0.1 |
| Pursuit, AgSurf | POSPOS | 0 | 0 | 2 | 1 | 0 | 0 | 3 | 3 | 1.1 | 0.8 |
| Odyssey, Merge | POSPOS | 0 | 0 | 2 | 1 | 0 | 0 | 6 | 3 | 2.0 | 0.9 |
| Viper, UAN | POSPOS | 0 | 0 | 1 | 1 | 0 | 0 | 3 | 1 | 0.8 | 0.4 |

**Table 3.** Effect of residual herbicide mixtures on winter wheat on crop density four weeks after emergence.

| | | 2015/16 | | 2015/16 | | 2015/16 | | 2015/16 | | 2016/17 | | 2016/17 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | St. Albert | | Edmonton | | Melita S. | | Melita N. | | Melita LJ's | | Lethbridge | | All sites | |
| Treatment | Timing | pl $m^{-2}$ | SE | pl $m^{-2}$ | SE | pl $m^{-2}$ | SE | pl $m^{-2}$ | SE | pl $m^{-2}$ | SE | pl $m^{-2}$ | SE | pl $m^{-2}$ | SE |
| Untreated | - | 216 | 17 | 208 | 31 | 237 | 10 | 242 | 11 | 214 | 8 | 245 | 18 | 227 | 7 |
| Pyroxasulfone | PREPRE | 191 | 17 | 236 | 28 | 231 | 13 | 223 | 9 | 215 | 11 | 299 | 32 | 232 | 10 |
| Authority | PREPRE | 238 | 29 | 286 | 30 | 220 | 12 | 220 | 10 | 206 | 17 | 238 | 11 | 233 | 8 |
| Pyroxasulfone/Authority | PREPRE | 214 | 14 | 219 | 44 | 244 | 7 | 224 | 7 | 222 | 2 | 274 | 30 | 234 | 8 |
| Pursuit, AgSurf | POSPOS | 254 | 4 | 244 | 17 | 225 | 14 | 205 | 21 | 210 | 13 | 280 | 16 | 236 | 8 |
| Odyssey, Merge | POSPOS | 224 | 9 | 221 | 18 | 232 | 13 | 224 | 6 | 220 | 5 | 282 | 18 | 234 | 6 |
| Viper, UAN | POSPOS | 226 | 6 | 232 | 21 | 247 | 8 | 213 | 15 | 219 | 14 | 300 | 25 | 239 | 8 |

**Table 4.** Effect of residual herbicide mixtures on winter wheat density in spring.

| | | 2015/16 St. Albert | | 2015/16 Edmonton | | 2015/16 Melita S. | | 2015/16 Melita N. | | 2015/16 Lethbridge | | 2016/17 Melita LJ's | | 2016/17 Lethbridge | | All sites | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | Timing | pl m$^{-2}$ | SE | pl m$^{-2}$ | SE | pl m$^{-2}$ | SE | pl m$^{-2}$ | SE | pl m$^{-2}$ | SE | pl m$^{-2}$ | SE | pl m$^{-2}$ | SE | pl m$^{-2}$ | SE |
| Untreated | - | 146 | 13 | 173 | 23 | 243 | 5 | 227 | 17 | 151 | 13 | 209 | 15 | 242 | 28 | 199 | 10 |
| Pyroxasulfone | PREPRE | 131 | 28 | 217 | 25 | 216 | 22 | 234 | 6 | 180 | 11 | 231 | 17 | 297 | 30 | 215 | 12 |
| Authority | PREPRE | 162 | 30 | 248 | 33 | 232 | 11 | 217 | 11 | 177 | 10 | 207 | 6 | 237 | 10 | 210 | 8 |
| Pyroxasulfone/Authority | PREPRE | 147 | 30 | 218 | 30 | 235 | 9 | 223 | 11 | 189 | 9 | 212 | 17 | 272 | 31 | 213 | 10 |
| Pursuit, AgSurf | POSPOS | 192 | 26 | 208 | 22 | 238 | 10 | 211 | 13 | 195 | 8 | 215 | 14 | 273 | 14 | 219 | 7 |
| Odyssey, Merge | POSPOS | 173 | 35 | 206 | 14 | 237 | 8 | 223 | 6 | 175 | 17 | 219 | 11 | 281 | 18 | 216 | 9 |
| Viper, UAN | POSPOS | 163 | 20 | 204 | 24 | 257 | 10 | 215 | 11 | 185 | 14 | 200 | 27 | 298 | 25 | 217 | 11 |

**Table 5.** Effect of residual herbicide mixtures on dry winter wheat biomass at anthesis.

| | | 2015/16 St. Albert | | 2015/16 Edmonton | | 2015/16 Melita S. | | 2015/16 Melita N. | | 2015/16 Lethbridge | | 2016/17 Melita LJ's | | 2016/17 Lethbridge | | All sites | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | Timing | g/m$^2$ | SE | g/m$^2$ | SE | g/m$^2$ | SE | g/m$^2$ | SE | g/m$^2$ | SE | g/m$^2$ | SE | g/m$^2$ | SE | g/m$^2$ | SE |
| Untreated | - | 685 | 72 | 728 | 39 | 1,933 | 97 | 1,364 | 86 | 369 | 12 | 928 | 82 | 1,190 | 134 | 1,028 | 96 |
| Pyroxasulfone | PREPRE | 491 | 97 | 891 | 53 | 1,583 | 146 | 1,348 | 39 | 448 | 17 | 938 | 76 | 1,499 | 157 | 1,033 | 92 |
| Authority | PREPRE | 655 | 94 | 894 | 36 | 1,618 | 137 | 1,206 | 104 | 426 | 26 | 915 | 59 | 1,320 | 41 | 1,009 | 80 |
| Pyroxasulfone/Authority | PREPRE | 530 | 68 | 874 | 113 | 1,749 | 23 | 1,276 | 36 | 456 | 21 | 981 | 102 | 1,515 | 166 | 1,068 | 97 |
| Pursuit, AgSurf | POSPOS | 637 | 46 | 823 | 59 | 1,957 | 108 | 1,366 | 110 | 376 | 29 | 921 | 76 | 1,240 | 25 | 1,046 | 97 |
| Odyssey, Merge | POSPOS | 653 | 69 | 878 | 38 | 1,913 | 176 | 1,274 | 60 | 383 | 34 | 924 | 28 | 1,352 | 86 | 1,054 | 94 |
| Viper, UAN | POSPOS | 580 | 47 | 843 | 44 | 1,839 | 78 | 1,402 | 40 | 445 | 33 | 850 | 124 | 1,407 | 92 | 1,052 | 94 |

**Table 6.** Effect of residual herbicide mixtures on winter wheat seed yield.

| | | 2015/16 St. Albert | | 2015/16 Edmonton | | 2015/16 Melita S. | | 2015/16 Melita N. | | 2015/16 Lethbridge | | 2016/17 Melita LJ's | | 2016/17 Lethbridge | | All sites | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | Timing | kg ha$^{-1}$ | SE | kg ha$^{-1}$ | SE | kg ha$^{-1}$ | SE | kg ha$^{-1}$ | SE | kg ha$^{-1}$ | SE | kg ha$^{-1}$ | SE | kg ha$^{-1}$ | SE | kg ha$^{-1}$ | SE |
| Untreated | - | 4,414 | 97 | 5,574 | 287 | 6,641 | 133 | 4,920 | 183 | 5,444 | 412 | 3,748 | 349 | 5,191 | 709 | 5,160 | 210 |
| Pyroxasulfone | PREPRE | 4,902 | 276 | 6,588 | 237 | 6,721 | 220 | 4,802 | 128 | 5,630 | 233 | 4,125 | 134 | 5,477 | 452 | 5,422 | 191 |
| Authority | PREPRE | 5,135 | 333 | 6,242 | 180 | 7,165 | 163 | 4,901 | 246 | 5,515 | 271 | 3,961 | 124 | 5,070 | 268 | 5,397 | 204 |
| Pyroxasulfone/Authority | PREPRE | 4,721 | 484 | 6,733 | 14 | 6,632 | 215 | 4,847 | 141 | 5,989 | 300 | 3,987 | 213 | 5,733 | 470 | 5,427 | 216 |
| Pursuit, AgSurf | POSPOS | 5,041 | 230 | 6,528 | 397 | 6,541 | 130 | 4,816 | 230 | 5,242 | 125 | 3,919 | 201 | 5,808 | 246 | 5,413 | 187 |
| Odyssey, Merge | POSPOS | 5,116 | 269 | 6,069 | 222 | 6,786 | 191 | 4,836 | 241 | 5,562 | 220 | 3,849 | 249 | 5,874 | 435 | 5,442 | 192 |
| Viper, UAN | POSPOS | 5,207 | 385 | 6,598 | 418 | 6,787 | 141 | 4,946 | 98 | 5,737 | 437 | 4,029 | 289 | 5,477 | 473 | 5,542 | 209 |

## *Conclusion*

There was no evidence that herbicides applied to peas, either longer residual imidazolinone herbicides, group 14 or 15 herbicides have negative effects on winter wheat emergence, crop stand or seed yield when planted after peas. This suggests that growers may safely grow winter wheat after peas under normal environmental conditions. Weed control was difficult to assess visually at most locations due to a lack of weeds at the time of application. At some locations, weeds were seeded in anticipation of this possibility; however, environmental conditions were still not conducive for germination of weed seeds.

# Assessment of 4 high yielding wheat varieties with low and high rate of fertility

***Project duration:*** 2017-2018
***Collaborators***: Ken Gross - Ducks Unlimited

## *Objectives*

1. To evaluate yield and quality among 4 high yielding wheat varieties subjected to low and high fertility rates
2. Determine appropriate winter wheat fertility program to achieve high yield (130 bu/ac or 8500 kg/ha) winter wheat

## *Background*

Achieving winter wheat yields over 100 bushel per acre is unorthodox but may be possible in Manitoba given the of newer higher performing winter wheat varieties and under ideal environmental conditions. With greater yield potential there is a greater demand for nitrogen to build those yields.

An experiment was conducted at the Manitoba Diversification Centres to explore high rates of nitrogen applied to newer high performing varieties of winter wheat. Though the rates are quite high they are implemented to illustrate variety potential which may have not been used on them in previous investigations.

## *Materials and Methods*

The experiment was initiated in the fall of 2017 at Melita, Carberry, Arborg and Roblin in Manitoba. Unfortunately Carberry, Arborg and Roblin were unable to establish the trial due to winter kill in early 2018. Only the Melita data will be summarized in this report.

The trial was a 4x2 (variety x fertility) split plot experiment replicated 3 times. Varieties were considered main plots and used Gold Rush, Gateway, Emerson, and Wildfire. Fertility treatments were subplots and were divided into LOW and HIGH fertility treatments.

To account or seasonal nitrogen mineralization, soil test results were assumed to have 1.4 times the value stated available.

Fertility Treatments are explained below:

LOW treatment was defined as the “normal producer practice” whereas the producer was to target 100 bu/ac yield target. It was proposed that for each bushel produced, 2.5 lbs/ac Nitrogen would need to be available to reach that goal. So 250 lbs N/ac – (Soil test N 48 x1.4) = 183 lbs/ac N applied. All nitrogen was sideband in the fall as a blend of 50% urea and 50% ESN urea.

HIGH treatment is defined as the "high yield practice", target yield was 130 bushel so this required 320 lbs/ac total available N. So 320 – (Soil test N 48 x 1.4) = 253 lbs/ac N to be applied. Of this requirement, 70% of the applied nitrogen was sideband in the fall as a blend of 50% urea and 50% ESN urea. The remaining additional 30% of the nitrogen budget was topdressed in the spring as Agrotain treated urea (applied May 24).

Phosphorous, potash and sulfur were applied with a granular blend of 30 (low)/50 (high), 20, 9 lbs/ac, respectively using MAP (11-52-0), Potash (0-0-60) and ammonium sulfate (21-0-0-24) in addition to the low and high nitrogen treatments.

**Table 1:** Total nutrient composition of the fall soil test at Melita prior to field operations at 0-24" depth, OM – 2.1%, pH 8.1, Zinc 0.86 ppm.

| Depth | N (lbs/ac) | P – ppm Olsen | K - ppm | S |
|---|---|---|---|---|
| 0-24" | 48 | 11 | 185 | 64 |

The Melita location was characterised by a Lyleton loamy fine sand soil located on legal land location NE 35-3-28 W1 on the NE corner of the quarter section. Seeding was done under no till system at a depth of 0.5 inches on canola stubble. A burn-off application of 0.75L $ac^{-1}$ Roundup and 15g $ac^{-1}$ granular Heat in a tank mixture was done to control weeds before wheat emergence. Application of 0.3L $ac^{-1}$ Mextrol alone and a tank mixture of 0.2L $ac^{-1}$ Achieve, 0.5L $ac^{-1}$ Mextrol + 1% v/v Turbocharge adjuvant was done for post-emergence weed control. Prior to harvesting, the plots were desiccated with an application of 0.5L $ac^{-1}$ Roundup to ensure dry down of stalks as well as controlling late weeds. Data collection included: emergence date, plant count in 2 x 1 m lengths, plant height, days to anthesis, days to maturity, harvest date, grain moisture, protein content and grain yield. Days to anthesis and maturity were defined when 50% or more of the plants in a plot had reached those stages. Harvesting of grain was done using a Wintersteiger plot combine. Yield and quality data were subjected to a factorial ANOVA with Minitab 18 statistical software, and treatment differences were assessed by Fisher's LSD and considered significant at the 5% level of significance.

## *Results*

There were significant differences among variety protein, and test weight. Gateway had greater test weight than all other varieties while Wildfire had greatest protein levels. Also the high fertility regime had significantly greater test weight. However there were no interactions between use of variety and fertility regime in terms of yield and height. There was an interaction in protein levels with variety and fertility. Wildfire with lower fertility levels resulted in the greatest protein level whereas Emerson with high fertility levels resulted in the lowest. It is believed that a combination of lack of rainfall and saturated nitrogen levels chosen as treatments may have reduced the effectiveness to decipher between responses. This may explain also that there were no significant differences in height or yield.

**Table 2:** Height, test weight, grain yield, and grain protein content among varieties of winter wheat with low and high fertility regimes, near Melita MB. 2018.

| Factor | | | Height cm | Test Weight (g/0.5L) | | Yield kg/ha | Protein % | |
|---|---|---|---|---|---|---|---|---|
| Variety | Gold Rush | | 66 | 397 | b | 6786 | 13.5 | b |
| | Gateway | | 66 | 403 | a | 6138 | 13.7 | b |
| | Wildfire | | 66 | 396 | b | 6086 | 14.0 | a |
| | Emerson | | 61 | 394 | b | 5933 | 13.2 | c |
| | | Significant? | No | Yes | | No | Yes | |
| Fertility | | Low | 66 | 396 | b | 6237 | 13.7 | |
| | | High | 65 | 399 | a | 6234 | 13.5 | |
| | | Significant? | No | Yes | | No | No | |
| V x F | Gold Rush | Low | 68 | 396 | | 6377 | 13.4 | c |
| | Gateway | Low | 69 | 401 | | 6449 | 13.7 | bc |
| | Wildfire | Low | 68 | 396 | | 6174 | 14.1 | a |
| | Emerson | Low | 61 | 390 | | 5949 | 13.5 | c |
| | Gold Rush | High | 65 | 397 | | 7195 | 13.6 | bc |
| | Gateway | High | 68 | 405 | | 5827 | 13.7 | bc |
| | Wildfire | High | 65 | 395 | | 5997 | 13.9 | ab |
| | Emerson | High | 62 | 399 | | 5918 | 13.0 | d |
| | | Significant? | No | No | | No | Yes | |
| P value | | Variety | 0.185 | **0.013** | | 0.100 | **0.001** | |
| | | Fertility | 0.514 | **0.046** | | 0.988 | 0.094 | |
| | | V x F | 0.841 | 0.219 | | 0.213 | **0.050** | |
| R-squared | | | 0.74 | 0.83 | | 0.76 | 0.96 | |
| Coefficient of Variation (%) | | | 7.8 | 0.9 | | 8.7 | 1.3 | |

In this trial, it is obvious that the LOW fertility rate was more than ample to provide sufficient needs to the crop in terms of Maximum Economic Rate of Nitrogen (MERN). In hindsight it would have been useful to have an even lower rate (i.e. 80 lbs N applied total) to illustrate a low input economic scenario. This would have provided a greater insight as to where below the MERN exist and where the MERN should be.

Targeting 100 to 130 bu/ac winter wheat yields may be unjustified given below average seasonal rainfall, however it may be possible to reach this goal given normal rainfall amounts. That being said, the economics and financial risk of applying that much nitrogen must be justified.

### *References*

**https://www.producer.com/2018/04/early-nitrogen-applications-critical-for-winter-wheat/**

# Validation of the current Fusarium Head Blight model for generating daily FHB Risk Maps for wheat

**Project duration:** 2017-2018

**Collaborators:** Anne Kirk – Cereals Specialist, Manitoba Agriculture

## *Objectives*

To determine the impact of fungicide application and timing on FHB in-season and in harvested wheat grain

## *Materials and Methods*

The experiment was initiated in 2017 at Melita and Carberry in southwestern Manitoba. Nine treatments (three varieties and three fungicide levels) were arranged in a 3 x 3 factorial design with 3 replicates across 4 site-years. Treatment materials are described in the table below:

**Table 1:** Treatment description for FHB validation in wheat

| Wheat variety | Fungicide application stage |
|---|---|
| Muchmore | Full head |
| Muchmore | Full head and 5d[†] |
| Muchmore | No Fungicide |
| AAC Brandon | Full head and 5d |
| AAC Brandon | Full head |
| AAC Brandon | No fungicide |
| AAC Tenacious | No fungicide |
| AAC Tenacious | Full head and 5d |
| AAC Tenacious | Full head |

[†]Second application of Prosaro® fungicide applied 5 days after full head

The previous crop for Melita site was roundup ready soybean. Melita site was seeded to 1.5 inches under no till system during the first half of May in 2018 and granular fertilizer blend was side banded during the seeding and a rate of 113-35-24-9 (N-P-K-S) lb $ac^{-1}$ was used. Weed control was done five weeks after seeding using a tank mixture of 0.2L $ac^{1}$ Achieve and 0.5L $ac^{-1}$ Mextrol for post emergence control of grassy and broad leaf weeds respectively. Prosaro® fungicide was applied to treatments at the recommended rate. Important data collected included; fusarium head blight severity on scale of 0 to 9, test weight, thousand kernel weight, grain yield and moisture content at harvest. An IM 9500 NIR grain analyzer was used to determine grain moisture and protein content from a 500g subsample of each treatment. Uncleaned subsamples of each plot were sent to Biovision (Winnipeg, MB) for DON (deoxynivalenol toxin) and FDK (Fusarium Damaged Kernels) analysis.

## *Results*

There were significant yield differences in yield and protein among use of variety. There was also differences in DON value only in plot untreated with fungicide. There were no differences for varieties or fungicide application in Fusarium index or FDK. Overall there were no interactions between use of

variety in combination with/without fungicide treatment an all parameters measured. Due to unfavorable environmental conditions to stimulate significant Fusarium, few conclusive results were realized.

Table: Effect of variety and fungicide use in spring wheat response to grain yield, grain protein, Fusarium Head Blight (FHB) index, fusarium damaged kernels, and DON values.

| Factor | Description | Yield kg/ha | | Protein % | | FHB Index % | FDK % | DON ppm | |
|---|---|---|---|---|---|---|---|---|---|
| Variety | AAC Brandon | 4234 | a | 13.8 | a | 0.9 | 0.00 | 0.01 | |
| | AAC Tenacious | 4030 | b | 12.7 | b | 0.0 | 0.00 | 0.01 | |
| | Muchmore | 3987 | b | 13.7 | a | 0.3 | 0.02 | 0.02 | |
| Fungicide | No Fungicide | 4020 | | 13.4 | | 0.5 | 0.02 | 0.04 | a |
| | Fung@FullHead | 4117 | | 13.4 | | 0.8 | 0.00 | 0.00 | b |
| | Fung@FullHead+5d | 4112 | | 13.4 | | 0.0 | 0.00 | 0.00 | b |
| P value | Variety | **0.002** | | **<0.001** | | 0.151 | 0.151 | 0.711 | |
| | Fungicides | 0.232 | | 0.903 | | 0.244 | 0.244 | **0.015** | |
| | Var x Fungicide | 0.512 | | 0.936 | | 0.593 | 0.593 | 0.842 | |

A multi-site summary is to be reported in the fall of 2019. Results will be updated on the Manitoba Diversification Centres website at: www.mbdiversificationcentres.ca

## Pepsico - Quaker oats variety evaluation

**Project duration:** 2018
**Collaborators**: Pepsico/Quaker

### *Objectives*

To evaluate milling quality, yield and B-glucans among 21 oat varieties

### *Background*

Presently, most oats varieties yield an average of 3.2 t $ha^{-1}$ but there is potential to have higher yielding varieties through continued breeding. Oat breeders are currently focusing on production of hybrids with higher yield potential to increase profits, improve nutritional benefits of livestock feed (Peterson, 1991) and adequate amounts of beta-glucans for health benefits such as lowering blood serum cholesterol levels in humans (Holthaus at al., 1996). In Manitoba, oat production has a wide seeding window from May 1st to June 10th, this means that the crop can be seeded late and still reach harvest maturity (Manitoba Agriculture, 2018). Canadian Prairies, characterized by inconsistent weather patterns and shorter growing seasons are ideal for oats production because of the wide seeding window and the ability to fully utilize a short growing season and attain sensible yields. It is therefore important to test

different varieties in different environments to determine their performance and possible adoption for production in specific areas.

## *Materials and Methods*

Twenty-two varieties were arranged in a randomized complete block design and 4 replicates (blocks) across 2 site-years. Melita site was characterized by imperfectly drained Waskada loam soil and seeding was done at a depth of 0.75 inches under no till system during the first half of May. Fertilizer application was sideband during seeding a rate of 115-35-24-9 (N-P-K-S) lb $ac^{-1}$. A burnoff application with 0.75L $ac^{-1}$ Roundup was done five days after seeding to ensure a clean seedbed upon oats emergence. A second weed control was done with 0.5L $ac^{-1}$ Mextrol five weeks after seeding for control of broad leaf weeds. Grain yield, thousand kernel weight, moisture content, bushel weight and protein content data were collected on site. Protein and moisture content were determined using an IM 9500 NIR grain analyzer. The data were then subjected to ANOVA using and Minitab 18 statistical package for comparison of the varieties. Mean separation was conducted using Fisher's LSD at the 5% significance level.

## *Results*

There were no differences among all varieties and parameters tested in Melita in 2018. A summary of their performance is in Table 1.

**Table 1:** Summary of data collected at the Melita Site 2018.

| Variety | Height cm | DTM days | Yield kg/ha | Lodging 1-9 (9=flat) | BYDV 1-9 (9= severe) |
|---|---|---|---|---|---|
| 1 | 81 | 84 | 4085 | 1.3 | 1.3 |
| 2 | 81 | 84 | 3863 | 1.0 | 2.3 |
| 3 | 81 | 85 | 3832 | 1.5 | 1.5 |
| 4 | 81 | 84 | 4008 | 1.3 | 1.8 |
| 5 | 81 | 84 | 4202 | 1.3 | 1.0 |
| 6 | 79 | 84 | 4230 | 1.3 | 1.8 |
| 7 | 80 | 85 | 3918 | 1.0 | 1.3 |
| 8 | 77 | 84 | 4068 | 1.5 | 1.8 |
| 9 | 74 | 81 | 3554 | 1.3 | 2.5 |
| 10 | 87 | 85 | 4308 | 1.3 | 1.5 |
| 11 | 79 | 84 | 3937 | 1.5 | 1.8 |
| 12 | 75 | 83 | 3925 | 1.0 | 2.3 |
| 13 | 82 | 84 | 3753 | 1.8 | 1.5 |
| 14 | 82 | 83 | 3853 | 1.5 | 1.5 |
| 15 | 76 | 82 | 3818 | 1.0 | 2.0 |
| 16 | 79 | 81 | 4088 | 1.0 | 2.3 |
| 17 | 85 | 83 | 4068 | 1.0 | 1.8 |
| 18 | 76 | 83 | 3614 | 1.3 | 1.5 |
| 19 | 74 | 82 | 3897 | 1.3 | 2.5 |
| 20 | 76 | 83 | 3688 | 1.3 | 2.5 |
| 21 | 78 | 84 | 3795 | 1.3 | 2.0 |
| 22 | 80 | 84 | 3885 | 1.8 | 1.8 |
| Grand Mean | 79 | 83 | 3927 | 1.3 | 1.8 |
| CV% | 9 | 2 | 10 | 38 | 44 |
| R-square | 0.25 | 0.34 | 0.29 | 0.24 | 0.30 |
| P value | 0.614 | 0.151 | 0.457 | 0.583 | 0.324 |
| LSD (p<0.05) | NS | NS | NS | NS | NS |

## *References*


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Manitoba Agriculture. Oat Production and Management. Accessed at https://www.gov.mb.ca on 17 December 2018.

Peterson, D. M., 1991. Genotype and Environment effects on Oat beta-Glucan Concentration. Crop Science 31 (6): 1517-1520.

# La Coop Fédérée oat variety evaluation

**Project duration:** 2018

**Collaborators:** LaCoop Fédérée, Christain Azar, Agr. M. Sc. Plant Breeder

## *Objectives*

To evaluate milling quality, yield and B-glucans among 30 oats varieties and lines

## *Background*

La Coop fédérée's oat breeding program aims to develop food and feed spring oat cultivars adapted for the Canadian market. The program originates from early breeding efforts that started during the 90's. Objectives of the program include improving agronomic traits, milling qualities and disease tolerance of the cultivars offered to Canadian farmers. The breeding station is located in Saint-Hyacinthe, 50 km east of Montréal. They contracted agronomic trials in eastern and western Canada to evaluate the adaptation and stability of their most advanced material. The program started trials in Melita since the spring of 2016. La Coop fédérée's breeding center employs 15 people during the winter and 25 during the summer.

## *Materials and Methods*

The experiment was conducted at Melita, Manitoba and was laid out as randomized complete block design with 30 treatments (varieties) replicated 3 times in 2018. Seeding was done directly on Waskada loam soil under no till system on 3 May 2018 at a depth of 0.75 inches. Nutrient application was done based on soil test results and crop requirements at a rate of 115-35-24-9 (N-P-K-S) lb $ac^{-1}$ by side banding during seeding. In-season weed control was done using 0.5 L $ac^{-1}$ Mextrol four weeks after seeding to control broad leaf weeds. When the treatments were at 97% harvest maturity overall, an application of 0.5 L $ac^{-1}$ Roundup was done to desiccate the stalks and to control late weeds in the plots. Data collection includes: grain moisture content at harvest, grain yield, protein content, thousand kernel weight, and bushel weight. The data was subjected to ANOVA using Minitab 18 statistical package to compare grain yield among oats varieties. Fisher's LSD was used for mean separation at the 5% significance level.

## *Results*

There were significant variety differences among thousand seed weight (TKW), test weight, lodging, leaf disease spotting, days to maturity and crop height (table 1). There were no differences in yield among varieties.

Samples were shipped to LaCoop Fédérée for milling quality analysis.

**Table 1:** Summary of data collected at Melita in 2018.

| Variety | Yield kg/ha | TKW g/1000 | Test g/0.5L | Lodge 0 to 9(9 flat) | Leafspot 0-9 (9 - 100%) | DTM days | HT cm |
|---|---|---|---|---|---|---|---|
| 13 | 5312 | 35.3 | 229.0 | 2.7 | 2.0 | 85.7 | 90.2 |
| 7 | 5023 | 39.2 | 238.5 | 0.7 | 3.7 | 82.7 | 77.3 |
| 16 | 4977 | 38.1 | 245.1 | 1.0 | 3.0 | 84.3 | 97.8 |
| 24 | 4920 | 36.1 | 223.4 | 0.0 | 2.7 | 84.3 | 76.3 |
| 11 | 4895 | 34.4 | 236.3 | 2.3 | 3.0 | 85.0 | 88.0 |
| 29 | 4878 | 36.3 | 228.5 | 0.3 | 3.7 | 83.0 | 80.3 |
| 30 | 4866 | 35.5 | 215.7 | 0.0 | 3.3 | 82.7 | 80.2 |
| 28 | 4852 | 31.7 | 219.9 | 0.3 | 2.7 | 83.7 | 86.3 |
| 19 | 4842 | 37.2 | 235.3 | 0.3 | 2.3 | 83.3 | 87.0 |
| 14 | 4839 | 36.3 | 232.9 | 0.3 | 2.0 | 85.7 | 94.7 |
| 25 | 4823 | 36.9 | 229.6 | 1.0 | 2.7 | 85.7 | 88.8 |
| 21 | 4777 | 31.5 | 237.5 | 1.7 | 2.3 | 83.7 | 93.5 |
| 1 | 4771 | 39.4 | 231.5 | 2.7 | 3.3 | 82.7 | 92.0 |
| 10 | 4753 | 36.3 | 230.2 | 1.3 | 3.0 | 83.0 | 92.0 |
| 8 | 4740 | 35.9 | 232.9 | 1.3 | 2.7 | 85.3 | 88.8 |
| 6 | 4732 | 34.3 | 231.8 | 0.3 | 2.7 | 85.3 | 81.5 |
| 4 | 4712 | 34.2 | 235.9 | 1.7 | 2.7 | 83.3 | 87.8 |
| 22 | 4659 | 36.2 | 242.8 | 2.3 | 2.7 | 83.3 | 90.7 |
| 3 | 4652 | 35.7 | 216.8 | 1.0 | 3.7 | 82.7 | 78.3 |
| 2 | 4636 | 39.0 | 228.7 | 0.0 | 2.0 | 84.7 | 88.7 |
| 18 | 4615 | 33.8 | 238.1 | 1.0 | 2.7 | 83.3 | 84.3 |
| 26 | 4580 | 33.2 | 244.3 | 2.0 | 3.0 | 82.3 | 89.8 |
| 20 | 4537 | 31.3 | 217.1 | 0.3 | 2.3 | 83.3 | 81.7 |
| 9 | 4525 | 36.3 | 233.5 | 0.0 | 2.7 | 82.0 | 90.8 |
| 5 | 4504 | 32.7 | 225.1 | 0.7 | 3.3 | 82.0 | 84.2 |
| 17 | 4479 | 33.5 | 236.3 | 0.3 | 3.0 | 82.0 | 82.3 |
| 12 | 4470 | 32.6 | 230.9 | 0.0 | 2.7 | 83.0 | 82.8 |
| 27 | 4462 | 34.8 | 242.5 | 1.7 | 3.0 | 83.3 | 87.2 |
| 15 | 4193 | 31.4 | 227.3 | 0.3 | 2.3 | 83.7 | 96.0 |
| 23 | 4119 | 33.6 | 225.9 | 0.3 | 3.3 | 83.3 | 84.2 |
| Grand Mean | 4705 | 35.1 | 231.5 | 0.9 | 2.8 | 83.6 | 86.8 |
| CV% | 7 | 6 | 2 | 29 | 19 | 1 | 4 |
| R-square | 0.43 | 0.71 | 0.82 | 0.64 | 0.57 | 0.78 | 0.76 |
| P value | 0.103 | <0.001 | <0.001 | <0.001 | 0.004 | <0.001 | <0.001 |
| LSD (p<0.05) | 559 | 3.5 | 7.7 | 1.3 | 0.9 | 1.7 | 6.4 |

# Pulse Genetics pea variety evaluation

**Project duration:** 2018

**Collaborators:** Pete Giesbrecht, Winkler

## *Objectives*

To test 7 advanced lines in the pea growing regions of Southwestern Manitoba and Eastern Saskatchewan to evaluate how they perform in those environment in comparison with the best registered varieties.

## *Background*

Pulse Genetics is a small pea breeding company based in Southern Manitoba that started as a dream in a hobby garden 9 years ago. The goal is to develop yellow and green pea varieties with excellent protein and yield, with an emphasis on premium seed quality. These new lines will exhibit consistent performance over a variety of environments.

## *Materials and Methods*

The variety trial was conducted at Melita on imperfectly drained Waskada loam soil under no till system. Roundup ready soybean was the previous crop grown at the site in 2017. The trial was arranged as randomized complete block design with 5 treatments (pea lines) replicated 3 times. The plots were early seeded on the 1$^{st}$ of May at a depth of 1.5 inches and this was followed by a burnoff application with 0.75 L ac$^{-1}$ Roundup applied May 8$^{th}$ prior to emergence. All treatments were pretreated with BASF inoculant prior to seeding. Granular fertilizer blend was side banded during seeding at a rate of 15-35-24-9 (N-P-K-S) lb ac$^{-1}$ based on soil test results and to meet pea crop requirements. An application of 0.2L ac$^{-1}$ Assure II with 1% v/v Merge adjuvant five weeks after seeding was followed up by 17.3g ac$^{-1}$ Odyssey with 0.5% v/v Merge adjuvant a week later for effective control of weeds in peas. Major data collected included: disease severity scores, pea aphid count, protein content, days to maturity and grain yield. A two-way ANOVA Minitab 18 for grain yield and protein comparison among pea lines was performed. Mean separation was conducted using Fisher's LSD at the 5% significance level.

## *Results*

There were significant differences in plant height, maturity, lodging, grain yield, thousand seed weight, and protein content (table). Lowest yield was PG8001, which was significantly different than all other varieties. CDC Meadow was the highest yield, which was used to compare to a commercial variety for all others. Several lines had superior protein content compared to CDC Meadow.

In 2019, WADO plans to continue trials in cooperation with Pulse Genetics.

**Table:** Characteristics and yield performance of several pea lines grown in Melita, 2018.

| Cultivar | Vigor 1 to 5 (5=most) | Height cm | Maturity days | Lodging 1-9 (9=flat) | Yield kg/ha | TKWT g/1000 seeds | Protien % |
|---|---|---|---|---|---|---|---|
| PG8001 | 5 | 43 | 78 | 2.0 | 3358 | 230 | 24.2 |
| PG2601 | 5 | 45 | 79 | 1.0 | 4023 | 217 | 24.5 |
| PG3308 | 4 | 44 | 83 | 1.3 | 4033 | 211 | 23.2 |
| PG6150 | 5 | 46 | 83 | 1.0 | 3775 | 215 | 24.8 |
| PG2908 | 5 | 46 | 77 | 1.0 | 3969 | 202 | 23.6 |
| PG2805 | 5 | 50 | 83 | 1.0 | 3770 | 228 | 23.7 |
| CDC Meadow | - | - | - | - | 4143 | - | 23.4 |
| C.V. (%) | - | 6 | 0.7 | 19 | 3 | 2.8 | 1 |
| LSD (p<0.05) | - | NS | 1.0 | 0.4 | 216 | 11 | 0.5 |
| P value | - | 0.075 | <0.001 | 0.002 | <0.001 | 0.002 | <0.001 |
| Grand Mean | 5 | 46 | 81 | 1.2 | 3867 | 217 | 23.9 |

## 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-Elroy Cober

### *Objectives*

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

### *Materials and Methods*

The trial was initiated in 2018 by AAFC and will run until 2023 across Canada at Ottawa, Beloeil, in Ontario, Brandon, Melita, Roblin and Morden in Manitoba, Outlook and Saskatoon in Saskatchewan. In Melita, the trial was arranged as randomized complete block design with 20 treatments (CN varieties) replicated 4 times on imperfectly drained Waskada loam soil. The previous crop grown on the field was roundup ready soybean. The treatments were inoculated with granular BASF inoculant prior to seeding at a depth of 1.5inches on the 11$^{th}$ of May. Seeding was done under no till system and granular fertilizer blend was side banded at a rate of 15-35-24-9 (N-P-K-S) lb ac$^{-1}$ during the same time. Chemical weed control included a burnoff application with 0.75L ac$^{-1}$ Roundup, in-season application of 0.91L ac$^{-1}$ Basagran + 0.15L ac$^{-1}$ Arrow and 0.5% v/v X-Act adjuvant in a single tank mixture and 0.45L ac$^{-1}$ Poast

Ultra + 0.75L $100L^{-1}$ Merge adjuvant. Prior to harvesting, an application of 0.69L $ac^{-1}$ Reglone with LI200 adjuvant were done so as to dry down soybean stalks and to control late weeds. Several observations were made and these included; emergence date (when 50% or more of plant had emerged from each plot), plant height, days to maturity, harvest date, moisture content at harvest, grain yield and protein content. The data were analyzed by AAFC in Ottawa.

## *Results*

Below are preliminary results from AAFC illustrating the relationship between yield and protein at the various locations. Note that the non-nodulating line (which is the point denoted by two error bars) provides an estimate of site N fertility and by using the difference can estimate fixed nitrogen for lines or sites.

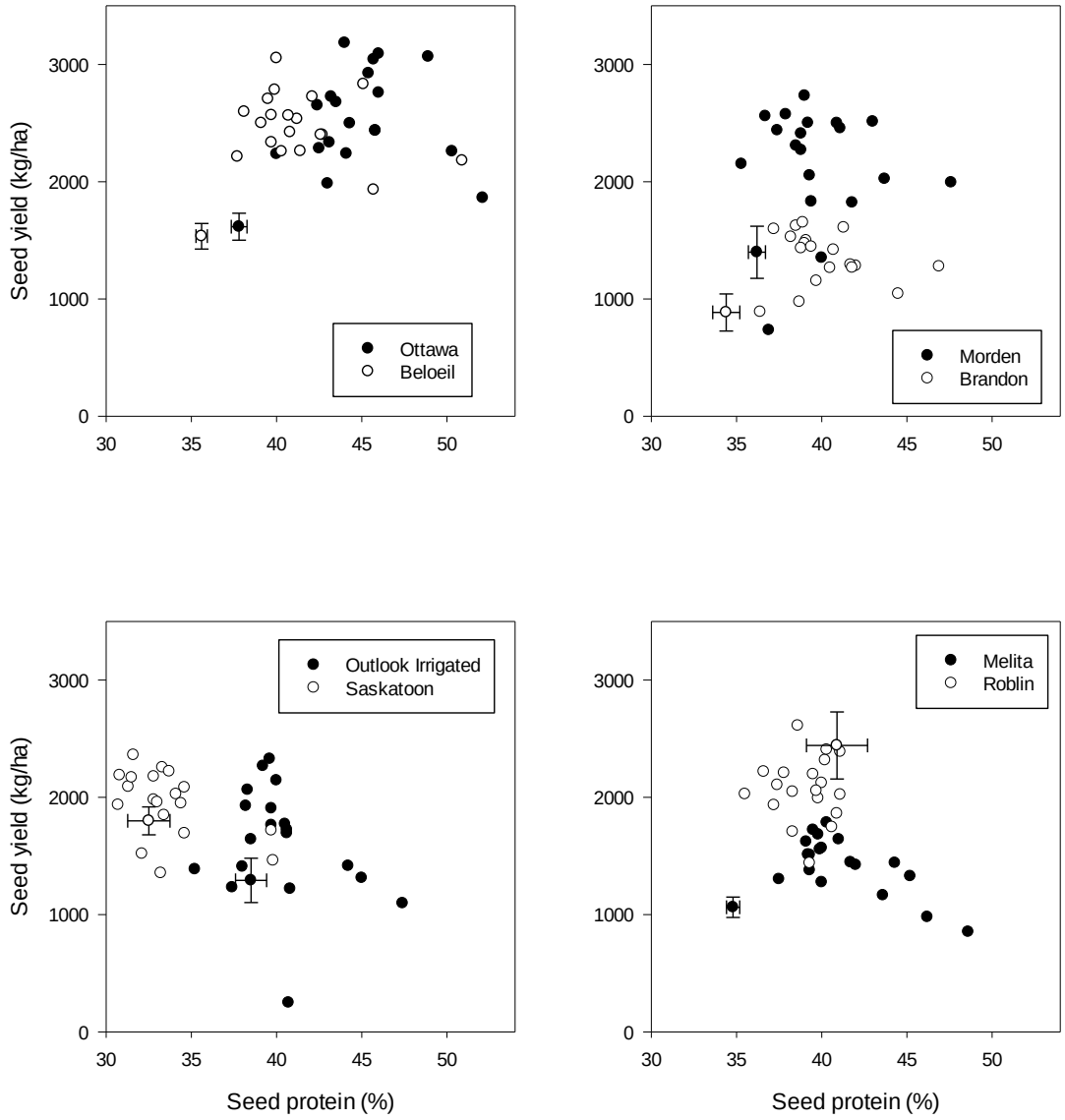



**Fig.1**: Seed yield and protein for each site. The error bars are two standard errors and are shown for the non-nodulating line in the trials.

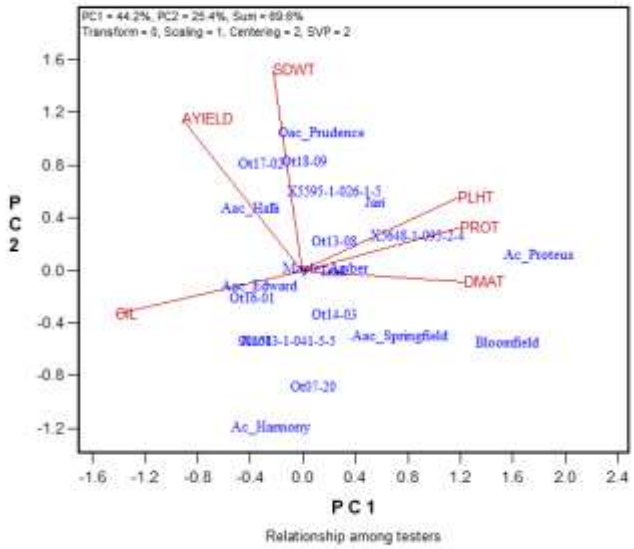



**Fig. 2**: GxE biplot for all sites and agronomy data, 2018.

In a biplot (figure 2), parameters with 180 degree angle are inversely related, such as protein vs. oil. Parameters at 90 degrees are independent, such as seed weight vs. oil or protein. Parameters with a small angle are correlated. Surprisingly, days to maturity and yield are not correlated in this data set.

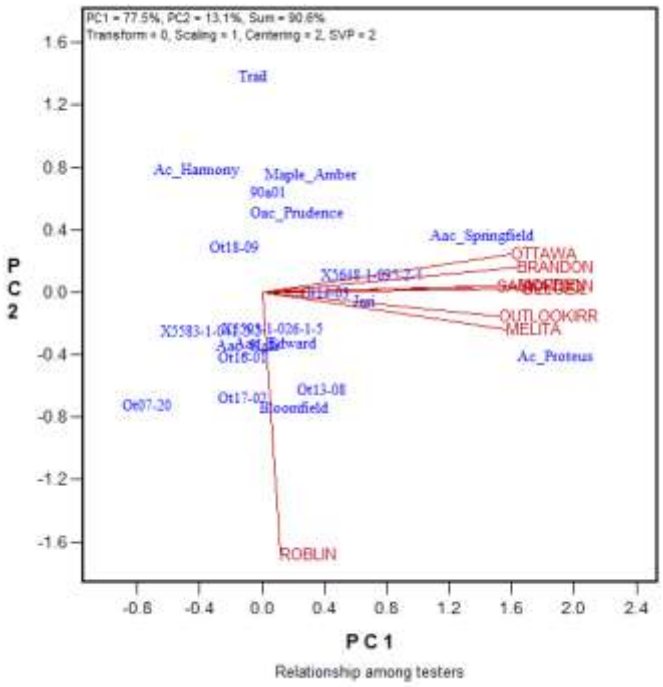



**Fig. 3:** A genotype by location biplot for seed protein, 2018.

As seen in Fig. 3, Roblin had high seed protein for the non-nodulating line (OT07-20) and in this biplot Roblin is distinct from all other locations.

Something different is happening at Roblin. The soil N fertility must have been extremely high.

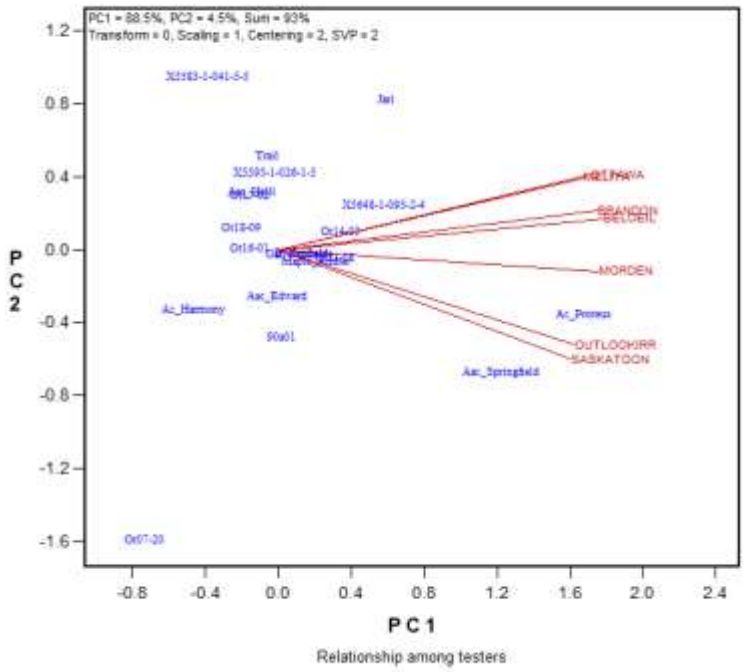



**Fig. 4**: A genotype by location biplot for seed protein, 2018 with Roblin excluded.

We do not see the two eastern locations (Ottawa and Beloeil) grouping separately from western sites.

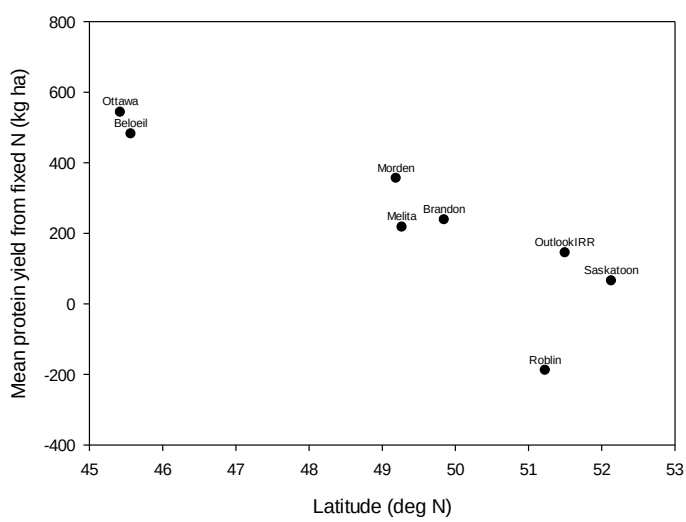



**Fig. 5**: Site means for protein yield from N-fixation (using the difference between nodulating lines and non-nodulating OT07-20) versus site latitude, 2018.

Again Roblin stands out with negative fixed protein yield values since OT07-20 both yielded well and had relatively high seed protein.

The GxE project will continue trials in 2019 across Canada.

## Best Management Practices-flax demonstration

**Project duration**: 2018-2019
**Collaborators**: Manitoba Diversification Centres

### *Objectives*

To provide a backdrop for field day extension on best management practices for successful flax production

### *Background*

Flax (*Linum usitatissimum*) production was introduced in the northern U.S. and Canada around 1800. Two types of flax that are grown include fiber flax grown especially in Europe for the fiber in its stem, and seed flax grown for the oil in its seed and nutritional value for humans and livestock (NDSU, 2007). In Canada, the majority of producers grow seed flax for processing into linseed industrial oil and linseed meal that is fed to livestock. In order to achieve higher yields and sustainable flax production, producers need to implement best flax management practices.

Best management practices in flax are activities and procedures that are designed to enhance sustainable agricultural production and these include; nutrient management, seeding date, rotation of flax with other crops, tillage operations, weed control methods, and pests and disease control. Historically, producers were not much worried about timing of these operations which resulted in significant yield losses for their flax crop. Proper timing of operations and adequate nutrient management does not only result in higher yields but also sustainable agricultural land use (Manitoba Agriculture, 2018).

Flax requires a season length of nearly 110 days and out of these days, 50 are required for the vegetative stage, 25 for flowering and 35 between flowering and maturity. Considering that the Canadian Prairies are characterized by a short growing season, the crop is ideal for production in this region because reaching maturity is assured if seeding is done early (Johnston et al., 2002). Flax seeding dates vary among regions but it is best to establish the crop early, especially during the first week of May in order to ensure full utilization of the growing season in the case of the Prairies that experience an early fall frost. Practices such as nutrient application must be based on soil test results as well as considering the previous crop, for instance, if the previous crop was an annual legume, nitrogen application must take into consideration nitrogen credits contributed by the legume hence reducing chances of over supplying nutrients to the flax crop (NDSU, 2007). Therefore, this small plot trial was conducted to demonstrate different management approaches to flax production and to recommend best management practices to flax producers.

## *Materials and Methods*

Three farming practises: BMP, Improving and Historic farmer were established as double strip plots with three blocks each. Plots were not randomized. The plots measured 9 m long x 2.88 m wide. Seeding dates differed depending on the farming practices and agronomic practices were applied as indicated in the table below:

**Description of treatments:**

| Action | Historic Farmer | Improving Farmer | BMP Farmer |
|---|---|---|---|
| Pre-Emergence Herbicide | None | Roundup (full 1L equivalent/acre) | Roundup + Authority + Aim |
| Stubble | RR soybean | RR soybean | RR soybean |
| Seed Date | 31-May-2018 | 22-May-2018 | 07-May-2018 |
| Seed Rate | 42 lbs/ac | 56 lbs | 70 lbs/ac |
| Seed Depth | 1 inch. | 0.75 inch. | 0.5 inch. |
| Target Fert. (lbs/ac Soil + Applied) | 70N + 25 P | 80 N + 25 P | 110 N + 35 P + 10 K |
| In crop Herbicides | Buctril M | Group 1 + Buctril M | Group1 + Basagran or Buctril/Curtail M |
| Fungicide | None | Headline EC | Priaxor |
| Desiccant | Swath | Swath | Reglone |

Data collected included: plant vigor on a 1 to 5 scale at 3 weeks after seeding, 2 x 1 m plant count at emergence, first flower and at harvest, disease rating, flower and maturity date, grain moisture content and yield.

## *Results and discussion*

Observations presented from this trial were for demonstration purposes. For the purposes of illustrating different management practices in flax production, data in the table indicates that BMP farmer treatment achieved 667.70 and 1411.73 kg ha$^{-1}$ more than the improving and the historic farmer treatments respectively (Table 1). Although the historic and improving farmer treatments had about a week longer time between flowering and maturity, this was not sufficient to compensate yield losses already incurred. On the other hand, early seeding at a proper seeding depth, application of adequate amount of nutrients and effective weed control was probably the reason behind higher yield obtained from BMP farmer treatments. Early seeding ensures that the crop establishes early and utilizes the available soil moisture for fast development before dry spells occur as is usually the case on the Prairies.

**Table 1**: Observation mean data for BMP, Improving and Historic farmer practices in flax production

| Practice | 3WAP Vigor 1-5 | Flowering date (Julian) | Lodging | Maturity Date (Julian) | Moisture % | †Yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|
| BMP | 4 | 172 | 1 | 211 | 7.57 | 2389.04 |
| Improving | 4 | 185 | 1 | 232 | 7.93 | 1721.34 |
| Historic | 4 | 197 | 1 | 242 | 8.30 | 977.31 |

†Simple averages, data for demonstration purposes only

### *References*

Johnston, A. M., Tanaka, D. L., Miller, P. R., Brandt, S. A., Nielsen, D. C., Lafond, G. P., Riveland, N. R. 2002. Oilseed Crops for Semi-Arid Cropping Systems in the Northern Great Plains. Agronomy Journal 94 (2): 234-241.

Manitoba Agriculture. Flax- Production and Management. Accessed at https:www.gov.mb.ca on 17 December 2018.

North Dakota State University Publications. 2007. Flax Production in North Dakota (A1038 Revised). Accessed at https://www.ag.ndsu.edu

## Demonstration of Fortress and Avadex herbicides for kochia control in pea

**Project duration**: 2018

**Collaborators**: Gowan Canada - Mike Grenier

### *Objectives*

To evaluate the efficacy of Fortress and Avadex herbicides as alternatives for control of kochia in peas

### *Background*

Kochia is well adapted to hot, dry conditions and soils with high salinity, typical of some agricultural lands in the Prairies. The weed is invasive, genetically diverse and is capable of producing over 30 000 seeds per plant. The seedlings usually emerge early in spring but germination can extend throughout the growing season. As a result, kochia is problematic in fallow periods between crops and nearly 70% losses in crop yield are assured if it emerges early. Furthermore, if not controlled effectively, it interferes with harvesting operations.

Herbicide resistance by kochia has been accelerated by its high genetic diversity, fast establishment and poor timing of herbicide application (Fischer et al., 2000). Under favorable conditions for germination, kochia seeds germinate in 2 to 3 hours and if no efforts are put in place such as application of soil incorporated herbicides, the weed becomes difficult to control as the season progresses. Research has shown that kochia is resistant to all four herbicide target sites: Group 2 ALS inhibitors, Group 4 synthetic auxins, Group 5 Photosystem II inhibitors and Group 9 EPSP synthase inhibitors (Thompson et al., 2013). Some of the ways that have been used to control kochia include application of preplant soil incorporated herbicides so as to start the field clean, early post emergence herbicide application when kochia seedlings are still small and effective herbicide rotations (Gustafson et al., 2015).

There is a need to explore other options such as Fortress and Avadex herbicides to control kochia in peas and other related crops. Avadex is a Group 8 while Fortress is classified as Group 3 and 8, and these

are preplant soil incorporated herbicides that can be used as effective alternative options for addressing herbicide resistance by kochia, wild oats and other problem weeds in the Prairies.

## *Materials and Methods*

The demonstration was conducted at Melita on imperfectly drained Waskada loam soils. The demonstration plots were not randomized but arranged in blocks as follows:

| **Treatment/Herbicide** | **Block** |
|---|---|
| UTC (2 guards) | 1 |
| Fortress MA | 1 |
| Edge granular† | 1 |
| GWN 10649 (new) | 1 |
| Fortress MA + Odyssey | 2 |
| Edge granular + Odyssey | 2 |
| GWN (new) + Odyssey | 2 |
| Odyssey (2 guards) | 2 |
| Odyssey (3 plots) | 3 |

†Granular herbicide was applied pre-seeding using a Valmar fertilizer spreader

Granular BASF inoculant was mixed with the seed and the plots were seeded on the 7th of May followed by a burnoff with 0.75L $ac^{-1}$ Roundup a day later. Granular fertilizer blend side banded at 15-35-24-9 (N-P-K-S) lb $ac^{-1}$ was applied during seeding. The plots were rolled over after seeding so as to create an even surface for easy harvesting. An application of 17.3g $ac^{-1}$ Odyssey mixed with Merge adjuvant was done for block (rep) 2 and 3 as part of the treatment. Two weeks before harvesting, the plots were desiccated using 0.65L $ac^{-1}$ Reglone mixed with LI200 adjuvant to dry down pea stalks.

## *Results*

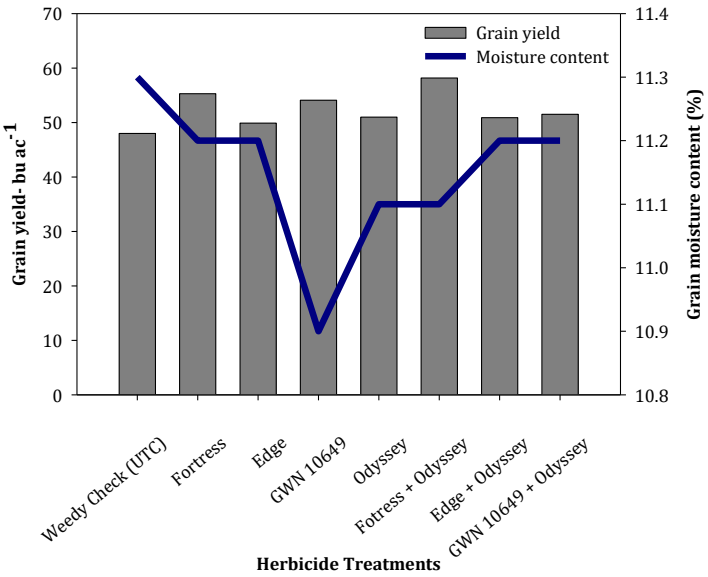



**Figure 1:** Grain yield and moisture content of peas treated with different herbicides at Melita in 2018.

The pea herbicide demonstration trial was conducted to demonstrate the efficacy of different types of herbicides to control weeds in peas. Overall the check (UTC) treatment had higher weed populations when compared with other herbicides treatments. This was based on visual observations and no statistical analysis was done. The lowest grain yield of 48 bu $ac^{-1}$ was recorded for the check treatment while Fortress + Odyssey treatment yielded 58.2 bu $ac^{-1}$. In general, all treatments out yielded the check treatment and had lower weed populations but pea grain moisture content did not differ much. The data presented only give an insight to efficacy and implications of different herbicides in weed control and yield of pea. These results were not analyzed because they do not meet the criteria for any statistical analysis as a result of no replication but there are plans to continue with the research for the next 2 or 3 years across different locations so as to come up with substantive conclusions and recommendations.

### *References*


Fischer, A. J., Messersmith, C. G., Nalewaja, J. D., Duysen, M. E. 2000. Interference Between Spring Cereals and *Kochia scoparia* Related to Environment and Photosynthetic Pathways. Agronomy Journal 92 (1): 173-181.

Gustafson, K., Wolf, R., Dahl, G., Spandl, E. 2015. Influence of Herbicides and Timing of Kochia (*Kochia scoparia*) Control in Spring Wheat (*T. aestivum*). Meetings paper: Applied Agronomic Research and Extension I. Madison, WI.

Thompson, C., Schlegel, A., Peterson, D. 2013. Glyphosate Resistant Kochia (*Kochia scoparia*) Management. Meetings paper: Applied Agronomic Research and Extension III. Madison, WI.


## Determining the optimum seeding window for soybeans in Manitoba

**Project duration:** 2017-2019

**Collaborators**: University of Manitoba, MPGA, Kristen MacMillan

### *Objectives*

The objective of this study is to determine the optimum seeding window for soybeans across Manitoba growing regions.

### *Background*

Traditional recommendations are to plant soybeans when soil temperature has warmed to at least 10°C, which is typically May 15-25 in Manitoba (Manitoba Agriculture). However, farmers have started to seed soybeans earlier and recent work by Dr. Yvonne Lawley and Cassandra Tkachuk (2017) supports this trend. They evaluated seeding dates across a range of soil temperatures from 6 to 14°C in 2014 and 2015; the earliest seeding dates maximized yield regardless of soil temperature and it was concluded that calendar date is a superior indicator. To update seeding date recommendations across a wider range of environments and using defined calendar dates, this study was initiated at Arborg, Carman, Dauphin and Melita in 2017 and will continue through 2019.

## *Materials and Methods*

The experimental design is a split plot RCBD, with seeding window as the main plot and variety as the split plot. The four seeding windows tested were “very early” (April 28 to May 4), “early” (May 8 to 14), “normal” (May 16 to 24) and “late” (May 31 to June 4). The short season variety S007Y4 and mid season variety NSC Richer were seeded within each seeding window.

## *Results*

The preliminary combined analysis from 2017 to 2018 indicates that soybean yield was affected by the main effects of environment (E) and seeding date (SD), and their interaction (E x SD). Overall, soybean yields were below average to average in these dry growing environments, ranging from 21-40 bu/ac, with the exception of Dauphin18 which yielded 64 bu/ac. Looking at individual environments (data not shown), yield maximization occurred in the first seeding window for 3 out 7 environments, out yielding the second and third dates by 2-12%. In the other 4 out of 7 environments, yield maximization occurred in the second seeding window (early) by 1-14% compared to the first and third dates. In 2 out of those 4 environments (Carman17 and Melita17), soybeans in the first seeding date were beginning to emerge and were exposed to spring frost which is an important consideration for very early seeding (Figure 1). Yield differences among the first three seeding windows were statistically similar in 5 out of 7 environments and reduced yield with late seeding was consistent across all environments contributing to a meaningful overall effect of seeding date (Figure 2). Overall, soybean yield was statistically similar when seeded between April 28 and May 24, seeding beyond which reduced soybean yield by 20% on average. At Arborg18, soybean yield was statistically higher at the second seeding date compared to the first and last date. Due to this occurrence and associated frost risk observed at two other environments, farmers may want to consider waiting until the 2nd week of May to seed soybeans in Manitoba. Other measurements being collected include emergence, crop phenology, maturity and seed quality. This data continues to be analyzed to help refine overall seeding date recommendations.

**Figure 1.** Soybean seedlings in the first seeding window (April 28 to May 4) were emerging and exposed to the last spring frost in 2 out of 7 environments, making frost exposure an important risk with very early seeding.

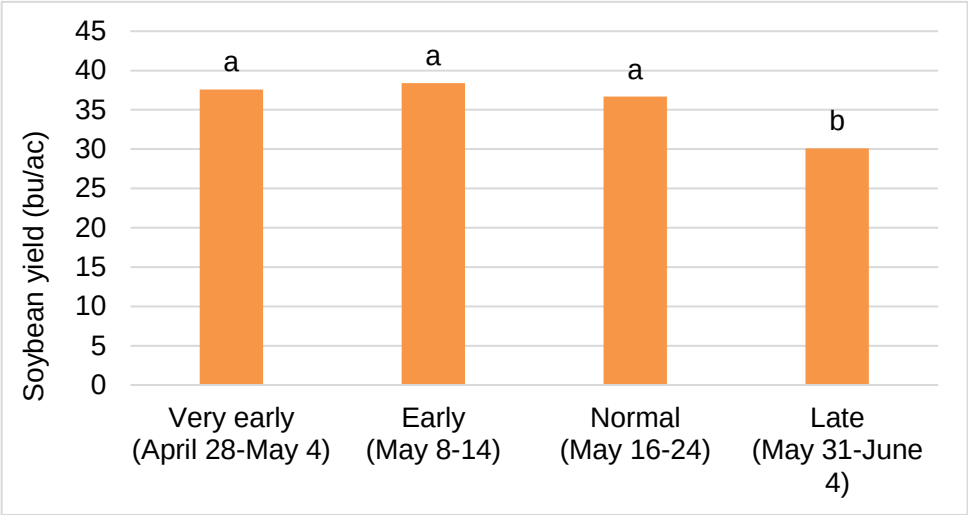



**Figure 2.** Soybean yield by seeding window among 7 site-years in Manitoba from 2017-2018. Means followed by the same letter are not statistically different at $P < 0.05$.


### *Acknowledgements*

Funding for this project has been provided by the Manitoba Pulse & Soybean Growers.


## Pre-harvest herbicide and desiccation options for straight-combining canola: Effects on plant and seed dry-drown, yield and seed quality


Lead Researchers:

| | |
|---|---|
| Chris Holzapfel | IHARF, Indian Head, SK |

Research Team Members:

| | |
|---|---|
| Jessica Pratchler | NARF – Melfort, SK |
| Jessica Weber | WARC – Scott, SK |
| Scott Chalmers | WADO – Melita, MB |
| Danny Petty | IHARF – Indian Head, SK |


2018 Brief Interim Report – Year 2 of 3 (2017-2020)

### *Objectives*

The project objectives were to evaluate the effectiveness of pre-harvest herbicide/desiccant applications for assisting plant and seed dry-down for the two dominant herbicide systems (Liberty Link® and Roundup®). The options and relative performance for Clearfield® canola would presumably be similar to Liberty Link® canola.

## *Methods*

Field trials were completed at four locations in the 2017 and 2018 growing seasons: Indian Head (SK), Melfort (SK), Scott (SK) and Melita (MB). In 2017, the varieties 233P (Liberty Link® - LL - glufosinate ammonium tolerant) and 45M35 (Roundup Ready® - RR - glyphosate tolerant) were seeded into cereal stubble in mid-May at a rate of 120 seeds/m2. In 2018, 233P was replaced with 255PC under the expectation (based on consultations with BASF) that this would result in more similar maturity between the two hybrids; however, actual results varied. With the exception of 2017-Melfort where no herbicides were applied, weeds were controlled using registered pre-emergent and in-crop herbicides. At Indian Head and Melita, conventional canola products (i.e. Edge, Lontrel, Muster, Assure 2) were utilized while, at Scott in both years and Melfort in 2018, each variety was sprayed with its partner in-crop herbicide (i.e. glyphosate or glufosinate ammonium). The pre-harvest treatments were targeted for 60-75% seed colour change (glyphosate and saflufenacil) or approximately 90% seed colour change (glufosinate ammonium and diquat); however, maturity between the two hybrids differed at some sites. At the sites where the relative maturity of the hybrids differed, compromises were either made in crop stage where treatments were applied or the application dates were adjusted to better accommodate differences in maturity between hybrids. For all products, excluding glyphosate applied alone (where lower application volumes were permitted but not required), the minimum solution volume was 187 l/ha (20 U.S. gallons per acre). Treatment application dates and other agronomic information for each location-year are provided in the Appendices (Tables A1 and A2). A total of 10 treatments were arranged in a RCBD with four replicates (Table 1). Treatment 7 (RR – glufosinate ammonium) was not included at the 2017-Melfort site.

**Table 1.** Treatment list for Canola Pre-harvest Application Study (CARP 2017.9).

| **Treatment Name** | |
|---|---|
| **1)** LL – untreated | **6)** RR – untreated |
| **2)** LL – glyphosate (890 g ai/ha) [Z] | **7)** RR – glufosinate ammonium (408 g ai/ha) [Y] |
| **3)** LL – saflufenacil (50 g ai/ha) [Z] | **8)** RR – saflufenacil (50 g ai/ha) [Z] |
| **4)** LL – glyphosate (890 g ai/ha) + saflufenacil (50 g ai/ha) [Z] | **9)** RR - glyphosate (890 g ai/ha) + saflufenacil (50 g ai/ha) [Z] |
| **5)** LL – diquat (40 g ai/ha) [Y] | **10)** RR – diquat (40 g ai/ha) [Y] |

LL – glufosinate ammonium tolerant; RR – glyphosate tolerant

[Z] 60-75% seed colour change; [Y] 90% seed colour change

Various data were collected through the growing season, at the time of harvest, and during the winter months. To help understand overall environmental conditions and potential inconsistencies between hybrids, emergence was assessed at approximately 3-4 weeks after seeding by recording the number of plants in 2 x 1 m sections of crop row per plot and converting the values to average plants/m$^2$. Once the treatments were applied, visual assessments of stem / overall plant dry-down (rating scale of 0-100) were completed on weekly intervals starting on the day of application with a final set of ratings on all plots immediately prior to harvest. The visual assessments of crop dry-down were not completed at Melfort 2017 and, in general, were rather subjective but were considered necessary to provide information on the overall rate of crop dry down. The target harvest timing was before the crop dried

down to the extent that treatment effects would no longer be evident but late enough that the canola could still be readily threshed and put through the combines without plugging or yield loss; however, all treatments within a given hybrid were always harvested on the same date. Both hybrids were combined on the same date for all location-years except Scott 2017 where the RR hybrid was harvested three days later than the LL hybrid, L233P in 2017. Immediately after harvest, percent seed moisture was determined by weighing minimum 100 g sub-samples fresh and again after being dried for at least 24 hours at 70 °C or higher. Whole plant (including seed) moisture was determined either immediately before or after harvest (depending on plot size/harvest area) by harvesting representative plants from each plot at ground level, determining their fresh versus dry weights and calculating percent gravimetric moisture content. Seed weight was determined by counting a minimum of 300 seeds for each plot using an automated seed counting machine, weighing the counted seeds to the nearest 0.00 g and calculating g/1000 seeds. Percent distinctly green seed was determined for each plot from a crushed 500 seed sample.

### *Results*

At this preliminary stage, response data have been analyzed and summarized on an individual location-year basis in order to assess data quality or importance differences in environmental conditions prior to any combined analyses. The response data analyzed were plant density, final visual dry down ratings (at harvest), seed moisture, whole plant moisture, seed yield, thousand seed weight, and percent green seed. A mixed model analyses (pre-harvest treatments fixed, replicate random) was used along with contrasts to compare pre-determined groups of treatments or, where applicable, individual treatments of interest. In addition to the contrasts, individual treatment means were separated using a multiple comparisons test (Fisher's protected LSD test). The specific contrast comparisons were: 1) untreated vs treated, 2) untreated vs glyphosate (LL only), 3) untreated vs glufosinate ammonium (RR only), 4) untreated vs saflufenacil; 5) untreated vs saflufenacil + glyphosate; 6) untreated vs diquat; 7) glyphosate vs saflufenacil + glyphosate; 8) glyphosate vs diquat (LL only); 9) glufosinate ammonium vs saflufenacil plus glyphosate (RR only), 10) glufosinate ammonium vs glyphosate (RR only); and 11) saflufenacil + glyphosate vs diquat.

**Table. Treatment means and tests of fixed effects for stem, seed, and whole plant dry-down at Melita, Manitoba. The treatments were pre-harvest / desiccation options for glufosinate ammonium (LL) and glyphosate (RR) tolerant canola. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test; *P* ≤ 0.05).**

| | Melita – 2017 | | | Melita – 2018 | | |
|---|---|---|---|---|---|---|
| **Treatment** | **Visual Dry-down** [Z] | **Seed Moisture** [Y] | **Plant Moisture** [X] | **Visual Dry-down** [Z] | **Seed Moisture** [Y] | **Plant Moisture** [X] |
| | ---------- % ---------- | | | ---------- % ---------- | | |
| 1) LL – Control | 71.3 cd | 8.7 abc | 30.4 a-d | 100 | 5.0 a | 12.2 a |
| 2) LL – Glyphosate | 88.8 ab | 8.1 bcd | 21.6 d | 100 | 4.9 a | 14.5 a |
| 3) LL – Saflufenacil | 71.3 cd | 8.2 bcd | 31.2 ab | 100 | 5.0 a | 16.2 a |
| 4) LL – Safl + Glyph | 83.8 b | 8.5 a-d | 25.1 bcd | 100 | 5.0 a | 14.5 a |
| 5) LL – Diquat | 91.3 ab | 8.1 bcd | 21.8 cd | 100 | 4.8 a | 9.2 a |
| 6) RR – Control | 67.5 d | 9.5 a | 36.1 a | 100 | 5.0 a | 8.5 a |
| 7) RR – Gluf. Amm. | 90.0 ab | 7.8 cd | 28.2 a-d | 100 | 5.1 a | 8.1 a |
| 8) RR – Saflufenacil | 82.5 bc | 9.1 ab | 33.9 ab | 100 | 4.9 a | 6.2 a |
| 9) RR – Safl + Glyph | 86.3 ab | 8.7 abc | 30.7 abc | 100 | 4.8 a | 9.2 a |
| 10) RR – Diquat | 97.5 a | 7.5 d | 26.5 bcd | 100 | 4.9 a | 8.3 a |
| S.E.M. | 5.23 | 0.43 | 3.06 | – | 0.08 | 2.59 |
| LSD [X] | 12.34 | 1.13 | 8.89 | – | ns | ns |
| Pr > *F* (p-value) | <0.001 | 0.033 | 0.032 | – | 0.264 | 0.079 |

[Z] Final ratings completed just prior to harvest [Y] Gravimetric water content of seed at harvest
[X] Gravimetric water content of above-ground plant material at harvest

**Table.Treatment means and tests of fixed effects for seed yield, thousand seed weight, and percent green seed at Melita, Manitoba. The treatments were pre-harvest / desiccation options for glufosinate ammonium (LL) and glyphosate (RR) tolerant canola. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test; *P* ≤ 0.05).**

| | Melita – 2017 | | | Melita – 2018 | | |
|---|---|---|---|---|---|---|
| **Treatment** | **Seed Yield** | **Seed Weight** | **Green Seed** | **Seed Yield** | **Seed Weight** | **Green Seed** |
| | ----- kg/ha ----- | g/1000 seeds | ------- % ------- | ----- kg/ha ----- | g/1000 seeds | ------- % ------- |
| 1) LL – Control | 3584 a | 3.28 a | 0.3 bc | 2219 a | 2.25 b | 0.3 bc |
| 2) LL – Glyphosate | 3496 a | 3.21 a | 0.1 c | 2123 a | 2.27 b | 0.3 c |
| 3) LL – Saflufenacil | 3502 a | 3.20 a | 0.1 c | 2088 a | 2.25 b | 0.7 ab |
| 4) LL – Safl + Glyph | 3689 a | 3.18 a | 0.4 bc | 2171 a | 2.28 b | 0.4 abc |
| 5) LL – Diquat | 3648 a | 3.21 a | 0.1 c | 2025 a | 2.31 b | 0.5 abc |
| 6) RR – Control | 3613 a | 3.24 a | 0.9 b | 2145 a | 2.57 a | 0.2 c |
| 7) RR – Gluf. Amm. | 3524 a | 3.21 a | 0.7 bc | 2278 a | 2.59 a | 0.2 c |
| 8) RR – Saflufenacil | 3436 a | 3.27 a | 0.5 bc | 2248 a | 2.57 a | 0.3 c |
| 9) RR – Safl + Glyph | 3304 a | 3.27 a | 0.2 bc | 2237 a | 2.58 a | 0.2 c |
| 10) RR – Diquat | 3577 a | 3.29 a | 1.9 a | 2127 a | 2.52 a | 0.7 a |
| S.E.M. | 122.4 | 0.073 | 0.24 | 77.2 | 0.037 | 0.13 |
| LSD [X] | ns | ns | 0.71 | ns | 0.091 | 0.38 |
| Pr > *F* (p-value) | 0.070 | 0.864 | < 0.001 | 0.422 | <0.001 | 0.054 |

Key Findings and Observations to Date:

1. With low weed populations, dry late season weather, and early maturity (i.e. LL canola at Indian Head and Melita 2017, Melita 2018) there was little benefit to pre-harvest applications. The risks associated with later harvest are (within reason) arguably much lower with modern shatter tolerant canola hybrids than previous straight-combining research that mostly preceded this trait have suggested. This is arguably more likely to be the case in southern environments where both seeding and harvest tend to be earlier and, in general, the growing seasons are longer. With this in mind, growers planning to straight-combine shatter tolerant canola hybrids who have seeded early, achieved uniform stands, kept things reasonably free of weeds, and have no reason to expect unusual harvest delays should consider not spraying a viable and preferable option. As further testament to the efficacy of modern shatter tolerant hybrids, no shattering whatsoever was reported for any treatments at any locations, despite the occurrence of occasional delays and unfavourable weather between the treatment applications and harvest.

2. Diquat performed consistently well for both herbicide systems with respect to reducing seed and/or whole plant moisture content. With some exceptions (i.e. Scott 2017), diquat result in equal to or greater reductions in whole plant moisture content than any other options, regardless of herbicide system. Averaged across hybrids, diquat reduced seed moisture content at harvest 75% of the time (6/8 site-years) and whole plant moisture 63% of the time (5/8 location-years). Furthermore, there was a tendency (significant at $P \leq 0.1$) for reduced whole plant moisture content at two of the three remaining location-years. Although it must be applied later to prevent yield and quality loss, visual stem dry down ratings and past experience indicate that diquat begins working more quickly than any of the other options evaluated. Waiting for the appropriate application stage is extremely important with this product. This was illustrated at multiple locations where percent green seed was significantly higher with diquat compared the other options, most notably for the RR hybrid at Indian Head 2017. No such effects were observed with any of the other pre-harvest options evaluated.

3. While not registered for this specific purpose, pre-harvest glyphosate reduced seed moisture content in LL canola 50% of the time (4/8 location-years) and reduced whole plant moisture content 75% of time (6/8 location-years). Despite the final reductions in seed and plant moisture frequently observed, glyphosate is initially slow and less likely to improve harvestability in dry falls or when applied at later crop stages. Consistent improvements in harvestability or earlier harvest cannot necessarily be expected when glyphosate is applied alone; however, our results show that such benefits can frequently occur with LL canola provided that the herbicide is given sufficient time to work.

4. Reductions in seed and crop moisture with saflufenacil have been somewhat less consistent and/or smaller than with diquat and, in certain cases with LL canola (i.e. seed moisture at Indian Head 2018, seed and whole plant moisture at Scott both years), it appeared that the glyphosate was having a greater impact on crop dry down than the saflufenacil in the tank mix. Overall, saflufenacil appeared to reduce seed moisture content 25% of the time (2/8 location-years) and whole plant moisture 38% of the time (3/8 location-years). While it appears that diquat is more effective from a strictly crop dry down perspective, a scenario where saflufenacil plus glyphosate tank mixes may be particularly beneficial is in

the presence of substantial perennial weed (i.e. Canada thistle) populations for which the producer requires both long-term control and reasonably fast desiccation. Glyphosate alone is notoriously slow to dry down mature perennial weeds and, from a resistance management perspective, utilizing multiple modes of action against the same species is becoming a more frequently recommended practice. Saflufenacil may accelerate dry-down over glyphosate alone for many broadleaf weeds, with specific outcomes likely varying with weed species and growth stage.

5. Glufosinate-ammonium is not a registered pre-harvest option for canola and, to our knowledge, there is no indication that it will become one; however, it was registered for this purpose in the 1990s (i.e. Harvest, 1995 Saskatchewan Crop Protection Guide). The performance of this product was somewhat inconsistent with reductions in seed moisture 38% of the time (3/8 location-years) and whole plant moisture content 25% of the time (50% of the time at $P \leq 0.10$). It is probable that the relatively poor performance observed is due in part to the late application stage that was implemented for this project.

Field trials were completed at all four locations (Indian Head, Melfort, Scott, and Melita) in 2017 and 2018. Despite a few challenges and concerns identified in the first year of the project, progress is being made and is going fairly well considering the challenges of managing both genetic differences and variable weather/environmental conditions.

All available results to date have been statistically analyzed, summarized, and interpreted. Preliminary results will be made publicly available to interested parties online (www.iharf.ca) and will continue to be incorporated into extension activities (i.e. oral presentations, crop tours, annual reports, popular press) where opportunities arise.

Funding Contributions in Part By:

# Linseed Coop Evaluation

**Project duration:** 2018-2020

**Collaborators:** CDC Saskatchewan, Dr. Helen Booker (flax breeder)

**Funding:** Manitoba Flax Growers Association, BASF

## *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. There were other sites across the Canadian Prairies in various soil zones but they will not be discussed in this report. Twenty-six varieties were arranged as a randomized complete block design with three replicates. Among the Diversification Centres in Manitoba, Melita and Roblin were successful to harvest. Carberry suffered from herbicide and trash residues and Arborg had deer damage and low rainfall.

**Table 1:** Agronomic parameters for Melita and Roblin sites

| Location | Melita | Roblin |
|---|---|---|
| Plot size ($m^2$) | 12.96 | 6.00 |
| Field Prep | None | none |
| Stubble | RR Soybean | fallow |
| Burnoff | Sulfentrazone 100 ml/ac + Roundup @ 0.75L/ac | Heat 28 g/ac Roundup 0.67L/ac |
| Seeding Moisture | fair | fair |
| Seed Date | 8-May-18 | 24-May-18 |
| Seeder | Seedhawk dual knife 6 rows x 9.5"Spacing | Fabro knife 5 rows x 9.5" spacing |
| Fertility Applied (N-P-K-S lb/ac Actual) | Sideband 102-35-24-9 | Midrow 82-10-0-0 |
| Herbicides | Assure II @ 0.2L/ac | Centurion 0.5L/ac + Curtail M 0.81L/ac |
| | Spot sprayed Mextrol | |
| | Arrow 150 ml/ac | |
| Dessication Date, Produ | Reglone 0.65L/ac | Reglone 0.65L/ac |
| Harvest Date | 14-Aug-18 | 11-Oct-18 |

Additional data other than yield collected from the trial includes: emergence date, vigor, height, days to maturity, grain moisture, thousand seed weight, lodging, stem dry down, determinate growth habit. Subsamples were sent back to the Crop Development Centre in Saskatoon for further fatty acid and protein analysis.

## *Results*

Significant differences in Melita and Roblin were found among varieties tested. Most first and second year experimental lines (FP) were highest yielding at both sites and ranked relatively similar to western

Canada yields. Roblin overall was highest yielding site compared to Melita due to greater seasonal rainfall amounts (Melita at 163 mm vs. Roblin 380 mm).

**Table 2:** Yield Data of Melita and Roblin sites compared to western Canada data as a whole.

| ENTRY | Zone 1 Melita | Zone 3 Roblin | Western Canada | Zone 1 Melita | Zone 3 Roblin | Western Canada |
|---|---|---|---|---|---|---|
| Checks | | kg/ha | | % of CDC Glas | | Rank (1=best) |
| CDC Bethune | 1441 | 2222 | 2032 | 97 | 97 | 21 |
| AAC Bright | 1274 | 2080 | 1963 | 94 | 91 | 23 |
| CDC Glas | 1543 | 2295 | 2165 | 100 | 100 | 16 |
| SVPG Entries | | | | | | |
| CDC Plava | 1457 | 2102 | 1998 | 97 | 92 | 22 |
| NuLin VT50 | 1353 | 2072 | 1962 | 96 | 90 | 24 |
| WESTLIN 60 | 1345 | 2000 | 1896 | 92 | 87 | 26 |
| WESTLIN 72 | 1591 | 2153 | 2113 | 99 | 94 | 18 |
| Topaz | 1523 | 2312 | 2195 | 104 | 101 | 13 |
| CDC Buryu | 1410 | 2179 | 2080 | 101 | 95 | 19 |
| AAC Marvelous | 1563 | 2303 | 2161 | 102 | 100 | 17 |
| AAC Prairie Sunshine | 1401 | 2199 | 2074 | 99 | 96 | 20 |
| CDC Rowland | 1609 | 2192 | 2191 | 102 | 95 | 14 |
| CDC Dorado | 1363 | 2069 | 1906 | 92 | 90 | 25 |
| 2nd Year Entries | | | | | | |
| FP2566 | 1689 | 2334 | 2243 | 105 | 102 | 11 |
| FP2567 | 1676 | 2242 | 2252 | 107 | 98 | 8 |
| FP2568 | 1689 | 2281 | 2250 | 103 | 99 | 10 |
| FP2569 | 1729 | 2387 | 2298 | 109 | 104 | 3 |
| FP2570 | 1712 | 2279 | 2235 | 105 | 99 | 12 |
| FP2571 | 1659 | 2294 | 2253 | 107 | 100 | 7 |
| FP2572 | 1714 | 2302 | 2260 | 106 | 100 | 6 |
| FP2573 | 1601 | 2188 | 2252 | 107 | 95 | 9 |
| FP2574 | 1684 | 2279 | 2271 | 104 | 99 | 5 |
| 1st Year Entries | | | | | | |
| FP2585 | 1665 | 2298 | 2323 | 106 | 100 | 1 |
| FP2586 | 1688 | 2159 | 2177 | 102 | 94 | 15 |
| FP2587 | 1639 | 2417 | 2277 | 103 | 105 | 4 |
| FP2588 | 1750 | 2456 | 2311 | 107 | 107 | 2 |
| Grand Mea | 1568 | 2234 | 2159 | | | |
| C.V. % | 9.1 | 5.1 | 6.0 | | | |
| LSD | 443 | 422 | 164 | | | |
| No. of Reps | 3 | 3 | 27 | | | |

Zone 1: Black and Grey Soil; Longer Growing Season (Indian Head, Redvers, SK and Melita, MB)
Zone 2: Brown and Dark Brown Soil (Saskatoon and Scott, SK)
Zone 3: Black and Grey Soil; Shorter Growing Season (Glaslyn, Melfort, SK, Arborg, Roblin, MB and Thunder Bay, ON)
Irrigation: Outlook 1 & 2, SK and Lethbridge, AB
Quebec: ST MATHIEU-de-BELOEIL

# Determining agronomic suitability of European flax (linseed) cultivars in agro-Manitoba

***Project Duration:*** 2018

***Collaborators***: MFGA, PCDF, PESAI, WADO, BASF, Limagrain NL, van de Bilt zaden en vlas

## *Objectives*

The current study was developed to examine agronomic attributes (yield, height and maturity) of European-origin flaxseed cultivars and to see if they have a competitive advantage and agro-climatic fit within Manitoba flax production areas.

## *Background*

With the declining popularity of flax as a rotational crop choice in Manitoba, farmers need incentive to grow a crop like flax. A longstanding complaint is that current flax cultivars are not keeping up with yield advances, similar to gains made in canola, soybeans and to a lesser extent, cereals. This disparity is what encourages a switch away from flax and into higher-yielding, more profitable crops. Flax does have an important role to fill in Manitoba. As a non-host crop for many of the major diseases in western Canada, flax is well suited to break disease cycles and provide a stable, steady return as part of a balanced rotation. With the closure of private breeding programs at Nutrien Ag Solutions, and the public breeding programs at Agriculture and Agri-Food Canada, only a single breeder of flax remains in Canada at the Crop Development Centre. With the introduction and evaluation of European lines, there may be the possibility of a higher yielding cultivar, or a cultivar with more desirable quality characteristics may be found to be well suited to Manitoba's agro-climate.

## *Materials & Methods*

*Experimental Design* – Randomized Complete Block Design

*Treatments* – Flax grown in plots, all treated identically at a single site for fertility and weed control as per PRCO standards for Linseed Co-op testing.

*Varieties* – CDC Bethune, FX204, FX305, FX406, FX511, FX608, FX707.

*Seeding rate treatment* - 40lbs/acre, adjusted for individual variety germination percentage

| | |
|---|---|
| *Stubble, soil type* - | Arborg – fallow, heavy clay soil |
| | Melita – soybean, Waskada loam |
| | Roblin – oat/barley silage, Erickson clay loam |
| *Fertility* (lbs/ac) - | Arborg – 50lbs N, 20lbs $P_2O_5$ |
| | Melita – 102lbs N, 35lbs $P_2O_5$, 24lbs $K_2O$, 9lbs S |
| | Roblin – 79lbs N, 10lbs $P_2O_5$ |
| *Plot size* - | Arborg – 7.1m$^2$ |
| | Melita – 12.27m$^2$ |
| | Roblin – 5.98m$^2$ |

*Data collected* – yield, plant height at maturity, days to maturity, flowering period

## *Results*

Immediate yield results showed no statistical difference between European-origin lines and the Canadian-derived check, CDC Bethune at two of three diversification sites. At Melita (WADO), significant differences were apparent, although no difference existed between the check and the highest yielding European variety.

## *Project findings*

Dry and drought-like conditions at the test sites contributed to lower overall yields in flax production, as evidenced by low commercial yield in the area according to MASC. Short-stature flax was a result of continued moisture stress, along with overall thinner than ideal stands and the opportunity for weed competition. European flax lines were consistently shorter when compared to CDC Bethune, ranging from 6 to 10 centimetres shorter than check height at 53.7cm (Table 2). Overall days to maturity (DTM) were +1 to -5 days from the 87 DTM CDC Bethune rating (Table 3). Correspondingly, flowering period in European flax varieties was +1 to -7 days in variance from the average 21 day flowering period of CDC Bethune (Table 4).

**Table 1:** Yield Comparisons in European Flaxseed Test

| | 2018 Yield | | | | | |
|---|---|---|---|---|---|---|
| | Arborg | | Melita | | Roblin | |
| **VARIETY** | kg/ha | bu/ac | kg/ha | bu/ac | kg/ha | bu/ac |
| CDC Bethune | 1675 | 26.6 | 2227 | 35.4 | 2057 | 32.7 |
| FX 204 | 1674 | 26.6 | 2169 | 34.5 | 1959 | 31.1 |
| FX 305 | 1717 | 27.3 | 2314 | 36.8 | 1598 | 25.4 |
| FX 406 | 1560 | 24.8 | 1973 | 31.4 | 1670 | 26.5 |
| FX 511 | 1358 | 21.6 | 2156 | 34.3 | 1518 | 24.1 |
| FX 608 | 1362 | 21.7 | 2116 | 33.6 | 1565 | 24.9 |
| FX 707 | 1447 | 23 | 1840 | 29.3 | 1608 | 25.6 |
| **SITE GRAND MEAN** | 1542 | 24.5 | 2114 | 33.6 | 1711 | 27.2 |
| CV% | 9.1 | | 3.7 | | 14.8 | |
| LSD | - | - | 140.8 | 2.2 | - | - |
| Significant Diff.? | No | | Yes | | No | |
| **Seeding Date** | 22-May | | 07-May | | 22-May | |
| **Harvest Date** | 20-Sep | | 14-Aug | | 11-Oct | |

**Table 2:** Mature plant height (in centimetres) of European lines against CDC Bethune check.

| Variety | Arborg | Melita | Roblin | Average | +/- Check |
|---|---|---|---|---|---|
| *CDC Bethune* | *43.8* | *62.0* | *55.3* | *53.7* | *0* |
| FX 204 | 35.7 | 51.7 | 55.7 | 47.7 | -6 |
| FX 305 | 37.8 | 51.7 | 46.0 | 45.2 | -9 |
| FX 406 | 39.7 | 53.3 | 48.0 | 47.0 | -7 |
| FX 511 | 36.8 | 49.3 | 45.7 | 43.9 | -10 |
| FX 608 | 36.2 | 50.0 | 46.3 | 44.2 | -10 |
| FX 707 | 41.3 | 46.0 | 45.3 | 44.2 | -10 |

**Table 3:** Days to maturity of European lines against CDC Bethune check.

| Variety | Arborg | Melita | Roblin | Average | +/- Check |
|---|---|---|---|---|---|
| *CDC Bethune* | *95* | *84* | *82* | *87* | *0* |
| FX 204 | 98 | 86 | 81 | 88 | +1 |
| FX 305 | 94 | 85 | 79 | 86 | -1 |
| FX 406 | 91 | 84 | 77 | 84 | -3 |
| FX 511 | 90 | 83 | 74 | 82 | -5 |
| FX 608 | 91 | 84 | 79 | 85 | -2 |
| FX 707 | 91 | 84 | 76 | 84 | -3 |

**Table 4:** Length of flowering period (in days) in European flax cultivars.

| Variety | Arborg | Melita | Roblin | Average | +/- Check |
|---|---|---|---|---|---|
| *CDC Bethune* | *29* | *22* | *11* | *21* | *0* |
| FX 204 | 31 | 25 | 11 | 22 | +1 |
| FX 305 | 20 | 15 | 10 | 15 | -6 |
| FX 406 | 13 | 22 | 11 | 15 | -6 |
| FX 511 | 16 | 17 | 11 | 15 | -6 |
| FX 608 | 16 | 22 | 12 | 17 | -4 |
| FX 707 | 16 | 12 | 13 | 14 | -7 |

Testing is underway at the University of Saskatchewan to determine oil content, fatty acid profile and other desirable characteristics. Further data will be communicated upon completion of this project.

# Industrial hemp grain and fibre variety evaluation

**Project duration**: ongoing
**Collaborators**: Canadian Hemp Trade Alliance

## *Background*

The Canadian Hemp Trade Alliance (CHTA) is a not-for-profit organization which represents over 260 growers across all 10 provinces as well as numerous processors, distributors, developers and researchers involved in Canada's rapidly growing industrial hemp industry.

There were a number of new developments in Canadian legislation in 2018 which very directly affects Canadian hemp growers. The CHTA website outlines these new developments, specifically the changes in Cannabis legislation as well as Health Canada's revision of Section 56 of the Controlled Drugs and Substances Act (CDSA). These changes now allow hemp farmers to immediately collect and store industrial hemp flower, bud and leaf material, a vital piece which was previously prohibited.

Jason Green, Head of Agriculture with Canopy Hemp and Director of the CHTA explains that this new permission allows hemp growers to learn more about the harvesting, drying and storing of their harvest materials, a key component in then bringing their product to market.

This trial looked at separate grain and fibre varieties of hemp.

## *Objectives*

To evaluate grain yield and fibre obtained from hemp varieties

## *Materials and Methods*

The trials were located at Melita, Roblin, Arborg and Carberry in Manitoba. Melita location was established on a previously roundup ready soybean field and was arranged as randomized complete block design with 15 treatments (varieties) replicated 4 times.

| Fertility | N | P | K | S |
|---|---|---|---|---|
| | lbs/ac | | | |
| Soil Test (0-24") | 30 | 8 | 600 | 190 |
| Applied | 117 | 35 | 25 | 10 |

| | |
|---|---|
| Soil Type | Waskada Loam |
| Legal Land Location | SW 18-4-26 W1 |
| Burnoff | May 18 0.75 L/ac Roundup |
| Seed Date | May 17th |
| Depth | 0.75" |
| Herbicides Used | Koril @ 0.5 L/ac applied June 13 |
| | Arrow @ 150 ml/ac June 13 + X-act @ 0.5% v./v. |
| Harvest Date Fibre | August 1st |
| Harvest Date Grain | August 24 to 30 |

### *Results*

Results Grain yield results are available through the SEED Manitoba guide (2018). Graphical yield results for Melita are displayed below according to grain and fibre yields.

**Figure:** Hemp Fibre Yield Results at Melita, 2018.

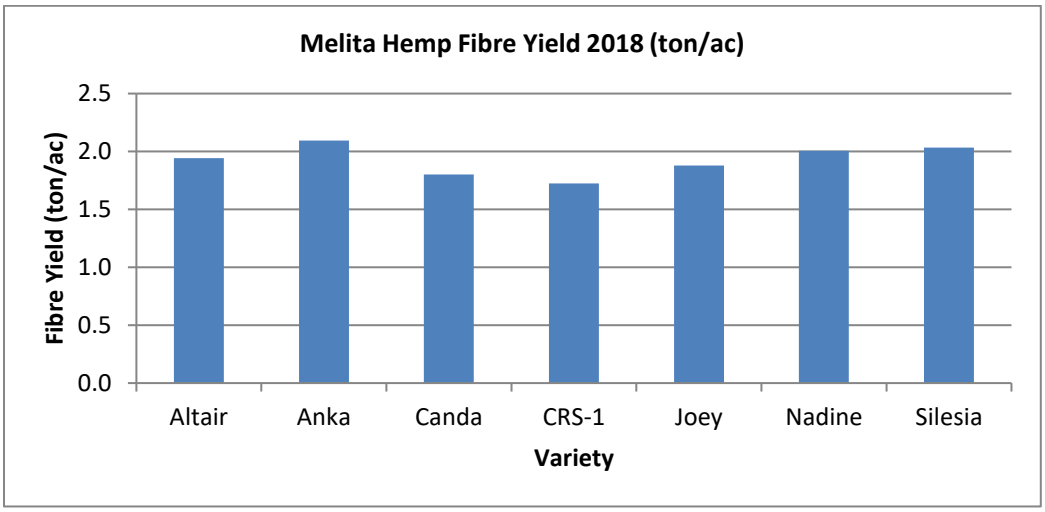
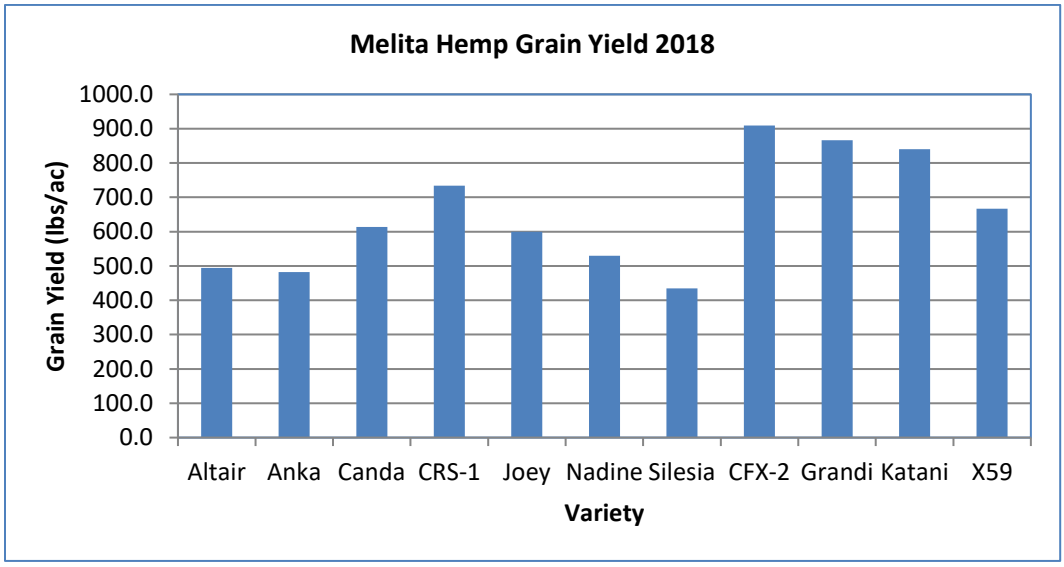



**Figure:** 2018 Hemp Grain Yield Results at Melita, 2018. LSD = 12 lbs/ac, C.V. = 10%



# Performance and adaptation of Quinoa varieties

**Project duration**: 2017, 2018, 2019

**Collaborators**: Percy Phillips-NorQuin

## *Objectives*

To determine yield potential of 5 quinoa varieties across different locations in Manitoba

## *Background*

Quinoa crop is adapted to a long growing season characterized by short day length and cool temperatures. Depending on the variety and weather conditions, the crop requires between 90 and 125 days to complete its life cycle (OMAFRA, 2012). Quinoa can also withstand temperature as low as -1.1°C but temperature below -2.2°C during mid-bloom stage can cause more than 70% yield loss due to flower abortion. Significant yields losses also occur when exposed to temperature below -6.7°C before dough stage (AAFRD, 2005). Research has also shown that elevated temperature above 35°C for lengthened periods during the reproductive stage can cause dormancy and pollen sterility in quinoa (Oelke et al. 1992; OMAFRA, 2012).

Although high altitude regions are not ideal for quinoa to reach its potential, research has shown that new varieties are capable of maturing within a short growing season such as that which is experienced on the Prairies. This could be the reason why quinoa production has been on the rise on the Prairies and in Canada at large over the past few years. Available data shows that there are more than 5 000 acres of quinoa in Canada, with most of the production being done in Saskatchewan where the crop was first introduced to Canada. As of 2014, there were a total of 38 quinoa producers but the number has since increased and includes Canada's biggest producer with 600 acres in Manitoba (NorQuin, 2014). The increase in the number of farmers and area under production could be attributed to the positive trends in weather patterns which seem to favor quinoa production, availability of new adapted varieties as well as profitability when comparing with other crops.

## *Materials and Methods*

The trials were conducted at four locations in Manitoba: Melita, Roblin, Carberry and Arborg. The trials were arranged as randomized complete block design with 5 treatments (varieties) and 3 replicates over 4 site-years. Varieties seeded were: PHX16-01, PHX16-02, PHX16-03, PHX16-07 and PHX16-08. In Melita, the plots were seeded on the 7th of May at a depth of 1 inch and a burnoff application with 0.75L $ac^{-1}$ Roundup was done on the following day. Granular and liquid fertilizer was side banded at 115-35-24-9 (N-P-K-S) lb $ac^{-1}$ during seeding. Post emergence weed control included 0.15L $ac^{-1}$ Arrow + 0.5% v/v X-Act adjuvant in a single spray application and a desiccant application with 0.059L $ac^{-1}$ Heat + 1L $ac^{-1}$ Roundup + 0.4L $ac^{-1}$ Merge adjuvant a week prior to harvest. Major insect pests of concern was goosefoot groundling moth larvae, these were controlled using 0.133L $ac^{-1}$ Cygon and 0.0332L $ac^{-1}$ Matador after assessing damage on the plants. Data collected included: emergence date, plant stand, days to heading, days to flowering, and days to maturity, grain yield and moisture content at harvest.

### *Results*

There were significant maturity, lodging and yield differences between varieties tested (Table). Lowest yielding variety PHX16-01 had poor germination leading to poor stand insect pressure (from goosefoot groundling larvae) causing poor standability and yield compared to all other varieties. PHX16-07 had matured someone earlier but this was not found to be significant compared to other varieties.

| Variety | Maturity days | Lodging 1 to 9 (9 flat) | Grain Yield kg/ha | |
|---|---|---|---|---|
| PHX16-01 | 107 | 9 | 288 | b |
| PHX16-02 | 110 | 2 | 1565 | a |
| PHX16-03 | 103 | 3 | 1404 | a |
| PHX16-07 | 99 | 1 | 1769 | a |
| PHX16-08 | 108 | 1 | 1792 | a |
| Coefficient of Variation % | 1.2 | | 16 | |
| LSD (p<0.05) | NS | | 403 | |
| P value | 0.41 | | 0 | |
| R-squared | 0.95 | 1.00 | 0.93 | |

### *References*

Alberta Agriculture, Food and Rural Development. 2005. Quinoa: The Next Cinderella Crop for Alberta?
Ontario Ministry of Agriculture, Food and Rural Affairs. 2012. Quinoa. In: A Resource for Specialty Crop Growers. Government of Ontario.

## Quinoa seeding date evaluation

**Project duration**: 2017
**Collaborators**: Percy Phillips-NorQuin

### *Objectives*

To determine the optimum seeding date and yield potential for quinoa

### *Background*

Quinoa originated from South America and is grown in areas that are prone to drought and low natural fertility. Despite having many nutritional benefits including being gluten free, quinoa remains a small niche crop in Canada. There is still extensive worldwide interest in the pseudo cereal as a result of its nutritional benefits and its adaptation to marginal soils characterised by high saline as well as dry conditions susceptible to frost (Jacobson et al., 2007; Eisa et al., 2012). Quinoa, just like corn and soybean, is a full season grain crop and requires a minimum of 250mm of evenly distributed rainfall throughout the growing season in order to reach its full potential. Therefore, timing of seeding becomes

crucial if the crop is to reach maturity before killing frost occurs, especially on the Canadian Prairies that are characterized by short growing season and sometimes erratic rainfall.

Seeding dates and life cycle for quinoa vary depending on the region but in most parts of the USA and the Andean region where it originated, seeding is done very early to ensure that the crop utilizes the full 6 months of its life cycle (Sajjad et al., 2014). Quinoa varieties also perform differently and can be influenced by the latitude and altitude from which they originated (Curti et al., 2016). Recent advances in breeding have tried to develop hybrids that can mature within the growing season in different climates including on the Canadian Prairies that are characterized by a short growing season normally averaging 115 days. The objective of this study was to determine the optimum seeding date for quinoa under climatic conditions that prevail on the Canadian Prairies.

## *Materials and Methods*

The trials were conducted at Melita, Arborg, Carberry and Roblin in Manitoba. The trials were arranged as randomized complete block design with 7 treatments (seeding dates) and 4 replicates over 4 site-years. Seeding dates in Melita for quinoa are presented in the results table.

Stubble – RR soybean
Residual Soil Fertility – 18 lbs/ac N (0-24”), 12 ppm P, 333 ppm K, 174 lbs/ac S (0-24”)
Burnoff – Roundup 0.75 ml/ac
Seeding Equipment – SeedHawk Dual Knife with 6 rows at 9.5” row spacing
Plot Size – 12.96 $m^2$
Seed Depth – 1”
Fertility Applied – Sideband 115 N - 35 P -24 K -9 S (lbs/ac) UAN and Granular blend
Insecticides –Cygon applied at 133 ml/ac for Goosefoot groundling moth larvae (stem worms) applied July 13, 27, & Aug 17
Herbicides - Arrow @ 150 ml/ac Applied June 13 for grassy weeds
Desiccants - Heat 59ml/ac + Roundup 1L/ac + Merge .4L/ac applied Sept 6 for May seed dates, Sept 28 for June seed dates.
Harvest Management – Straight cut 25-Sep for May seed dates, swathed June seed dates on Oct 4 and brought those into shed for drying, threshed week later.

## *Results*

There were significant differences in stand, vigor, days to flower, height, maturity, yield and lodging among seed date treatments. In general, June plantings had greater stand assessments likely due to better soil moisture conditions. Early soil moisture plantings had lesser stand values and vigor since drought conditions were underway. Greatest plant height occurred with early plantings likely since later plantings were affected by shorter day length (photosensitivity). Maturity was longest for early and late plantings but not for intermediate seed dates. Yield was greatest for form most dates except June 4 and June 12 which were significantly lower. Lodging was greatest on May 7 and June 4 plantings and lodging may be influenced by incidence of goosefoot groundling moth (*Scrobipalpa atriplicella*) causing secondary stem fungal infections that weakens the stems leading to lodging later in season.

**Table 1:** Results of various seeding dates for quinoa in Melita, MB grown in 2018.

| Seed Date | Stand 1-5 (good) | Vigor 1-5 (5 good) | Flower days from seeding | Height cm | Maturity days from seeding | Yield kg/ha | Lodge 1-5 (5 flat) |
|---|---|---|---|---|---|---|---|
| 07-May | 2.8 | 3.1 | 43 | 107 | 107 | 1545 | 1.8 |
| 14-May | 3.3 | 2.4 | 44 | 96 | 98 | 1500 | 1.0 |
| 18-May | 3.0 | 3.9 | 42 | 89 | 94 | 1653 | 1.0 |
| 25-May | 3.9 | 4.1 | 36 | 85 | 84 | 1382 | 1.0 |
| 04-Jun | 4.0 | 3.5 | 34 | 89 | 88 | 912 | 1.8 |
| 12-Jun | 4.1 | 3.9 | 30 | 78 | 92 | 928 | 1.0 |
| 18-Jun | 3.9 | 3.1 | 30 | 83 | 105 | 1406 | 1.3 |
| Grand Mean | 3.6 | 3.4 | 37 | 90 | 95 | 1332 | 1.3 |
| CV% | 14 | 10 | 1 | 9 | 2 | 27 | 24 |
| LSD | 0.7 | 0.5 | 0.3 | 11.4 | 2.5 | 538.8 | 0.4 |
| P value | 0.004 | <0.001 | <0.001 | 0.001 | <0.001 | 0.05 | 0.002 |
| R-squared | 0.67 | 0.82 | 1.00 | 0.71 | 0.97 | 0.52 | 0.70 |

Picture: Arrow pointing to larva of the goosefoot groundling moth which feeds inside the stems of quinoa plants.

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# Effect of applied urea and agrotain treated urea in soybean and flax intercrop

***Project duration***: 2017, 2018, 2019

## *Objectives*

1. Determine yield obtained from soybean and flax intercropped in paired rows
2. Determine the precision spread of urea on soybean yield and nodulation with and without agrotain inhibitors
3. Determine the effects of fertilizer and crop type (interaction) in soybean-flax intercrop on yield and nodulation

## *Background*

Intercropping is an agricultural system that has been embraced worldwide as a result of its benefits that include: greater yields, less disease, pests and weed pressure, soil and moisture conservation and improving soil nutrient status without the need for more synthetic fertilizers than in sole cropping systems (Szumigalski and Van Acker, 2005). Although there might be challenges in harvesting mixed crops, there has been an increase in acres under intercropping in Western Canada as a result of benefits associated with it. Any intercropping system involving soybean usually results in nitrogen credits for the succeeding crop and this in turn results in reduction in fertilizer costs and higher gross returns.

Most intercropping systems involve a legume and non-legume crop so as to maximize benefits from both crops. In most cases, legume-cereal intercrops result in increased dry matter production and grain yield more than sole crops. When there is a limitation in fertilizer nitrogen, biological nitrogen fixation becomes the major source of nitrogen in mixed cropping systems involving a legume crop (Fujita et al., 1992). The use of legumes that are tolerant to nitrate and whose biological nitrogen fixation is less affected by application of combined nitrogen, may increase the amount of N available for the other component crop without affecting nodulation of the legume itself. When applying nitrogen to legumes, it is important to consider factors such as the source, timing and placement depth. Research conducted by Takahashi et al. (2012) suggested that deep placement of coated urea at seeding did not depress nodulation resulting in improved soybean growth and increase in seed yield while top dressing with the same fertilizer inhibited nodule activity after R3 stage, and subsequently resulted in low seed yield. In a related study by Laboski (2006), Agrotain was shown to effectively reduce the conversion of surface applied urea or urea ammonium nitrate to ammonium resulting in increased grain yield due to reduced nitrogen losses. This study therefore seeks to determine the influence of soybean and flax intercrop and whether agrotain inhibitor has any influence on nodulation and seed yield between the component crops.

## *Materials and Methods*

The trial was conducted at Melita in southwestern Manitoba. The treatments were established on a previously roundup ready soybean field with a Waskada loam soil. A randomized complete block design with 4 treatments replicated 3 times was used. Seeding was done on the 23rd of May at a depth of 1 inch and treatments were applied as indicated in the table below.

**Table 1:** Treatment description for Soybean-flax intercrop

| Treatment[a] | Crop | Application rate (lb $ac^{-1}$) |
|---|---|---|
| 1 | Soybean | No N-check |
| 2 | Soybean | 60 Agrotain N |
| 3 | Soybean | 60 Urea N |
| 4 | Flax | No N-check |
| 5 | Flax | 60 Agrotain N |
| 6 | Flax | 60 Urea N |
| 7 | Soybean and Flax | No N-check |
| 8 | Soybean and Flax | 60 Agrotain N |
| 9 | Soybean and Flax | 60 Urea N |

[a]Treatments 7 through 9 involved 2 soybean rows in the middle and 2 flax rows on either side of the soybean rows

All soybean seed was treated with granular BASF inoculant before seeding and granular fertilizer blend was side banded at a rate of 15-35-24-9 (N-P-K-S) lb $ac^{-1}$ during seeding. A tank mixture of 0.1L $ac^{-1}$ Sulfentrazone and 0.75L $ac^{-1}$ Roundup was applied as burnoff a day after seeding. Another chemical weed control application with 0.1L $ac^{-1}$ Arrow + 0.91L $ac^{-1}$ Basagran + 0.5% v/v X-Act was done in a single tank mixture about 5 weeks after seeding. A desiccant in the form of 0.69L $ac^{-1}$ Reglone + LI200 adjuvant was applied two weeks before harvesting, this also acted as a way of controlling late weeds. Data collected included: nodule counts, light interception, soil moisture content, above ground biomass yield, days to maturity, grain yield and moisture content at harvest. The data were subjected to factorial ANOVA Minitab 18 statistical packages for determination of treatment differences. Mean separation was conducted by Fisher's LSD at the 5% level of significance.

## *Results*

Intercropping significantly increased soybean nodules than when then crop was grown alone ($P<0.001$), on the other hand, significant grain yield and land equivalent ratio (LER) reduction was observed in intercropped treatments than in standalone soybean or flax treatments. The addition of urea or Agrotain treated urea also significantly reduced nodule development and soybean yield compared to soybeans without additional nitrogen application; however under this same fertility treatment intercropping with flax significantly increased nodulation, lessening the negative effect of the fertilizer on nodule development. There was no difference in nodule development or soybean yield between urea and Agrotain treated urea.

Flax yield and LER reduced by intercropping with soybean and flax yields increased significantly with the use of urea fertilizers compared to the untreated check.

Total yield overall was significantly greater ($P<0.001$) in flax than in monocrop flax and intercrop. Use of urea fertilizers did not significantly make a difference overall, however the combination of cropping and fertilizer use made some influence. Use of Agrotain fertilizer resulted in greater flax yield specifically likely because Agrotain's purpose is to increase nitrogen use efficiency by reducing volatilization, making it more readily available than untreated urea. Generally intercropping effect blurred the differences between flax and soybean in relation the their individual yield response to nitrogen. It is also possible that soybean treatments may have been using the additional nitrogen for its own growth making it less available to flax, despite the urea being placed on top of flax rows specifically for this reason. Soybean can be notorious for utilizing locally available nitrogen in the soil prior to fixing it with Rhizobia.

There were significant differences in soybean plant height with taller soybean plants in monocrop treatments than in intercrop. Adding to this, the combination of intercropping and the addition of urea also exacerbated stunting of bean height compared to monocrop soybeans. This may be due to flax increasing in plant height with additional urea application which may compound moisture stress in the intercrop soybean (photo right).

**Table 2:** Summary of mean nodule count, grain yield and land equivalent ration of flax and soybean monocrops and intercrops.

| Factor | | | Soybean | | | Flax | | TOTAL | Overall |
|---|---|---|---|---|---|---|---|---|---|
| | | | **Nodules** | **Yield** | **S-LER** | **Yield** | **F-LER** | **Yield** | **T-LER** |
| | | | (Log10) per plant | kg/ha | | kg/ha | | kg/ha | |
| Crop | Soybean | 1 | 1.32 b | 929 a | 0.879 a | - | - | 929 b | 0.88 b |
| | Flax | 2 | - | - | - | 1266 a | 1.02 a | 1266 a | 1.02 a |
| | Intercrop | 3 | 1.53 a | 141 b | 0.133 b | 882 b | 0.71 b | 1023 b | 0.84 b |
| | Significant? | | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Fertility | 0N | 1 | 1.59 a | 604 | 0.572 | 942 c | 0.76 b | 1031 | 0.89 |
| | Agrotain | 2 | 1.37 b | 498 | 0.470 | 1225 a | 0.99 a | 1149 | 0.97 |
| | Urea | 3 | 1.32 b | 503 | 0.476 | 1055 ab | 0.84 ab | 1039 | 0.88 |
| | Significant? | | Yes | Yes | No | Yes | Yes | No | No |
| Interaction | Soybean | 0N | 1.58 a | 1056 | 1.00 | - | - | 1056 bcd | 1.00 ab |
| | | Agrotain | 1.24 b | 876 | 0.83 | - | - | 876 cd | 0.83 b |
| | | Urea | 1.14 b | 856 | 0.81 | - | - | 856 d | 0.81 b |
| | Flax | 0N | - | - | - | 1067 | 0.86 | 1067 bcd | 0.86 b |
| | | Agrotain | - | - | - | 1478 | 1.20 | 1478 a | 1.20 a |
| | | Urea | - | - | - | 1254 | 1.00 | 1254 b | 1.00 ab |
| | Intercrop | 0N | 1.60 a | 153 | 0.14 | 818 | 0.66 | 971 cd | 0.81 b |
| | | Agrotain | 1.51 a | 121 | 0.14 | 971 | 0.78 | 1091 bc | 0.90 b |
| | | Urea | 1.50 a | 149 | 0.26 | 856 | 0.68 | 1005 cd | 0.82 b |
| | Significant? | | Yes | No | No | No | No | Yes | No |
| P values | | Crop | **<0.001** | **<0.001** | **<0.001** | **<0.001** | **<0.001** | **<0.001** | **0.015** |
| | | Fertility | **0.001** | 0.074 | 0.063 | **0.021** | **0.021** | 0.126 | 0.21 |
| | | C x F | **0.017** | 0.136 | 0.123 | 0.340 | 0.320 | **0.017** | **0.030** |
| R-square | | | 0.90 | 0.98 | 0.98 | 0.83 | 0.85 | 0.80 | 0.80 |
| Coefficient of Variation % | | | 6 | 15 | 14 | 13 | 14 | 12 | 12 |

**Table 3:** Summary of response to intercropping and fertility regime for crop height, thousand seed weight (TKWT) of harvest grain, crop light use and volumetric water content (VWC) of soil moisture during grain development in soybean and flax monocrop and intercrops.

| Factor | | | Soybean | | Flax | Overall | |
|---|---|---|---|---|---|---|---|
| | | | **Height** | **TKWT** | **Height** | **Light Use** | **VWC** |
| | | | cm | g/100 seeds | cm | % | % |
| Crop | Soybean | 1 | 50 a | 72 a | - | 85 a | 12.5 a |
| | Flax | 2 | - | - | 65 | 75 b | 7.0 b |
| | Intercrop | 3 | 46 b | 52 b | 66 | 76 b | 8.6 b |
| | Significant? | | Yes | Yes | No | Yes | Yes |
| Fertility | 0N | 1 | 49 | 64 | 63 b | 75 b | 9.7 |
| | Agrotain | 2 | 48 | 65 | 67 b | 81 a | 9.2 |
| | Urea | 3 | 48 | 57 | 68 a | 80 a | 9.2 |
| | Significant? | | No | No | Yes | Yes | No |
| Interaction | Soybean | 0N | 52 a | 70 | - | 84 ab | 13.4 |
| | | Agrotain | 51 ab | 74 | - | 86 a | 12.1 |
| | | Urea | 48 bc | 71 | - | 85 a | 11.8 |
| | Flax | 0N | - | - | 61.7 | 66 e | 7.3 |
| | | Agrotain | - | - | 66.0 | 81 abc | 6.2 |
| | | Urea | - | - | 67.3 | 78 bcd | 7.3 |
| | Intercrop | 0N | 45 cd | 58 | 64.0 | 75 d | 8.4 |
| | | Agrotain | 45 d | 57 | 67.0 | 78 cd | 9.2 |
| | | Urea | 48 bcd | 42 | 68.3 | 76 cd | 8.4 |
| | Significant? | | Yes | No | No | Yes | No |
| P values | | Crop | **<0.001** | **<0.001** | 0.192 | **<0.001** | **0.002** |
| | | Fertility | 0.798 | 0.326 | **0.007** | **0.001** | 0.896 |
| | | C x F | **0.021** | 0.356 | 0.833 | **0.005** | 0.933 |
| R-square | | | 0.80 | 0.70 | 0.71 | 0.87 | 0.64 |
| Coefficient of Variation % | | | 4 | 17 | 3 | 4 | 30 |

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# Relay crop/intercrop legumes in Hemp Grain Production

***Report period:*** 2018
***Project duration*** 2017-2019
***Collaborators***: Hemp Genetics International

## *Objective*

To assess the effects of legumes and other intercrops with hemp on hemp grain production and determine legume regrowth parameters.

## *Rational*

On the Canadian prairies, hemp growers have been investigating the merits of relay cropping legume cover crops in hemp stands. This trial explores the benefits of doing so by studying the effect on hemp grain production and assessing regrowth of relay crops. This is year 2 of performing the trial.

Clovers, hairy vetch, or alfalfa act as a post-harvest cover to compete against weeds, reduce compaction, increase water use and fix nitrogen. The purpose of seeding pea with hemp was to try to increase grain production per acre. Use of fall rye was to compete with weeds (both physically and chemically through allelopathy) and then be terminated by a group 1 herbicide.

## *Materials and Methods*

Clovers, alfalfa and rye were hand broadcast after seeding. Peas and vetch were were inoculated with granular pea *Rhizobia* inoculant (Nodulator-G Pea/Lentil, BASF) and seeded with the hemp down the same seed shank.

Location: Melita; legal land location SW 18-4-26 W1; Waskada Loam
Design: Randomized Complete Block Design; treatments replicated 3 times, plot size 12.96m2
Burn-off: Roundup transorb @ 0.5 L/ac + Liberty @ 0.75 L/ac applied May 23rd
Previous crop: RR Soybean
Seed Date: May 17, 2018
Hemp seed depth: 0.75”
Fertilizer: N-P-K-S: 126-35-25-10 (lbs/ac) Sideband UAN + granular blend
In Crop Herbicides: Arrow @ 150 ml/ac plus X-act adj. @ 0.5L/100L. applied June 13, 2018
Hemp Grain Harvest Date: August 24, 2018
Relay Biomass Date: September 20$^{th}$
Rainfall during trial: 164 mm (65% of normal)

**Table 1:** Treatments of relay crops inter-seeded (broadcast or in seed row) with hemp and their respective variety and seeding rate (lbs/ac).

| Treatment | Seed Method | Description | Variety | Seed Rate (lbs/ac) |
|---|---|---|---|---|
| 1 | Seeded | Hemp (Check) | Katani | 25 |
| 2 | Broadcast | Sweet Clover | Norgold | 5 |
| 3 | Broadcast | Alfalfa | Rancher's Choice | 8 |
| 4 | Broadcast | Red Clover | Altaswede | 5 |
| 5 | Seeded together | Hairy Vetch | WADO | 25 |
| 6 | Seeded together | Field Pea | CDC Meadow | 80 |
| 7 | Broadcast | Fall Rye | Danko | 20 |

## *Data Collected*

- Emergence – 2 x 1 m counts per plot both hemp and relay
- Soil moisture after harvest (6" soil meter, HydraSense II hand held unit)
- Hemp Crop height
- Hemp thousand kernel weight (500 seed count)
- Grain yield (hemp and field pea)
- Soil test Nitrogen after harvest (3 sample composite per plot)

Data were subjected to a two-way analysis of variance (ANOVA) using Minitab 18 statistical software to determine if means were significantly different. Mean separation was conducted using Fisher's LSD at the 5% level of significance.

## *Results*

Due to the combination of broadcast seed and the lack of precipitation during the spring in 2017 but less so in 2018, there was poor emergence rates in sweet clover, alfalfa, red clover, and rye (Figure 1). Peas & hairy vetch emerged fairly well since they were placed deeper in the soil with hemp seed. Establishment of relay was related to final success after hemp harvest of the relay crop. For example, due to poor emergence with red clover a poor biomass harvest was realized. Hairy vetch improved emergence in 2018 due to it being placed below ground. Most other relay covers also improved in 2018 over 2017 values as there were several small rains that assisted in germination.

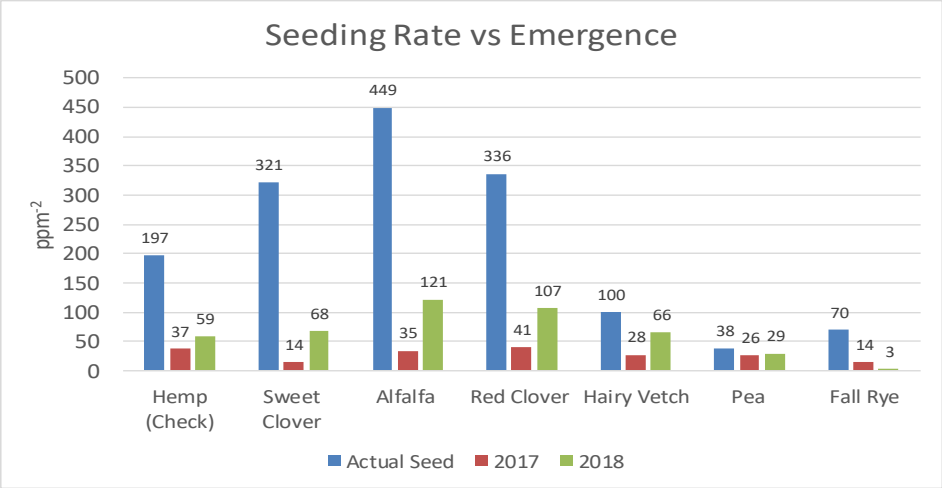


**Figure 1:** Seeding rate and emergence of hemp and its corresponding relay crop.

There were no differences (p=0.152) in crop height (average of 117 cm), soil moisture after harvest or thousand kernel weight of hemp compared to the check treatment. There were significant differences in grain yield (p = 0.015) and relay crop biomass taken one month after hemp grain harvest (p=0.001). Hemp was significantly reduced with alfalfa and hairy vetch. Sweet clover, field pea, rye and red clover did not reduce hemp yield significantly. For field pea, additional harvest was achieved and did significantly over yield in total grain yield compared to the hemp check yield.

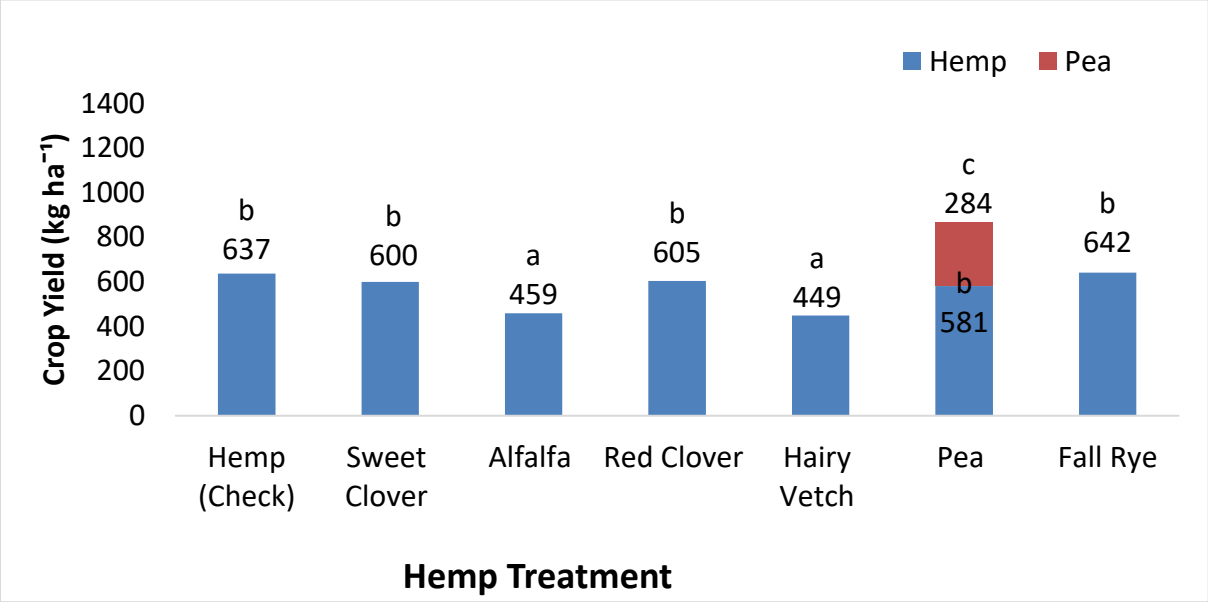


**Figure 2:** Hemp grain yield response to relay/intercrops inter-seeded. Pea grain yield also harvested and combined with hemp yield for that treatment.

Hairy vetch was by far the most successful relay species post harvest yielding about 1/2-ton dry matter. All other species were significantly lower yielding. Pea was non-existent as the plant had completely died from maturity and no re-growth was realized.

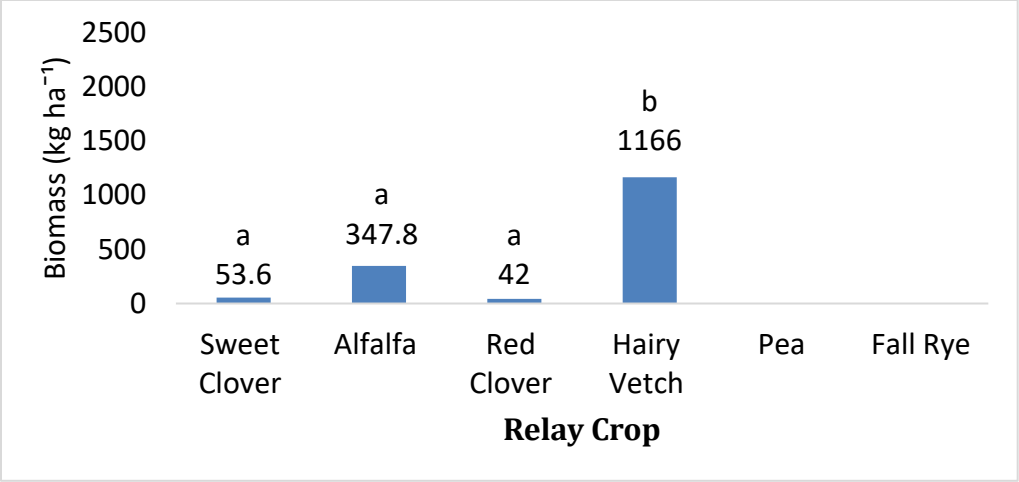


**Figure 3:** Biomass of the relay crops following hemp harvest in Melita taken Oct 23, 2019.

### *Discussion*

Lack of overall rainfall during the year reduced the establishment and competitive ability of the relay crops to thrive. Alfalfa, peas and hairy vetch competed fairly well with limited water resources with the hemp. However, by competition appeared to reduce hemp yield. This may be due to similar root zones competing for water when water was limited.

It was hypothesized that rye was "shaded out" by hemp after bolting, in addition to being severely disabled from an in-crop herbicide application with the group 1 herbicide.

**Picture:** Taken just prior to biomass sampling on Oct 23rd. Note how hairy vetch and alfalfa did fairly well, while red clover, rye and pea had poor development.

In a producer's situation it appears that hairy vetch or sweet clover may be prospective species to inter-seed with hemp. Hairy vetch produced a significant amount of post-harvest biomass which could be used as pasture or as a soil building tool to fix nitrogen or add soil carbon. Hairy vetch did flower at hemp harvest, but did not produce seed. Hairy vetch also grew nearly as tall the hemp and climbed the crop to the level of the seed head. Alfalfa also appeared to have a decent post harvest stand which would establish well next growing season. By mid-August, sweet clover was showing signs of drought stress, but was still present as a green stem rosette after harvest. Red clover and rye appeared to fail to establish and compete reducing overall stand.

The practicality of intercropping field pea was minimal given the effort it would take to clean out a mere 284 kg/ha. Economically and practically this would not be feasible. Perhaps on a normal to wet year this mixture would be economically beneficial, as would some of the other relay species that negatively affected hemp yield.

The trial is planned to be repeated in 2019 with hopes to have normal to wetter weather conditions as a contrast to 2017 and 2018 conditions.

# Intercropping corn and hairy vetch

**Project duration**: 2018
**Collaborators**: WADO

## *Objectives*

1. To evaluate the merits of growing hairy vetch in the understory of grain corn
2. To evaluate tolerance level of hairy vetch to different types and dosages of herbicides: Roundup (540 g ae $ac^{-1}$), Basagran, Koril and Mextrol

## *Background*

Corn and hairy vetch intercrop provides a potential for improved weed control due to vetch's creeping growth habit competing against weeds. In addition, nitrogen fixation by hairy vetch may result in reduced costs on fertilizer, improved potassium availability for subsequent crops and improved soil biodiversity (Cook et al., 2010; OMAFRA, 2012). When grown in a mix with Roundup ready corn, there is need for effective application rates of Roundup that will control weeds but not kill the beneficial hairy vetch. It is important to determine the most effective herbicide type and application rates that will achieve the desired control without being detrimental to the intended crops and the environment. Roundup on its own at low rates does not usually result in control of hairy vetch as a weed, however, when tank mixed with other broad leaf herbicides it can be effective. Considering the importance of hairy vetch as a forage crop, it can be useful as an understory crop that can be grazed in fall after harvesting corn. This study seeks to identify the types and application rates of herbicides that will be tolerated by hairy vetch for the purposes of maintaining it as a cover crop and forage for livestock.

## *Materials and Methods*

The trial was first established at Lyleton on 16 May but was later terminated and reseeded at Melita on 13 June. The trial was arranged as split plot design with 10 treatments and 3 replicates. Before seeding, an application of Roundup at 1.25L $ac^{-1}$ was done to burnoff winter wheat that had been seeded to cover pathways. Corn was seeded at a depth of 2 inches while hairy vetch was seeded at 0.75 inches and granular fertilizer blend was applied at the same time by banding method at a rate of 122-41-27-11 (N-P-K-S) lb $ac^{-1}$. Herbicide treatments were applied using a Co2 sprayer. Corn-hairy vetch treatments are described in the table below.

**Table 1: Corn-Hairy Vetch Treatments**

| Treatment | Description |
|---|---|
| 1 | Corn-check 0.75L $ac^{-1}$ Roundup at V3 stage |
| 2 | Hairy vetch-check 0.91L $ac^{-1}$ Basagran |
| 3 | Corn + Hairy vetch-check, hand weed + 0.91L $ac^{-1}$ Basagran |
| 4 | Corn + Hairy vetch, 0.2L $ac^{-1}$ Roundup at V3 stage |
| 5 | Corn + Hairy vetch, 0.5L $ac^{-1}$ Roundup at V3 stage |
| 6 | Corn + Hairy vetch, 0.75L $ac^{-1}$ Roundup at V3 stage |
| 7 | Corn + Hairy vetch,1L $ac^{-1}$ Roundup at V3 stage |
| 8 | Corn + Hairy vetch, 0.33L $ac^{-1}$ Roundup sprayed at V3 and V8 stage of corn |
| 9 | Corn + Hairy vetch, 0.5L $ac^{-1}$ Roundup and 0.4L $ac^{-1}$ Koril tank mixed at V3 |
| 10 | Corn + Hairy vetch, 0.5L $ac^{-1}$ Roundup + 0.5L $ac^{-1}$ Mextrol 450 tank mixed at V3 |

Grain yield was not measured because the trial was established late in the growing and did not reach physiological maturity by the end of the season. The only data collected for analysis was above ground biomass for both the corn and hairy vetch, wet weeds and assessment of herbicide injury to hairy vetch. These data were subjected to ANOVA using Minitab 18 statistical package to compare differences among treatments. Separation of means was done by using Fisher's LSD at the 5% level of significance.

## *Results*

There were significant differences ($p<0.001$) in hairy vetch herbicide injury among treatments with herbicide and compared to hand weeded and herbicide checks. Treatments with Koril or Mextrol in addition to glyphosate caused more injury to hairy vetch than glyphosate rates alone. Also the ultra-low rate of glyphosate (0.2 L/ac) cause significantly less injury than higher rates of glyphosate (Figure 1).

Use of any herbicide caused significant less ($p<0.001$) weed biomass than weed check (Figure 1).

There were significant differences ($p<0.001$) in corn and hairy vetch dry matter biomass production from herbicide application treatments (Figure 2). Treatment 3 (hand weeded check for corn and hairy vetch) resulted in a reduction in corn biomass due to the competitive nature of hairy vetch when not suppressed by herbicide. Generally any sort of herbicide treatment caused a reduction in hairy vetch biomass while causing an increase in corn biomass. Treatment 2 and 3 seem to provide satisfactory suppression (injury) of hairy vetch early in the season which prevented the vetch from affecting corn biomass later in season.

Adding additional herbicides such as Koril (trt 9) or Mextrol (trt 10) did not reduce biomass in hairy vetch later in the season despite causing significant injury to the plants 3 WAA.

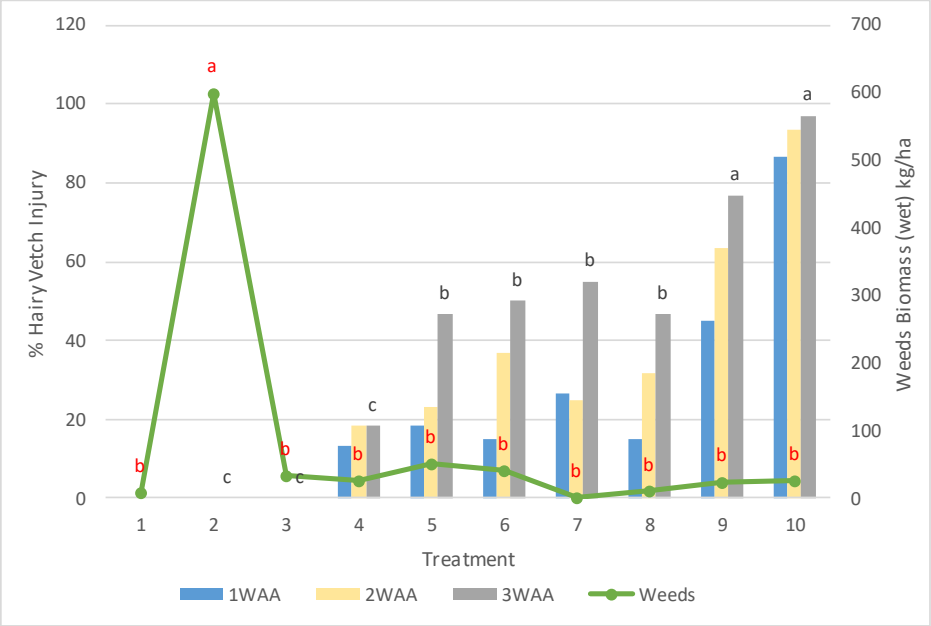


**Figure 1:** Effect of herbicide treatments on percent hairy vetch injury 9 (bars) 1 week after application (WAA), 2 and 3 weeks after application, and the relationship of weed biomass (line). Red letters of significance are for weed biomass, black are for herbicide injury on 3 weeks after application.

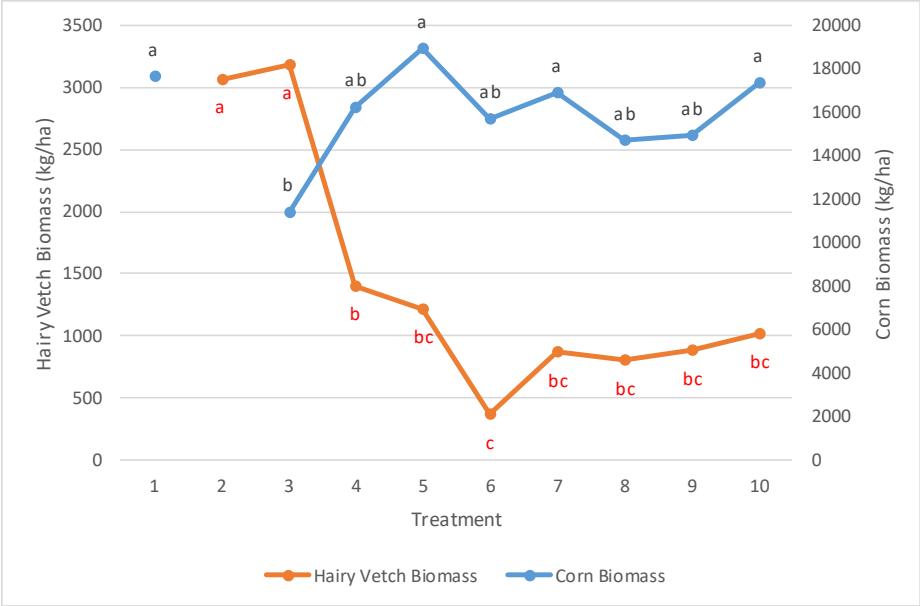


**Figure 2:** Effect of herbicide application treatments on hairy vetch (dry) biomass and corn (dry) biomass. Red letters of significance are for hairy vetch biomass, black are for corn biomass.

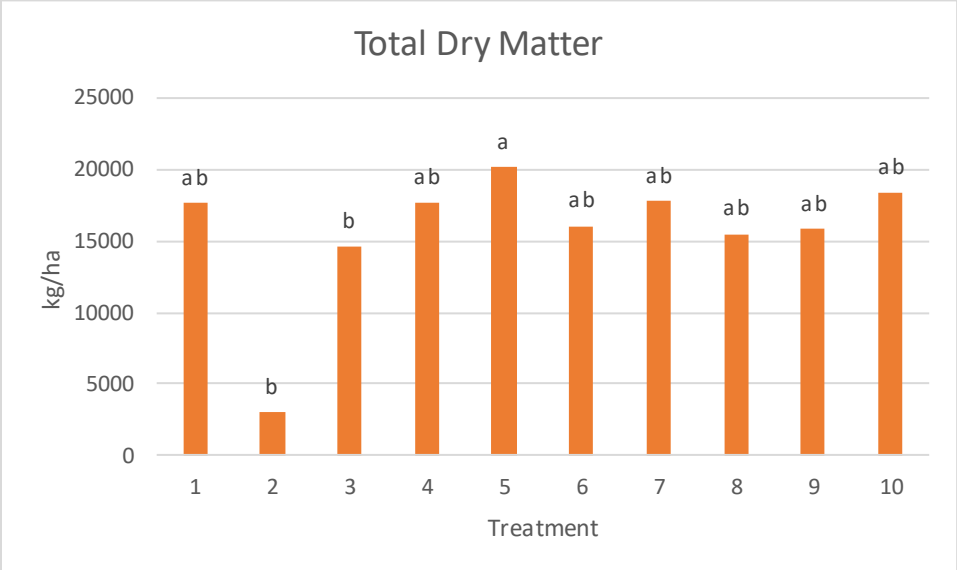


**Figure 3:** Effect of herbicide application treatments on total (dry) biomass in corn and hairy vetch intercrops

There was significant differences ($p<0.001$) among treatments total biomass (corn and hairy vetch combined and dried). Treatment 5 (0.5 L/ac glyphosate at V3) offered the highest amount of biomass compared to treatment 3 (weed free but absence of glyphosate) and 2 (hairy vetch only no corn). It is suspect that hairy vetch in treatment 3 was too competitive with corn reducing corn's overall yield, whereas treatment 5 offered early suppression of hairy vetch but did not completely disable hairy vetch growth later in season. There were no treatment differences in total biomass production between treatments 1 and 4 to 10 likely because corn provides such a significant impact on biomass production Seasonally dry conditions exacerbated the competitive nature of hairy vetch in corn. Soil moisture was at a noticeable deficit in corn growth.

Grain yield in corn was not collected due to the lack of maturity in the corn due to the late seeding date.

### *Conclusions*

Additional site data is required to make more accurate conclusion as to a recommendation on glyphosate rate. Since it was a dry year, an additional year under normal to wet conditions would show contrast to the 2018 season. The attempt to seed on time to enable grain production in corn will prove to provide interesting results. In normal precipitation year, hairy vetch has not reduced grain corn yield according to previous results compiled at WADO (2017 WADO Annual Report) however the use of bromoxinyl (Koril) was applied at 0.4 L/ac in that trial.

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OMAFRA, 2012. Cover Crops: Hairy vetch. www.omafra.gov.on.ca

## Effect of fungicide and alfalfa understory with pea-canola intercrop production

**Project duration**: 2018

**Collaborators**: WADO

### *Objectives*

1. To determine if pea canola intercrop out-yield and are more profitable than monocrop peas or canola.
2. To determine if fungicide application is a possible best management practice for disease control
3. To determine the effect of relay cropping alfalfa in pea-canola stands

### *Background*

Peas, canola and alfalfa have potential in organic rotations but their individual yields are limited by competition from weeds, insect pests and diseases (Fernandez et al. 2014). Intercropping can provide several benefits that include: amendment of soils through addition of nutrients by the plants themselves at low costs, biological management of insect pests and diseases, conservation of soil moisture and overall increase in grain yield than a sole crop. Most intercropping systems around the globe involving legumes and cereals are beneficial to both crop and livestock systems. Although there are challenges in machinery use during seeding, separation of seed after harvest and insurance coverage concerns , there is a marked increase in the number of producers that are interested in various intercropping systems as a result of the benefits associated with it.

Research conducted by Szumigalski and Van Acker (2006) showed that pea-canola intercrop systems resulted in consistent land equivalent ratios for grain nitrogen yield and this suggests that intercrops, in

particular, pea-canola could be useful for improving nitrogen use efficiency on per land area basis. Apart from pea-canola intercrop, alfalfa-canola can also be another option. It incorporates a perennial pasture crop which may aid in improving productivity and nutrient use efficiency as well as reducing disease incidence (Craig et al. 2013). Including alfalfa as a relay crop in a pea-canola intercrop would leave alfalfa to continue to grow in fall after harvesting and it can provide hay the following growing season. This study therefore seeks to evaluate the impact of intercrops involving pea, canola and alfalfa relay crop as best management tools for improving productivity and control fungal diseases.

## *Materials and Methods*

The trial was conducted at Melita in southwestern Manitoba in 2018. Eight treatments were arranged as randomized complete block design (split-plot) and replicated 3 times. Treatment materials are presented below:

| **Main Plot**[†] | **Subplot** |
|---|---|
| Pea | No fungicide |
| Canola | Fungicide |
| Pea-Canola | |
| Pea-Canola-Alfalfa | |

[†]Each of the main plot treatments had double plots, one with no fungicide and the other one with Lance fungicide

Plots were seeded into soybean (RR) stubble into a Waskada loam on the legal land location SW 18-4-26 W1 with a SeedHawk dual knife airdrill. Variety of pea used was 'CDC Meadow', target seed rate was 85 plants $m^{-2}$ in monocrop. Canola variety used was '5545 CL' seeded at 85 plants $m^{-2}$ in monocrop. In intercrops, peas and canola were seeded at 64 and 43 plants $m^{-2}$. Alfalfa variety 'Rancher's Choice' was seeded at 8 lb $ac^{-2}$ and was broadcast after seeding peas and canola. The plots were rolled soon after seeding so as to level the ground and to bury rocks for ease of harvesting.

A burnoff application with 0.75L $ac^{-1}$ Roundup was done on the 18$^{th}$ of May followed by seeding on the 22$^{nd}$ of May and a depth of 0.75 inches was used. Granular fertilizer blend was side banded to all treatments at a rate of 15-35-24-9 (N-P-K-S) lb $ac^{-1}$ while liquid urea was applied to plots with canola only at a rate of 105 N lb $ac^{-1}$. The lack of applied nitrogen was to highlight any economic benefit as a intercrop compared to the monocrops. Background soil tests at a depth of 0-24" indicated soil nutrient levels of N-P-K-S at 25-22-538-58 lbs $ac^{-2}$.

Weed control after seeding was achieved by applying 17g $ac^{-1}$ Odyssey mixed with 0.5% v/v Merge adjuvant. Two fungicide treatments were done on the 10$^{th}$ and 18$^{th}$ of July using Lance fungicide at a rate of 140g $ac^{-1}$. Data collected included: plant counts, pea aphid counts (July 23), fungal disease (Mycospharella blight severity in pea July 24 (early pod)), and soil moisture content [(HyraSenseII probe); 6" depth Aug 26, 2018 (before harvest)] and gravimetric soil moisture (3 composite of soil cores at a depth of 24" Oct 2, 2018 (after harvest)), nodule counts at R1 stage of peas, soil nitrate tests in fall, seed weight, grain moisture and grain yield. The data were subjected to ANOVA using Minitab 18 statistical software to determine treatment differences. Mean separation was conducted using Fisher's LSD at the 5% level of significance.

## *Results*

There were significant differences among pea, canola and total yield among crop system used (Table 1). Monocrop pea and monocrop canola yielded significantly better than the intercrop crop component. In total yield monocrop pea significantly out yielded monocrop canola and total intercrop yield. However, intercrop yields were significantly greater than monocrop canola. Similar conclusions follow with partial land equivalent ratios of pea or canola, however there is not a significant crop that was outstanding in total land equivalent ratio.

There were no significant differences with fungicide use compared to untreated checks and there was no interaction between fungicide use and cropping system in terms of yield performance.

The lack of an over yielding effect typically observed in previous research from WADO was not apparent this season most likely due to lack of rainfall and low subsoil moisture reserves.

**Table 1:** Yield response of pea and canola monocrop and intercrop to fungicide and/or alfalfa use.

| Factor | | | Pea | | Canola | | Total Pea & Canola | |
|---|---|---|---|---|---|---|---|---|
| | | | Yield | PLER | Yield | CLER | **Yield** | **TLER** |
| | | | kg/ha | | kg/ha | | kg/ha | |
| Crop | Pea | | 3019 a | 0.98 a | - | - | 3019 a | 0.98 |
| | Canola | | - | - | 2235 a | 0.99 a | 2235 c | 0.99 |
| | Peaola | | 1322 b | 0.43 b | 1305 b | 0.57 b | 2627 b | 1.00 |
| | Peaola Alf | | 1349 b | 0.44 b | 1291 b | 0.58 b | 2640 b | 1.02 |
| | Significant? | | Yes | Yes | Yes | Yes | Yes | No |
| Fungcide | check | - | 1930 | 0.63 | 1620 | 0.72 | 2663 | 1.01 |
| | fungicide | + | 1863 | 0.61 | 1601 | 0.71 | 2598 | 0.99 |
| | Significant? | | No | No | No | No | No | No |
| C x F | Pea | - | 3082 | 1.00 | - | - | 3082 | 1.00 |
| | | + | 2956 | 0.96 | - | - | 2956 | 0.96 |
| | Canola | - | - | - | 2281 | 1.00 | 2281 | 1.00 |
| | | + | - | - | 2189 | 0.97 | 2189 | 0.97 |
| | Peaola | - | 1338 | 0.44 | 1322 | 0.58 | 2660 | 1.02 |
| | | + | 1306 | 0.42 | 1288 | 0.56 | 2593 | 0.99 |
| | Peaola Alf | - | 1371 | 0.45 | 1256 | 0.56 | 2627 | 1.01 |
| | | + | 1327 | 0.43 | 1326 | 0.60 | 2653 | 1.04 |
| | Significant? | | No | No | Yes | Yes | No | No |
| P values | Crop | | **<0.001** | **<0.001** | **<0.001** | **<0.001** | **<0.001** | 0.634 |
| | Fungicide | | 0.298 | 0.292 | 0.761 | 0.936 | 0.360 | 0.481 |
| | C x F | | 0.791 | 0.877 | 0.556 | 0.559 | 0.866 | 0.803 |
| R-square | | | 0.99 | 0.99 | 0.98 | 0.98 | 0.94 | 0.91 |
| Coefficient of Variation % | | | 6.6 | 6.8 | 8 | 8 | 6 | 6 |

Means with the same letter in the same column are not significantly different; PLER = Pea Land equivalence ratio; CLER = Canola Land equivalence ratio TLER = Total Land equivalence ratio; TKWT = Thousand Kernel Weight.

Pea plant disease (Mycosphaerella blight) was significantly less in peaola with alfalfa than peaola or monocrop pea. It may be possible that alfalfa may be reducing rain soil splash which could act as a physical barrier to reduce infection. Interestingly, use of a split application of fungicide did not make a difference.

Aphid presence was found to be significantly greater in monocrop pea compared to intercrop pea. Plots were not treated with an insecticide.

Lodging was found to be significantly less in monocrop pea than in canola and peaola plots. This may be due to a heavier canopy of crop in intercrops and canola, compared to monocrop pea.

There was no difference in pea pod height or pea seed weight (TKWT) in main plots or subplots. Interestingly, canola seed weight was significantly greater in peaola containing alfalfa compared to peaola without alfalfa especially in fungicide treated subplots.

In terms of soil moisture, there was more soil moisture at a 6" depth in monocrop canola than monocrop pea or peaola plots at harvest. Over a month later, gravimetric soil moistures showed that were no differences in main plots or subplots at a soil depth of 24".

There were no significant differences in residual soil nitrogen values after harvest in main plots or subplots.

**Table 2:** Summary of data collected of pea and canola monocrop and intercrops to fungicide and/or alfalfa use in Melita, 2018. Means with the same letter in the same column are not significantly different.

| Factor | | Pea Disease | Aphids | Lodge | Pod HT | TKWT Pea | TKWT Can | Soil Probe | Soil Grav | Residual Soil N |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0-9 (9 severe) | #/plant | 1-9 (9 flat) | cm | g/1000 | g/1000 | %VWC | %mass | lbs/ac |
| Crop | Pea | 2.0 a | 6 a | 1.0 c | 44 | 161 | - | 1.5 b | 8 | 23 |
| | Canola | - | - | 2.2 a | - | - | 3.45 ab | 2.8 a | 8 | 17 |
| | Peaola | 1.8 a | 3 b | 1.7 b | 43 | 168 | 3.39 b | 1.7 b | 8 | 21 |
| | Peaola Alf | 1.4 b | 2 b | 2.3 a | 45 | 168 | 3.55 a | 1.8 b | 7 | 17 |
| | Significant? | Yes | Yes | Yes | No | No | Yes | Yes | No | No |
| Fungcide | check - | 1.7 | 3 | 1.8 | 44 | 167 | 3.45 | 2.0 | 8 | 21 |
| | fungicide + | 1.7 | 6 | 1.8 | 44 | 164 | 3.48 | 1.9 | 8 | 18 |
| | Significant? | No | No | No | No | No | No | No | No | No |
| C x F | Pea - | 2.0 | 5 | 1.0 | 45 | 163 | - | 2.0 | 9 | 24 |
| | + | 2.0 | 7 | 1.0 | 44 | 159 | - | 1.1 | 7 | 21 |
| | Canola - | - | - | 2.0 | - | - | 3.47 b | 2.6 | 8 | 21 |
| | + | - | - | 2.3 | - | - | 3.44 b | 3.0 | 8 | 13 |
| | Peaola - | 1.8 | 1 | 1.7 | 42 | 169 | 3.45 b | 1.7 | 8 | 21 |
| | + | 1.9 | 4 | 1.7 | 45 | 166 | 3.34 b | 1.7 | 8 | 20 |
| | Peaola Alf - | 1.4 | 3 | 2.3 | 45 | 169 | 3.44 b | 1.7 | 7 | 17 |
| | + | 1.3 | 2 | 2.3 | 44 | 166 | 3.66 a | 1.9 | 7 | 17 |
| | Significant? | No | No | No | No | No | Yes | No | No | No |
| P values | Crop | **0.006** | **0.014** | **<0.001** | 0.497 | 0.218 | **0.031** | **0.004** | 0.421 | 0.708 |
| | Fungicide | 0.833 | 0.149 | 0.347 | 0.770 | 0.317 | 0.525 | 0.823 | 0.264 | 0.454 |
| | C x F | 0.580 | 0.305 | 0.441 | 0.312 | 0.977 | **0.024** | 0.141 | 0.380 | 0.886 |
| R-square | | **0.94** | **0.95** | **0.98** | **0.82** | **0.76** | **0.90** | **0.91** | **0.63** | **0.28** |
| Coefficient of Variation % | | **12** | **39** | **11** | **5** | **4** | **0.7** | **23** | **12** | **48** |

## *Economics*

A brief economic assessment of the various treatments was performed based on Manitoba Agricultures 2019 Cost of Production and market values for peas and canola of \$6.30 $bu^{-1}$ and \$9.00 $bu^{-1}$, respectively. Also, pesticides were based on Suggested Retail Price (SRP) values of those products used in this study (Table 3).

**Table 3**: Costs of production associated with reproducing the situations of the treatments involved in this tri al that are applied to gross income values to realized net returns.

| **Fungicide (subplot)** | No Fungi | Fungicide | No Fungi | Fungicide | No Fungi | Fungicide | No Fungi | Fungicide |
|---|---|---|---|---|---|---|---|---|
| **Crop System (Main Plot)** | pea monocrop | pea monocrop | canola monocrop | canola monocrop | Peaola | Peaola | Peaola Alf | Peaola Alf |
| N Rate Applied lbs/ac | 0 | 0 | 105 | 105 | 0 | 0 | 0 | 0 |
| **Operating Cost** | | | | | | | | |
| Seed and Treament | $ 30.25 | $ 30.25 | $ 62.50 | $ 62.50 | $ 46.37 | $ 46.37 | $ 80.37 | $ 80.37 |
| Fertilizer | $ 39.92 | $ 39.92 | $ 98.22 | $ 98.22 | $ 39.92 | $ 39.92 | $ 39.92 | $ 39.92 |
| Herbicide* | $ 22.58 | $ 22.58 | $ 22.58 | $ 22.58 | $ 22.58 | $ 22.58 | $ 22.58 | $ 22.58 |
| Fungicide | $ - | $ 39.00 | $ - | $ 39.00 | $ - | $ 39.00 | $ - | $ 39.00 |
| Insecticide | | | | | | | | |
| Fuel | $ 20.38 | $ 20.38 | $ 24.21 | $ 24.21 | $ 24.21 | $ 24.21 | $ 24.21 | $ 24.21 |
| Machinery Operating | $ 10.00 | $ 10.00 | $ 10.00 | $ 10.00 | $ 10.00 | $ 10.00 | $ 10.00 | $ 10.00 |
| Crop Insurance | $ 20.00 | $ 20.00 | $ 16.00 | $ 16.00 | $ 20.00 | $ 20.00 | $ 20.00 | $ 20.00 |
| Other** | $ 8.25 | $ 8.25 | $ 8.25 | $ 8.25 | $ 10.25 | $ 10.25 | $ 10.25 | $ 10.25 |
| Land Taxes | $ 15.00 | $ 15.00 | $ 15.00 | $ 15.00 | $ 15.00 | $ 15.00 | $ 15.00 | $ 15.00 |
| Drying Cost | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Interest (5% for 6 months) | $ 4.16 | $ 5.13 | $ 6.42 | $ 7.39 | $ 4.71 | $ 5.68 | $ 5.56 | $ 6.53 |
| Total Operating | **$ 170.54** | **$ 210.51** | **$ 263.18** | **$ 303.15** | **$ 193.04** | **$ 233.01** | **$ 227.89** | **$ 267.86** |
| **Fixed Cost** | | | | | | | | |
| Land Investment | $ 60.44 | $ 60.44 | $ 60.44 | $ 60.44 | $ 60.44 | $ 60.44 | $ 60.44 | $ 60.44 |
| Machinery Depreciation | $ 66.65 | $ 66.65 | $ 66.65 | $ 66.65 | $ 66.65 | $ 66.65 | $ 66.65 | $ 66.65 |
| Machinery Investment | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Storage Cost*** | $ 4.84 | $ 4.84 | $ 4.84 | $ 4.84 | $ 9.68 | $ 9.68 | $ 9.68 | $ 9.68 |
| Total Fixed | **$ 131.93** | **$ 131.93** | **$ 131.93** | **$ 131.93** | **$ 136.77** | **$ 136.77** | **$ 136.77** | **$ 136.77** |
| **Labour Cost^** | $ 20.00 | $ 20.00 | $ 20.00 | $ 20.00 | $ 22.00 | $ 22.00 | $ 22.00 | $ 22.00 |
| TOTAL COST | **$ 322.47** | **$ 362.44** | **$ 415.11** | **$ 455.08** | **$ 351.81** | **$ 391.78** | **$ 386.66** | **$ 426.63** |

* based one burnoff application of Roundup Transorb

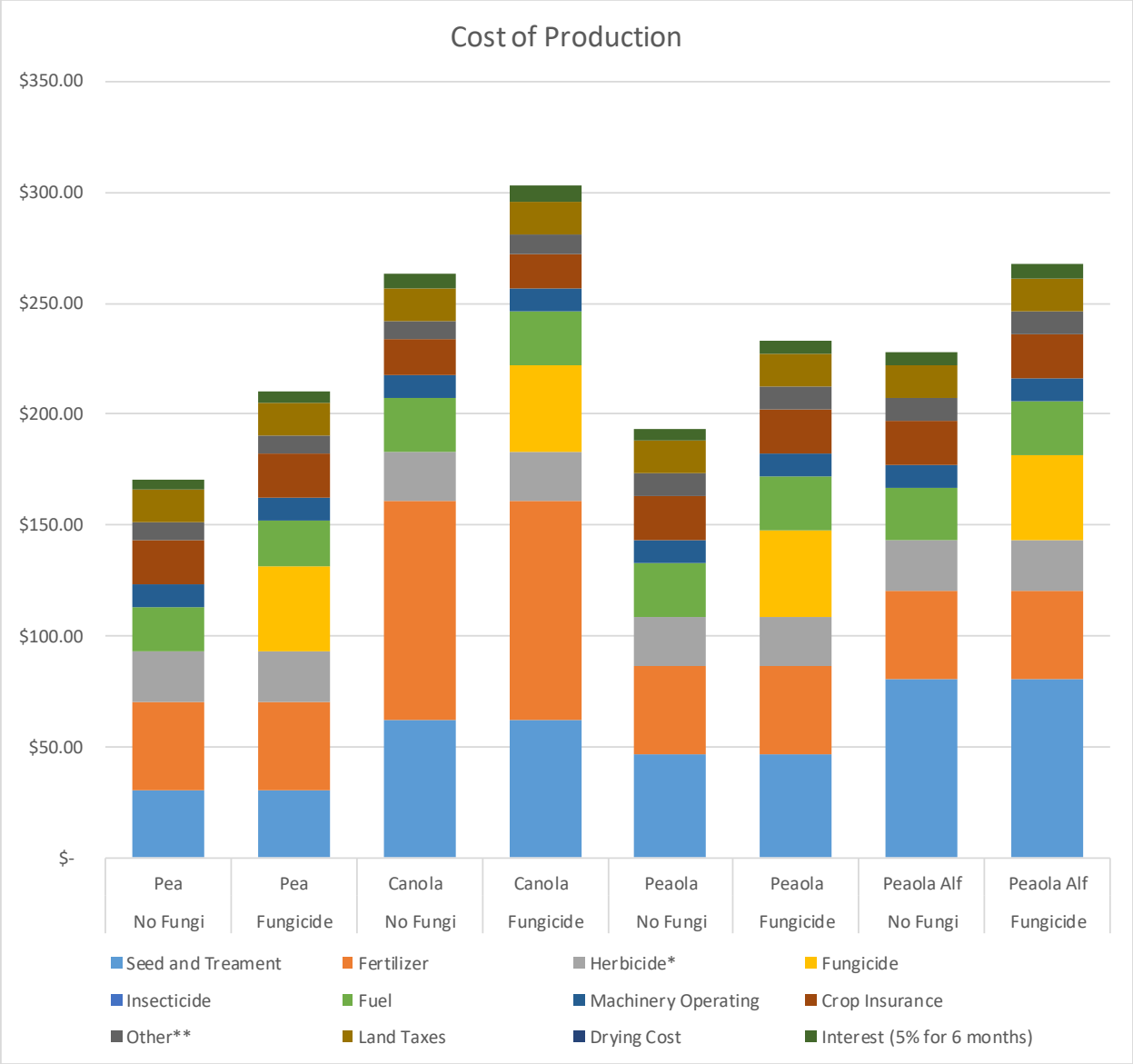
**based on an extra cost of $1/ac to use a rotary seed cleaner, $1/ac for an extra auger

***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

Note that there are different costs of production depending on the treatment. Treatments such as monocrop canola pose significant cost with the addition of nitrogen fertilizer compared to all other treatments. Also those with the addition of a fungicide application or the addition of alfalfa seed also substantially increased in cost. Intercrop treatments also increased in total seed cost since seeding rates were increased for those treatments (Table 4).

**Table 4:** Cost of production broken down into segments of operating inputs.




After applying cost of production to gross revenues, an analysis of variance was performed on the realized net incomes for each treatment. There were significant differences ($p<0.038$) in net income by cropping system. All cropping systems lost money overall, however peaola and canola lost the least amount followed by peaola with alfalfa and monocrop peas.

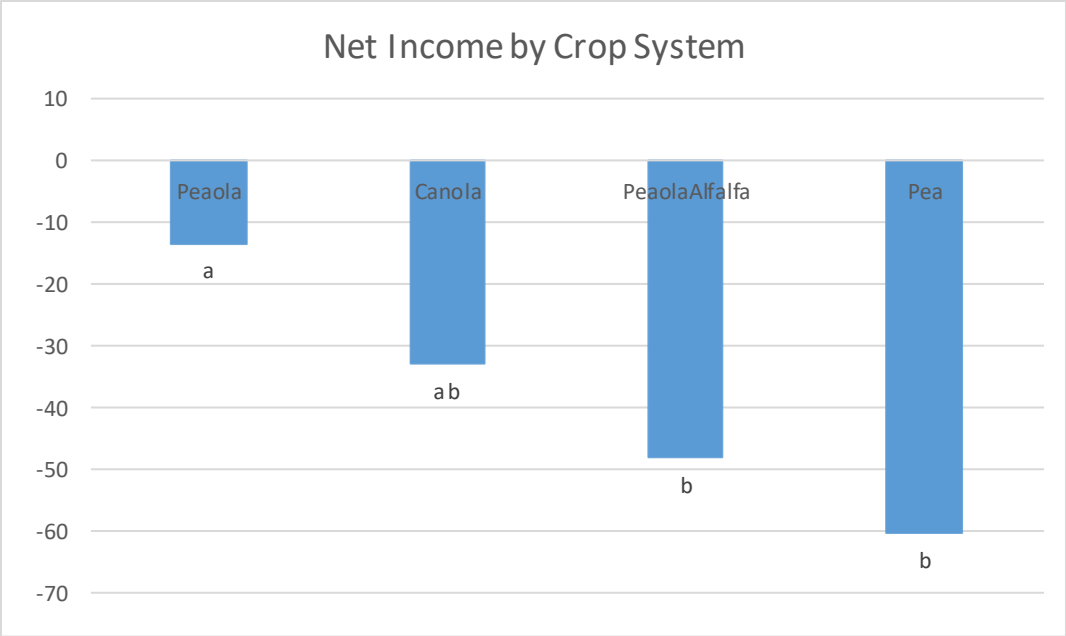



**Figure 1:** Net incomes of cropping systems

There was also a significant difference ($p<0.001$) overall in net income when observing the use of fungicides. Fungicide use resulted in a net loss of \$62 $ac^{-1}$ whereas not using a fungicide resulted in a \$15 $ac^{-1}$ loss. This may have been different if environmental conditions were more conducive to disease.
There were no significant differences ($p<0.799$) between the interaction of crop system and use of fungicide (Figure 2).

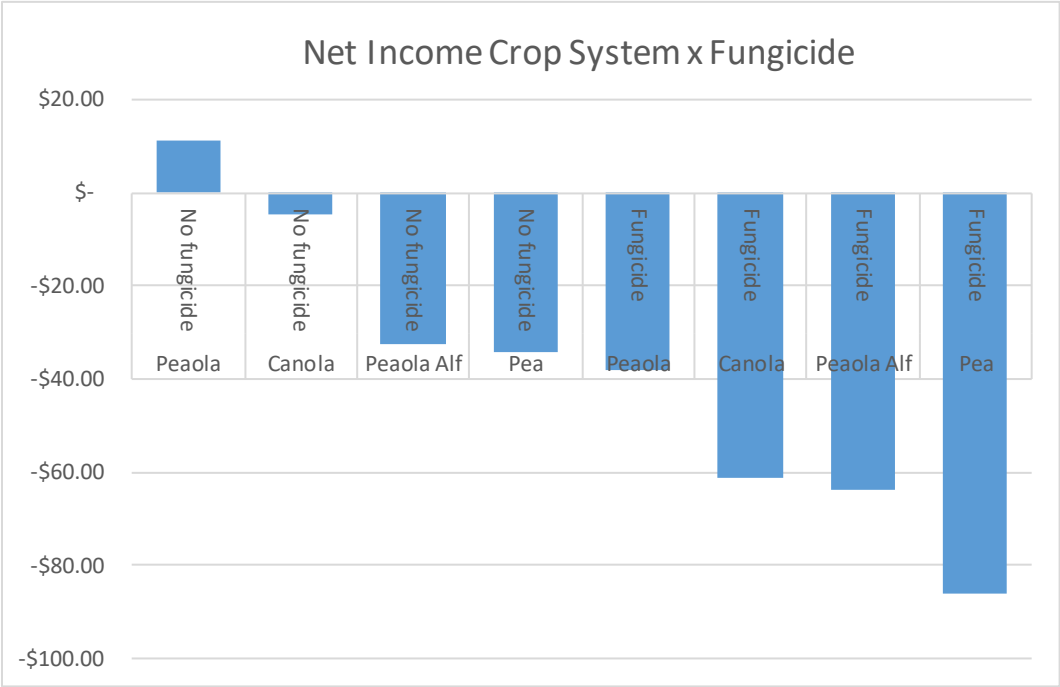



**Figure 2:** Net incomes realized with cropping system and fungicide use.

## *Discussion*

Intercropping peas and canola appeared to provide intrinsic benefits such as reducing pea plant disease from Mycosphaerella and prevent infection from pea aphids. The addition of alfalfa provided a successful establishment for future needs. Benefits such as hay production the following year, enhancing soil biology during the fall months, providing some nitrogen fixation, immobilization of nutrients prone to erosion or leaching, potential grazing value in the following year and possibly reduce salinity, manage excess water and compaction problems.

The addition of alfalfa in peaola situations may also utilize additional light, water and nutrients available in stands of peaola that, are sparse in places. It also may take advantage of saline, saturated areas where peas or canola do not grow well. These benefits are difficult to measure in small plot and may be realized in field scale conditions.

When considering the use of a fungicide in order to provide a yield and economic advantage, one must consider the environmental conditions that influence disease pressure, the economic value of the crop and the potential return on investment in doing so.

Photo: Peaola with the addition of alfalfa

Photo: Peaola without alfalfa. Note a few gaps are visible compared to the photo with alfalfa.

Photo: Regrowth of alfalfa under peaola (left green strip) versus peaola without (right). Note there is some volunteer canola. Photo taken September 25th.

### *References*

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Fernandez, A. L., Sheaffer, C. C., Wyse, D. L. 2014. Productivity of Field Pea and Lentil with Cereal and Brassica Intercrops. Agronomy Journal, 107 (1): 249-256.

Szumigalski, A., Van Acker, R. C. 2006. Nitrogen Yield and Land Use Efficiency in Annual Sole Crops and Intercrops. Agronomy Journal, 98 (4): 1030-1040.

## Prairie Mountain Hops 2018 Farm Report

### *Cooperator: Randy and Lyn Tye*

### *Introduction*

Hops (*Humulus lupulus* L.) are viney plants that have flowering structures called cones (loosely termed the "hops" of the plant used as a bittering and aroma flavor additive to beer and have been used for centuries as a natural preservative.

During the 2017 and 2018 summer, WADO partnered with Prairie Mountain Hops (PMH) farm in an advisory role assisting with fertility management, pest management, scouting, and various other tasks. In addition, WADO and PMH submitted an application to Manitoba's Ag Action Program for capital funding to assist PMH with the purchase of harvest and processing equipment.

PMH is located several miles south of Boissevain MB. It was established in 2017 with 2.5 acres of plants (approx. 2500 plants). In 2018 PMH built a greenhouse to grow plant cuttings to expand their acreage to a total of 6 acres with plans to reach 15 acres in the future.

Eight varieties of hops are now growing at PMH including Centennial, Cascade, Willamette, Comet, Chinook, Mount Hood, Nugget and Brewers Gold.

Hop production is traditionally a highly laborious and intensive agricultural endeavor.

### *Seasonal Management*

PMH were off to a busy year in 2018.

A zonal soil test (high and low slopes) was taken in early spring to determine background soil nutrient levels of the hops yard. Overall field soil tests at a depth of 0-12" showed nutrient values of 71 lbs/ac N, 11 ppm (Olsen) P, 277 ppm K, 34 lbs/ac S, Boron at 0.7 ppm, Cu at 0.71 ppm, Zn at 1.98 ppm, pH of 7.1, and soil organic matter of 6.3% .

PMH applied fertilizer and broadcast a blend of 22-16-8-5 derived from urea, monoammonium phosphate, potash and ammonium sulfate at a rate of 356 lbs/ac on May 1.

Plastic weed barriers removed, bull shoots were trimmed May 15, and new shoots trained on string which are attached to guidewires. In addition, fields were fertilized, weeds were mowed and excess shoots trimmed.

By mid June hop aphids moved in as well as two-potted spider mites in early July. Pesticides including spirotetramat (Movento) and abamectin (Agri-Mek) were applied to control them, respectively. During the unusually hot & dry months of August, spider mites were more difficult to control. A few plants with downy mildew found in July were removed and terminated to prevent further infection. Cyazofamid (Torrent) fungicide was applied as a preventative as well. The variety 'Williamette' was most prone to downy mildew so infected vines were cut and disposed to prevent further disease cycles. The presence of ladybugs and their larvae reduced number of aphids later in season as well.

Rainfall and subsoil moisture was sparse (51% of normal 319 mm for April 15- September 11) in 2018 for PMH, so water via tank and hose was applied to plants. An additional application of 15 lb/ac nitrogen (28-0-0 + water) was applied in July to boost vine growth. Growing Degree Days (GDD) accumulations for the area between April 1 and September 11 was 1807 (normal 1528) at base 5°C [Data sourced from Manitoba Agriculture Ag-Weather Program, Boissevain location]

### *Harvest*

By early September hop cones were mature for harvest. Harvest started September 4th and was finished September 11th. 'Centennial' and 'Cascade' followed by 'Comet' were varieties harvested first as wet hops (sold and shipped as is off the vine). Then, the rest of Centennial, Williamette, and the rest of Cascade were harvested as dry hops (dried then processed in pelletizer). Hops were harvested by pulling on the bine and the string breaking off the guidewire or by cutting the top of the string. Bines were loaded into a truck and taken to the harvester.

The bine was fed into a Wolverine hops harvester (photo) which would strip off cones, sort them from leaves. Hop cones were air dried with heat and fan system. Dried hops were run through a 10 hp Lawson pelletizer mill and made into pellets that could be sold to brewers and readily used in the beer making process.

### *Update*

In 2018, WADO partnered PMH with on a funding application to the Ag Action Manitoba program under the Canadian Agriculture Partnership to secure funds to purchase a hops harvester, a pelletizer, a vaccum sealer, construction of a hops drier, a hops cooler, and electrical upgrades. Securing funding was successful and during the 2018/2019 winter months, construction is underway.

PMH sold all of their 2018 harvest to craft brewers. In addition, they have new orders for plant purchases and have pre-sold all their hop production obtainable for the 2019 season.

## *Hop Variety Yields*

Given the plants were producing the first year after establishment, respectable yields were drawn from rows despite the severe lack of rain and a couple bouts with aphids and spider mites.

Cascade was the most productive variety producing 0.8 lbs per plant followed by Williamette, then Comet and finally Centennial (hop production table). In total approximately 580 lbs of hops was produced over 1.65 acres.

In terms of quality, brewers have noted that the aroma of the hops was "exceptional" compared to hops sourced from the pacific coast. Samples were analyzed for alpha and beta acids as well as essential oils (Table) [Commodity Lab Vancouver, North Vancouver, B.C.]

**2018 Production and Quality Summary**

Hop Production

| Variety | Production Year | Acres Grown | Total Yield lbs | Yield (dry) lbs/ac | No. Producing Plants | Yield lbs/plant |
|---|---|---|---|---|---|---|
| Cascade | 1 | 0.25 | 200 | 800 | 250 | 0.80 |
| Centennial | 1 | 1.00 | 200 | 200 | 1000 | 0.20 |
| Comet | 1 | 0.15 | 55 | 379 | 145 | 0.38 |
| Williamette | 1 | 0.25 | 125 | 500 | 250 | 0.50 |

Alpha and Beta Acids

| Variety | Type | Alpha Acids | Beta Acids | HSI* | Oil (ml/100g) |
|---|---|---|---|---|---|
| Cascade | dry cone | 5.8 | 6.0 | 0.23 | 1.4 |
| Cascade | dry cone | 6.5 | 6.5 | 0.23 | 2.0 |
| Cascade | dry cone | 6.4 | 6.4 | 0.24 | 0.9 |
| Centennial | dry cone | 7.4 | 3.6 | 0.28 | 3.0 |
| Centennial | dry cone | 8 | 3.5 | 0.28 | 3.8 |
| Centennial | dry cone | 8.3 | 3.5 | 0.28 | 3.6 |
| Comet | dry cone | 6.7 | 3.5 | 0.26 | 1.1 |
| Williamette | dry cone | 3.4 | 2.7 | 0.31 | 1.9 |

*Hops Storage Index (measure of the degradation of alpha and beta acids during storage)

WADO
Westman Agricultural
Diversification Organization Inc.

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