WADO

Westman Agricultural Diversification Organization

2020 ANNUAL REPORT

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Introduction

The Westman Agricultural Diversification Organization Inc. (WADO) manages a wide range of value-added and diversification agriculture research and demonstration projects that are summarized in this report. WADO operates in the southwest region of Manitoba and works in conjunction whenever possible with the other Diversification Centres in Roblin (PCDF), Arborg (PESAI) and Carberry (CMCDC). The non-profit organization owes its success to the excellent cooperation and participation it receives from the its Board of Directors, cooperating land owners, local producers, industry partners and cooperating research institutes. WADO acts as a facilitator and sponsor for many of the Ag Extension events held across the province in conjunction with other Manitoba Agriculture and Resource Development 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 for these organizations.

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

2020 Industry Partners

Agriculture and Agri-Food Canada
Avondale Seeds
Barkers Agri-Centre
BASF
Bacqué 40 Communications
Canada MB Crop Diversification Centres
Canadian Agronomics Inc.
Canadian Agricultural Partnership
Canadian Hemp Trade Alliance
Canola Council of Canada
Composites Innovation Centre
Ducks Unlimited Canada
Flax Council of Canada
Glacier Farm Media
Hemp Genetics International
Manitoba Agriculture & Resource Development
Manitoba Canola Growers Association
Manitoba Crop Alliance
Manitoba Crop Variety Evaluation Team
Manitoba Pulse & Soybean Growers Assoc.
Manitoba Cooperator
Melita Chamber of Commerce
Mustard 21
Non-Profits Summer Student Program
OMAFRA
Parkland Crop Diversification Foundation
Parkland Industrial Hemp Growers
Paterson Grain
PepsiCo /Quaker
Pest Surveillance Lab.
Phillex Limited
Prairie Mountain Hops
Prairies East Sustainable Ag Initiative
Pride Seeds
Reston School
Roquette Canada Ltd
Saskatchewan Canola Development Commission
SaskFlax
Seed Manitoba
Sollio Agriculture
South East Research Farm
University of Alberta
University of Manitoba
University of Saskatchewan (Crop Development Centre)
Western Grains Research Foundation
Western Producer

WADO Directors

WADO functions with a board of directors that assist in communications, activities and project development. The directors are from all across southwest Manitoba and they have a direct connection to farming and agriculture. The directors listed below are those that participated with WADO operations in 2020.

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

Southwest Manitoba Agriculture and Resource Development staff members are also part of the WADO board:
Lionel Kaskiw – Souris
Amir Farooq - Hamiota
Scott Chalmers - Melita

Board Advisor: Elmer Kaskiw – Shoal Lake

Farmer Co-operators 2020 Trial Locations

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

An arial view of WADO main trial site at Melita in 2020, soil type- Newstead loam

WADO Staff

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

Justice Zhanda (P.Ag.) joined Manitoba Agriculture and Resource Development from the University of Manitoba in 2018 as a Technician assigned to WADO. He is responsible for field operations, plot management, data collection, sample processing, data management, report preparation and writing, equipment maintenance and other duties as assigned.

Leanne Mayes is the organization's full time Research Associate responsible for data collection, procurement of day-to-day supplies, equipment repairs and maintenance and other administrative duties as assigned. **Chantal Elliott** remained with WADO through the winter to assist with sample analysis and equipment repairs and maintenance. **Kayla Moore** joined WADO as a summer student from Old's College in 2020 and assisted with data collection as well as processing sample. **Rachelle McCannel**l (University of Saskatchewan) joined us for the second time as a summer student in 2020.

WADO Staff 2020 (left to right): Rachel, Justice, Leanne, Chantal, Scott, and Kayla

Got an Idea or Proposal?

The Westman Agricultural Diversification Organization continually looks for new research project ideas, value-added ideas, partnerships and producer production concerns to address current and future challenges in agriculture. If you have any ideas, please forward them to:

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c/o Scott Chalmers, Manitoba Agriculture and Resource Development
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Melita, MB R0M 1L0
204-522-3256 (office)
204-522-5415 (cell)
204-522-8054 (fax)
scott.chalmers@gov.mb.ca

2020 Weather Report and Data – Melita Area

Table a: Melita 2020 Season Report by Month (Normal based on 30-year average)

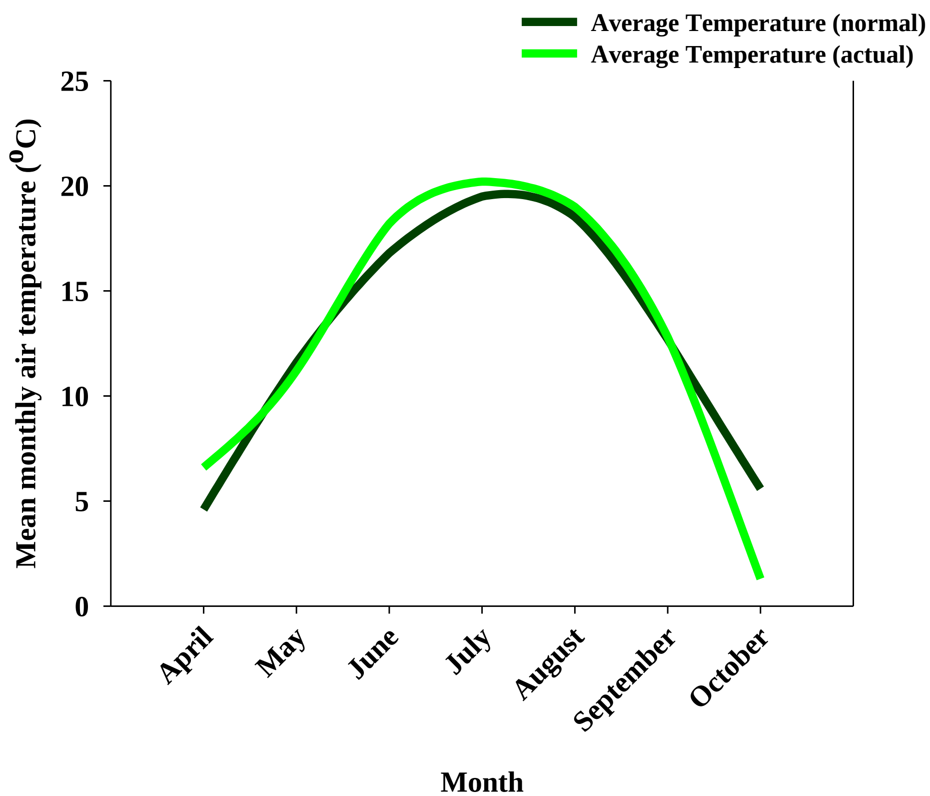
Month	Precipitation (mm)		Temperature °C		Corn Heat Units		Growing Degree Days (T >5°C)	
	Actual	Normal	Average	Normal	Actual	Normal	Actual	Normal
April	0	20	6.6	4.6	115	74	47	24
May	20	53	11.2	11.6	359	365	204	205
June	63	101	18.2	16.8	626	583	395	351
July	62	69	20.2	19.5	720	712	454	453
August	34	78	19	18.5	662	659	433	415
September	7	35	12.8	12.7	378	369	226	211
October	15	31	1.3	5.6	112	116	52	40

Source : "https://web43.gov.mb.ca/climate/SeasonalReport.aspx"

Table b: Season summary April 15 – October 31, 2020

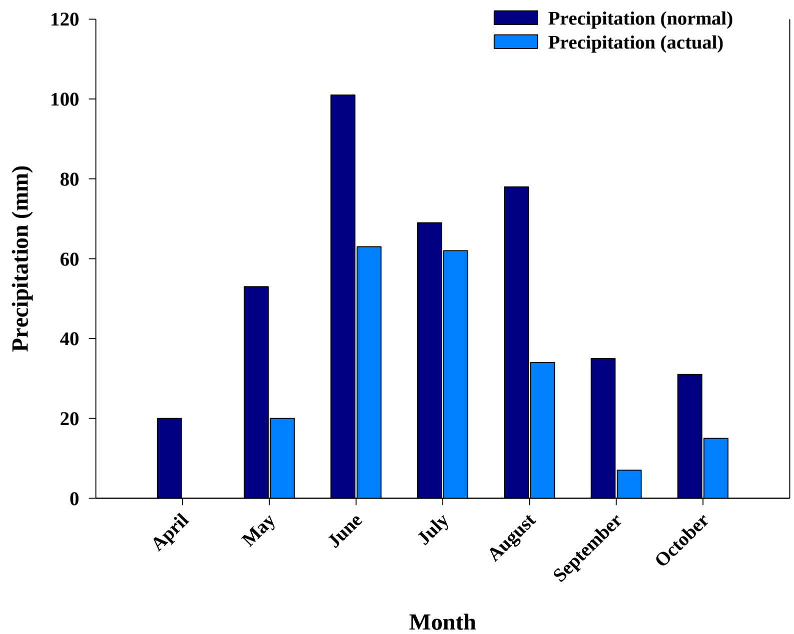
	Actual	Normal	% of Normal
Number of Days	200		
Growing Degree Days$_5$	1811	1699	107
Corn Heat Units	2972	2878	103
Total Precipitation (mm)	201	387	52

Source : "https://web43.gov.mb.ca/climate/SeasonalReport.aspx"



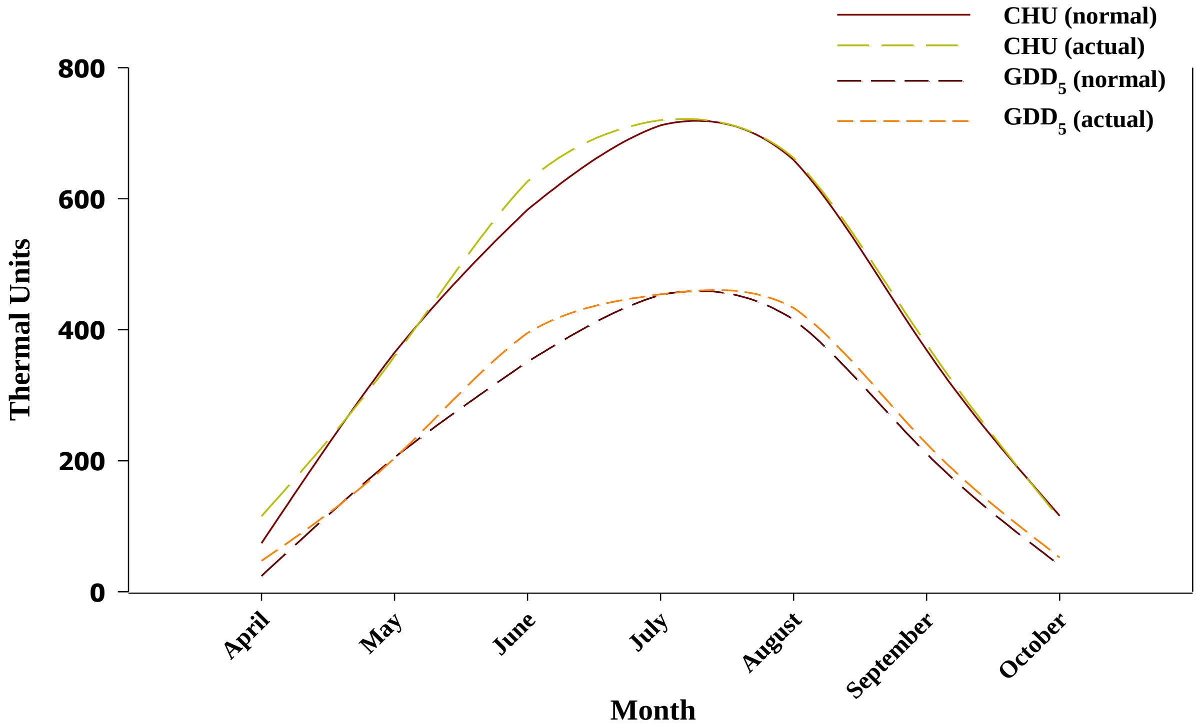
Mean monthly air temperature recorded at Melita from April 15 to October 31 2020

Average monthly temperatures were above normal between the months of April and September and followed a normal distribution. Thus, cooler temperatures were recorded in April (8°C) and October (1.3°C). Temperature peak was in July which set a record mean of 20.2°C while 18.2°C and 19°C were recorded in June and August, respectively. These warmer temperatures were ideal for heat accumulation required for crop development, overall.



Precipitation (mm) (normal and actual) recorded at Melita between April 15 and October 31 2020

The 2020 growing season was drier than 2019 with no precipitation recorded in April and below 30-year normal values throughout the whole season. Crop establishment was heavily reliant on residual moisture from snow melt and about 20 mm precipitation recorded during the month of May. The highest amounts of precipitation were 63 mm and 62 mm, and were received in June and July, respectively (Table a). This was crucial because it coincided with the critical crop development stages that required adequate moisture. Unlike 2019, where the highest amount of 100 mm was recorded in August, the same month received about 34 mm. Overall, the seasonal precipitation recorded was about 48% below normal and not evenly distributed throughout the season.



CHU and GDD_5 accumulated at Melita from April 15 to October 31 2020

Growing degree days (GDD) are calculated as follows:

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

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

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

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

Where: 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 2020 Precipitation Map and the 2020 Corn Heat Unit Map. These can be found at http://www.gov.mb.ca/agriculture/weather/manitoba-ag-weather.html.

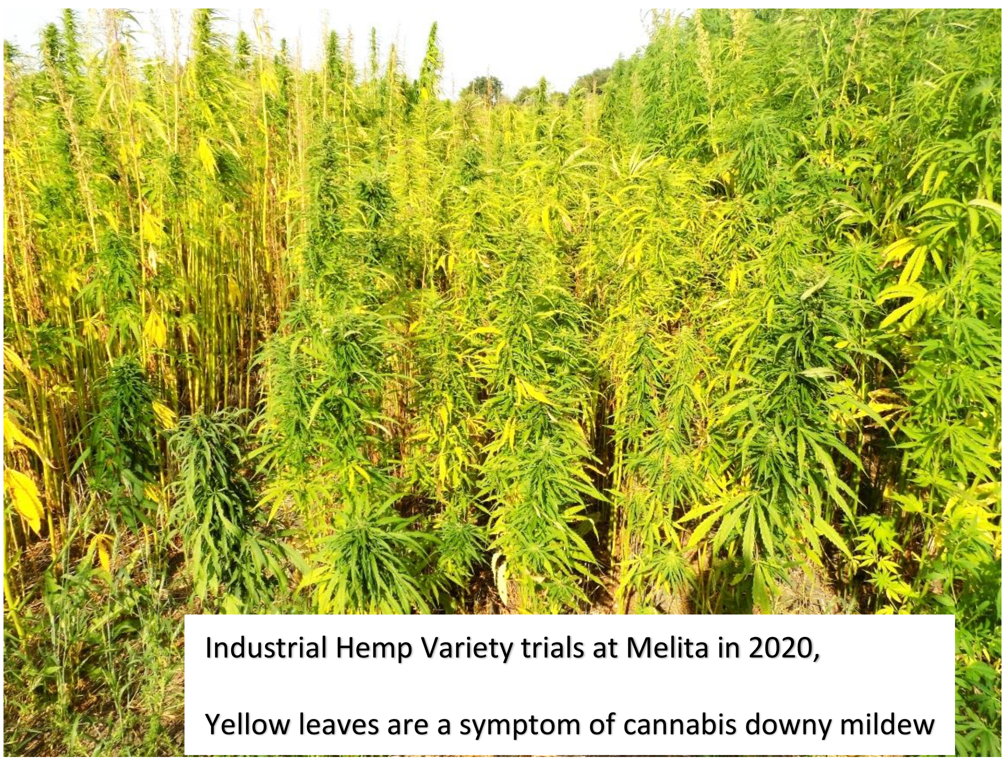
WADO Tours and Special Events

Like other organizations that host public events, WADO faced challenges as a result of the COVID-19 pandemic in 2020, resulting in the cancellation of traditional field days. However, individual presenters visited our sites while following health guidelines and conducted virtual tours that can be found on our website (www.mbdiversificationcentres.ca).

We would like to thank the WADO staff, Manitoba Agriculture and Resource Development employees and the guest speakers who made it happen under these restrictive conditions. The goal was to disseminate research information to producers and the Industry regardless of the method, and this was achieved.

MCVET Corn variety trials at Melita in 2020

Dry bean Inoculation trial at Melita in 2020



Industrial Hemp Variety trials at Melita in 2020,

Yellow leaves are a symptom of cannabis downy mildew

WADO Plot Statistics

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

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

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

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

For differences among treatments to be significant, the P-value must be less than 0.05. A P-value of 0.001 would be considered highly significant.

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

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

Grain Processing at WADO

The following process flow is used for grain handling from the plots until the grain is sent to collaborators:

Harvest grain – Hege 140 for hemp and Wintersteiger small plot combines for other grains

↓

Grain cleaning – depending on specifications by the collaborators, some require uncleaned grain

↓

Grain weighing – grain yield and test weight (if not done during harvest), thousand kernel weight

↓

Grain moisture and protein analysis – Labtronics 919 moisture tester, IM 9500 NIR grain analyzer

↓

Collect sub samples, analyze data and send to collaborators for further analysis

1.0 MCVET Variety Evaluations

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

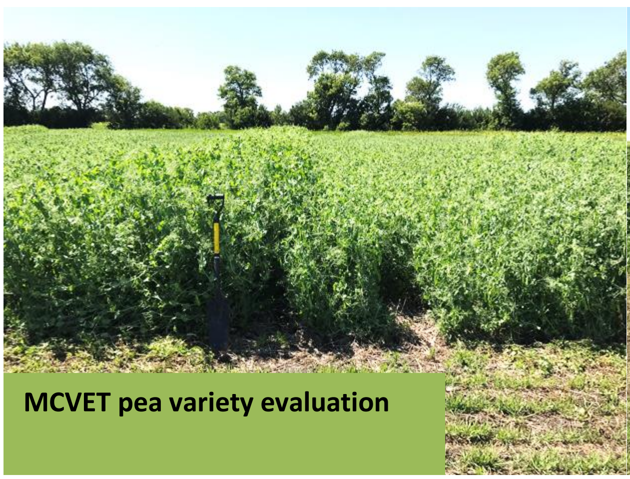
The purpose the MCVET variety evaluations is to grow both familiar (checks or reference) and new varieties side by side in a replicated manner in order to compare and contrast various variety characteristics such as yield, maturity, protein content, disease tolerance and many others. From each MCVET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

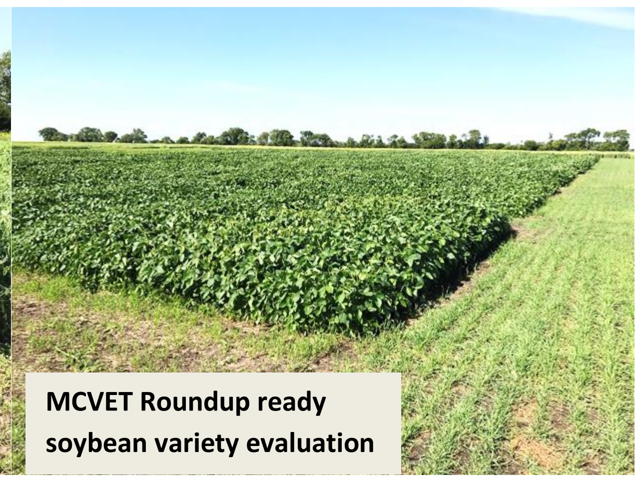
Table 1a summarizes the WADO grown MCVET trials agronomy for each crop type. The table provides extra insight and when combined with the weather summary, provides helpful insight into variety performance especially when compared year to year. Grain corn and sunflower variety evaluation results for 2020 are available in supplemental section 29.0 and 30.0 of this report and can also be accessed at www.mbcropalliance.ca .

Table 1a: Agronomy practices for selected MCVET crops in 2020. Yield data is published in the 2020 Seed Manitoba Guide.

Crop**	Pre-Emergence Burn off (rate/ac)	Soil Moisture	Seeding Date	Seeding Depth (inch.)	Fertilizer Applied (actual lb/ac) N-P-K-S-Zn	Chemistry-post emergence herbicides rate/ac	Harvest Date
Winter wheat	0.75 L Roundup + 0.015 L Aim	High	16-Sep-19	0.5	60*-35-20-3.5-0.8 + 60N in spring	0.2 L Achieve + 0.5 L Mextrol + 1% turbocharge	03-Aug-20
Fall rye	0.75 L Roundup + 0.015 L Aim	High	16-Sep-19	0.5	60*-35-20-3.5-0.8 + 60N in spring	0.2 L Achieve + 0.5 L Mextrol + 1% turbocharge	03-Aug-20
Barley	0.5 L Roundup + 0.015 L Aim	Good	19-May-20	0.625	100-35-20-8-2	0.81 L Tundra	11-Aug-20
Spring wheat	0.67 L Roundup + 0.015 L Aim	Good	06-May-20	0.625	100-35-20-8-2 + 30N top dress	0.81 L Tundra, 0.5 L Roundup + 0.042 L Heat	18-Aug-20
Oats	0.5 L Roundup + 0.015 L Aim	Good	07-May-20	0.625	100-35-20-8-2	0.5 L Mextrol, 0.5 L Roundup + 0.042 L Heat	17-Aug-20
Corn	0.5 L Roundup + 0.015 L Aim	Excellent	20-May-20	1.75	10-40-24-9-2.2 + 113N* 82N + 80N + 2 L Boron and Copper top dressed	0.67 L Roundup + 0.15 L Mextrol	08-Oct-20
Sunflower	0.1L Authority, 0.3 L Rival, 0.5 L Roundup, 0.015 L Aim	Excellent	20-May-20	1.25	10-40-24-9-2.2 + 113N*, 2 L Boron and Copper	0.2 L Assure II + 8 g Muster tank mixed, 0.34 L Assert + 155g pH adjuster	30-Sep-20 and 13-Oct-20
FY RR Soybean	0.5 L Roundup + 0.015 L Aim	Excellent	19-May-20	1	10-35-20-8-2 + inoculant	0.33 L Roundup	17-Sep-20
Conv. Soybean	0.5 L Roundup, 0.015 L Aim, 0.65 L Rival, 0.1 L Authority	Excellent	21-May-20	1	10-35-20-8-2 + inoculant	0.1 L Arrow + 0.5% Xact +0.91 L Basagran	17-Sep-20
Dry Beans	0.5 L Roundup, 0.015 L Aim, 0.65 L Rival	Excellent	19-May-20	1	10-35-20-8-2 + 160N split top dress	0.1 L Select + 0.91 L Basagran + 0.5% v/v Xact 0.65 L Reglone desiccant	09-Sep-20
Peas	0.5 L Roundup + 0.015 L Aim + 0.1 L Authority	Ample	06-May-20	1.25	10-35-20-8-2 + 6g/plot inoculant	17.3 g Odyssey + 0.5% v/v Merge, 0.1 L Arrow, 0.65 L Reglone desiccant	17-Aug-20
RR Soybean	0.5 L Roundup + 0.015 L Aim	Excellent	19-May-20	1	10-35-20-8-2 + inoculant	0.33 L Roundup	18-Sep-20

****All trials established on wheat stubble, *N applied in fall at 50% ESN and 50% Urea**





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

Project duration: 2019-2020
Collaborators: Ducks Unlimited, Western Ag & Professional Agronomy

Objectives

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

Background

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

Nitrogen is most often the focus of crop fertility in field studies. However, having a balanced approach and considering other essential nutrients, such as, phosphorus, potassium and sulphur and, micronutrients available in the soil offers great yield potential when nitrogen needs of the crop are met. Perhaps more efficient returns on investment potential can be achieved.

Materials and Methods

This study was established at four locations; Melita, Arborg, Carberry and Roblin in Manitoba in the fall of 2019 (Table 2b). In Melita, wheat was seeded into wheat stubble to a depth of 0.5" on September 16 using a 6-row dual knife seed hawk air seeder. The soil was characterized as Ryerson5Loam/Regent5Loam. Preemergence weed control was necessary to ensure a clean seedbed and this was done using Roundup tank mixed with Aim at 0.75 L ac^{-1} and 0.015 L ac^{-1}, respectively. Post emergence weed control was done in spring by application of Achieve and Mextrol herbicides tank mixed at 0.2 L ac^{-1} and 0.5 L ac^{-1}, respectively, with 1% of Turbocharge added as an adjuvant. As a preventative measure for fungal diseases such as fusarium head blight (FHB) and stem rust, a spray application was done with Prosaro at 0.325 L ac^{-1} at 75% heading. The treatment structure consisted of a factorial arrangement of two fertilizer management practices and three winter wheat varieties in a randomized complete block design. The three winter wheat varieties utilized were; Gateway, Elevate and Wildfire. Fertilizer treatments included:

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

A summary of fall soil tests conducted at Melita, Roblin, Carberry and Arborg, and fertilizer treatments for 2019/2020 are presented in Table 2a.

Table 2a: Fall Soil test results by site and fertilizer treatments for winter wheat in 2019/2020 season

Fall Soil Test - All Values (lbs/ac)				
	Location			
Nutrient	**Melita**	**Roblin**	**Carberry**	**Arborg**
N	31	39	38	53
P	11	76	32	4
K	84	132	179	19
S	205	22	16	523
Zn	1.0	0.64	0.52	0.08
Producer Practice Application (all N applied in Spring)				
N	100	100	100	100
P	30	30	30	30
K	0	0	0	0
Balanced Practice application recommendations (Western Ag Processional Agronomy Laboratory) 50% N applied in fall				
N	155	135	145	125
P	55	15	40	55
K	85	30	20	50
S	0	10	10	0
Zn	0	0	0	2

Table 2b: Site description and agronomics for winter wheat trial in 2019/2020 season

Location	Melita	Carberry	Roblin	Arborg
Cooperator	WADO	CMCDC	PCDF	PESAI
Legal	NW23-3-27W1	South ½ of 8-11-14 W1	NE 20-25-28 W1	NW 16-22-2 E1
Rotation (2 yr.)	LLcanola-s. wheat	Canola (2019), Soybean (2018)	Barley silage (2019 &2020)	spring wheat canola
Soil Series	Ryerson Loam	Ramada Clay Loam	Erickson clay loam	Fyala heavy clay
Soil Test Done? (Y/N)	Yes	Yes	Yes	
Field Prep	no till	no till	harrowed	no till
Stubble	spring wheat	Canola	Barley	Canola
Burn off (Date/Rate per ac/Products)	Roundup 0.75L + Aim 15 ml	Roundup 0.67 L + Heat 29 g + Water 40 L; sprayed before seeding (September 17, 2019)	Sep 12 Glyphosate 0.67 L	No burn off
Soil Moisture at Seeding	Excellent	Good	Good	
Seed Date	Sep/16	Sep/16	Sep/19	Sep/17
Seed depth (Inches)	0.5	1.5	0.625	1
Seeder (drill/planter?)	Knife drill	Knife drill	Disc drill	Disc drill
Errors at seeding	None	N/A	None	
Topdressing	May/04	May/07	May/12	May/12
Herbicides (Date, Rate/ ac, Name)	Achieve 0.2 L Mextrol 0.5 L + turbocharge 1%	June 12 Fitness 90 ml	May 26 Axial 0.5 L Prestige XC 0.18 L	None
Fungicides (Prosaro)	23-Jun	26-Jun	09-Jun	19-Jun
Harvest Date	Aug/03	Aug/11	Aug/24	Aug/10
Total Precipitation (mm) (Seeding > Harvest)	332	415	319	345

Results

Winter wheat yield was not significantly influenced by variety, fertilizer management practice or interaction of the two factors at Melita but there was a significant (P=0.004) variety influence on protein content. Gateway had 13.5% protein compared to Elevate and Wildfire that had 12.2% and this could be due to genetic differences between the varieties. Although there were relatively low grain yields at Roblin compared to other sites, there was a significant influence of variety (P<0.001), variety x fertilizer management practice (P=0.012) and no significant effect of fertilizer management practice on winter wheat yield. Wildfire yielded significantly more grain (4145 kg ha^{-1}) compared to Elevate (3234 kg ha^{-1}) and Gateway (2875 kg ha^{-1}). An interaction of Wildfire variety x balanced fertilizer management practice significantly contributed to more grain yield (4692 kg ha^{-1}) compared to other interactions while Wildfire variety x 100% spring applied fertilizer management practice yielded significantly more grain (3598kg ha^{-1}) than balanced fertilizer application on Gateway variety (2732 kg ha^{-1}). As observed at Melita, protein content was significantly (P=0.001) high for Gateway variety (15.6%) compared to Elevate (14.6) and Wildfire (14.2%). Fertilizer management practice also significantly (P=0.022) influenced protein content at Roblin with balanced fertilizer having 15.1% compared to 100% spring applied on 14.5%. At Carberry, there was a significant influence of variety (P<0.001) and fertility management practice (P=0.001) on winter wheat grain yield. Wildfire, Elevate and Gateway yielded 6864 kg ha^{-1}, 6336 kg ha^{-1} and 5822 kg ha^{-1}, respectively.

A balanced fertilizer management practice resulted in approximately 8.33% more grain yield compared to 100% spring applied practice. There was no significant influence by any of the treatments on protein content. At Arborg, variety significantly influenced winter wheat grain yield (P=0.024) and protein content (P=0.007) while fertility management practice had a significant influence on yield (P=0.014) alone. On variety influence, Wildfire had the highest yield (6082 kg ha^{-1}) while Gateway and Elevate had 5233 kg ha^{-1} and 5110 kg ha^{-1}, respectively. Gateway variety continued to show similar trends as other sites with significantly higher protein content (13.3%) compared to Elevate (12.2%) and Wildfire (12.3%). Combining data from all sites resulted in significant influence by variety (P<0.001) on yield and protein content while fertility management practice significantly (P<0.001) influenced yield only. Four-site year analysis showed Wildfire leading in yield at 5473 kg ha^{-1} followed by Elevate with 4891 kg ha^{-1} and Gateway at 4588 kg ha^{-1}. On the other hand, Gateway had the highest combined protein content of 14.3% compared to 13.3% for Elevate and Wildfire. Balanced fertility management significantly influenced winter wheat grain yield resulting in attainment of 5199 kg ha^{-1} compared to 100% spring applied fertility management practiced that attained 4769 kg ha^{-1} (Table 2c).

Table 2c: Analysis of variance for winter wheat yield (kg ha^{-1}) and protein content (%) at Melita, Roblin, Carberry, Arborg and combined for all sites in 2019/2020 season

			Location									
			Melita		Roblin		Carberry		Arborg		All Sites	
	Treatment		Yield	Protein	Yield	Protein	Yield	Protein	Yield	Protein	Yield	Protein
Variety	Elevate	1	4884	12.2b	3234b	14.6b	6336b	14.4	5110b	12.2b	4891b	13.3b
	Gateway	2	4420	13.5a	2875b	15.6a	5822c	14.8	5233b	13.3a	4588c	14.3a
	Wildfire	3	4803	12.2b	4145a	14.2b	6864a	14.6	6082a	12.3b	5473a	13.3b
Fertility	100%Spring	1	4628	12.6	3292	14.5b	6065b	14.8	5089b	12.6	4769b	13.6
	Balanced	2	4776	12.7	3545	15.1a	6616a	14.4	5861a	12.5	5199a	13.7
Var x Fert	1,1		4706	12.4	3258bc	14.5	6157	14.6	4538	12.3	4665	13.4
	1,2		5062	12	3210bc	14.6	6515	14.2	5681	12.1	5117	13.2
	2,1		4312	13.2	3019bc	15	5489	14.9	4692	13.6	4378	14.2
	2,2		4528	13.8	2732c	16	6154	14.6	5774	12.9	4797	14.4
	3,1		4866	12.1	3598b	14	6549	14.8	6038	12.1	5263	13.2
	3,2		4739	12.3	4692a	14.5	7180	14.4	6126	12.4	5684	13.4
	P values	Variety	0.210	0.004	<0.001	0.001	<0.001	0.371	0.024	0.007	<0.001	<0.001
		Fertilizer	0.500	0.675	0.143	0.022	0.001	0.055	0.014	0.548	<0.001	0.738
		Var x Fert	0.644	0.361	0.012	0.226	0.49	0.968	0.225	0.282	0.988	0.351
		CV%	10	5	10	3	4	3	10	4	8	4

Results from this study indicate that a balanced fertilizer management approach could be a better option than the farmer practice of applying all nitrogen in spring. This is largely due to the fact that winter wheat requires adequate starter nitrogen during early days of establishment in fall and when it resumes development in spring. There is also a likelihood that nitrogen losses from fall vs spring applied nitrogen due to leaching, volatilization and immobilization. Furthermore, the use of Agrotain urease inhibitors with urea may have had an impact on the final grain yield and protein content of wheat. Continued field study would be necessary to effectively develop fertilizer management recommendations that winter wheat producers can use for their areas of production.

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

Project duration: 2018/19-2020/21
Collaborators: Dr. Paul R. Bullock, Manasah Mkhabela –University of Manitoba

Objectives

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

Background

Fusarium Head Blight (FHB), also known as head scab, is a devastating disease of wheat, barley and durum with a worldwide distribution especially in areas where weather conditions are warm and humid. The fungal disease, caused by many species including *Fusarium graminearum* Schwabe, is capable of causing significant losses in grain yield, test weight and seed germination (Steiner et al., 2017). In addition to losses in grain yield, fusarium species produce mycotoxins among them, Type-B trichothecenes such as deoxynivalenol (DON) or nivalenol as well as the resorcyclic acid lactone zearalenone, which has potential of causing serious economic losses and health risks in humans and livestock (Prandini et al. 2008; Steiner et al., 2017). There are various prediction models currently in place but more accurate and specific ones are essential, especially for varying Prairie weather conditions. These tools are essential in assisting producers with estimates of FHB risk levels and develop plans to curb the disease either through timing of fungicide sprays or timing of planting. Some of the available models that are currently in use include;

the Penn State and the Ontario DonCast models. Because of their specificity to their place of origin, very few models have been adapted to other regions that experience varying weather conditions (Giroux et al. 2016), hence the need to develop or modify existing models to suit Prairie environmental conditions. Given the severe losses in production and quality caused by the FHB, the ability to accurately predict its occurrence will play a significant role in reducing year to year risk for producers. Therefore, modification and/or validation of the already available models would be essential for accurate prediction of FHB based on weather conditions on the Prairies.

Materials and Methods

Five plot sites in each of the three Prairie provinces, Alberta, Manitoba and Saskatchewan were established in 2018/19 growing season. Winter wheat, spring wheat, durum and barley were laid out in a split plot design with 4 main plots for crop type and a randomized complete block design of 4 replicates and 3 varieties inside each main plot (except durum – 1 variety) for a total of 10 treatments. As a result of a shortage of seed, winter wheat was only replicated 3 times during the 2018/19 growing season but a 4th replicate was included in 2019-2020 season.

In fall 2019, Melita location was established on Ryerson5LoamRegent5Loam soil under no till system and on wheat stubble. Winter wheat was seeded on 16 September 2019 while spring wheat, barley and durum were seeded on 11 May 2020. Preemergence weed control in winter wheat and spring cereals was done using 0.75 L ac^{-1} Roundup tank mixed with 0.015 L ac^{-1} Aim. Post emergence weeds in barley, spring wheat and durum were controlled with 0.81 L ac^{-1} Tundra tank mixed with 0.5 L ac^{-1} Mextrol, 0.2 L ac^{-1} Achieve and 1 % Turbocharge adjuvant. Fertilizer application for winter wheat was done first at seeding at a rate of 60-35-20-3.5-0.8 (N-P-K-S-Zn) actual lb. ac^{-1} followed by top dressing with 60 lb. ac^{-1} N in spring. The N portion of basal dressing for winter wheat consisted of equal proportions of Urea and ESN source. For spring seeded cereals, fertilizer was side banded during seeding at a rate of 100-35-20-8-2 (N-P-K-S-Zn) actual lb ac^{-1}. All fertilizer applications were based on soil test results and expected crop demands. Seeding depth for winter wheat was 0.5” while 0.75” depth was used for spring cereal as a result of differences in soil moisture at time of seeding. Adhesive type spore traps were installed at 2 central spots within the plots at the beginning of anthesis (BBCH 61) to capture FHB spores. The spore traps were replaced weekly for 4 weeks ensuring the traps were place at the same height as the cereals in the plots. Additional data collected included; plant counts, days to heading, maturity, harvest, protein content, thousand kernel weight, grain moisture content at harvest, FHB score on affected head and weed pressure where necessary. Grain analysis for protein and moisture was done at WADO using IM9500 NIR grain analyzer. The data were analyzed by the collaborator at the University of Manitoba.

Results and Discussion

The research trial is in its second year and a progress report will be made available upon completion of the analysis by the collaborators. A final analysis for all site-years will be available when the trial is concluded in 2021.

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4.0 PepsiCo - Quaker oats variety evaluation

Project duration: 2019-2020
Collaborators: PepsiCo/Quaker – Derek Herman, Plano TX

Objectives

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

Background

There has been renewed interest in the production of oats as a result of its role in livestock feed as well as part of a healthy human diet. Production of oats (*Avena sativa* L.) is influenced by several factors that include; rainfall or precipitation, temperature, solar irradiation and soil conditions in which the crop is being grown (Sorrells and Simmons, 1992). These factors appear to affect the crop at different phenology stages during the season. Therefore, timing of seeding is crucial in a given production area so as to synchronize it with the occurrence of ideal weather conditions favorable for growth and development.

Oat production has been on the rise in Canada with an estimate of +15 % to 4 million tons in 2019 (Statistics Canada, 2019). This has been attributed to a 15.2% increase in harvested area (to 2.9 million acres) coupled with new higher yielding varieties available for producers across Canada. New varieties still need to be tested across different environments so as to allow producers to have a wide selection of the ones that match their objectives.

Materials and Methods

The trial was arranged as randomized complete block design with 19 varieties replicated 4 times on Newstead loam soils in Melita. Plots were established on spring wheat stubble under no till system on the 7st of May 2020. Seeds were placed at 0.625 inches' depth using a dual knife Seed hawk air seeder. All fertilizer requirements were met by side banding during seeding at a rate of 100-35-20-8-2 (N-P-K-S-Zn) actual lb. ac^{-1}. Fertilizer application was done based on soil test results and also to meet requirements of the crop. Preemergence weed control was done a day after seeding using a tank mix of 0.5 L ac^{-1} Roundup and 0.015 L ac^{-1} Aim. Post emergence weed control was achieved by the application of 0.5 L ac^{-1} Mextrol at stage 15 on BBCH scale for control of broad leaf weeds. Data collected included; days to heading, plant height at maturity, days to maturity, grain yield, lodging and incidence of diseases that included; crown rust, stem rust and smut. The trial was harvested on 17 August with a Classic Wintersteiger small plot harvester equipped with Harvest Master H2 Classic weighing system.

Results

Major highlights of this trial were grain yield, days to maturity, lodging rating and disease incidence. These are meant for variety development decisions. Summaries of results are available from the project collaborators upon request.

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5.0 Sollio oat variety evaluation

Project duration: 2019-2020
Collaborators: Sollio Ltd. (QC), Christain Azar, Agr. M. Sc. Plant Breeder

Objectives

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

Background

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

Materials and Methods

The trial was established on the 6th of May 2020 on Newstead loam soils under no till system in Melita. A randomized complete block design with 30 treatments (varieties) and 3 replicates was used. Seeds were placed into good moisture conditions at 0.625" depth using a Seed hawk dual knife air seeder. Fertilizer was side banded at the same time as seeding at a rate of 100-35-20-8-2 (N-P-K-S-Zn) actual lb. ac^{-1} and this was based on soil analysis results. Initial weed control was done using a tank mix of 0.67 L ac^{-1} Roundup and 0.015 L Aim ac^{-1} a day after seeding. Post emergence weed control was done at 5 leaf stage of oats using 0.5 L ac^{-1} Mextrol for control of broad leaf weeds and some grasses. All spray applications were done using a tractor mounted boom sprayer with conventional flat fan nozzles and pressure set at 40 psi. Data collected included; emergence percentage, plant height, early and late lodging, days to maturity, thousand kernel weight, grain yield, protein content and disease incidence for leaf spots, crown rust and stem rust.

Results

This study is aimed at variety development and results are made available by the collaborator upon request.

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

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

Objectives

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

Background

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

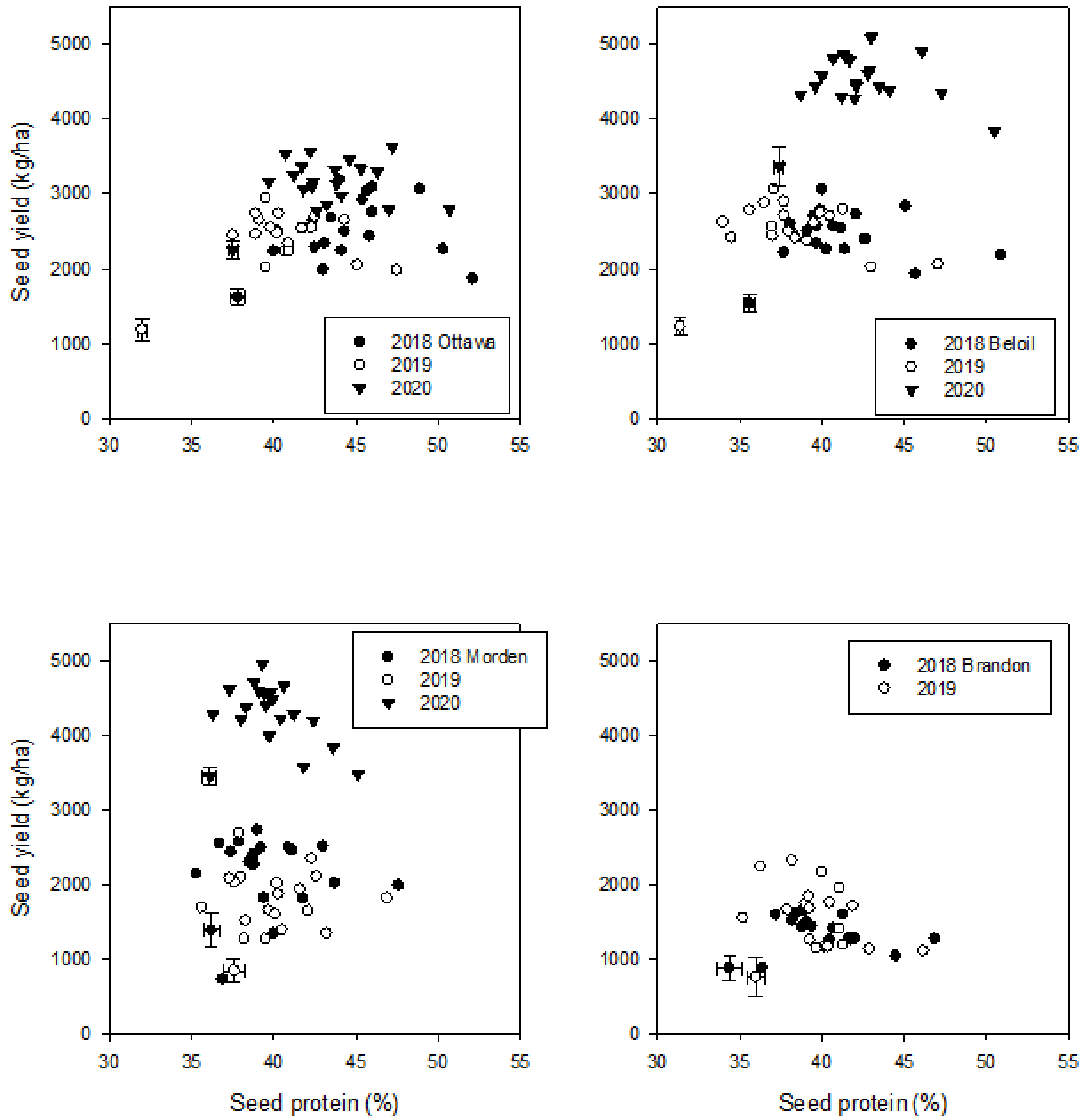
Materials and Methods

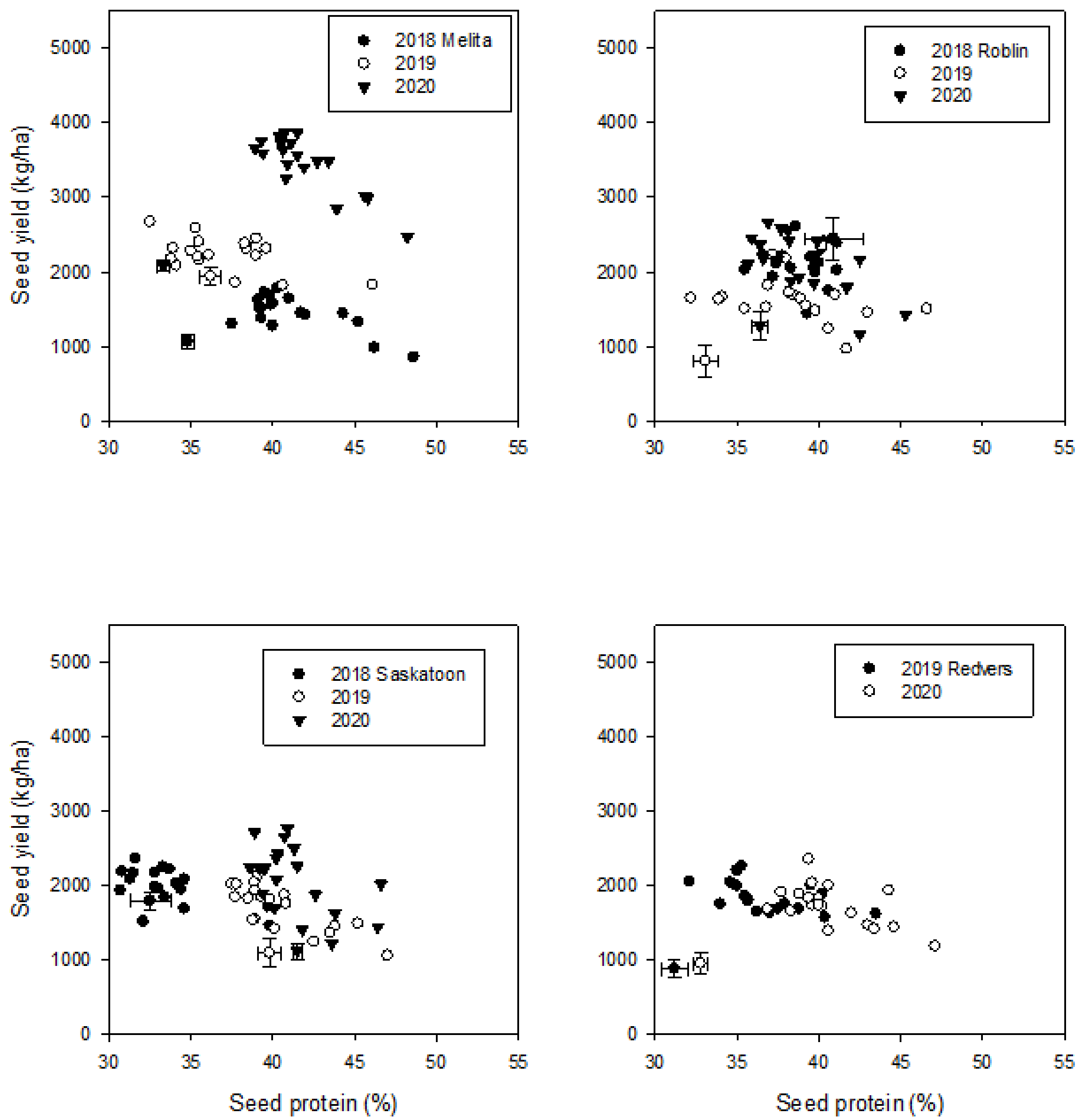
The trial was initiated in 2018 by AAFC and will run until 2021 across Canada at Ottawa, Beloeil, in Ontario, Brandon, Melita, Roblin and Morden in Manitoba, Outlook and Saskatoon in Saskatchewan. In the 2020 growing season in Melita, the trial was arranged as a 5 x 4 x 4 alpha lattice in a randomized complete block design with 20 treatments (conventional varieties) replicated 4 times on Newstead loam soil. The treatments were inoculated with granular BASF inoculant prior to seeding at a depth of 1" on the 21st of May. Seeding was done under no till system on wheat stubble and granular fertilizer blend was side banded at a rate of 10-35-20-8-2 (N-P-K-S-Zn) lb. ac^{-1} at the same time. Chemical weed control included a burn off application with a single tank mix of 0.5 L ac^{-1} Roundup, 0.1 L ac^{-1} Authority, 0.65 L ac^{-1} Rival and 0.015 L ac^{-1} Aim and in-season application of 0.91 L ac^{-1} Basagran + 0.1 L ac^{-1} Arrow and 0.5% v/v Xact adjuvant in a single tank mix. A follow up application with 0.1 L ac^{-1} Arrow was done a week later to control grasses. During the season 0.034L ac^{-1} Matador was applied in July and August to control grasshopper populations. Several observations were made and these included; emergence date, plant height at maturity, days to 50% flowering, days to maturity, harvest date, moisture content at harvest, grain yield and protein content. Harvesting occurred on the 18th of September when all plots were past harvest maturity and moisture seed moisture content ranged from 13 to 16%. Data were analyzed by AAFC in Ottawa.

Results and Discussion

This section presents results from various locations in Canada, including Melita, and summaries are for combined data analysis from 2018 to 2020.

Individual sites over years





2018 Melita
2019
2020
2018 Roblin
2019
2020
2018 Saskatoon
2019
2020
2019 Redvers
2020
Seed yield (kg/ha)
Seed protein (%)

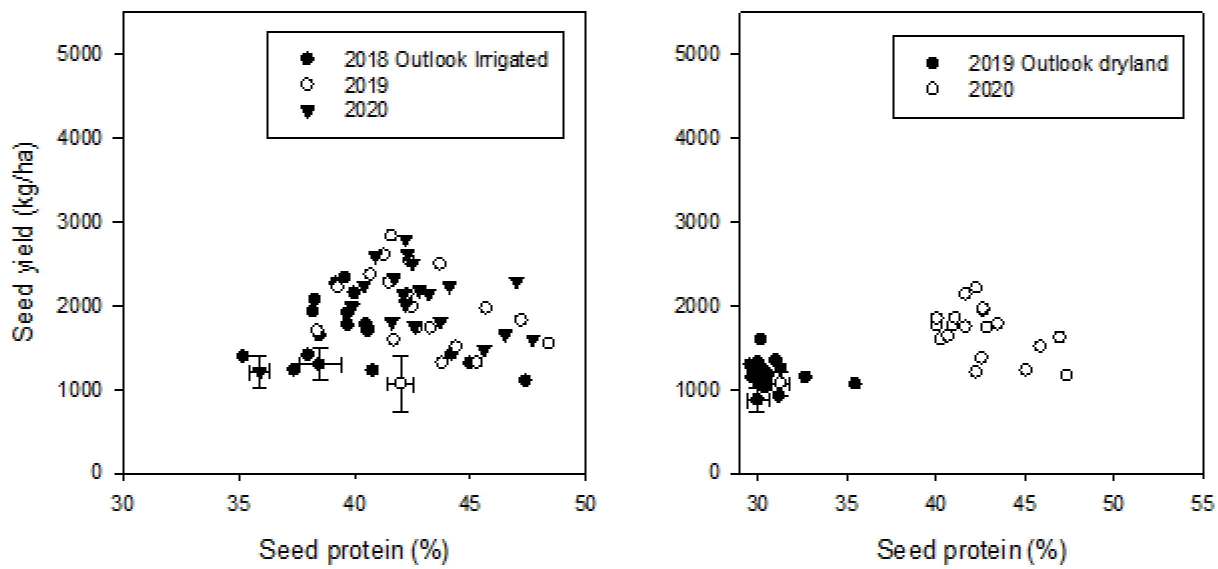


Fig.1. Seed yield and protein for each site. The error bars are two standard errors long and are shown for the non-nodulating line at each location.

At many locations, 2020 was a higher yielding year as well as some sites also having higher protein. There was a striking difference between 2019 and 2020 Outlook dryland sites.

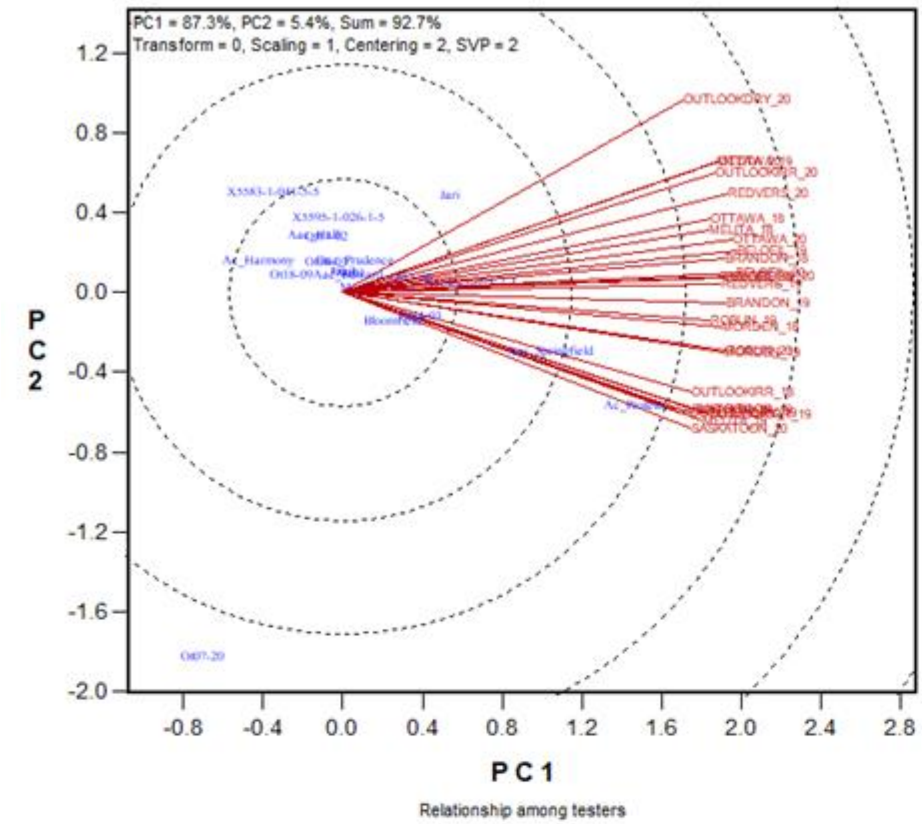


Fig.2. A genotype by location biplot for seed protein content, 2018-2020 with Roblin-2018 excluded. In this biplot, we see little east-west sorting of locations.

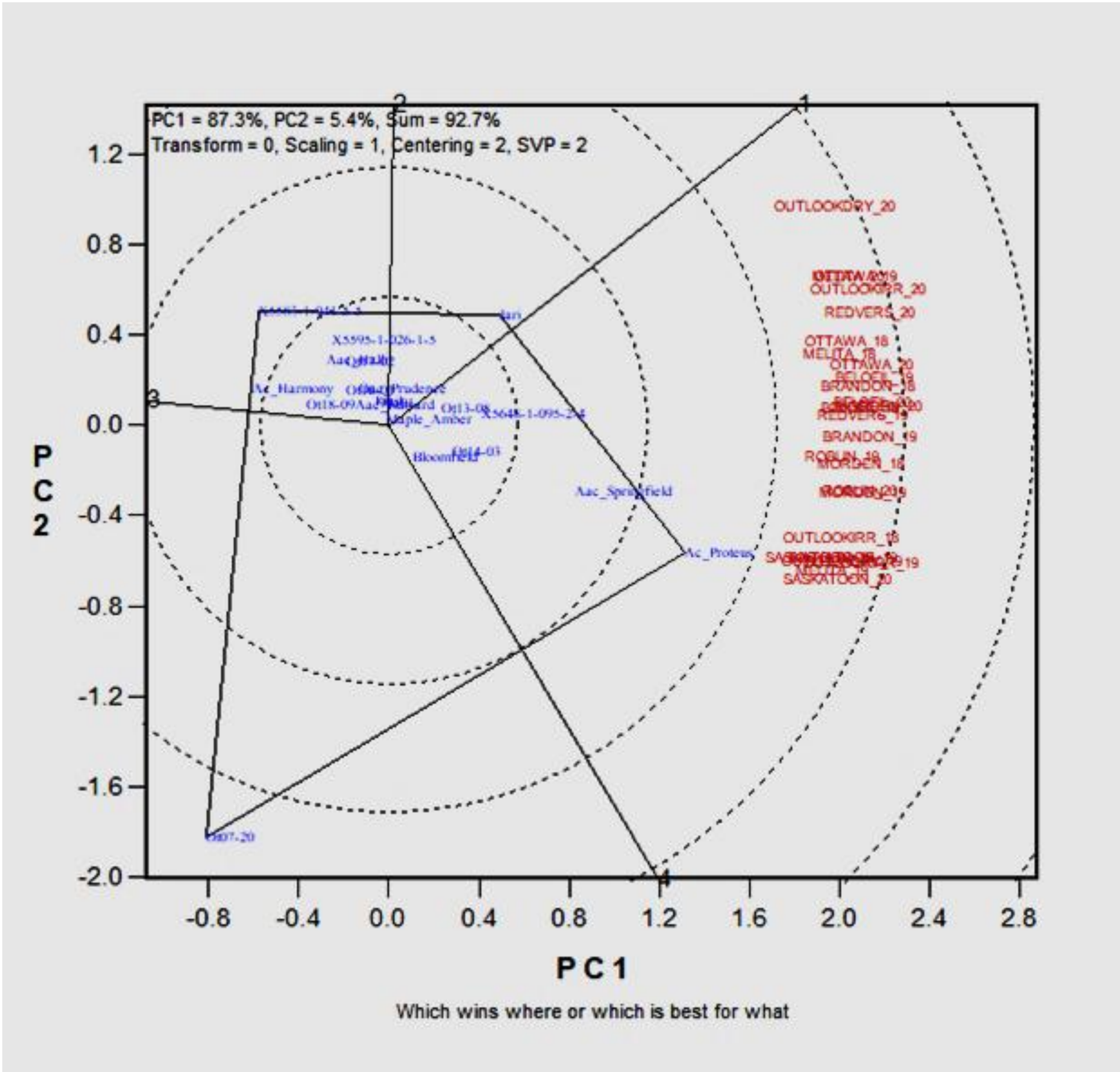


Fig. 3. A which-won-where biplot for seed protein, or which was the highest protein line in which group of locations. The biplot shows one highest protein line with all locations responding similarly. This indicates that this high protein line performs across all locations without a genotype by environment ranking change for seed protein.

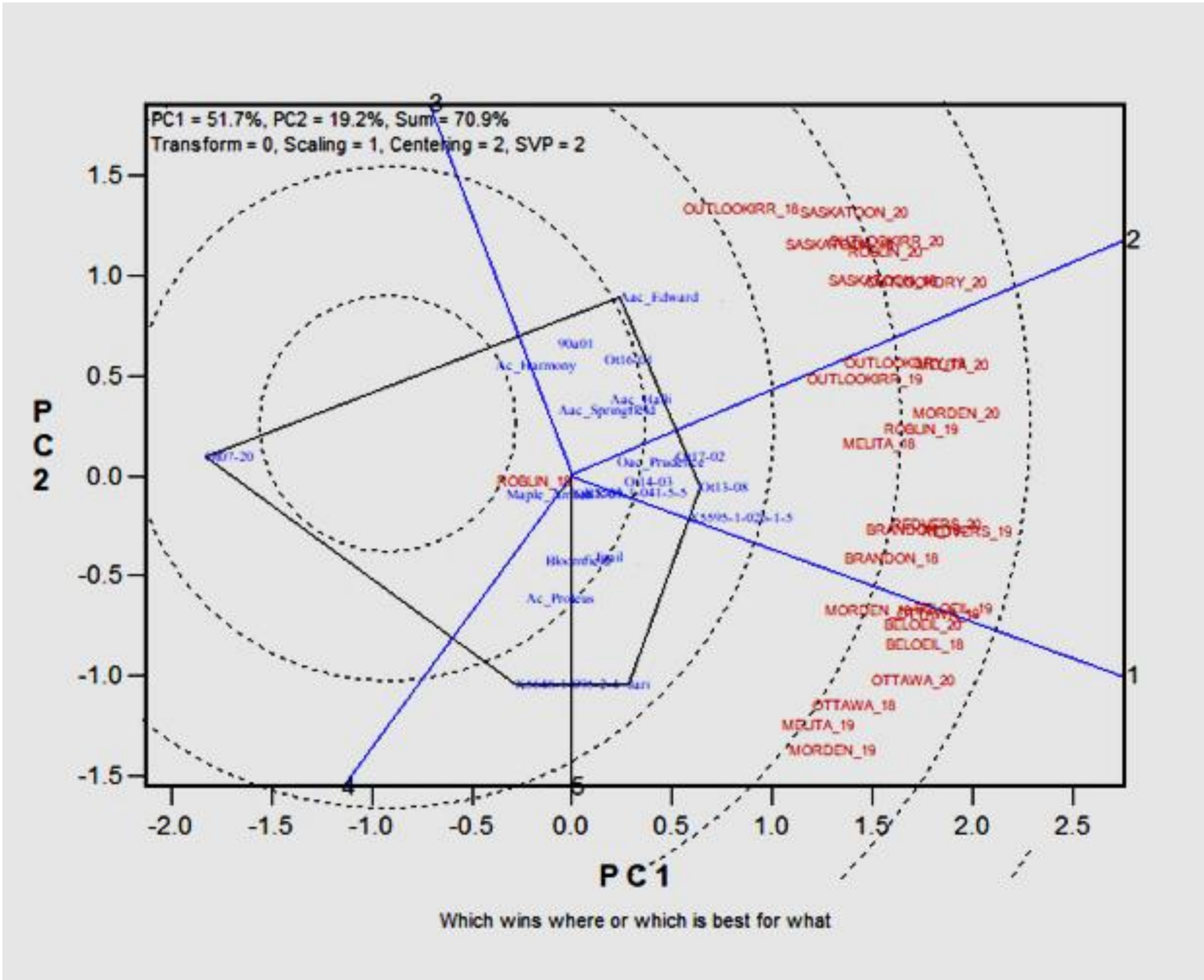


Fig. 4. A which-won-where biplot for protein yield (kg protein ha^{-1}). Here we see the locations broken into three groups corresponding approximately to Eastern Canada, Eastern Prairies, and Prairies. Maturity is playing some role here with the winning protein yield variety being earlier maturing in the Prairie group compared to the Eastern Canada group.

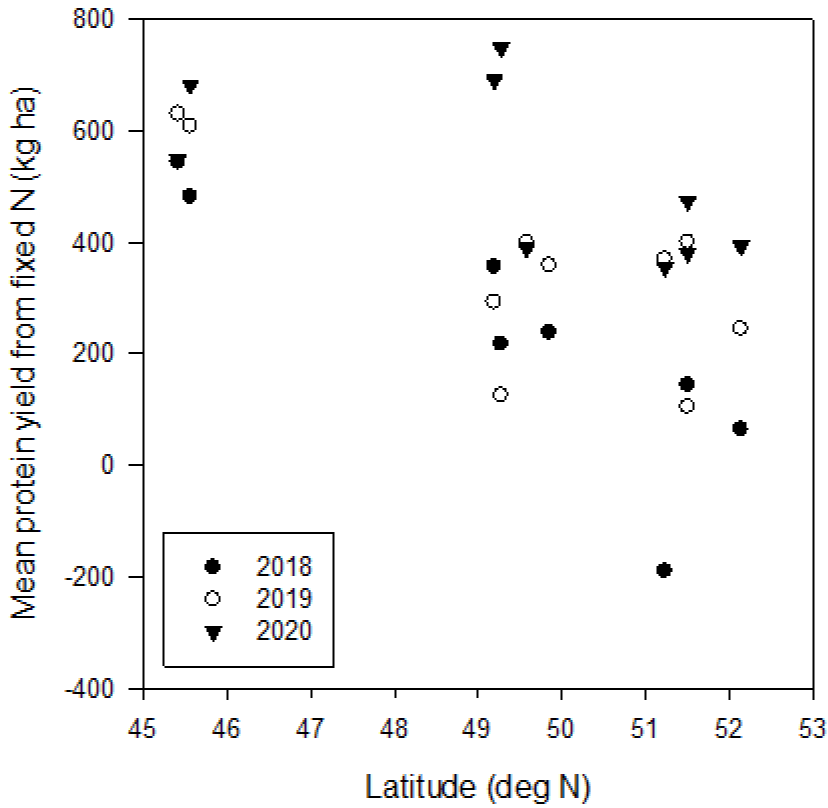


Fig. 5. Estimates of protein yield produced from fixed N versus site latitude. There was more N fixed in 2020 but the trend to lower fixed N protein with higher latitude continues.

Soybean protein quality analysis (Hadinezhad, AAFC Ottawa) from 2019 and 2020 is underway now. This work was paused during COVID-19 work from home requirements.

Work on weather data collection and analysis (Glenn, AAFC Brandon) in support of the project has proceeded without any major issues or variances noted. Basic summaries of the 2018 and 2019 growing season conditions (temperature and precipitation) relative to climate normal have been completed for all study locations based on common data available from the nearest Environment and Climate Change Canada (ECCC), provincial (e.g., Manitoba Ag-Weather Program [MAWP] and AgWeather Quebec), and AAFC operated weather stations.

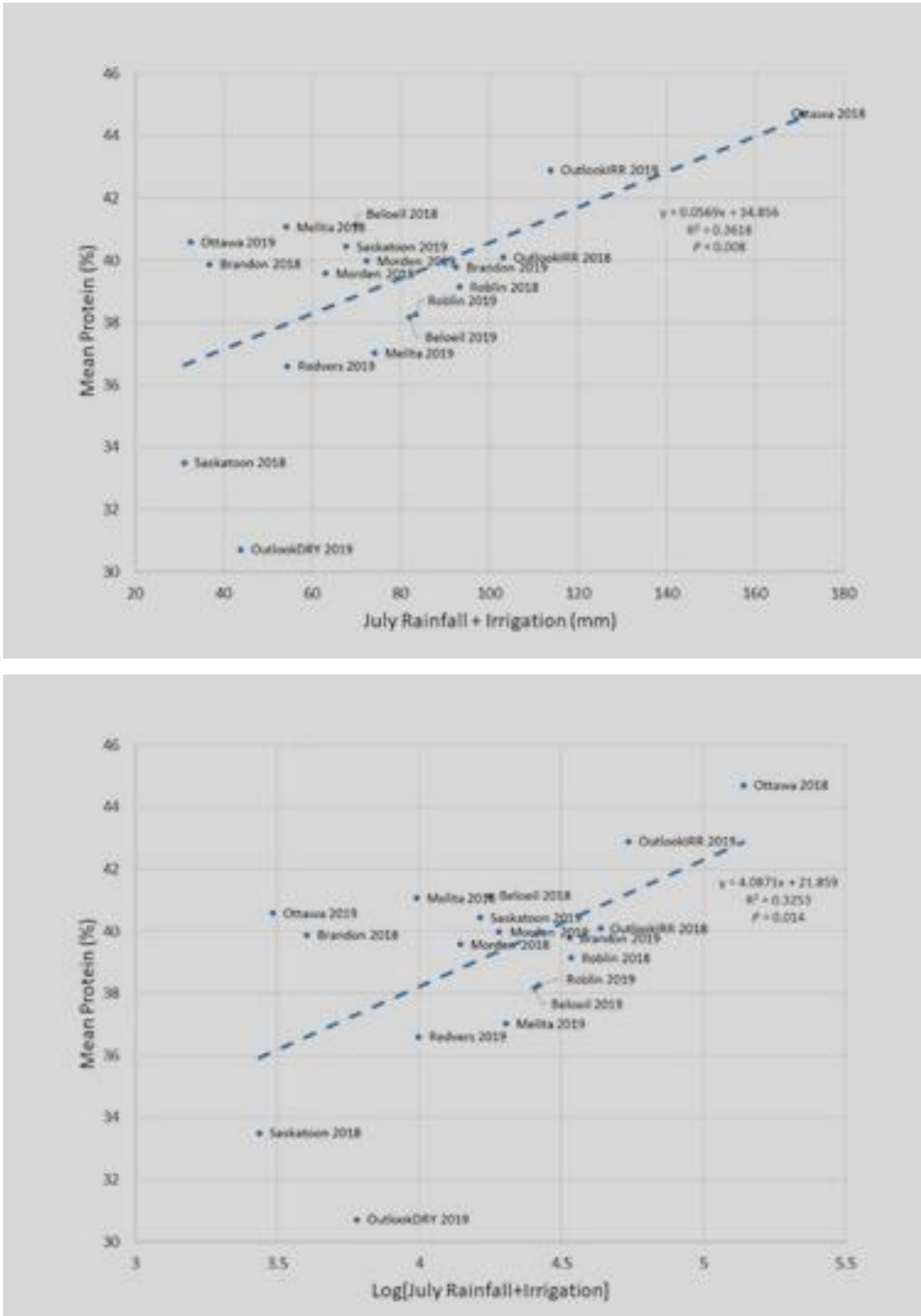
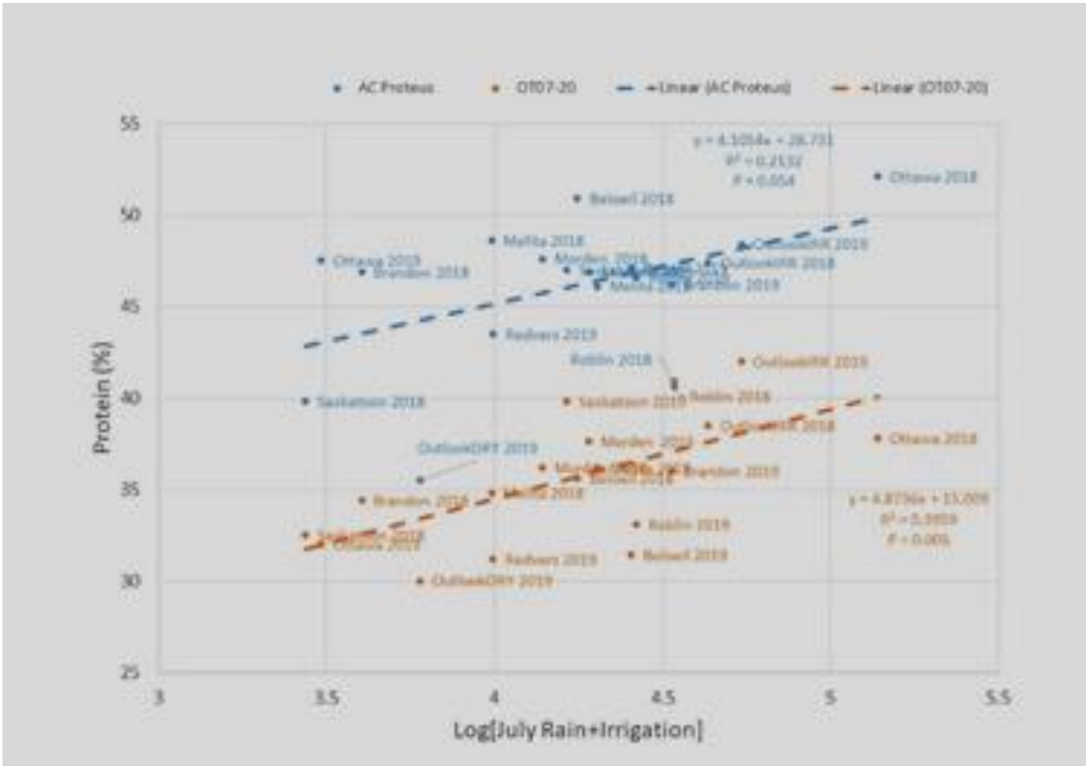


Fig. 6. July rainfall vs mean seed protein on a site basis. Water plays an important role in nitrogen fixation as nitrogen fixation is reduced before photosynthesis is reduced during a water stress.



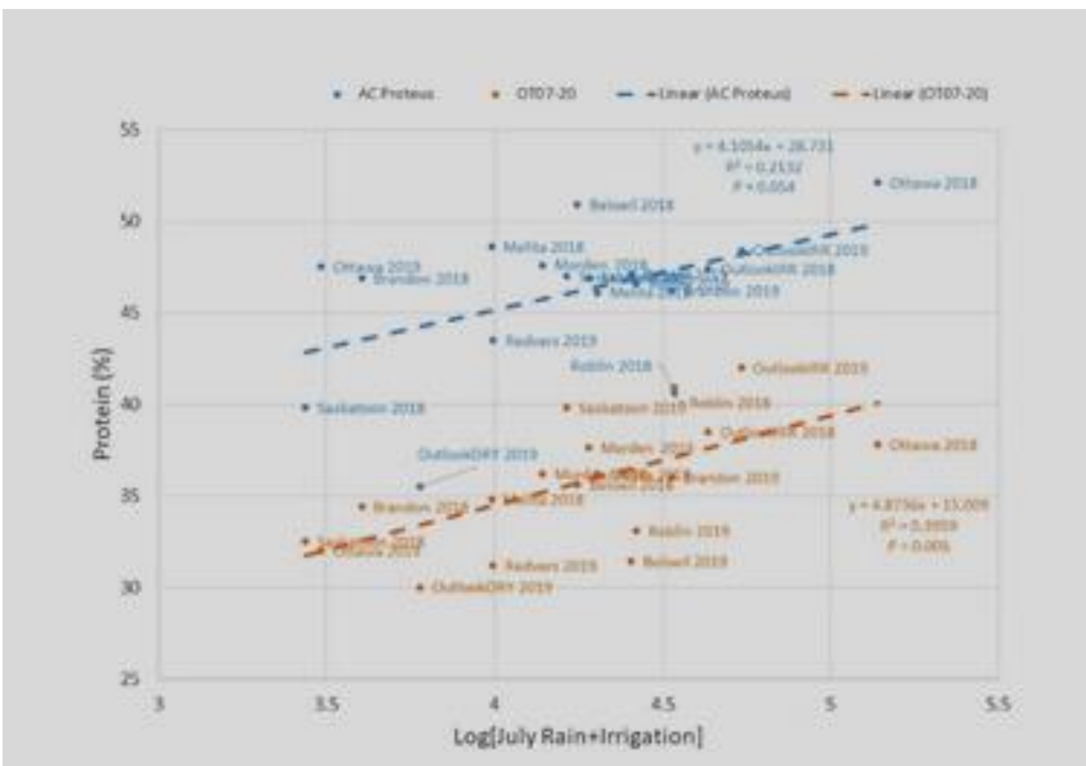


Fig. 7. The role of July water on seed protein in the highest and lowest seed protein lines. As OT07-20 is a non-nitrogen fixing line and derives all its nitrogen from the soil, the role of soil water in soil nitrogen mineralization and uptake is also seen.

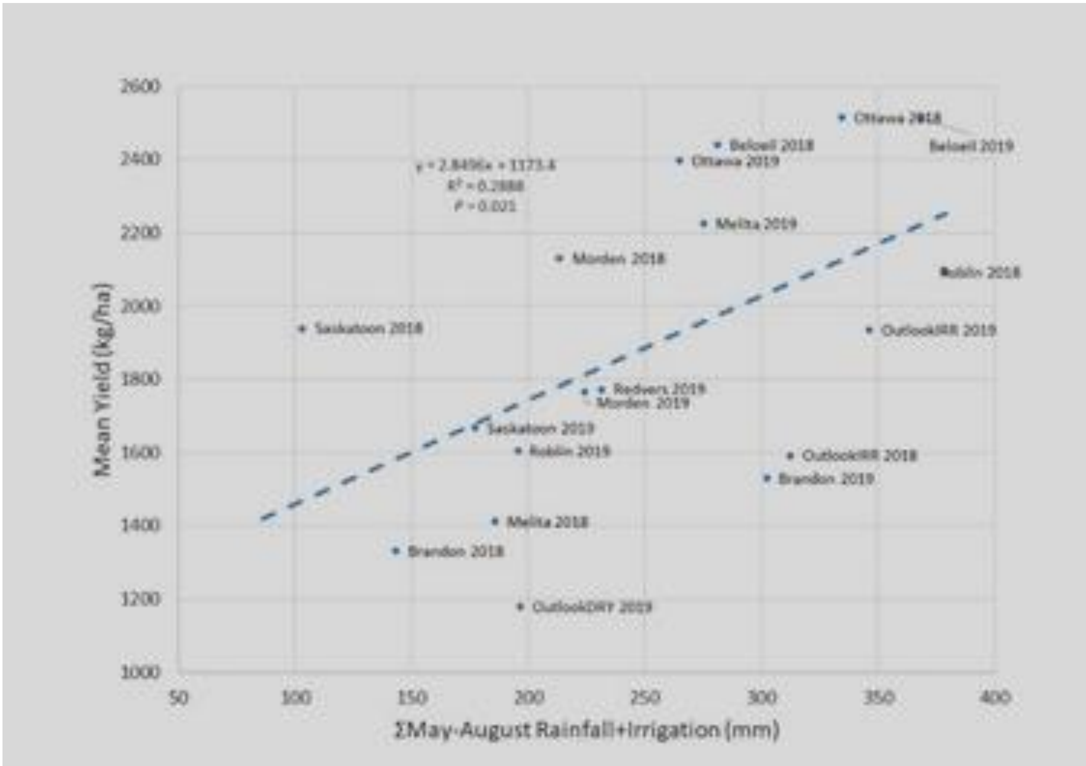


Fig. 8. Season long precipitation versus seed yield. Water is also an important driver of seed yield.

Genomic Analysis

- Plant materials from four (3 western and 1 eastern) locations have been collected (in 2019) and subjected to another round of RNA sequencing (using funds from a complimentary A-based collaborative genomics proposal) to further confirm 2018 RNA-seq data. Considering the genome-wide and large-scale nature of the second round of RNA sequencing, it has multiple benefits over the originally proposed quantitative PCR analyses. This approach and downstream analysis will confirm the stable candidate genes with differential gene expression at genome-scale over multiple years. Reconfirmed candidate genes will be tested through quantitative PCR analyses (for their further differential expression stability) in year 4.
- The process of analyzing combined RNA-sequencing data from 2018 and 2019 as well as data from 2019 is currently underway and results are expected at a later stage.
- For 2018 samples, gene candidates with differential geographic expression (either directly involved in a given pathway such as seed protein content or indirectly influencing the expression of any other gene(s) (i.e., transcription factors)) involved in soybean seed protein biosynthesis have been identified and further investigated with gene ontology (GO) analyses. Considering the

genome-wide scale of this project, data is generated in multiple files at TB (Terabyte) scales, including long lists of candidate genes with certain cut-offs and GO categorists. As an example, a snapshot of a simplified meta-data (not detailed) analysis for seed protein content (GO of protein and oil) is presented here.

Table 1. Differential meta-data expression analysis for genes involved in seed protein content (2018 data for genes with protein related GOs)

Ottawa vs West DESeq, adjusted p-value and edgeR adjusted p-value < 0.01, log2_FC ≥ 3, **up-regulated genes**

Unique genes with **protein**-related GOs that appear **in at least two Lines**

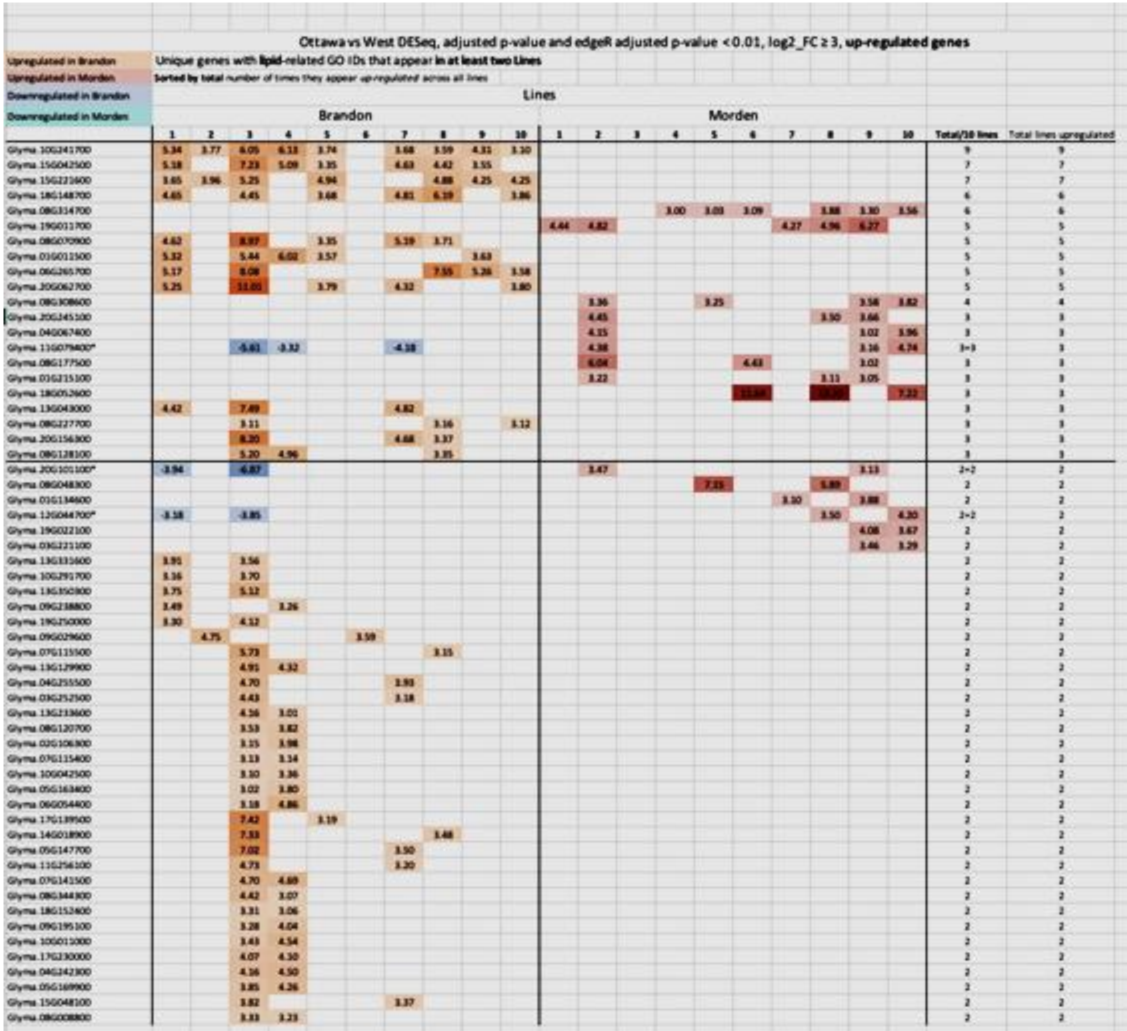
Sorted by total number of times they appear up-regulated across all lines

Upregulated in Brandon | Upregulated in Morden | Downregulated in Brandon | Downregulated in Morden

Lines	Brandon 1	2	3	4	5	6	7	8	9	10	Morden 1	2	3	4	5	6	7	8	9	10	Total Lines	Cumulative lines upregulated
Glyma.10G231800		8.64			4.66			5.67	4.16	4.64		8.57		3.49	4.37	4.17		5.86	4.05	4.30	5+7	12
Glyma.04G105200											3.73	[illegible]	4.11	3.56	4.73	5.00		6.42	5.55	6.63	9	9
Glyma.11G040500	3.46	4.12			4.46			3.35	3.16	3.39											6	6
Glyma.06G105500											3.28		3.45				3.36	3.38	4.48	3.32	6	6
Glyma.17G153300												3.62			3.65				3.32	3.40	4	4
Glyma.18G029400												3.29				3.08			3.74	3.43	4	4
Glyma.13G087100															4.43			3.87	3.81	3.83	4	4
Glyma.04G089000															3.20		3.72	5.66	4.23		4	4
Glyma.05G197900	3.90		3.56	4.09																	3	3
Glyma.18G286700	3.13		3.95	5.41																	3	3
Glyma.07G084200			5.03	3.94				3.01													3	3
Glyma.16G061400			4.49		3.33		3.17														3	3
Glyma.19G186300											3.62		3.04						3.05		3	3
Glyma.16G180900											5.18		6.90		4.29						3	3
Glyma.13G053600													3.01			3.45			4.08		3	3
Glyma.13G233300																3.33		3.37	3.01		3	3
Glyma.05G010300*	-4.44		-5.23		-5.14			-8.26				4.58							3.05		2	2
Glyma.01G004700																	3.91	3.04			2	2
Glyma.15G107100																	4.53		5.21		2	2
Glyma.12G044700*	-3.18		-3.85															3.50		4.20	2	2
Glyma.04G104300																			4.20	3.28	2	2

Upregulated in Brandon
Upregulated in Morden
Downregulated in Brandon
Downregulated in Morden

Table 2. Differential meta-data expression analysis for genes involved in oil content (2018 data for genes with oil related GOs)



Ottawa vs West DESeq, adjusted p-value and edgeR adjusted p-value < 0.01, log2_FC ≥ 3, **up-regulated genes**

Unique genes with **lipid**-related GO IDs that appear **in at least two Lines**

Sorted by total *number of times they appear up-regulated across all lines*

Upregulated in Brandon / Upregulated in Morden / Downregulated in Brandon / Downregulated in Morden

	Lines																					
	Brandon										Morden											
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	Total/10 lines	Total lines upregulated
Glyma.10G241700	5.34	3.77	6.05	6.13	3.74		3.68	3.59	4.31	3.10											9	9
Glyma.15G042500	5.18		7.23	5.09	3.35		4.63	4.42	3.55												7	7
Glyma.15G221600	3.65	3.96	5.25		4.94			4.88	4.25	4.25											7	7
Glyma.18G148700	4.65		4.45		3.68		4.81	6.19		3.86											6	6
Glyma.08G314700														3.00	3.03	3.09		3.88	3.30	3.56	6	6
Glyma.19G011700											4.44	4.82					4.27	4.96	6.27		5	5
Glyma.08G070900	4.62		8.97		3.35		5.19	3.71													5	5
Glyma.01G011500	5.32		5.44	6.02	3.57				3.63												5	5
Glyma.06G265700	5.17		8.08					7.55	5.26	3.58											5	5
Glyma.20G062700	5.25		11.03		3.79		4.32			3.80											5	5
Glyma.08G308600												3.36			3.25				3.58	3.82	4	4
Glyma.20G245100												4.45						3.50	3.66		3	3
Glyma.04G067400												4.15							3.02	3.96	3	3
Glyma.11G079400*			-5.61	-3.32			-4.18					4.38							3.16	4.74	3+3	3
Glyma.08G177500												6.04				4.43			3.02		3	3
Glyma.01G215100												3.22						3.11	3.05		3	3
Glyma.18G052600																[illegible]		[illegible]		7.22	3	3
Glyma.13G043000	4.42		7.49				4.82														3	3
Glyma.08G227700			3.11					3.16		3.12											3	3
Glyma.20G156300			8.20				4.68	3.37													3	3
Glyma.08G128100			5.20	4.96				3.35													3	3
Glyma.20G101100*	-3.94		-6.87									3.47							3.13		2+2	2
Glyma.08G048300															7.15			5.89			2	2
Glyma.01G134600																	3.10		3.88		2	2
Glyma.12G044700*	-3.18		-3.85															3.50		4.20	2+2	2
Glyma.19G022100																			4.08	3.67	2	2
Glyma.03G221100																			3.46	3.29	2	2
Glyma.13G331600	3.91		3.56																		2	2
Glyma.10G291700	3.16		3.70																		2	2
Glyma.13G350800	3.75		5.12																		2	2
Glyma.09G238800	3.49			3.26																	2	2
Glyma.19G250000	3.30		4.12																		2	2
Glyma.09G029600		4.75				3.59															2	2
Glyma.07G115500			5.73					3.15													2	2
Glyma.13G129900			4.91	4.32																	2	2
Glyma.04G255500			4.70				3.93														2	2
Glyma.03G252500			4.43				3.18														2	2
Glyma.13G213600			4.16	3.01																	2	2
Glyma.08G120700			3.53	3.82																	2	2
Glyma.02G106300			3.15	3.98																	2	2
Glyma.07G115400			3.13	3.14																	2	2
Glyma.10G042500			3.10	3.36																	2	2
Glyma.05G163400			3.02	3.80																	2	2
Glyma.06G054400			3.18	4.86																	2	2
Glyma.17G139500			7.42		3.19																2	2
Glyma.14G018900			7.33					3.48													2	2
Glyma.05G147700			7.02				3.50														2	2
Glyma.11G256100			4.73				3.20														2	2
Glyma.07G141500			4.70	4.69																	2	2
Glyma.08G344300			4.42	3.07																	2	2
Glyma.18G152400			3.31	3.06																	2	2
Glyma.09G195100			3.28	4.04																	2	2
Glyma.10G011000			3.43	4.54																	2	2
Glyma.17G230000			4.07	4.30																	2	2
Glyma.04G242300			4.16	4.50																	2	2
Glyma.05G169900			3.85	4.26																	2	2
Glyma.15G048100			3.82				3.37														2	2
Glyma.08G008800			3.33	3.23																	2	2

Upregulated in Brandon
Upregulated in Morden
Downregulated in Brandon
Downregulated in Morden

G x E soybean variety trial with non-nodulating treatment showing N deficiency at Melita in 2020

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7.0 Efficacy of herbicides in flax

Project duration: 2020
Collaborators: Saskatchewan Crop Development Centre, Helen Booker

Objectives

- To compare efficacy of standard (Authority) treatments to experimental (Armezon) treatments on flax and weeds.
- To observe any safety concerns with herbicide combinations

Background

Flax (*Linum usitatissimum*) is an important crop known for its value in food and fibre industrial markets around the world. However, flax has a low competitive ability with weeds compared to other crops and it is recommended to be grown on relatively weed free fields. Various weed management strategies that include; competitive varieties, early seeding, increased seeding rates and the use of pre- and post-emergence herbicides can help to effectively control weeds and reduce yield loss than employing one control factor alone (Kurtenbach et al., 2019). Preemergence weed control is crucial in flax to reduce yield loss since flax is a weak competitor with weeds (Berglund and Zollinger, 2007). Post emergence weed control, if done soon after weed emergence to small weeds and flax seedlings, usually results in better control and allows more time for flax recovery from possible herbicide injury than when herbicides are applied to larger weeds and flax later on in the growing season. There is currently a challenge in herbicide options for flax as a result of herbicide resistance. Therefore, herbicide injury on flax caused by the use of different herbicide combinations needs to be examined. There is need to investigate possible alternative options, combinations and timing of application for control of both broad leaf weeds and grasses. Armezon® herbicide, which is classified as Group 27, is an effective tank-mix option that is currently registered as a post emergence herbicide for control of tough broad leaf weeds and grasses in corn and has potential for use in flax for control of Group 1 resistant grasses due to its suppression effect on grasses (Table 7.0a). Currently, the herbicide is not registered for use in flax in Manitoba but extensive field trials can provide for a pathway to registration and this will benefit flax producers. This study seeks to evaluate several herbicides including Authority, Mextrol, Koril, Select and experimental Armezon used alone or tank mixed with compatible herbicides in flax in order to effectively control resistant weeds and reduce yield losses as a result. The study also seeks to evaluate any safety concerns with the use of different herbicide mixes in flax.

Table 7.0a List of Weeds controlled by Armezon, Authority, Mextrol, Koril and Select

Weeds Controlled	Herbicide Name				
	Armezon	Authority	Mextrol	Koril	Select
	Herbicide Group				
	27	14	4 + 6	6	1
Barnyard Grass	S				C
Foxtail Green	S				C
Foxtail Yellow	S				C
Quack grass					C
Volunteer Cereals					C
Wild Oats					C
Wild Buckwheat		C	C	C	
Night-flowering Catchfly			C		
Chickweed	S				
Cleavers		S			
Cocklebur			C	C	
Dandelion					
Flixweed			C		
Hemp-nettle					
Kochia	C	C	C	C	
Lambs quarters	S	C	C	C	
Round leaved Mallow					
Wild Mustard	C		C	C	
Red Root Pigweed	C	C	S	C	
Russian Thistle	S		C	C	
Shepherds Purse			C		
Annual Smartweed	S		C	C	
P. Sow thistle			TG		
Stinkweed			C	C	
Canada Thistle			TG		
Vol. Canola	C		C	C	

C – Control

S – Suppress

TG – Top growth

Adapted from 2019 Manitoba Crop Protection Guide

Materials and Methods

The trial was conducted at Melita, Roblin and Arborg in Manitoba, as randomized complete block design with 9 herbicide treatments replicated 3 times. Herbicide treatments included; UTC (no weeding), UTC (hand weeded), 0.1 L ac^{-1} Authority applied before seeding, 0.015 L ac^{-1} Armezon post emergence + Merge adjuvant, Authority before seeding and Armezon post emergence, Authority before seeding and 0.5 L ac^{-1} Mextrol 450 + 0.1 L ac^{-1} Select + Amigo adjuvant at 2-4 inches crop height, Authority before seeding and

0.49 L ac^{-1} Bromoxynil + Select at 2-4 inches crop height, Armezon + Mextrol + Select + Amigo adjuvant post emergence, and Armezon + Bromoxynil + Select post emergence. Herbicide treatments were applied using a calibrated CO_2 backpack sprayer. Herbicide formulation and treatment description is summarized in Table 7.0b. At Melita, all plots were seeded using a 6 row dual knife Seed hawk air seeder with rows spaced at 0.24 m at a depth of 0.5" on the 8^{th} of May 2020. All fertilizer requirements were achieved during seeding by side banding with the same implement at 108-35-20-8-2 (N-P-K-S-Zn) actual lb ac^{-1}. A burn off application with 0.5 L ac^{-1} Roundup and 0.015 L ac^{-1} Aim was done over all plots after seeding and other herbicide treatments were applied as per protocol. Reglone was applied to all plots as a desiccant and control late weeds one week prior to harvesting. Ratings for phytotoxicity % compared to the unsprayed check on flax were taken at 2 and 4 weeks after treatment while herbicide injury on weeds compared to hand weeded check was only assessed at 2 weeks after treatment. Additional data were collected for flax height at 2 weeks after treatment, flax count at 4 weeks after treatment, top weed species, weed density at flowering, seed yield and moisture content.

Table 7.0b Herbicide formulation and treatment description of flax herbicide trial in 2020

Trade name	Chemical	App. Rate g a.i./L	Field Rate ml/ac	Water Vol. Rate gal/ac	Treatment
Armezon	Topramezone	336	15	10	4,5,8,9
Merge	Adjuvant		0.25L/100L	10	3,4
Authority	Sulfentrazone	480	100	10	3,5,6,7
Mextrol	MCPA + Bromoxynil	225 + 225	500	10	6,8
Koril	Bromoxynil	235	490	10	7,9
Select	Clethodim	252	100	10	6,7,9,9
Amigo	Surfactant		0.5L/100L	10	6,8

Treatments

1. UTC (no weeding)
2. UTC (Hand weeded check)
3. Authority (pre-seed) 100 ml/ac
4. Armezon (in crop) 15 ml/ac + Merge @ 0.25L/100L 10 gpa
5. Authority (pre-seed) + Armezon (in crop)
6. Authority (pre-seed) + (Mextrol 450 0.5L/ac + Select 100 ml/ac + Amigo in crop) 2-4" stage
7. Authority (pre-seed) + (Bromoxynil 0.49L/ac [Koril] + Select) 2-4" stage
8. Armezon + (Mextrol 450 + Select + Amigo)
9. Armezon + (Bromoxynil + Select)

General plot management differed from site to site in 2020. Summary of site description, agronomy information, spray information and assessment dates are presented in Tables 7.0c and d.

Table 7.0c: Characterization and Agronomy information for Arborg, Melita and Roblin in 2020

Description	Site		
	Arborg	Melita	Roblin
Research Group	**PESAI**	**WADO**	**PCDF**
Legal Land Location	NW 16-22-2 E1	SE 26-3-27 W1	NE 20-25-28 W1
Soil Series	Fyala heavy clay	Newstead Loam	Erickson clay loam
Stubble	wheat	spring wheat	silage barley
Field Prep	no till	harrowed, no till	harrowed, no till
Soil Test N-P-K (lbs/ac)	112-22-380	35-18-900	66-92-1224
Fertilizer App N-P-K-S-Zn (lbs/ac)	50(B)-20 (SB)-0	108-35-20-8-2 Zn (SB)	54-10-0 (SB)
Seeder Type	disc drill	Knife drill	disc drill
Rows and Spacing (inches)	8 (7.5)	6 (9.5)	5 (9.5)
Seed Date	21-May	08-May	27-May
Seed Depth	0.75"	0.5"	0.5"
Fungicide/Insecticides	NA	NA	NA
Desiccation Product	Reglone	Reglone	Reglone
Harvest Date	08-Sep	24-Aug	04-Sep
Growing Season Meteorology information (Seed Date - Harvest Date)			
GGDs actual Base 5*C	1403	1380	1157
GGDs normal	1242	1313	1141
Precipitation actual	195	168	225
Precipitation normal	252	272	215

GDD – growing degree days, B – broadcast, SB – side banded, NA – not applicable

Table 7.0d Spraying information for Arborg, Melita and Roblin site in 2020

Spraying Information	Site		
	Arborg	Melita	Roblin
Spray Tip	TeeJet AI80015	TeeJet AI8002	BFS Orange AI 01
Water Volume (imp. Gal/ac)	10	10	10
Burn off	NA	08-May	29-May
Burn off Product (Rate)	NA	Roundup (0.5 L/ac) + Aim (15 ml/ac)	Roundup (0.64L/ac)
Pre-Emerg app Date	22-May	08-May	29-May
In-crop app Date	13-Jun	04-Jun	25-Jun
Assessments:			
Crop Injury 2WAA	26-Jun	18-Jun	08-Jul
4WAA	13-Jul	02-Jul	22-Jul
Weed Injury Date 2WAA	26-Jun	26-Jun	08-Jul
Weed Count Date at flower	13-Jul	02-Jul	27-Jul
Crop Height Date 2WAA	13-Jul	20-Jul	22-Jul

Results and discussion

Weed injury percentage was significantly (P=0.001) different among treatments at 2 weeks after application of weed control alternatives at Roblin (Table 7.0e). Application of Authority as a pre-seed injured 73% of the sampled weeds compared to 43% observed for a tank mix of Armezon + Bromoxynil + Select applied in-crop. High efficacy of Authority applied prior to seeding could have been as a result of activation by rainfall following herbicide application. All other herbicide options, including Armezon applied in-crop alone were less effective, with only 5 to 8% weed injury at 2 WAA and were not significantly different. At 2 WAA of treatments, flax injury (47%) was significantly (P<0.001) high when Armezon + Mextrol + Select (treatment 8) were applied post emergence in a single tank mix. All other options resulted in between 0 and 3% flax injury and could be considered to be safe options for the crop in this regard. Further observations made at 4 WAA of the treatment materials found significant (P=0.014) recovery of flax from 47% to 22% for treatment 8 while other alternatives ranged between 0 and 1%. Crop height measurements at 2 WAA of treatments, again, showed that a combination of Armezon + Mextrol + Select applied to flax resulted in significantly (P<0.001) lower height (16 cm) compared to other herbicide options. Although weed injury was only 5% and comparable to 7 other herbicide treatment at 2 WAA, application of Armezon + Mextrol + Select reduced crop height at the same observation period. This might give an indication of negative impact that this combination might have, such as influencing flax development and ultimate yield in the long term. On the other hand, a tank mix of Armezon + Bromoxynil + Select resulted in crop height that was not significantly different from treatments 1, 3, 4 and 5 and is acceptable compared to treatment 8 (Table 7.0e). Therefore, Armezon + Bromoxynil + Select applied in-crop and Authority applied pre-seed could be better options when considering herbicide injury percentages and crop height impact. There were no significant yield differences observed regardless of herbicide treatment applied but numerically, in-crop application with Armezon achieved the highest seed yield of 4041 kg ha^{-1}.

Overall high coefficient of variation for weed injury was as a result of treatment 9 (Armezon + Bromoxynil + Select) and 3 (Authority pre-seed), which had lots of variation. Flax emergence was lower than expected due to excessively dry conditions at crop establishment. The site was seeded on the 27th of May but only received about 5.1 mm of rainfall between the 26th of May and the 5th of June (web43.gov.mb.ca/Climate/DailyReport.aspx).

Table 7.0e GLM Analysis of variance for weed injury, weed density, flax emergence, crop injury, crop height and crop yield at Roblin in 2020

Treatment	Weed Injury (%) 2WAA	Weed Density ppms at flower	Flax Emergence ppms	Crop Injury (%)		Crop Height (cm) 2WAA	Crop Yield (kg/ha)
				2WAA	4WAA		
1. UTC (no weeding)	*	51	155	*	*	39abc	3097
2. UTC (Hand weeded check)	*	*	149	*	*	44a	1939
3. Authority (pre-seed)	73a	53	134	0b	0b	40ab	2976
4. Armezon (in crop)	8c	72	136	0b	0b	35bcd	4041
5. Authority + Armezon	5c	52	158	3b	0b	37abcd	3141
6. Authority + [Mextrol + Select (in crop)]	5c	60	150	3b	0b	31cd	3110
7. Authority + [Bromoxynil + Select (in crop)]	5c	41	157	2b	0b	30d	3013
8. Armezon + Mextrol + Select	5c	68	146	47a	22a	16e	2418
9. Armezon + Bromoxynil + Select	43b	62	180	3b	1b	33bcd	2864
P value (treatment)	**0.001**	0.573	0.794	**<0.001**	**0.014**	**<0.001**	0.320
Coefficient of Variation	33	10	21	85.8	196.2	14	29

At Melita, there were significantly (P=0.005) more weed injury percentages with herbicide combinations than single herbicide treatments (Table 7.0f). A combination of Armezon + Bromoxynil + Select caused higher weed injury percentages compared to other herbicide treatments. Higher weed injury percentages for combination treatments involving Authority were probably as a result of adequate rainfall for herbicide activation following application of treatments. Herbicide combinations also caused significant (P=0.004) reduction in weed densities compared to Armezon or Authority applied alone. Overall, weed density was lower at Melita compared to Arborg and Roblin, which could be due to site specific differences. It is also important to note that although Armezon (in-crop) application alone caused little injury on weeds and flax than when applied in combination with other herbicides at 2WAA, it did not have a negative impact on flax height compared to combination herbicides. Crop injury recovery was observed at 4 WAA of combination herbicides involving Armezon, which explains the ability of flax to recover in the short term after herbicide treatment. Flax emergence was not significantly different at Melita but the plant stand was more than 300% better than Roblin across all herbicide treatments. This was probably due to differences in soil moisture at crop establishment between the two sites. There were no significant differences in flax seed yield across all treatments and the yields were lower than at Roblin site overall.

Table 7.0f GLM Analysis of variance for weed injury, weed density, flax emergence, crop injury, crop height and crop yield at Melita in 2020

Treatment	Weed Injury (%) 2WAA	Weed Density ppms at flower	Flax Emergence ppms	Crop Injury (%)		Crop Height (cm) 2WAA	Crop Yield (kg/ha)
				2WAA	4WAA		
1. UTC (no weeding)	*	23a	541			37ab	2473
2. UTC (Hand weeded check)	*	*	537			36ab	2508
3. Authority (pre-seed)	27bc	13ab	520	0d	0b	37ab	2512
4. Armezon (in crop)	7c	21a	567	0d	0b	37ab	2376
5. Authority + Armezon	45bc	6bc	473	10cd	0b	34ab	2762
6. Authority + [Mextrol + Select (in crop)]	78ab	4c	500	20bc	0b	31bc	2490
7. Authority + [Bromoxynil + Select (in crop)]	92a	4c	537	10cd	2b	32abc	2603
8. Armezon + Mextrol + Select	72ab	4c	506	43a	8a	26cd	2596
9. Armezon + Bromoxynil + Select	93a	5c	524	37ab	10a	24d	2526
P value (treatment)	**0.005**	**0.003**	0.627	**0.001**	**0.008**	**0.002**	0.699
Coefficient of Variation	28	26	10	68.4	140.7	11	9
MSE	4.257	0.07	2881	0.0102	0.001	14.2	50518
GM	7.467	1	522	0.15	0.02	33	2540

Weed injury percentage was significantly (P<0.001) high among all combination treatments including Armezon applied in-crop and ranged from 60% to 87% compared with Authority (pre-seed) that only caused 10% injury (Table 7.0g). Treatments 6, 8 and 9 had best weed control with 80, 87 and 85% weed injury at 2 WAA, respectively. It is possible that efficacy of Authority was low as a result of low rainfall within 2 weeks of application of the herbicide. Authority applications require a moderate rainfall of between 10 to 20 mm or equivalent irrigation within 10 to 14 days for proper activation. During the 2-week period from application of Authority, Arborg site only received 3.8 mm rainfall (https://web43.gov.mb.ca/Climate), which was not adequate for activation of the herbicide and could explain the reason why there was only 10% weed injury. Weed density measured at flowering was significantly (P=0.037) different at Arborg. The ideal herbicide option was considered to be the one with the lowest weed density after herbicide treatment relative to other options under consideration. In this regard, weed density was significantly lower in Authority + {Mextrol + Select (in-crop)} (11 ppms) and Armezon + Mextrol + Select (15 ppms). Similar pattern in crop injury recovery as with Melita and Roblin was observed at Arborg with initially high injury percentages at 2 WAA followed by significant (P=0.007) recovery at 4 WAA. Crop height was also significantly (P<0.001) reduced in combination herbicide options especially treatment 8 and 9 that included Armezon + Mextrol + Select and Armezon + Bromoxynil + Select, respectively. Flax plants in these treatments were more than 50% shorter in height compared to the non-weeded check at 2 WAA. Perhaps Bromoxynil and Mextrol components influenced the reduction in flax height. Flax seed yield was significantly (P<0.001) high in combination herbicides that had Armezon in the mixture and was comparable to the hand weeded check. Overall, flax yield ranged from 1889 kg ha^{-1} to 3553 kg ha^{-1}, with the lowest being the non-weeded check as expected. Although it caused significantly high percentage in weed injury during the first 2 WAA, the MCPA component in Mextrol with Armezon + Mextrol +Select appeared to have reduced flax seed yield. Probably application rates of the Mextrol component might need to be revised so as to reduce the impact on yield but not compromising on weed control.

Table 7.0g GLM Analysis of variance for weed injury, weed density, flax emergence, crop injury, crop height and crop yield at Arborg in 2020

Treatment	Weed Injury (%) 2WAA	Weed Density ppms at flower	Flax Emergence ppms	Crop Injury (%)		Crop Height (cm) 2WAA	Crop Yield (kg/ha)
				2WAA	4WAA		
1. UTC (no weeding)	*	96a	264	*	*	42ab	1889e
2. UTC (Hand weeded check)	*	*	313	*	*	47a	3553a
3. Authority (pre-seed)	10b	93ab	293	8	12ab	35bc	2217de
4. Armezon (in crop)	60a	109a	304	13	13ab	20d	2574cd
5. Authority + Armezon	67a	104ab	317	13	7c	32c	3198ab
6. Authority + [Mextrol + Select (in crop)]	80a	11c	279	12	6c	46a	3007bc
7. Authority + [Bromoxynil + Select (in crop)]	78a	68abc	315	17	8bc	22d	3052b
8. Armezon + Mextrol + Select	87a	15bc	315	28	15a	17d	2944bc
9. Armezon + Bromoxynil + Select	85a	70a	277	23	13ab	19d	3116ab
P value (treatment)	**<0.001**	**0.037**	0.290	0.242	**0.007**	**<0.001**	**<0.001**
Coefficient of Variation	12	17	10	15.2	25.7	13	10

A combined site analysis conducted to determine performance of herbicide treatments across different environments found no significant differences in efficacy on weed injury, weed density at flowering stage and flax emergence. However, based on numerical figures available, Armezon + Bromoxynil + Select option caused the highest percentage in weed injury (74%) while other options ranged from 25 to 58% (Table 7.0h). Crop injury at 2 WAA varied significantly (P=0.003) and application of Armezon (pre-seed) + Mextrol + Select (in-crop) caused the highest flax injury (39%) while other herbicide options ranged from 3 to 21%. At 4 WAA there were significant (P=0.023) differences in flax injury as observed at individual site analysis and there were also significant recoveries from herbicide injury within the 2-week period from the initial observation. The impact of treatments 8 and 9 were not significantly different on crop injury at 4 WAA. Height of flax was significantly (P=0.004) different due to different herbicide options applied. Treatments 7, 8 and 9 resulted in significantly shortened flax plants at 2 WAA and the heights were 28, 20 and 25 cm, respectively, compared with hand weeded check that had 42 cm at the same observation period. There were also significant treatment x site interactions in flax plant height (P=0.007), weed density (P=0.015) at 2 WAA and crop yield (P=0.048). Differences in site characterization may have influenced results of these responses to different herbicide options available in this study. Selection of herbicide options to use will likely be based on their performance in a specific geographical area.

Table 7.0h GLM Combined (Melita, Arborg and Roblin) Analysis of variance for weed injury, weed density, flax emergence, crop injury, crop height and crop yield in 2020

Treatment	Weed Injury (%) 2WAA	Weed Density ppm at flower	Flax Emergence ppms	Crop Injury (%)		Crop Height (cm) 2WAA	Crop Yield kg/ha
				2WAA	4WAA		
1. UTC (no weeding)	*	57	320	*	*	39ab	2486
2. UTC (Hand weeded check)	*	*	333	*	*	42a	2667
3. Authority (pre-seed)	37	53	315	3c	4b	37abc	2568
4. Armezon (in crop)	25	67	336	4c	4b	31bcd	2997
5. Authority + Armezon	39	54	316	9bc	2b	34abcd	3034
6. Authority + Mextrol + Select (in crop)	54	25	309	12bc	2b	36abc	2869
7. Authority (pre-seed) + Bromoxynil + Select (in crop)	58	38	336	9bc	3b	28cde	2889
8. Armezon (pre-seed) + Mextrol + Select (in crop)	54	29	322	39a	15a	20e	2653
9. Armezon + Bromoxynil + Select (in crop)	74	46	327	21b	8ab	25de	2835
P value (treatment)	0.647	0.058	0.821	**0.003**	**0.023**	**0.004**	0.876
P value (Site)	0.220	0.202	0.159	0.291	0.208	<0.001	0.392
P value (Site x Treatment)	**0.015**	0.075	0.481	0.056	0.082	**0.007**	**0.048**

Weed species composition differed across the 3 sites under study in 2020 (Table 7.0i). Arborg had predominantly red root pig weed in treatments 1, 2, 4 and 8 while lambsquarters was only present in treatment 1 and 2. At Melita, biennial wormwood was predominant in treatments 1, 3, 4 and 6 while volunteer wheat appeared in more than 50% of the treatments. At Roblin, volunteer canola was predominant in all treatments followed by green foxtail.

Table 7.0i Summary of four major weeds (ranked as most to least) by site after herbicide treatment at flower stage in 2020

Treatment	Site		
	Arborg	Melita	Roblin
1	RRP> C> D> LQ	BW> D> VW> CT	C> GF> LQ> SP
2	RRP> D> C> LQ	D>W	C> GF> LQ> D
3	WB> D	BW> VW> WB> K	C> GF
4	RRP> C> WB> D	BW> D> WB> VW	C> GF
5	D> WB> RRP	WB> CT> VC> BW	C> GF> D
6	C> D> RRP> WB	BW> VW> WO> VW	C> GF> D
7	D	D> VW> RRP> BW	C> GF> SP
8	RRP> C> D	WB> BW	C> GF> LQ

Key

RRP – red root pig weed, C – volunteer canola, D – dandelion, WB – wild buckwheat, LQ – lamb's quarters, BW – biennial wormwood, WO – wild oat, K – kochia, VW – volunteer wheat, CT – Canadian thistle, GF – green foxtail, SP – shepherd's purse

Conclusions

Interestingly there were no flax injuries with Authority + Mextrol option but Armezon in combination with Mextrol caused injuries. Based on these preliminary findings, this combination should be avoided in real farm situations unless further studies with reduced applications rates of Mextrol can prove otherwise. Armezon on its own did not seem to show crop injury, but it stunted the height of flax, which could reduce seed yield. Arborg was the only site that showed yield loss based on herbicide use in general. At this site, Armezon showed yield loss both in sole use, and in combination with Mextrol. More research is needed to address if MCPA alone (a component in Mextrol) combined with Armezon is at fault to cause crop injury in flax.

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8.0 Evaluation of Dry bean inoculants in Manitoba

Project duration: 2020-2021

Collaborators: University of Manitoba, MPGA, Kristen MacMillan

Objectives

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

Background

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

Materials and Methods

The trial was set up on Newstead loam soil in Melita, Manitoba in 2020. Nine treatments were arranged as randomized complete block design with 3 bean types (market classes) and 3 inoculation strategies replicated 4 times. The three dry bean market classes were; Navy bean (T9905), Pinto bean (Windbreaker) and Black bean (Eclipse) while inoculation treatments included; Non-inoculated/ Non-fertilized (control), BOS (self-adhering peat), and Primo (granular) inoculants. Seed bed preparation involved harrowing to spread out wheat straw from the previous crop. A burnoff application with a tank mix of 0.5 L ac^{-1} Roundup and 0.015 L ac^{-1} Aim was done prior to seeding on 27 May. Seeding was done at a depth of 1.25” using a 6 row dual knife Seed hawk air seeder at 100 000 seeds ac^{-1} for Pinto beans and 130 000 seeds ac^{-1} for Navy and Black beans. The aim was to achieve a plant stand of 70 000 plants ac^{-1} and 100 000 plants ac^{-1} for Pinto and, Navy and Black beans, respectively. Basal fertilizer application was side banded during seeding at 10-35-20-8-2 (N-P-K-S-Zn) actual lb. ac^{-1}. It was necessary to clean seeding parts and seed boxes between different treatments using an air compressor so as to reduce contamination. In-crop weed control was done post 2 trifoliate stage using a tank mix of 0.91 L ac^{-1} Basagran and 0.1 L ac^{-1} Arrow + 0.5% v/v X-act adjuvant. This was followed up by a single application of 0.1 L ac^{-1} Arrow + X-act adjuvant 10 days later to control volunteer wheat that was not controlled with the initial post emergence application. Grasshopper populations were reduced by the application of 0.034 L ac^{-1} Matador on 30 July. Data collection included; soil sampling, weekly staging from emergence until maturity, 3 m plant population taken from 2 middle rows at 4 weeks after planting, nodulation ratings between R2 and R3 development stages, days to full maturity, grain yield, moisture and protein content.

Results and discussion

This is an ongoing research and preliminary results and discussion for this study are combined for Melita and Carman sites, please refer to:

2019_2020_Annual_Report_Soybean_and_Pulse_Agronomy_Lab_MacMillan.pdf (umanitoba.ca) on pages 43 to 47.

Dry bean Inoculation trial with marked visual differences at Melita in 2020

Acknowledgements

Manitoba Pulse and Soybean Growers Association, University of Manitoba.

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9.0 General Mills: Evaluation of Oat Variety to Population and Nitrogen Rates

Project duration: 2020- ongoing

Collaborators: General Mills

Objectives

- Evaluate agronomic traits of new oat varieties
- Evaluate influence of plant population, nitrogen and their interactions on oat yield.

Background

Recently, oat production has shifted from a late seeded fill crop to an economically viable crop, ushering premium markets and more options for producers in Western Canada (May et al. 2020). Canada produces 3 million tons of oats annually and is the largest producer of oats globally. Western Canada alone, accounts for nearly 90% of Canada's oat production and this has transformed the crop from domestic to a major Canadian export (Statistics Canada, 2017). With new oat varieties available, there is need to study how plant population and nitrogen application affects development and yield of oats. This information will be helpful to farmers when they choose agronomic practices that apply to their areas of production so as to attain higher oat yields.

Methods

General Mills trial included advanced variety yield trial and variety x plant population x N rate trial. These were conducted in Melita, Manitoba on Newstead loam soils in 2020. Treatments were replicated 3 times, except the nitrogen rate component. The variety x population trial involved two varieties, CDC Arborg and CDC Endure at seeding rates of 0.5, 0.9, 1.3, 1.7 and 2.1 million plants per acre. Varieties used for the advanced variety yield trial were; Hayden, CDC Arborg, OT3112, AC Morgan, CS Campden, AAC Douglas, CDC Ruffian and CDC Endure. All plots were first harrowed to spread wheat straw uniformly across the trial site before seeding with no tillage occurring. The variety trial was seeded on May 7th using a dual knife seed hawk air seeder at a depth of 0.625” while the plant population x N trial was seeded the following day with the same settings. Basal fertilizer application for the trials was side banded during seeding at 100-35-20-8-2 (N-P-K-S-Zn) actual lb. ac^{-1} while additional blocks received 30 and 60 N lb. ac^{-1} in block 5, and 6 respectively. A burnoff application with 0.5 L ac^{-1} Roundup tank mixed with 0.015 L ac^{-1} Aim was done soon after seeding followed up by in-crop application of 0.5 L ac^{-1} Mextrol to control post emergence broad leaf weeds on 3 June. A desiccant was applied about a week prior to harvesting using a tank mix of 0.5 L ac^{-1} Round and 0.042 L ac^{-1} Heat LQ on 11 August 2020. Data collected included; heading date, lodging assessment, maturity date, moisture content, test weight and grain yield. Additionally, green stems were scored at maturity.

Results

Results are proprietary and more information can be made at the request of General Mills Inc. (Brookings, South Dakota).

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10.0 Linseed Coop Evaluation

Project duration: 2018-2020

Collaborators: CDC Saskatchewan, Dr. Megan House (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 varieties were arranged in a 4 x 5 alpha lattice design and replicated 3 times. Melita site was seeded at 0.5" depth on May 8th under wheat stubble. Fertilizer was banded during seeding at a rate of 108-35-20-8-2 actual (N-P-K-S-Zn) lb. ac^{-1} following recommendations as per soil test results from AgVise Laboratories Inc. Chemical weed control included; 0.1 L ac^{-1} Authority, 0.5 L ac^{-1} Roundup and 0.015 L ac^{-1} Aim applied as a burnoff after seeding and 0.1 L ac^{-1} Select + 0.5% v/v X-Act adjuvant + 0.91 L ac^{-1} Basagran applied as post emergence herbicide for control of grasses and some broad leaf weeds. Reglone was applied as a desiccant at 0.65 L ac^{-1} one week prior to harvesting in order to control late weeds and to dry flax stems. Additional data other than yield collected from the trial included: 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

Three experimental lines, FP2591, FP292 and FP2573 recorded the highest yields of 2951, 2946 and 2881 kg ha^{-1}, respectively, among other experimental lines and compared with newly released flax varieties. Among experimental lines, the lowest predicted seed yield recorded was 2490 kg ha^{-1} for FP2605 while the lowest yield for newly released varieties was 2558 kg ha^{-1} for CDC Dorado (Table 10.0). Overall, results show a potential of high yielding experimental lines to be considered for future registration if additional tests over varying environments are consistent.

Table 10.0 Predicted means for flax variety yield trial at Melita in 2020

Variety Name	†Predicted Yield Mean (kg ha^{-1})
AAC Bright	2787
AAC Marvelous	2862
AAC Prairie Sunshine	2682
CDC Bethune	2683
CDC Dorado	2558
CDC Glas	2873
CDC Rowland	2839
FP2573	2881
FP2591	2951
FP2592	2946
FP2596	2568
FP2597	2721
FP2598	2605
FP2599	2767
FP2600	2844
FP2601	2643
FP2602	2658
FP2603	2665
FP2604	2653
FP2605	2490

†Predicted means were generated using a linear mixed model that adjusted values based on variance estimated by the environment of all locations tested in 2020

Detailed results for the 2020 trial will be available at https://agbio.usask.ca/cdcflax (Dr. Megan House).

11.0 Evaluation of cadmium tolerance in different flax varieties

Project Duration: 2020
Collaborators: CDC Saskatchewan, Dr. Megan House

Objectives

- Characterize cadmium tolerance levels in flax

Background

Flax (Linum usitatissimum) is one of the most important oil and fibre crops grown in Canada and this country contributes more than 35% of the world's production. As a result of its global market share, production shifts in Canada can significantly shift global market trends. Apart from its use in the oil and fibre industries, flax has also been used as a functional food ingredient with increasing importance on the global market (Morris, 2005). Flax is also known to have medicinal properties that play a role in reducing risks associated with cardiovascular diseases, cancer and gastrointestinal disorders. Although it is regarded as an important crop that can improve health styles, previous studies have shown that flaxseed often accumulates significant amounts of cadmium that surpass the recommended dietary critical limit of 0.3 ug Cd g^{-1} of flaxseed (Becher et al., 1997). The accumulation of cadmium in flax is a serious health threat because many flax varieties are capable of accumulating excess levels beyond the critical limits that can cause harm to humans (Hocking and McLaughlin, 2000). Cadmium is a toxic element that can cause significant health implications in the kidneys causing renal tubular dysfunction (Lei, 2006). Intensive research is necessary to determine tolerance levels in available flax varieties so as to reduce the risk of cadmium toxicity and ensure human safety with increased flaxseed utilization in food and pharmaceutical industries.

Materials & Methods

The trial was conducted on Newstead loam soil following soybean and spring wheat rotation at Melita in 2020. A non replicated modified augmented experimental design (type 2) was used in large rectangular blocks/ whole plots. Subplots were arranged within the large rectangular block and there were 7 subplots in each section with the central subplot serving as a check (control). A dual knife Seed hawk air seeder was used to mark seeding lines at 1" depth and apply fertilizer blend at 100-35-20-8-2 (N-P-K-Zn) actual lb ac^{-1} before banding seed by hand on the 5^{th} of June. Small plots were planted by hand with two rows at 9.5" spacing using a garden hoe, then rows covered with soil using a rake. Preemergence herbicides applied included a tank mix of 0.5 L ac^{-1} Roundup + 0.015 L ac^{-1} Aim + 0.1 L ac^{-1} Authority and 0.65 L ac^{-1} Rival. In-crop weed control was done by the application of 0.1 L ac^{-1} Arrow + 0.5% v/v X-act adjuvant on 3^{rd} July. Reglone was applied as a desiccant at 0.65 L ac^{-1} on 3 September on all plots except 4 and 6. Data collected included seeding date, emergence date, plant stand, start of flowering date (5% flowering), end of flowering date (95% flowering), petal color, flower shape, plant height, lodging score, disease rating of pasmo and aster yellows, maturity date, harvest date and seed yield.

Results and Discussion

Results for this trial were not ready for publication at the time this report was compiled but will be shared during 2021. https://agbio.usask.ca/cdcflax/profile-pages/megans-profile.php

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12.0 Industrial hemp grain and fibre variety evaluation

Project duration: May 2020 – September 2020

Collaborators: Canadian Hemp Trade Alliance, WADO, Manitoba Horticultural Productivity Enhancement Centre, PCDF, PESAI, James Frey (PI) – Manitoba Agriculture and Research Development

Objectives

- To evaluate industrial hemp varieties for the National Hemp Variety Field Trials coordinated by the Canadian Hemp Trade Alliance

Background

[Adapted from the CHTA 2021 call for cultivars]: The CHTA is a national organization that champions a diverse and robust Canadian hemp industry which benefits all stakeholders along the value chain. Established in 2003, the Alliance membership includes farmers, processors, equipment suppliers, consumer product suppliers, consultants, researchers, students, industry associations and government. CHTA's services and programs include: stakeholder communication and consultation; domestic and international market development; research coordination; standards development; and, policy and regulatory advocacy. In 2020, the National Hemp Variety Field Trials were implemented at 12 sites across Canada (NB, QC, ON, MB, and AB), including at the four Manitoba Diversification Centres. The 2019 CHTA report for all sites can be accessed here.

Materials and Methods

The trial was conducted on Newstead loam soil in Melita in 2020. Land preparation involved harrowing and no till before seeding. The trial was laid out as randomized complete block design with 5 grain varieties and 6 dual purpose varieties replicated 4 times. Grain varieties included; Picolo, X59, Grandi, Katani and CRS-1 (check) while dual purpose varieties were; Altair, Petera, CRS-1, Vega, CFX-2 and NWG 2730. Soil sampling and testing were done in spring to determine available nutrients, which was the basis for calculating nutrient application in the current season (Table i). A truck mounted hydraulic soil sampler and the grid sampling method were used. Plots were seeded on May 12th at 0.5” depth and granular fertilizer was side banded during the same time at 125 – 35 – 20 – 8 – 2 (N – P – K – S – Zn) actual lb. ac^{-1}. In-crop herbicide application with 0.4 L ac^{-1} Koril tank mixed with 0.1 L ac^{-1} Arrow + 5% v/v X-Act on the 5th of June. Data collected included emergence date, plant vigor rating, plant height, lodging, disease rating, male to female ratio, grain yield, moisture content and cannabinoid content. In addition to these data, above ground dry biomass for dual purpose varieties was determined for stems, leaves and seeds.

Table i: Spring Soil test results for Melita (Newstead loam soil) in 2020

Spring Soil Test							
pH	**OM**	**N 0-6" lb/ac**	**N 6-24" lb/ac**	**N-(N1+N2)**	**P-O ppm**	**K ppm**	
7.5	3.0	4	12	16	4	249	
Ca ppm	**Mg ppm**	**S lb/ac 0-6"**	**S lb/ac 6-24"**	**Zn ppm**	**Salt1**	**Salt2**	**CEC meq**
2195	329	12	60	0.71	0.20	0.23	14.36

Results and Discussion

The evaluations tested entries for grain (Table 1) and fibre yield (Table 2), cannabinoids (Table 3), and agronomic variables (Table 4). The results are adapted from a report compiled from data for all participating trial sites (12 in total). Due to herbicide injury, grain yields for MHPEC are not available.

Table 1: Grain yield by variety (lb ac^{-1})

	PESAI		PCDF		WADO		Mean (All Sites)
	Lb ac^{-1}	% Check*	Lb ac^{-1}	% Check*	Lb ac^{-1}	% Check*	Lb ac^{-1}
Grain entries							
CRS-1*	-	-	1093.8	100.0	1338.7	100.0	1216.2
Grandi	-	-	895.1	81.8	1334.3	99.7	1114.7
Katani	-	-	841.7	77.0	1353.0	101.1	1097.3
Picolo	-	-	744.6	68.1	1189.1	88.8	966.8
X59	-	-	1279.0	116.9	1103.6	82.4	1191.3
% CV	-	-	18.1	-	6.8	-	12.5
Dual purpose (grain and fibre) entries							
CRS-1*	1453.6	100.0	745.5	100.0	1203.3	100.0	1134.1
Altair	1307.5	90.0	741.9	99.5	1063.5	88.4	1037.7
Vega	1619.3	111.4	812.3	109.0	1230.9	102.3	1220.8
Petera	730.4	50.2	402.6	54.0	847.9	70.5	660.3
CFX-2	-	-	548.7	73.6	1052.8	87.5	800.7
% CV	14.4	-	16.1	-	7.9	-	12.8

* Check = CRS-1, repeated for both Grain and Dual-Purpose entries

Table 2: Fibre yield by variety (lb ac^{-1})

	PESAI		PCDF		MHPEC		WADO		Mean (All Sites)
	Lb ac^{-1}	% Check*	Lb ac^{-1}	% Check*	Lb ac^{-1}	% Check*	Lb ac^{-1}	% Check*	Lb ac^{-1}
Grain entries									
CRS-1	-	-	-	-	4364.4	100.0	-	-	4364.4
Picolo	-	-	-	-	1870.4	42.9	-	-	1870.4
X59	-	-	-	-	3596.6	82.4	-	-	3596.6
% CV	**-**	**-**	**-**	**-**	**17.6**	**-**	**-**	**-**	**17.6**
Dual purpose (grain and fibre) entries									
CRS-1	5314.7	100.0	5985.4	100.0	-	-	4522.0	100.0	5046.6
Altair	6734.5	126.7	7882.6	131.7	-	-	5859.8	129.6	6825.6
Vega	6339.0	119.3	6448.6	107.7	-	-	5536.5	122.4	6108.0
Petera	10569.8	198.9	9160.7	153.1	-	-	7059.6	156.1	8930.0
CFX-2	-	-	4800.8	80.2	-	-	3276.0	72.4	4038.4
% CV	**19.6**	**-**	**13.3**	**-**	**-**	**-**	**10.1**	**-**	**14.3**

* Check = CRS-1, repeated for both Grain and Dual-Purpose entries

Table 3: Cannabidiol (CBD) and Cannabigerol (CBG) content by variety (%) *

	PESAI		PCDF		MHPEC		WADO		Mean (All Sites)	
	CBD	CBG	CBD	CBG	CBD	CBG	CBD	CBG	CBD	CBG
CRS-1	1.37	0.07	1.64	0.06	2.04	0.08	1.44	0.05	1.62	0.06
Altair	1.36	0.06	1.11	0.05	-	-	1.22	0.03	1.27	0.06
CFX-2	-	-	1.46	0.05	-	-	1.54	0.05	1.23	0.05
Grandi	-	-	1.48	0.05	-	-	1.55	0.04		
Katani	-	-	1.34	0.05	-	-	1.44	0.04	1.50	0.06
Petera	0.77	0.03	1.27	0.07	-	-	0.92	0.03	1.51	0.05
Picolo	-	-	1.40	0.05	1.68	0.06	1.45	0.05	1.39	0.04
Vega	1.31	0.06	1.12	0.05	-	-	1.30	0.04	1.80	0.08
X59	-	-	1.44	0.03	1.50	0.03	1.60	0.03	0.99	0.04

* Derived from leaf and flower parts from upper 20 cm of plant

Table 4: Agronomic characteristics by variety

	PESAI	PCDF	MHPEC	WADO	Mean (All Sites)
	Lb/ac	Lb/ac	Lb/ac	Lb/ac	Lb/ac
Early vigor (at canopy closure, 1-10, 1=low)					
CRS-1*	8.0	6.8	7.8	7.5	7.5
Altair	8.4	6.8	-	8.0	7.7
CFX-2	-	8.0	-	7.8	7.9
Grandi	-	6.5	-	7.0	6.8
Katani	-	6.5	-	7.0	6.8
Petera	8.3	6.5	-	7.8	7.5
Picolo	-	6.8	6.8	7.0	6.9
Vega	8.4	7.0	-	8.0	7.8
X59	-	6.5	7.8	8.3	7.5
Plant height (cm)					
CRS-1*	180	183	120	162	161.3
Altair	193	199	-	184	192.0
CFX-2	-	169	-	142	155.5
Grandi	-	160	-	130	145.0
Katani	-	155	-	155	155.0
Petera	240	206	-	210	218.7
Picolo	-	156	112	156	141.3
Vega	181	192	-	169	180.7
X59	-	164	115	164	147.7
Days to maturity					
CRS-1*	108	-	-	97	102.5
Altair	110	-	-	101	105.5
CFX-2	-	-	-	101	101.0
Grandi	-	-	-	98	98.0
Katani	-	-	-	97	97.0
Petera	118	-	-	122	120.0
Picolo	-	-	-	98	98.0
Vega	104	-	-	101	102.5
X59	-	-	-	99	99.0
Emergence (number of days after sowing, 50% emergence)					
CRS-1*	-	11	7	9	9.0
Altair	-	11	-	9	10.0
CFX-2	-	11	-	9	10.0
Grandi	-	11	-	9	10.0
Katani	-	11	-	9	10.0
Petera	-	11	-	9	10.0
Picolo	-	11	7	9	9.0
Vega	-	11	-	9	10.0
X59	-	11	7	9	9.0
Seedling mortality (%)					
CRS-1*	-	7.0	0.0	8.5	5.2
Altair	-	3.8	-	9.3	6.6
CFX-2	-	0.6	-	15.9	8.3
Grandi	-	6.8	-	13.9	10.4
Katani	-	8.4	-	11.3	9.9
Petera	-	7.5	-	16.8	12.2
Picolo	-	12.2	31.6	12.2	18.7
Vega	-	8.4	-	15.5	12.0
X59	-	19.4	0.0	19.4	12.9

* Check = CRS-1, repeated for both Grain and Dual-Purpose entries

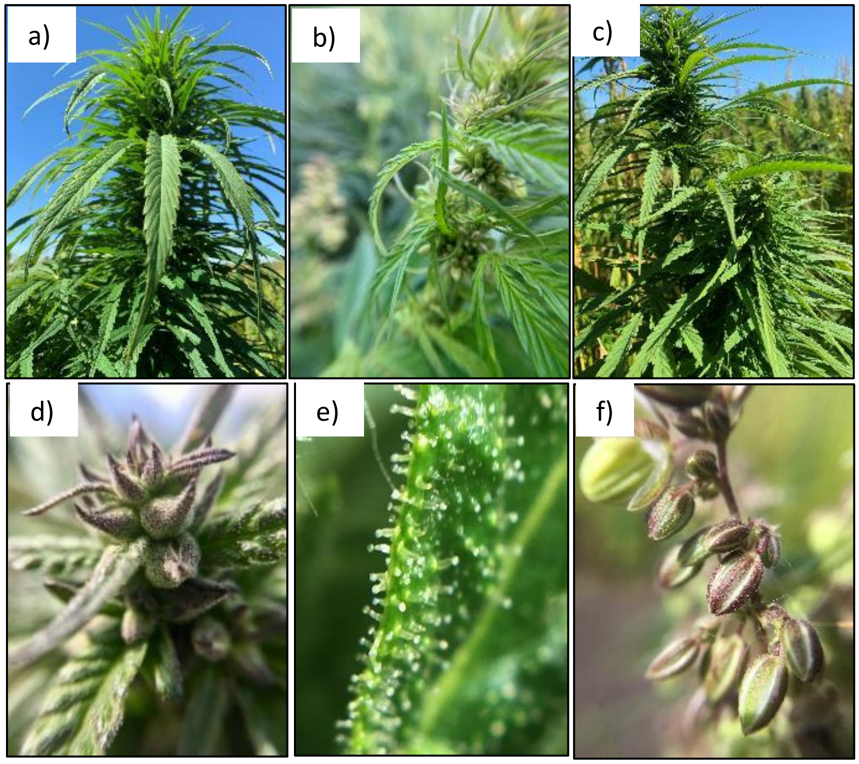

Figure 1: a) hemp plant, b) hemp plant at flowering, c) hemp plant nearing grain maturity, d) hemp plant with trichomes forming on flower and leaf parts, e) close-up of trichomes on a hemp leaf, f) hemp flowers

Industrial hemp at heading stage at Melita in 2020

13.0 Performance and adaptation of Quinoa varieties

Project duration: 2017-2020
Collaborators: Phillex Ltd. - Percy Phillips, WADO

Objectives

- To determine yield potential of 7 quinoa varieties across different locations in Manitoba

Background

Bolivia and Peru are the world's top producers of quinoa followed by Ecuador, USA, China, Chile, Argentina, France and Canada, which altogether contribute 15 to 20% to the world's total production (Bazile, et al., 2016). Quinoa has a vast genetic diversity resulting from its fragmented and localized production over the centuries in many regions around the world. The crop can withstand low temperature around -1.1°C but if it gets below -2.2°C during mid-bloom stage it can cause more than 70% yield loss due to flower abortion. Significant yield losses also occur when exposed to temperature below -6.7°C before dough stage (AAFRD, 2005). On the other hand, elevated temperature above 35°C for lengthened periods during the reproductive stage can cause dormancy and pollen sterility in quinoa (OMAFRA, 2012). A major setback in growing quinoa in Canada and in high altitude regions is the short growing season because the crop requires up to 150 days from planting to seed harvest (Jacobsen, 2003). In this regard, early maturity becomes the most important characteristic when selecting varieties suitable under these conditions especially on the Prairies that experience cooler and shorter growing season.

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

Materials and Methods

The trial was conducted at four locations in Manitoba: Melita, Roblin, Carberry and Arborg. It was arranged as randomized complete block design with 7 treatments (varieties) and 3 replicates over 4 site-years. Varieties seeded were: PHX20-01, PHX20-02, PHX20-03, PHX20-04, PHX20-05, PHX20-06 and

PHX20-07. In Melita, the plots were seeded with a dual knife air seeder on the 8th of May into good soil moisture at a depth of 0.5”. Granular blend and liquid fertilizer were side banded at 108-35-20-7-2 (N-P-K-S-Zn) lb ac^{-1} during seeding. Preemergence weed control was done using 0.5 L ac^{-1} Roundup tank mixed with 0.015 L ac^{-1} Aim to ensure a clean seedbed on crop emergence. In-season post emergence weed control for grasses was done once using 0.1 L ac^{-1} Arrow + 0.5% v/v X-Act adjuvant. The major insect pests of concern were stem borer fly larvae (*Amauromyza karli* [Hendel]) and lygus, which were controlled twice by application of Cygon 480EC at 0.4 L ac^{-1} at 3-week interval in July. Data collected included: emergence date, plant stand, lodging, plant vigor, days to maturity, grain yield and moisture content at harvest. The data were subjected to two-way ANOVA using Minitab 18 and mean comparison was done using Fishers LSD at the 5% level of significance.

Results and Discussion

There were highly significant ($P<0.001$) differences in emergence days of quinoa with an early variety requiring 11 days while late varieties required 18 days from seeding to emergence. When rated for lodging, it was found that all other treatments had significantly ($P<0.001$) low rating of either 1 or 2 compared to a high rating of 7 for PHX20-01 variety. Plant height at maturity was significantly ($P = 0.008$) different among quinoa varieties and ranged from 112 to 148 cm. The tallest variety was the same with the highest lodging rating, which could have been a result of weak stems unable to sustain the weight of quinoa heads or severe damage caused by quinoa stem borer fly larva early in the season. Regardless of significant differences in days to emergence and plant height, all varieties required similar days to reach maturity. This could have been possible as most crops, including quinoa, tend to recover and compensate for the lost time during the early phases of development. Grain yield of quinoa was significantly ($P = 0.014$) different with PHX20-04 recording 3826 kg ha^{-1}, more than twice the yield of PHX20-03. Yield from other varieties were not significantly different. Overall, grain yield ranged from 1658 to 3826 kg ha^{-1} resulting in a high coefficient of variation. Although the yields obtained were in the expected range, there is potential to get more if improved varieties and pests and disease control options are made available. During the season, there were observations of Downey mildew and stem borer fly larva damage, which could have reduced potential yield of some quinoa varieties. Currently, there are few registered chemicals for use in quinoa in Manitoba and this could be a drawback in improving quinoa yields. Quinoa variety trials will continue to be conducted in Southwest Manitoba and other suitable areas to ascertain the ones that are well adapted to the Prairies.

Table 13.0 Analysis of variance for days to emergence, lodging, plant height, days to maturity, plant vigor and seed yield of quinoa at Melita in 2020

Treatment/ Variety	Emergence days	Lodging 1-9 (9=flat)	Height cm	DTM Days	Vigor 1-9 (9=most)	Yield kg/ha (@13%)
PHX20-01	18a	7a	148ab	108	7c	1800b
PHX20-02	18a	2b	135ab	103	7c	1998b
PHX20-03	12cd	2b	126bc	99	8ab	1658b
PHX20-04	12bcd	1b	114c	107	7bc	3826a
PHX20-05	13bc	1b	112c	104	7bc	2251b
PHX20-06	14b	1b	122bc	113	7bc	2551b
PHX20-07	11d	2b	121bc	116	8ab	1915b
P value	**<0.001**	**<0.001**	**0.008**	0.438	**0.037**	**0.014***
Significant?	**Highly**	**Highly**	**Yes**	**No**	**Yes**	**Yes**
CV%	**6.2**	**24.2**	**7.7**	**9.1**	**5.0**	**26.9***

***P-value of 0.005 and CV of 22.9% if treatment 2 is excluded in yield analysis**

Quinoa harvesting at Melita in 2020

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14.0 Faba-Flax, Faba-Buckwheat, Faba-Oat and Oat-Pea Intercropping dynamics & Row Arrangement

Project duration: 2020

Collaborators: WADO, PCDF

Objectives

- To determine the influence of row orientation on intercrops compared to monocrops
- To determine grain, forage and quality output obtained from intercrops involving oats

Background

Intercroppings systems are growing in popularity in Canada because their use has contributed to enhanced livestock production due to improved grain yield and forage quality. The importance of including legumes in intercropping systems is fall grazing for integrated crop and livestock systems, which can also compliment grazing of crop residues (Andersen et al., 2020). This helps save stored forage resources for winter feeding, thus reducing feed costs. Faba bean is one of the most important potential crops that can be used for this purpose. The crop has key environmental benefits in its ability to fix atmospheric nitrogen symbiotically under a wide range of environmental conditions making nitrogen available under diversified crop rotations (Kopke and Nemecek, 2010; Andersen et al., 2020). Faba bean enhances sustainable agricultural systems through diversified intercrops which provide an environment for soil microbes to improve soil conditions such as aeration and organic matter content. In other studies, inclusion of faba bean in intercropping systems has been shown to increase phosphorus mobilization making it more available to plants. When determining faba bean intercropping options, it is crucial to select one that provides more benefits in terms of soil health improvement, dry matter yield and disease reduction. Previous studies have examined various faba bean: non-legume seeding ratios such as

75%:25%, 50%:50% and 25%:75%. They found out that the most productive intercrop was that of faba bean-oats at 25%:75% seeding ratio (Dhima et al., 2013). As a result of potentially higher dry matter and protein content for intercrops involving faba bean, this can be an alternative to sole faba bean in forage production. The purpose of this study was to evaluate the influence of row orientation on faba bean and oat intercrops compared to sole crops and to determine grain, forage and quality output from these intercrops.

Materials and Methods

The trials were conducted at Melita on Newstead loam soils and Erickson clay loam soils at Roblin in 2020. Plots were established under no till practices with only harrowing necessary to evenly spread crop residues from the previous season. Treatments were arranged as randomized complete block design with four treatments replicated three times for each cropping system (Table 14.0a (i)).

Table 14.0a (i) Treatment description (target seed rate in plants per meter square) for Flax-Oat, Flax-Buckwheat, Flax-Pea and Flax-Faba bean at Melita in 2020

Faba-Oat	Faba-Buckwheat	Oat-Pea	Flax-Faba
1.Faba 'Snowbird' (54) *	Faba	Oat	Flax 'Neela' (500)
2.Oat 'Summit' (225)	Buckwheat 'Horizon' (161)	Pea 'Amarillo' (85)	Faba
3.Faba (75%), Oat (25%), mixed	Faba (75%), Buckwheat (25%), mixed	Oat (25%), Pea (75%), mixed	Flax (25%), Faba (75%), mixed
4.Faba (50% field rate), Oat (25%), alternate rows	Faba (50% field rate), Buckwheat (25%), alternate rows	Oat (25%), Pea (50% field rate), alternate rows	Flax (25%), Faba (50% field rate), alternate rows

'Variety name'; (target seeding rate in plants per m square) *

Characterization and agronomic information for Melita and Roblin is presented in Table 14.0a(ii).

Combine setting for oat-faba, oat-pea and faba-flax were; 1300 rpm cylinder speed, 950 rpm wind speed and 3 mm concave clearance while adjustments were made to 600 rpm cylinder speed, 850 rpm wind speed and 12 mm concave clearance for faba-buckwheat. A mixed model ANOVA was run to determine differences between treatments. Cropping systems were considered as fixed factors while location (nested within reps) and reps were random factors. Treatment mean separation was done using Tukey's test at 95% confidence interval.

Table 14.0a(ii) Site characterization and agronomy information for Melita and Roblin in 2020

Description	Site Characterization	
	Melita	Roblin
Research Group	WADO	PCDF
Legal Land Location	SE 26-3-27 W1	NE 20-25-28 W1
Soil Series	Ryerson Loam	Erickson clay loam
Stubble	spring wheat	silage barley
Field Prep	harrowed, no till	harrowed, no till
Soil Test N-P-K (lbs/ac)	56-22-584	66-94-1224
Fertilizer App N-P-K-S-Zn (lbs/ac)	50-35-20-8-2	2-10-0-0-0
Seeder Type	Dual knife drill	Double Disc drill
Rows and Spacing (inches)	6 (9.5)	5 (9.5)
Burnoff Date/Product (Rate/ac)	Roundup 0.5L + Aim 15 ml May 11, Authority 80 ml + Rival 0.65L May 12; Buck-Faba: 0.5L Roundup + 15 ml Aim	May 29, Roundup (0.65L)
Seed Date	May 11, Buck-Faba May 21	27-May
Seed Depth	1.5" (Pea-Oat, Faba-Oat, Faba-Flax), 1" (Buck-Faba)	3/4" Faba-Oat; Pea-Oat, 1/2" all others
Herbicides	MCPA Amine500 @ 0.15L/ac Oat pea intercrop June 5	N/A
	Basagran + Arrow @ 0.91L/ac + 100 ml/ac + X-Act 0.5% June 10 on Faba-Flax	
Harvest Date	Faba-Oat, Pea-Oat Aug 17, Faba-Flax Aug 26, Faba-Buck Sept 10	02-Oct
Forage Harvest Date	11-Jul	14-Aug
Growing Season	**(May 11 - Sept 10)**	**27-May to 2-Oct**
GGDs actual Base5*C	1526	1287
GGDs normal	1485	1271
Precipitation actual	167	236
Precipitation normal	299	263

GDD = growing degree days

*Growing season length=Seeding date to Harvest date

B= broadcast, SB = sideband

NA = not applied

Results and Discussion

Grain Yield

There were significant differences in both faba bean and oat grain yield in the faba-oat intercrop at Melita and Roblin. At Melita, faba bean yield was 38% and 61% higher in sole crop compared to mixed and alternate cropping systems, respectively (P<0.001). Oat yield in the sole crop was not significantly different from alternate cropping system. Mixed and alternate cropping systems did not significantly differ in oat grain yield obtained. However, yield from sole crop oat was significantly higher than mixed cropping system (P=0.01). At Roblin, faba bean grain yield was significantly higher (P<0.001) in sole crop compared to mixed and alternate cropping systems and the difference amounted to 67% and 70%, respectively. As expected also, sole crop oat had significantly higher (P=0.001) grain yield compared to mixed and alternate cropping systems that had 40% and 50% lower oat grain yield, respectively. A combined site analysis found significant differences in faba bean grain yield between sole crop (P=0.047) and alternate cropping system but not with mixed cropping system. There were no significant differences in oat grain yield when the two sites were combined (Table 14.0b).

Pea grain yield from cropping systems in pea-oat intercrop was significantly different at Melita and Roblin. At Melita, pea yield in the sole crop was 2440 kg ha^{-1} and 3812 kg ha^{-1} more (P<0.001) than mixed and alternate cropping systems, respectively. Mixed cropping system yielded significantly higher than the alternate cropping system also. As expected again, oat yield was significantly (P<0.001) higher in the sole crop (6212 kg ha^{-1}) compared to mixed (2528 kg ha^{-1}) and alternate (4301 kg ha^{-1}) cropping systems (Table 14.0c). At Roblin, pea yield (479 kg ha^{-1}) in the sole crop was significantly (P=0.036) different from that of the alternate (409 kg ha^{-1}) cropping system but did not differ significantly with mixed (279 kg ha^{-1}) cropping system. Oat yield in sole crop was 42% and 37% significantly (P=0.005) higher than in mixed and alternate cropping systems, respectively. Generally, grain yields were very low at Roblin compared to Melita probably as a result of differences in agroecological regions.

Faba bean grain yield from cropping systems in faba-buckwheat intercrop was significantly (P=0.009) different at Melita. Faba bean grain yield obtained from alternate cropping system was the lowest (2237 kg ha^{-1}) while mixed and sole crop yielded 36% and 42% more, respectively. Buckwheat yield in sole crop was significantly (P<0.001) higher than mixed and alternate cropping systems that had 7- and 4-times lower grain yield, respectively. At Roblin, faba bean grain yield in sole crop was significantly (P=0.001) more than in mixed and alternate cropping systems by 44% and 59%, respectively. Buckwheat yield was significantly (P=0.005) more by about 50% compared with mixed and alternate cropping systems. There were no significant differences in grain yield between mixed and alternate cropping systems at both sites. A combined analysis of the sites did not find significant differences in grain yield, at least in the current season but there is a possibility that with additional site years of data, differences in yield can be observed (Table 14.0d).

There were significant differences in grain yield from faba-flax intercrop at Melita and Roblin (Table 14.0e). At Melita, faba bean grain yield was significantly (P=0.002) lower than sole and mixed cropping systems by more than 1300 kg ha^{-1}. Flax grain yield was statistically the same between mixed and alternate cropping systems but was significantly (P<0.001) higher by 10 and 4 times, respectively, in flax sole crop. At Roblin, faba bean grain yield was significantly (P=0.039) lower in the alternate cropping system compared to the sole crop by about 1500 kg ha^{-1} while there were no significant differences between sole crop and mixed cropping system. Flax yield was significantly (P<0.001) higher in sole crop than mixed and alternate cropping systems. There were no significant differences in grain yield between mixed and alternate cropping systems. Flax grain yield averaged over Roblin and Melita was significantly (P=0.014) higher in sole crop (2710 kg ha^{-1}) compared to mixed (744 kg ha^{-1}) and alternate (827kg ha^{-1}) cropping systems (Table 14.0e).

Dry forage yield

Faba-Oat intercrop did not significantly influence dry forage yield at Melita but the yield ranged from 6699 kg ha^{-1} to 10149 kg ha^{-1} in 2020. However, at Roblin, dry forage yield was significantly (P=0.002) different between sole crop oat and sole faba bean only. Yield from sole crop oat (12680 kg ha^{-1}) was not significantly different from mixed (10793 kg ha^{-1}) and alternate (8720 kg ha^{-1}) cropping systems. There were no significant differences in dry forage yield when the 2 sites were combined (Table 14.0b).

Similar to faba-oat intercrop, there were no significant differences in dry forage yield observed in all cropping systems under pea-oat intercrop at Melita. Dry forage yields ranged from 9014 kg ha^{-1} to 10510 kg ha^{-1}. At Roblin, there were also no significant differences in dry forage yield and the ranges were 9260 kg ha^{-1} to 10553 kg ha^{-1} (Table 14.0c).

Land equivalence ratio

At Melita, faba-oat intercrop LER for faba bean and oat were significantly (P<0.001 and P=0.003) lower in mixed and alternate cropping systems compared to sole crops that had LER of 1. However, total LER was significantly (P=0.005) higher in mixed (LER=1.09) and alternate (LER=1.11) intercrops signaling a significant benefit of intercropping versus sole cropping (Table 14.0b). At Roblin, LER was significantly lower (P<0.001) when faba and oat were analyzed separately. Total LER for both crops was also below 1, meaning there was no advantage of intercropping over sole cropping at Reston in 2020. When both sites were considered, sole crop prevailed compared to intercrop as the LER for the later were less than 1 for intercrops.

Pea and oat LER were significantly (P<0.001) low when crops were analyzed separately at Melita. Pea performed better in mixed compared to alternate intercropping system while the performance was vice versa for oat. Total LER suggested that there was a significant (P=0.004) benefit of pea-oat intercrop when an alternate cropping system (LER=1.13) is adopted compared to mixed (LER=1.05) or sole cropping system (LER=1) (Table 14.0c). At Roblin, while partial LERs were significantly lower than 1 for oat or pea, total LER suggested a significant (P=0.039) benefit of intercropping pea with oats using either mixed (LER=1.40) or alternate (LER=1.19) cropping systems. A combined site analysis showed significant differences in partial LERs but there was no benefit in adopting any of the intercropping systems over sole crops and both mixed and alternate cropping systems did not have an advantage over the other.

Land equivalent ratio for sole (LER=1) faba bean and mixed (LER=0.9) cropping systems was significantly (P=0.01) higher than alternate cropping system (LER=0.59) at Melita. Mixed cropping option had an advantage over alternate cropping system. Buckwheat LER was significantly (P<0.001) lower for mixed (LER=0.14) and alternate (LER=0.25) cropping systems compared to the sole crop (LER=1) (Table 14.0d). The TLER was not significantly different, hence, similar benefits could be obtained from adopting either cropping systems. At Roblin, LER for faba bean sole crop was significantly (P=0.001) higher than mixed and alternate cropping systems that had values less than 1. Buckwheat LER for the sole crop was also significantly (P=0.03) higher than the other two cropping systems (Table 14.0d). Similar to results from Melita, there were no benefits of adopting either intercropping systems over sole crops at Roblin in 2020. However, a combined analysis of the two sites showed mixed (TLER=1.06) cropping system to be a significantly (P=0.005) better option than alternate (TLER=0.87) cropping system.

Land equivalent ratio for sole (LER=1) faba bean and mixed (LER=1.04) cropping systems was significantly (P=0.002) higher than alternate (LER=0.73) cropping system for faba-flax intercrop at Melita (Table 14.0e). Flax LER was significantly (P<0.001) lower for mixed and alternate cropping systems compared to sole crop. The TLER for mixed (TLER=1.13) cropping system was significantly (P=0.024) higher than alternate (TLER=0.98) cropping system. In this case, mixed cropping system would be a better option than alternating rows of flax and faba bean. At Roblin, alternate cropping system had significantly (P=0.025) lower LER (0.73) compared to faba bean sole crop. Flax LER in mixed and alternate cropping systems was also significantly (P<0.001) lower than flax sole crop. Neither cropping systems proved to be better options over sole crops at Roblin in 2020.

Protein content and Seed weight

Oat protein ranged from 9.93% to 11.2% for faba-oat intercrop at Melita but there were no significant differences between cropping systems. However, at Roblin, alternate (11.08%) cropping system had significantly (P=0.034) higher protein content than sole (10.03%) crop oat. There were no significant differences between mixed and alternate cropping systems, and between mixed and sole crop (Table 14.0f). Oat seed weight based on a 500 seed count was significantly (P=0.042) different at Melita. Oat seed in sole crop weighed 38.23 g per 500 seed count, while seed in mixed and alternate cropping systems weighed 33.84 g and 35.62 g per 500 seed count, respectively. Faba bean seed weight was also measured for 500 seed count and there were significant (P=0.031) differences in seed weight at Melita. Alternate cropping system produced faba bean seed with 216.3 g per 500 seed count while mixed and sole crop had 6.79 g and 26.87 g lower seed weight, respectively. There were no significant differences in seed weight for faba-oat intercrop systems at Roblin in 2020.

Oat protein for pea-oat intercrop was significantly (P=0.006) higher in mixed (10.93%) and alternate (10.47%) cropping systems compared to sole crop (9.87%) at Melita. Similar trends were observed at Roblin with significantly (P<0.001) higher oat protein in mixed (10.98%) and alternate (10.81%) cropping systems compared to sole crop (9.93%) (Table 14.0f). Pea seed weight at Melita was significantly (P=0.032) higher in alternate (129.25 g) cropping system while mixed cropping system seed weighed 121.64 g per 500 seed count. There were no significant differences in pea seed weight at Roblin. At all sites, there were also no significant differences in oat seed weight in 2020.

Table 14.0b Mixed Model Analysis of variance for Faba-Oat dry forage yield, grain yield and LER at Melita and Roblin in 2020

Location	Crop System	Dry Forage kg/ha	Grain Yield (kg/ha)		Land Equivalent Ratio		
			Faba	Oat	Faba	Oat	Total
Melita	MonoOat	10030	*	5597a	*	1a	1b
	MonoFaba	6699	4944a	*	1a	*	1b
	Mixed	8433	3070b	2571b	0.62b	0.47c	1.09a
	Alternate	10149	1941c	3972ab	0.39c	0.72b	1.11a
	P value	**0.07**	**<0.001**	**0.01**	**<0.001**	**0.003**	**0.005**
	CV	**16**	**8**	**15**	**8**	**10**	**3**
Roblin	MonoOat	12680a	*	4879a	*	1a	1a
	MonoFaba	6527b	2892a	*	1a	*	1a
	Mixed	10793ab	962b	2926b	0.33b	0.60b	0.93ab
	Alternate	8720ab	869b	2457b	0.30b	0.51b	0.81b
	P value	**0.012**	**<0.001**	**0.001**	**<0.001**	**<0.001**	**0.007**
	CV	**16**	**12**	**8**	**6**	**6**	**5**
REML (both sites)	MonoOat	11355	*	5238	*	1a	1
	MonoFaba	6613	3918a	*	1	*	1
	Mixed	9613	2016ab	2748	0.48	0.54b	1.01
	Alternate	9435	1405b	3215	0.35	0.61ab	0.96
	P value	0.100	**0.047**	0.112	†NH	**0.043**	†NH
	CV	**9**	**7**	**8**		**6**	

†NH= non homogenous data, therefore no statistical analysis done

Table 14.0c Mixed Model Analysis of variance for Pea-Oat dry forage yield, grain yield and LER at Melita and Roblin in 2020

Location	Crop System	Dry Forage kg/ha	Grain Yield (kg/ha)		Land Equivalent Ratio		
			Pea	Oat	Pea	Oat	Total
Melita	MonoOat	10510	*	6212a	*	1a	1b
	MonoPea	10030	6735a	*	1a	*	1b
	Mixed	9744	4295b	2528c	0.64b	0.41c	1.05b
	Alternate	9014	2923c	4301b	0.44c	0.69b	1.13a
	P value	**0.256**	**0.001**	**<0.001**	**<0.001**	**<0.001**	**0.004**
	CV	**8**	**8**	**4**	**6**	**4**	**3**
Roblin	MonoOat	10300	*	3771a	*	1a	1a
	MonoPea	10553	497a	*	1a	*	1a
	Mixed	10373	409ab	2181b	0.82ab	0.58b	1.40a
	Alternate	9260	279b	2373b	0.56b	0.63b	1.19a
	P value	**0.621**	**0.036**	**0.005**	**0.029**	**0.003**	**0.039**
	CV	**16**	**17**	**10**	**15**	**9**	**13**
REML (both sites)	MonoOat	10405	*	4991	*	1a	1
	MonoPea	10291	3616	*	1a	*	1
	Mixed	10058	2352	2355	0.73ab	0.49b	1.23
	Alternate	9137	1601	3337	0.50b	0.66b	1.16
	P value	0.181	†NH	†NH	**0.034**	**0.016**	†NH
	CV	**6**			**7**	**5**	

Table 14.0d Mixed Model Analysis of variance for Faba-Buckwheat grain yield and LER at Melita and Roblin in 2020

Location	Crop System	Grain Yield (kg/ha)		Land Equivalent Ratio		
		Faba	Buckwheat	Faba	Buckwheat	Total
Melita	MonoBuckwheat	*	1497a	*	1a	1
	MonoFaba	3878a	*	1a	*	1
	Mixed	3475a	212b	0.90a	0.14c	1.04
	Alternate	2237b	366b	0.59b	0.25b	0.82
	P value	**0.009**	**<0.001**	**0.01**	**<0.001**	0.118
	CV	**11**	**13**	**11**	**6**	**10**
Roblin	MonoBuckwheat	*	949a	*	1a	1
	MonoFaba	3461a	*	1a	*	1
	Mixed	1951b	494b	0.56b	0.53b	1.09
	Alternate	1427b	474b	0.41b	0.50b	0.92
	P value	**0.001**	**0.005**	**0.001**	**0.003**	0.087
	CV	**11**	**14**	**10**	**12**	**6**
REML (both sites)	MonoBuckwheat	*	1223	*	1	1ab
	MonoFaba	3669	*	1	*	1ab
	Mixed	2713	353	0.73	0.33	1.06a
	Alternate	1832	420	0.50	0.38	0.87b
	P value	0.085	†NH	0.101	†NH	**0.005**
	CV	**7**		**7**		**5**

Table 14.0e Mixed Model Analysis of variance for Faba-Flax grain yield and LER at Melita and Roblin in 2020

Location	Crop System	Grain Yield (kg/ha)		Land Equivalent Ratio		
		Faba	Flax	Faba	Flax	Total
Melita	MonoFlax	*	2296a	*	1a	1ab
	MonoFaba	4875a	*	1a	*	1ab
	Mixed	5034a	223b	1.04a	0.10c	1.13a
	Alternate	3553b	569b	0.73b	0.25b	0.98b
	P value	**0.002**	**<0.001**	**0.002**	**<0.001**	**0.024**
	CV	**5**	12	**5**	**5**	**5**
Roblin	MonoFlax	*	3124a	*	1a	1
	MonoFaba	2947a	*	1a	*	1
	Mixed	1740ab	1265b	0.63ab	0.41b	1.03
	Alternate	1483b	1085b	0.52b	0.35b	0.86
	P value	**0.039**	**<0.001**	**0.025**	**<0.001**	0.426
	CV	**23**	**7**	**19**	**6**	**13**
REML (both sites)	MonoFlax	*	2710a	*	1a	1
	MonoFaba	3911	*	1	*	1
	Mixed	3387	744b	0.83	0.25b	1.08
	Alternate	2518	827b	0.62	0.30b	0.92
	P value	0.222	**0.014**	0.228	**0.034**	0.057
	CV	**8**	**6**	**9**	**4**	**6**

Table 14.0f Analysis of variance for Faba-Oat and Pea-Oat protein content and seed weight at Melita and Roblin in 2020

	Faba-Oat				Pea-Oat			
Location	Cropping System	Oat Protein %	Seed weight (g/500seeds) Oats	Seed weight (g/500seeds) Faba	Cropping System	Oat Protein %	Seed weight (g/500seeds) Pea	Seed weight (g/500seeds) Oats
Melita	MonoOat	9.93	38.23a	*	MonoOat	9.87b	*	42.19
	MonoFaba	*	*	189.43b	MonoPea	*	125.05ab	*
	Mixed	11.2	33.84b	209.51ab	Mixed	10.93a	121.64b	39.453
	Alternate	10.73	35.62ab	216.3a	Alternate	10.47a	129.25a	42.247
	P value	0.081	**0.042**	**0.031**	**P value**	**0.006**	**0.032**	0.261
Roblin	MonoOat	10.03b	26.33	*	MonoOat	9.93b	*	26.333
	MonoFaba	*	*	205	MonoPea	*	124.67	*
	Mixed	10.71ab	25.33	218.33	Mixed	10.98a	129.33	29
	Alternate	11.08a	24.67	227.67	Alternate	10.81a	125.67	28.33
	P value	**0.034**	0.365	0.223	**P value**	**<0.001**	0.703	0.806

Conclusions

Protein content was significantly high in intercrops compared to sole crops. Seed weight also increased in alternate compared to mixed cropping system as observed in pea-oat and faba-oat intercrops. Land equivalent ratio increased in alternate and mixed cropping system compared to sole crops meaning that there were benefits in intercropping than sole cropping. This was especially observed in faba-buckwheat, pea-oat and faba-oat when individual sites were analyzed. Grain yield from mixed cropping system matched that of sole crop in some cases, indicating a potential for another option that farmers can choose from if their objectives include crop diversification. Forage yield was also promising and such cropping systems as the ones in this study could be useful for farmers who are integrate with livestock production. Results from this study are from 2 site-years and additional site-years of data are required to validate these findings and come up with recommendations that farmers can use in their respective areas of production.

References

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15.0 Corn Grain and Silage variety evaluation

Report period: 2021
Project duration: 2020-2020
Collaborators: Pride Seeds

Objective

- To assess agronomic performance and quality of grain and silage corn varieties in Manitoba

Rational

Extensive breeding work on early maturing hybrids has led to expansion of corn production to cooler and short season regions of Canada such as the Prairies (Guyader et al., 2018). Corn can either be grown for grain or silage. While economic production of grain corn is dependent on grain yield, corn silage success depends on dry matter and nutritive value. Therefore, this study was aimed at evaluating agronomic performance of grain and silage corn varieties for Manitoba conditions.

Materials and Methods

Corn plots were established under dry land conditions on loamy fine sand soils at Melita, Manitoba in 2020. Land preparation involved harrowing and rotor tilling. Plots were arranged as randomized complete block design with 3 grain corn (A3993G2 RIB, A4646G2 RIB and XP20071RR) and 2 silage corn (AS1017RR and A4705HMRR) treatments replicated 3 times. Basal fertilizer was broadcasted on the 5th of May using a Valmar' pull type granular fertilizer spreader and incorporated with a rotor tiller afterwards. The application rates used were 113N (ESN/Urea 50: 50 Blend) – 10N-40P-24K-9S-2.2Zn actual lb. ac^{-1}. The plots were seeded on the 20th of May with a Wintersteiger corn planter set at 1.75" depth followed by an application of 2 L ac^{-1} boron (1 lbs/ac) and copper (2 lbs/ac), and 82 lb. N ac^{-1} actual using Agrotain 46-0-0 on the 22nd of May. There were high volatilization issues resulting in a decision to apply another 80 lb. N ac^{-1} of the same product just before it rained on the 5th of June. Sulphur was also applied at 50 lb. ac^{-1} actual using 21-0-0-24 fertilizer source on 17 June. Herbicide application was done 3 times during the season, with the initial application done as a burn off using 0.5 L ac^{-1} Roundup tank mixed with 0.015 L ac^{-1} Aim. The second application was done in-crop using 0.67 L ac^{-1} Roundup tank mixed with 0.15 L ac^{-1} Mextrol followed by 0.3 L ac^{-1} Roundup tank mixed with 0.5 L ac^{-1} Mextrol twenty-four days later. Few incidences of cutworms during the early stages of corn emergence were controlled by application of 0.034 L ac^{-1} Matador. Silage treatments were hand harvested at 25 to 50% milk line, weighed with a hanging scale and a sub sample chopped with a PTO driven silage chopper. The samples were stored in a refrigerator in air tight zip lock bags before being sent for quality analysis. The quality test was conducted at Central Testing Lab using the 2FF test (Wet Chemistry) in Winnipeg). Grain treatments were harvested using a Wintersteiger combine equipped with an H2 harvest master that records yield, test weight, moisture content and bushel weight. Other data collected included days required to reach silking stage (R5), stalk lodge, root lodge and fallen cobs. Analysis of variance was calculated using Minitab 18 with variety as a fixed factor and all responses as random factors. Means were deemed significant at $P<0.05$ using Fisher's LSD.

Results and Discussion

Days to silking varied significantly ($P<0.001$) among the three grain corn varieties (Table 15.0a). A3993G2 RIB and XP20071RR varieties required 4.7 and 3.7 days fewer, respectively, than A4646G2 RIB to reach silking stage. This is critical in estimating dates to grain filling and physiological maturity. Under Manitoba conditions where the growing season is short and the temperatures are cooler, farmers benefit from corn varieties that silk earlier because there is a chance that they reach maturity earlier and can be harvested when dry hence reducing drying costs. Although basing maturity on number of days instead of heat units is not ideal, it gives an option to farmers when planning their farm operations. Moisture content at harvest ranged from 15 to 17% but was not significantly different among corn varieties. Grain test weight was significantly lower ($P=0.002$) for A4646G2 RIB variety (62.5 kg hL^{-1}) with 17% moisture content while XP20071RR variety had the highest at 69.5 kg hL^{-1} with 15% moisture content. There were significant differences in test weights between A3993G2 and XP20071RR varieties. Grain corn yield ranged from 6612 kg ha^{-1} (109 bu ac^{-1}) to 686 kg ha^{-1} (113 bu ac^{-1}) but was not significantly different. Grain yield from 2020 was below the provincial average of 150 bu ac^{-1} and this could be attributed to inadequate moisture and heat units received.

Corn silage varieties tested in 2020 did not show any significant differences in any of the responses except for calcium content ($P=0.020$). AS1017RR variety had 0.11% while A4705HMRR variety had 0.07% calcium content (Table 15c). ADF and NDF percentages ranged from 28.2 to 30.7 and 46.53 to 50.18, respectively for the two varieties and is within the desirable ranges but because there were no significant differences between the varieties, there is no advantage of selecting one over the other. The trial was conducted for only one season and with few varieties to compare. Additional site-years of data may be necessary to in in order to provide both grain and silage producers with options of varieties to select from.

Table 15.0a Analysis of variance for grain yield, test weight and days to maturity of three grain corn varieties at Melita in 2020

Variety	Days to Silk	Cob Down %	Stalk Lodge %	Root Lodge %	Moisture %	Grain Test Wt. kg/hL	Grain Yield kg/ha (15%)	Grain Yield bu/ac
A3993G2 RIB	71.3**c**	0	2	0	17	68.4a	6769	112
A4646G2 RIB	76**a**	0	0	0	17	62.5b	6876	113
XP20071RR	72.3**b**	0	2	0	15	69.5a	6612	109
P Value	**<0.001**	N/A	0.559	N/A	0.106	**0.002**	0.877	0.877
Significant	**Yes**	No	No	No	No	**Yes**	No	No
CV%	0.5	N/A	149	N/A	6	2	9	9

Table 15.0b Analysis of variance for silage yields, days to maturity, stalk lodge and moisture content of two silage corn varieties at Melita in 2020

Variety	Days to Silk	Cob Down %	Stalk Lodge %	Root Lodge %	Moisture % at harvest	Silage Yield at 65% M.C kg/ha	Silage Yield at 65% M.C ton/ac
AS1017RR	76.3	0.0	2.7	0.0	59.7	61089	24.7
A 4705HMRR	71.3	0.0	1.7	0.0	61.7	56222	22.8
P Value	N/A	N/A	0.225	N/A	0.597	0.501	0.501
Significant	N/A	N/A	No	N/A	No	No	No
CV%	N/A	N/A	33	N/A	**6**	**12**	**12**

Table 15.0c Analysis of variance for silage quality tests of two corn silage varieties at Melita in 2020

Variety	ADF (%)	Ca (%)	Crude Protein%	Digest. Energy	Mg (%)	Energy			
						Meta	Net Gain	Net Lact.	Net Maint.
AS1017RR	30.7	0.11	7.57	2.91	0.21	2.41	0.93	1.50	1.53
A 4705HMRR	28.2	0.07	7.45	3.02	0.18	2.51	1.01	1.56	1.61
P Value	0.285	**0.020**	0.772	0.286	0.270	0.279	0.259	0.275	0.286
Significant	No	**Yes**	No	No	No	No	No	No	No
CV%	10	8	6	3	11	3	6	4	5

Variety	NDF	Non-Fibre Carb	P	K	RFV	TDN
AS1017RR	50.18	31.46	0.17	1.21	120.7	65.9
A 4705HMRR	46.53	35.22	0.20	1.11	135.3	68.5
P Value	0.398	0.346	0.188	0.463	0.346	0.284
Significant	No	No	No	No	No	No
CV%	9	11	10	12	11	3

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16.0 Intercropping corn and hairy vetch

Project duration: 2018-2021
Collaborators: WADO

Objectives

- To evaluate the merits of growing hairy vetch in the understory of grain corn
- To evaluate tolerance level of hairy vetch to different types and dosages of herbicides: Roundup Transorb (540 g ae ac^{-1}), Basagran Forte, Koril and Mextrol 450

Background

Corn and hairy vetch intercrop provide a wide range of ecosystem services that include erosion protection and improved weed control due to hairy vetch's creeping growth habit (Brainard et al., 2012). In addition, nitrogen fixation by hairy vetch may result in reduced 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

Treatments applied in 2020 were similar to the ones applied in 2019 (Table 16a). The trial used the same randomized complete block design with 10 treatments and 3 replications as in 2019. The site was harrowed in 2019 and rotor tilled before seeding in 2020. Soil characterization in 2020 was Lr7Sr3 (Lauder loamy fine sand, Souris loamy fine sand). Seeding was done on the 20th of May using an air seeder at 0.5" depth for vetch while corn was seeded at 19 cm in-row spacing with a corn planter set at 2" seeding depth. Basal fertilizer was applied at 100-35-20-8-2 (N-P-K-S-Zn) actual lb. ac^{-1}. Seeding rate of 28 000 ppa was used for DeKalb corn variety 26-28 RR while WADO common hairy vetch was seeded at 20 lb. ac^{-1}. A weed burnoff application with 0.5 L ac^{-1} Roundup tank mixed with 0.5 L ac^{-1} Aim was done on the 22nd of May using a side-by-side ATV sprayer. Boron and Copper elements were sprayed at 2 L ac^{-1} each on the same day as burnoff application. Another fertilizer element, Sulphur, was applied in-crop on the 17th of June at 50 lb. ac^{-1} with 21-0-0-24. All initial treatment applications were done on June 19 and a follow up done on July 3 for treatment 8 that required a second application at V8 stage of corn development.

Table 16a. Corn-Hairy Vetch treatment description

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

Data collection was similar to 2019 since it's a replicated trial over 3 seasons. Percent hairy vetch injury was assessed weekly for 3 weeks after application of herbicide treatments. Wet weeds biomass was collected from 2 x 1 m^2 sampling points randomly selected from each plot to determine weed density at R1 (silking stage of corn). At about 30% kernel moisture content (R6-physiological maturity of corn), above ground corn and hairy vetch biomass was collected separately from 2 x 1 m^2 sampling areas from each plot. Corn grain yield was harvested from two corn rows of each plot using a Wintersteiger small plot combine harvester. Data were subjected to 2-way 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 and Discussion

There were no significant differences in hairy vetch injury during the first and second week after application of treatments. However, significant differences ($P<0.001$) in hairy vetch injury were observed at 3 weeks after application of the products (Table 16b). Application of Roundup and Mextrol 450 at 0.5 L ac^{-1} each caused the 88% hairy vetch injury while other products caused between 13% and 53% at 3 WAA of treatments. Roundup alone at 0.5L ac^{-1} resulted in 30% hairy vetch injury at 3 WAA in the corn-vetch treatment. Wet weeds biomass harvested at R1 stage of corn development was significantly high ($P=0.003$) in corn-vetch treated with 0.5 L ac^{-1} Roundup and 0.5 L ac^{-1} Mextrol 450 (5700 kg ha^{-1}). Wet weeds biomass for this treatment was not significantly different to the corn check (0.75 L ac^{-1} Roundup), corn-vetch (0.75 L ac^{-1} Roundup), and corn-vetch (1 L ac^{-1} Roundup). On the other hand, 3183 kg ha^{-1} wet weeds were harvested when Roundup was applied alone at 0.5 L ac^{-1} (Figure 16a). Split application with 0.33 L ac^{-1} Roundup at V3 and V8 caused 28% hairy vetch injury not significantly different from 0.5 L ac^{-1} Roundup treatment and wet weeds biomass yield of 950 kg ha^{-1} at R1 stage of corn development. Lower wet weeds biomass yield could have been due to the second treatment with Roundup at V8 stage of corn development for treatment 8, which ensured control of weeds that emerged after the initial application at V3 stage of corn development (Table 16b).

Table 16b Analysis of variance for wet weeds biomass (kg ha^{-1}) and hairy vetch injury at 1, 2 and 3 weeks after application of treatments at Melita in 2020

	Factor	Hairy Vetch injury			Wet weeds
		1WAA	2WAA	3WAA	kg ha^{-1}
1	Corn (check), 0.75L ac^{-1} Roundup at V3	0	0	0	4883**ab**
2	Hairy Vetch (check), 0.91L ac^{-1} Basagran	*	*	*	1733**cde**
3	Corn (check) + vetch hand weed + 0.91L ac^{-1} Basagran	*	*	*	117**e**
4	0.2L ac^{-1} Roundup at V3	17	13	13**d**	3033**bcd**
5	0.5L ac^{-1} Roundup at V3	25	30	30**cd**	3183**bcd**
6	0.75L ac^{-1} Roundup at V3	22	27	30**cd**	3833**abc**
7	1L ac^{-1} Roundup at V3	42	50	53**b**	4883**ab**
8	0.33L ac^{-1} at V3 and V8	20	25	28**cd**	950**de**
9	0.5L ac^{-1} Roundup + 0.4L ac^{-1} Koril (tank mixed)-V3	37	37	40**bc**	3533**abc**
10	0.5L ac^{-1} Roundup +0.5L ac^{-1} Mextrol 450 (tank mixed)-V3	74	93	88**a**	5700**a**
	Significant?			**Yes**	**Yes**
	P-Value			**<0.001**	**0.003**
	C.V. (%)			**62**	**68**

Dry matter biomass data showed no significant differences in stalk + cob or grain corn yield with coefficient of variation of 17% and 22%, respectively. The lowest grain corn yield was 3628 kg ha^{-1} for the corn-vetch treated with 0.5 L ac^{-1} Roundup while the highest was obtained from the corn check treated with 0.75 L ac^{-1} at V3. Hairy vetch biomass was significantly different (P<0.001) and as expected, hairy vetch control treated with 0.91 L ac^{-1} Basagran had the highest yield (7866.7 kg ha^{-1}) compared to other treatments (Table 16c). There were no significant differences in hairy vetch yield when Roundup was applied alone at any rate between 0.2 L ac^{-1} and 0.75 L ac^{-1}. With these application rates, hairy vetch biomass yield ranged from 2733 kg ha^{-1} to 4600 kg ha^{-1}. The lowest hairy vetch yield (1267 kg ha^{-1}) was from corn-vetch treated with 0.5 L ac^{-1} Roundup and 0.5 L ac^{-1} Mextrol 450 at V3 stage of corn. This is the same treatment that caused the highest hairy vetch injury (88%) when assessed at 3 WAA of herbicides. Hairy vetch could not recover from the effects of Roundup + Mextrol application, hence the significantly low yield. Combined biomass analysis for grain corn, stalk + cob and hairy vetch found significant differences (P<0.001) among the treatments. However, among all treatments with Roundup applied alone or in a mixture with either Koril or Mextrol 450, there were no significant differences and total dry biomass yield ranged from 18765 kg ha^{-1} to 21930 kg ha^{-1} (Figure 16b). The highest total biomass yield was obtained from hand weeded corn + vetch treated with 0.91 L ac^{-1} Basagran (26415 kg ha^{-1}) while the lowest, as expected, was from hairy vetch control (7890 kg ha^{-1}) treated with the same herbicide and rate.

Table 16c Analysis of variance for stalk + cob, grain yield, hairy vetch and total dry matter biomass (kg ha^{-1}) at Melita in 2020

	Factor	Dry Matter Biomass kg ha^{-1}			
		Stalk + Cob	Grain Yield	Hairy Vetch	Total
1	Corn (check), 0.75L ac^{-1} Roundup at V3	16100	5102	*	21203**b**
2	Hairy Vetch (check), 0.91L ac^{-1} Basagran	*	*	7866.7**a**	7890.4**c**
3	Corn (check) + vetch hand weed + 0.91L ac^{-1} Basagran	16446	4635	5333**b**	26415**a**
4	0.2L ac^{-1} Roundup at V3	13487	3843	4600**bc**	21930**ab**
5	0.5L ac^{-1} Roundup at V3	12488	3628	3800**cd**	19916**b**
6	0.75L ac^{-1} Roundup at V3	14294	4671	2733**def**	21698**ab**
7	1L ac^{-1} Roundup at V3	12719	4513	1533**fg**	18765**b**
8	0.33L ac^{-1} at V3 and V8	14986	4606	3466.7**cde**	23059**ab**
9	0.5L ac^{-1} Roundup + 0.4L ac^{-1} Koril (tank mixed)-V3	14025	4702	2367**efg**	21094**b**
10	0.5L ac^{-1} Roundup +0.5L ac^{-1} Mextrol 450 (tank mixed)-V3	14371	5042	1267**g**	20679**b**
	Significant?	No	No	**Yes**	**Yes**
	P-Value	0.514	0.117	**<0.001**	**<0.001**
	C.V. (%)	**17**	**22.37**	**57**	**26**

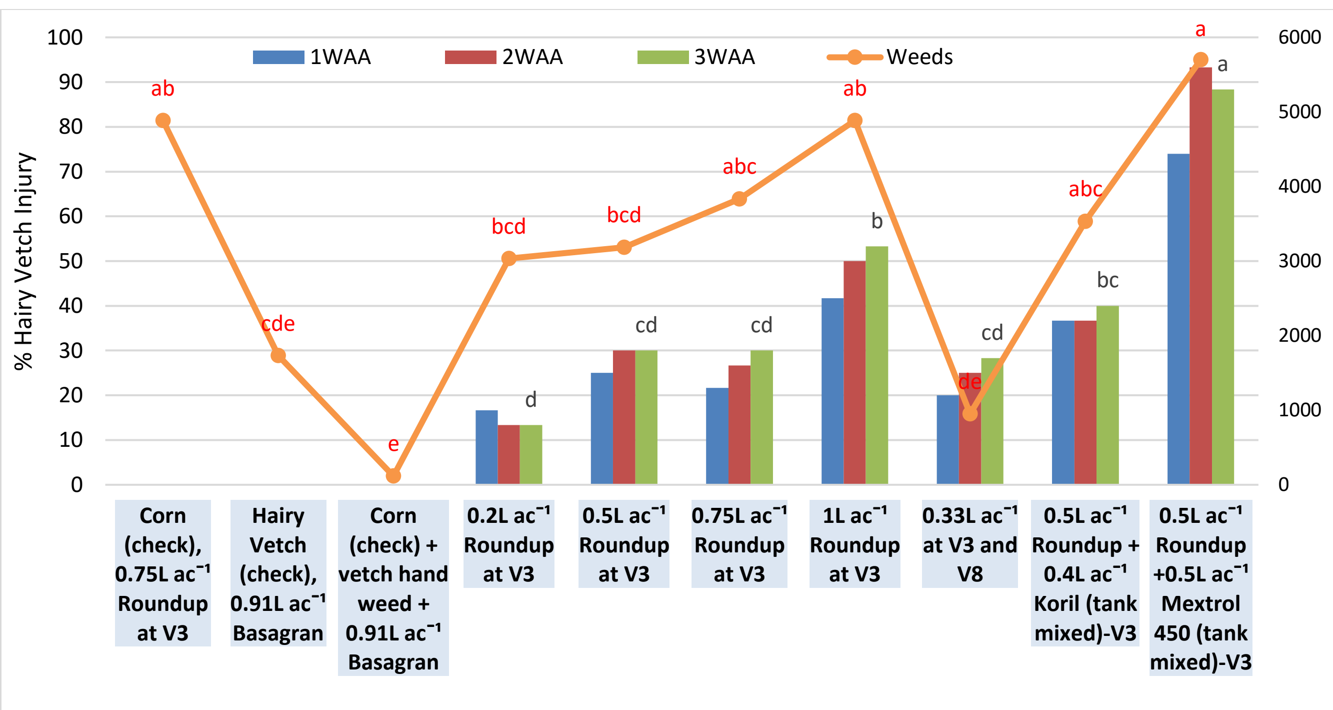

Figure 16a Hairy vetch injury percentage at 1, 2 and 3 WAA of treatments and wet weeds biomass at Melita in 2020

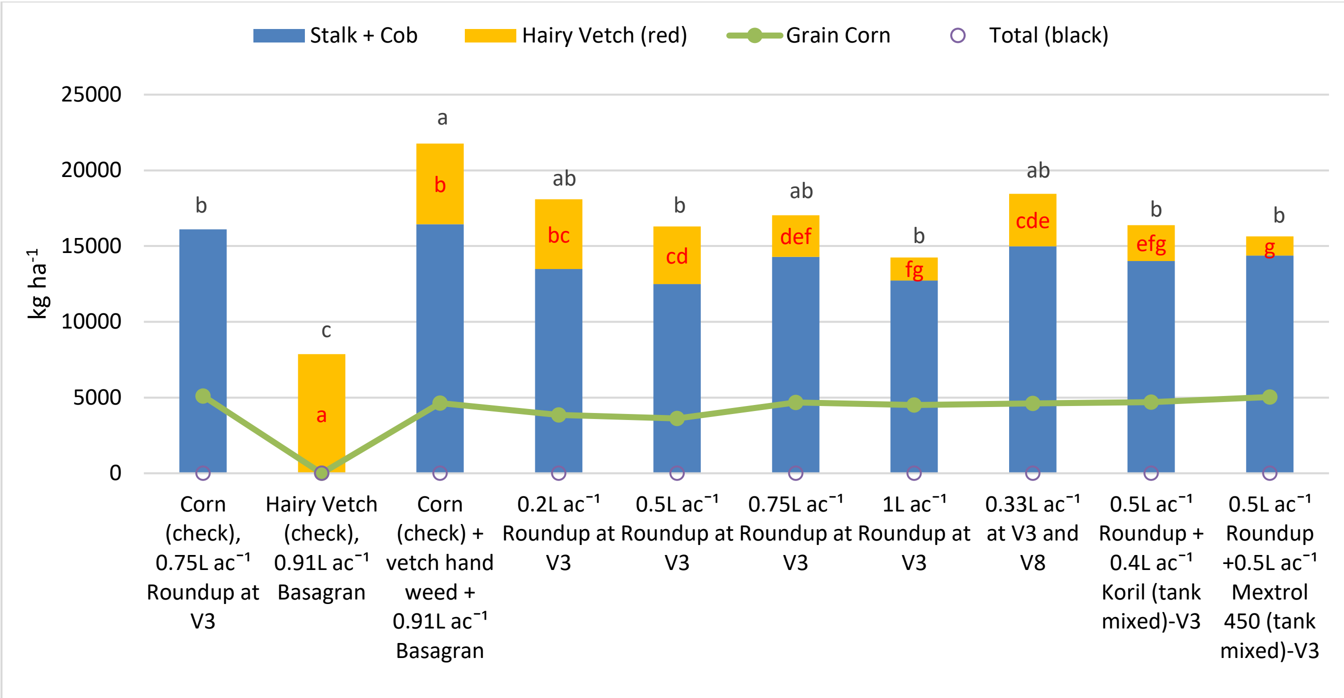

Figure 16b Dry biomass (kg ha^{-1}) for corn stalk + cob, hairy vetch and grain corn at Melita in 2020

Conclusions

There were significant differences in the herbicide injury on the hairy vetch. Treatment 10 (0.5 L ac^{-1} Roundup and 0.5 L ac^{-1} Mextrol 450) caused more damage on hairy vetch, and also had the most weeds compared to other treatments. Applying 1 L ac^{-1} Roundup was also harsh on hairy vetch while split application of Roundup at 0.33 L ac^{-1} at V3 and V8 stages of corn caused minimal damage but controlled weeds the best. Treatments applied did not significantly influence corn grain yield. Hairy vetch biomass was significantly different depending on treatment and rate used. Generally, there was less hairy vetch biomass with increases in hairy vetch injury. For Injury x hairy vetch biomass, Pearson's correlation was significant; $P<0.001$, $r = -0.766$, R-squared = 59%. Total dry biomass was not any different than check corn (Treatment 1), except for the hand weeded check (Treatment 3), which had the highest biomass overall. Results from the current year showed that herbicide treatments had more effect on hairy vetch compared to the previous year. This could probably have been due to environmental conditions such as salinity, weather (wind, temperature and humidity) and plant development stage at spray time. High coefficient of variation values especially for hairy vetch injury at 3WAA and wet weeds biomass could have been due to large variation in the data set, for example, vetch injury ranged from 0% to 88% while wet weeds biomass ranged from 117 kg ha^{-1} to 5700 kg ha^{-1}. This could have been caused by variation in salinity conditions between treatments. Exclusion of outliers could perhaps significantly reduce variations and improve reliability of the data. Currently, there are only 2 years of grain corn yield data, which is not sufficient to formulate recommendations that producers can use. Therefore, an additional site-year of grain corn yield is required so as to get an idea of necessary recommendation for producers interested in this cropping system.

References

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

17.0 Pea (oat-barley-canola) intercrop evaluation

Project duration: 2020-ongoing
Collaborators: Roquette, WADO

Objectives

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

Background

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

Materials and Methods

The trials were conducted at Melita, Manitoba with detailed legal land description and agronomy described in Table 17b. Soil sampling and testing was done in spring prior to seeding and fertilizer application was based on soil analysis results (Table 17a) so as to meet crop requirements. Three intercrop trial options were arranged as randomized complete block design with 5 treatments each for pea-oat and pea-barley, and 6 treatments for pea-canola. Each of the treatments was replicated 4 times. Pea-oat trial included 100% pea (control), 100% pea: 15% oats, 100% pea: 25% oats, 100% pea: 50% oats-, and 100% oats (control). Pea-barley trial included 100% pea (control), 100% pea: 15% barley, 100% pea: 25% barley, 100% pea: 50% barley-, and 100% barley (control). Pea-canola trial included 100% pea (control), 100% pea: 25% canola, 100% pea: 50% canola, 75% pea: 25% canola, 75% canola: 25% canola-, and 100% canola (control). Various data collected included crop emergence counts in row 2 and 5, weed counts, aphid counts per 10 random plants, foliar diseases, root rot, lodging and grain yield. Additional data included protein content analysis, percent split peas, land equivalence ration calculation for each crop and thousand kernel weight. Data were analyzed with Minitab 18 by running a general linear model for response variables to treatments. Tukey test was used to compare means at 5% level of significance. P-values were derived from transformed data using either Johnson or Box Cox method.

Table 17a 2020 Spring soil test results for Melita site

Spring Soil Test							
pH	**OM**	**N 0-6" lb/ac**	**N 6-24" lb/ac**	**N-(N1+N2)**	**P-O ppm**	**K ppm**	
7.9	2.8	7	27	34*	7	327	
Ca ppm	**Mg ppm**	**S lb/ac 0-6"**	**S lb/ac 6-24"**	**Zn ppm**	**Salt1**	**Salt2**	**CEC meq**
2575	469	14	102	0.58	0.23	0.33	17.62

*Optimal for pea production

Table 17b: Melita trial site description and agronomy in 2020

Trial	Roquette Intercrop
Location	Melita
Cooperator	Bert Kirkup/Maria Snyder
Legal	SE 26-3-27 W1
Rotation (2 yr.)	soybean, s. wheat
Rotation Herbicide (2 yr.)	Viper, Roundup/PumaTraxos2
Soil Series	Newstead Loam
Soil Test Done? (Y/N)	Yes
Field Prep	harrowed May 5
Stubble	Spring wheat
Burnoff (Date/Rate-ac/Products)	Rival 0.65L on Peaola only May 8, Glyphosate 0.5L + Aim 15 ml May 11
Soil Moisture at Seeding	Good
Seed Date	08/05/20
Seed depth	0.75"
Seeder (drill/planter?)	Seed hawk dual knife air seeder
Fertility Applied (NPKS-lb/ac Actual)	9-35-20-8-2Zn
Topdressing (Date/Rate)	None
Herbicides (Date, Rate/ac, Name, Gal/ac)	June 4 Odyssey 17.3g + Merge 5% on Peaola, MCPA amine500 0.15L June 5 10 gal/ac Backpack on oat/barley pea, June 9 arrow 100 ml
Fungicides	None
Insecticides	May 26 Pounce 63 ml/ac Cotyledon V1 flea beetles May 28 Pounce 63 ml/ac Cotyledon V1 flea beetles
Desiccation Date, Product	Aug 11 42 ml/ac Heat Pea-Barley, Pea-Canola
Harvest Date	Pea-Barley Aug 12, Pea-OAT & canola Aug 19
GGDs actual (Seed date>Harvest) Base5*C	1303
GGDs Normal (seed date>Harvest)	1249
Precipitation (actual) SD>HD	166
Precipitation (normal) SD>HD	262
Combine settings	Concave clearance: 9mm Cylinder: 800 rpm Fan speed: 930 rpm
Cleaning	Pea-Oat and Barley trials used spiral first then table cleaner Peaola used table cleaner Barley and pea splits were hard to separate

Results and Discussion

Peas in 100% pea: 50% oat required significantly (P=0.036) fewer days to maturity (82) compared to the pea check (85.8 days) while either combination were not significantly different from 100% pea: 15% oats and 100% pea: 25% oats. Oat control treatment required significantly (P=0.040) fewer days to maturity (84) compared to oat in the 100% pea: 15% oats. On the other hand, days to maturity for oat control were not significantly different from oats in either 100% pea: 25 or 50% oat densities. Kernel weight of oat was significantly (P=0.012) greater in oats sole crop at 20.9g per 500g sample compared to 100% pea: 15 or 25% oats that had 18.6g and 18.7g, respectively with the same sample size. Pea protein content was significantly high (P=0.008) for 100% pea: 50% oat compared to pea-oats at 100% pea: 15 and 25% oat. Protein content of oats was highest and the same in all pea-oat densities (10.9%) except in oat sole crop that had a significantly (P=0.001) lower content at 9.2%. This implies that intercropping pea with oat has some significant benefit on protein content, which may in turn increase the value of the crop (Table 17c). Percentage of split peas was significantly lower (P=0.006) in 100% pea: 15% oat (2.1%) compared to pea sole crop (3.5%) and 100% pea: 50% oat (3.3%) (Table17d). An intercrop with 100% pea: 25% oat (2.8%) did not have significantly different pea splits from the rest of the crop density options in 2020. Therefore, not much pea quality is compromised when oats is included in the intercrop than growing a sole pea crop. This could be as a result of some protection provided by oat on pea during harvesting the crop.

Table 17c Analysis of variance for Pea-Oat emergence, leaf diseases, days to maturity and protein content at Melita in 2020

Treatment	Actual Emergence (ppms)		Leaf Disease^		DTM (days)		TKWT (g/500)		Protein (%)	
Description	**Pea**	**Oat**	**Pea**	**Oat**	**Pea**	**Oat**	**Pea**	**Oat**	**Pea**	**Oat**
100% Peas (check)	53	-	2.5	-	85.8**a**	-	122.6	-	23.2**b**	-
100% Peas, 15% Oats	53	27	3.1	2.5	84.5**ab**	87.5**a**	120.6	18.6**b**	23.4**ab**	10.9**a**
100% Peas, 25% Oats	64	40	3.4	3.2	83.8**ab**	84.5**ab**	121.1	18.7**b**	23.2**b**	10.9**a**
100% Peas, 50% Oats	54	66	2.7	2.9	82.0**b**	84.8**ab**	119.2	19.3**ab**	23.8**a**	10.6**a**
100% Oat	-	136	-	4.2	-	84.0**b**	-	20.9**a**	-	9.2**b**
P value			0.230	0.324	**0.036**	**0.040**	0.238	**0.012**	**0.008**	**0.001**
CV%			21	36	2	2	2		1	

Table 17d Analysis of variance for Pea-Oat lodging score, weed population, splits, seed diseases, root rot and aphid count at Melita in 2020

Treatment	Lodging	Weeds	Pea			
Description	1-5	ppms	Splits (%)	Seed Disease (%)	Root Rot (1-7)	Aphids (per plant)
100% Peas (check)	1.3ab	6	3.5**a**	2.0	0.2	1.9
100% Peas, 15% Oats	1.0b	8	2.1**b**	1.3	0.3	1.9
100% Peas, 25% Oats	1.0b	5	2.8**ab**	1.3	0.3	1.8
100% Peas, 50% Oats	1.8ab	9	3.3**a**	1.8	0.6	1.7
100% Oat	2.5a	9	-	-	-	-
P value	**0.013**	0.196	**0.006**	0.743	0.157	0.964
CV%	38	51	14	74	58	61

As expected, there were highly significant (P<0.001) yield differences between pea check (100% pea), oat check (100% oats) and other pea-oat intercrop options (Table 17e). 100% pea: 15% oat resulted in pea yield of 58.8 bu ac^{-1} which was significantly lower than pea check (79.9 bu) but higher than yield in 100% pea: 50% oats (42.2 bu). Oat yield in 100% pea: 15 or 25% oats was significantly lower than that obtained from 100% pea: 50% oats (74.5 bu ac^{-1}). Oat yield increased with an increase in oats density while pea yield decreased probably as a result of interspecific competition for nutrients and growing space between the two crops. Partial land equivalent ratios for pea and oats followed the same pattern as yield, with significantly higher LER (P<0.001) in the check compared to other pea-oat intercrop options. Pea LER in 100% pea: 15% was significantly higher (0.74) than in 100% pea: 25% and 50% oat, which had 0.66 and 0.52, respectively. Oat LER in 100% pea: 50% oat were significantly higher than 100% with either 15 or 25% oats. For total land equivalent ratio for 100% pea: 50% oat were significantly greater (P=0.017) than in 100% pea: 15% oat. Basing on the TLER, there was a significant yield benefit for intercropping pea and oats at different densities compared to sole crop.

Economic analysis insert table gives an insight to what a producer can expect in terms of operating costs, gross revenue and net revenue from different pea-oat intercrop options. Although sole oats have the lowest operating costs, profitability seems to be very low compared to other available options.

Table 17e Pea-Oat yield (bu/ac), land equivalence ratio and economic analysis at Melita in 2020

Description	Yield (bu/ac)		Land Equivalent Ratio			Economic Analysis		
						COP	Gross Rev	Net Rev
	Pea	Oat	PLER	OLER	TLER	$/ac	$/ac	$/ac
100% Peas (check)	79.1a		1.00a	-	1.00	346	646	300
100% Peas, 15% Oats	58.8b	43.8c	0.74b	0.44c	1.18b	342	645	303
100% Peas, 25% Oats	52.1bc	57.3c	0.66bc	0.58c	1.23ab	358	642	284
100% Peas, 50% Oats	42.2c	74.5b	0.52c	0.75b	1.27a	349	625	277
100% Oat		99.5a	-	1.00a	1.00	300	376	76
P value	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.017**			
CV%	**8**	**9**	**9**	**9**	**3**			

There were no significant differences in pea leaf disease ratings regardless of the intercrop option used (Table 17f). Monocrop barley (control) had significantly (P=0.013) higher leaf disease rating (3.5) compared to barley in 100% pea: 15% barley (2.5). The other intercrop options were not significantly different. Monocrop pea required significantly (P<0.001) more days to reach maturity compared to alternative intercrop options. There were no significant differences in pea days to maturity when barley was seeded at 15 or 25% and at 25% or 50% density. Kernel weight for barley was significantly higher (P=0.045) in the control treatment (18.8 g per 500 seed sample) compared to 50% barley that had 17 g. Pea protein content in the intercrops was not significantly different from the control/sole crop. However, all the three pea-barley intercrop options had significantly higher (P<0.001) barley protein content than the barley check. Split peas were significantly (P=0.034) low in the pea check compared to 100% pea: 50% barley intercrop (Table 17g). Overall, split pea percentages ranged from 4.5 to 9.6 per sample collected.

Table 17f Analysis of variance for Pea-Barley emergence, leaf diseases, days to maturity, TKWT and protein content at Melita in 2020

Description	Actual Emergence (ppms)		Leaf Disease^		DTM (days)		TKWT (g/500)		Protein (%)	
	Pea	Barley	Pea	Barley	Pea	Barley	Pea	Barley	Pea	Barley
100% Peas (check)	53	-	2.7	-	85.3**a**	-	123.4**a**	-	23.4	-
100% Peas, 15% Barley	57	25	2.8	2.5b	83.0**b**	80.0	121.0**a**	17.5**ab**	23.0	14.1**a**
100% Peas, 25% Barley	64	34	2.6	2.7ab	82.3**bc**	80.0	123.4**a**	17.3**ab**	23.6	13.8**a**
100% Peas, 50% Barley	63	76	2.9	2.8ab	80.8**c**	80.0	119.8**a**	17.0**b**	23.3	14.2**a**
100% Barley (check)	-	147	-	3.5a	-	77.0	-	18.8**a**	-	11.7**b**
P value			0.290	**0.013**	**<0.001**	N/A	**0.039**	**0.045**	0.186	**<0.001**
CV%			8	16	1	N/A	1	1	1	4

Table 17g Analysis of variance for Pea-barley lodging, weed population, split peas, seed diseases, root rot and aphid count at Melita in 2020

Description	Lodging	Weeds	Pea			
	1 to 5	Ppms	Splits (%)	Seed Disease (%)	Root Rot (1-7)	Aphids (per plant)
100% Peas (check)	1.0	17	4.5b	3.0	0.3	1.4
100% Peas, 15% Barley	1.0	17	5.8ab	1.5	0.4	1.4
100% Peas, 25% Barley	1.0	21	6.0ab	2.0	0.7	1.4
100% Peas, 50% Barley	1.8	20	9.6a	1.3	0.7	0.8
100% Barley (check)	1.0	14	-	-	-	-
P value	0.102	0.662	**0.034**	0.485	0.319	0.694
CV%	37	39	32	76	73	79

Pea yield was significantly high (P=0.005) in the check compared to the intercrop options (Table 17h). The yield of pea in the check was 81.5 bu ac^{-1} compared to 63.9, 62.5 and 55.5 bu ac^{-1} for pea in 15, 25 and 50% barley density, respectively. Barley yield was also significantly higher (P<0.001) in the check compared to the intercrops. The yield of barley was in the check was 60.6%, 51.3% and 45.3% more than that obtained from barley densities at 15%, 25% and 50%, respectively. Pea LERs were significantly lower than the check while barley LERs were not significantly different. Total LER showed no significant yield benefit in using any of the intercropping options over sole crop in 2020. Compared to other cropping systems, adopting 100% barley production results in net revenue loss of -$87 while adopting sole pea production results in at least 30% more net revenue than adding different densities of barley.

Table 17h Pea-barley yield (bu/ac) Land Equivalence Ratio and economic analysis at Melita in 2020

Description	Yield (bu/ac)		Land Equivalent Ratio			Economic analysis		
						COP	Gross Rev	Net Rev
	Pea	Barley	Pea	Barley	TLER	$/ac	$/ac	$/ac
100% Peas (check)	81.5a		1.00**a**	-	1	346	665	319
100% Peas, 15% Barley	63.9b	18.5**b**	0.79**b**	0.39**b**	1.1837	341	605	264
100% Peas, 25% Barley	62.5b	22.9**b**	0.77**b**	0.49**b**	1.2621	343	613	270
100% Peas, 50% Barley	55.5b	25.7**b**	0.69**b**	0.55**b**	1.2355	346	568	222
100% Barley (check)		47.0**a**	-	1.00**b**	1	299	211	-87
P Value	**0.005**	**<0.001**	**0.004**	**<0.001**	0.171			
CV%	**11**	**14**	**11**	**12**	**4**			

There were no significant differences in days to maturity and leaf diseases for either canola or pea intercrop options compared to the checks. Protein content of canola was significantly low (P<0.001) in the pea check (16.6%) while densities of 100% pea: 25% canola, 100% pea: 50% canola, 75% pea: 25% canola and 75% pea: 50% canola had 20.9%, 20.1%, 20.5% and 19.7% protein content, respectively. There was no significant change in protein content of pea with different intercropping options (Table 17i). There were also no significant differences observed in lodging, weed populations, split pea percentages, seed diseases, root rot and aphid populations among different crop densities or pea-canola (Table 17j). Based on these results, varying pea-canola crop density did not influence many responses. Perhaps there needs to be more variation in crop density proportions of pea and canola or additional site years of study are required before recommendations can be made to producers interested in the intercrop option in question.

Table 17i Analysis of variance for pea-canola emergence, leaf diseases, days to maturity, TKWT and protein content at Melita in 2020

Description	Actual Emergence (ppms)		Leaf Disease^		DTM (days)		TKWT (g/500)		Protein (%)	
	Pea	Canola	Pea	Canola	Pea	Canola	Pea	Canola	Pea	Canola
100% Peas (check)	51		2.7		89		120.6		23.1	
100% Peas, 25% Canola	56	13	2.7	0.2	88	89	125.8	120.6	23.2	20.9a
100% Peas, 50% Canola	51	25	2.5	0.1	88	88	127.7	125.8	23.2	20.1ab
75% Peas, 25% Canola	37	16	2.5	0.0	88	89	125.3	127.7	23.1	20.5ab
75% Peas, 50% Canola	35	19	2.6	0.1	88	90	125.6	125.3	23.2	19.7b
100% Canola (check)		36		0.1		90		125.6		16.6c
P value			0.602	0.561	0.445	0.063	0.166	0.258	0.961	**<0.001**
CV%			10	192	1	1	3	4	1	2

Table 17j Analysis of variance for pea-canola lodging, weed population, split peas, seed disease, root rot and aphid count at Melita in 2020

Description	Lodging	Weeds	Pea			
	1 to 5	Ppms	Splits (%)	Seed Disease (%)	Root Rot (1-7)	Aphids (per plant)
100% Peas (check)	1.0	8	2.6	2.0	1.3	1.2
100% Peas, 25% Canola	1.3	9	2.8	2.0	1.4	1.7
100% Peas, 50% Canola	1.3	9	2.6	1.3	1.5	1.0
75% Peas, 25% Canola	1.3	13	2.6	1.5	1.3	2.0
75% Peas, 50% Canola	1.3	4	2.5	1.5	0.8	1.9
100% Canola (check)	1.0	15				
P value	0.822	0.377	0.747	0.908	0.794	0.698
CV%	34	73	14	82	68	79

Similar to pea-barley intercrop, yield of control pea (87.5 bu ac^{-1}) and canola (31.6 bu ac^{-1}) was significantly higher than intercrops (P<0.001). Pea yield from all pea-canola density options were not significantly different and yield ranged from 66.2 to 76.1 bu ac^{-1}. On the other hand, canola yield from 75% pea: 50% canola was significantly higher (13.7 bu ac^{-1}) than 75% pea: 25% canola (9 bu ac^{-1}) and 100% pea: 25% canola (7.8 bu ac^{-1}). Pea LER was significantly lower (P<0.001) in all the intercrops compared to the check that had a value of 1.0 (Table 17k). Canola LER followed the same pattern as yield, with significantly (P<0.001) low LER compared to the control that had the same value as pea check LER. The highest TLER ratio was observed in the 100% pea: 50% canola (1.22) while the lowest was in the 75% pea: 25% canola (1.07) intercrop (P=0.004). Adoption of 100% canola production appears not to be logical, at least based on 2020 results, because of very low net revenue of $26 ac^{-1} compared to 100% pea production or combining pea with canola at different densities resulting in over $300 ac^{-1} in net revenue in most cases.

Table 17k Pea-canola yield, Land Equivalent Ratio and economic analysis at Melita in 2020

Description	Yield (bu/ac)		Land Equivalent Ratio			Economic analysis		
						COP	Gross Rev	Net Rev
	Pea	Canola	Pea	Canola	TLER	$/ac	$/ac	$/ac
100% Peas (check)	87.5a		1.00**a**		1.00	346	714	368
100% Peas, 25% Canola	76.1b	7.8**c**	0.87**bc**	0.25**c**	1.11**bc**	378	717	339
100% Peas, 50% Canola	76.4b	10.9**bc**	0.87**bc**	0.35**bc**	1.22**a**	394	759	365
75% Peas, 25% Canola	68.8b	9.0**c**	0.79**bc**	0.28**c**	1.07**c**	369	672	303
75% Peas, 50% Canola	66.2b	13.7**b**	0.76**c**	0.43**b**	1.19**ab**	385	709	324
100% Canola (check)		31.6**a**		1.00**a**	1	364	390	26
P value	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.004**			
CV%	6	12	6	12	4			

Overall, intercropping pea-canola (Table 17k) at various densities would be a better option in terms of profitability when comparing with net revenue obtained from pea-barley (Table 17h) or pea-oats (Table 17e) options. Apart from revenue obtained from the crops, producers would also benefit from intercropping pea-canola more than other options due to high compatibility of the two crops in suppression of pests and diseases as discovered in previous studies of intercropping systems. It would also be worthwhile to consider fall soil sampling in order to determine if soil nutrient dynamics are affected by various pea intercrop combinations and densities. Results from this study are from one year of field research, which only provides an insight of available options for producers to choose from and additional site-years of data would cement the best option under varying weather conditions. Therefore, this study will be conducted again in successive season and farmer recommendations will be done based on large data sets.

References

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Lauk, R. and Lauk, E. 2008. Pea-oat intercrops are superior to pea-wheat and pea-barley intercrops. Acta Agriculturae Scandinavica, Section B-Soil & Plant Science, 58: (2)139 - 144. DOI: 10.1080/09064710701412692

18.0 Advanced yield tests for Malt barley [AA Barley, AB Barley, AC Barley, AFOO Barley]

Project duration: 2018 (AFOO), 2019 (AC, AB & AA)
Collaborators: Agriculture and Agri-food Canada, Brandon

Objectives

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

Background

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

Materials and Methods

The advanced yield trials of barley were conducted at Melita in 2020 under the same conditions as Western Coop hulless barley (Section 19.0). All the yield tests were arranged as randomized complete block design with 30 treatments (varieties) and 3 replicates for AA barley, AB barley and AC barley, and

26 treatments (varieties) and 3 replicates for AFOO barley. Due to the number of treatments and to deal with reducing variability, a serpentine layout was ideal for the trials. A burn off herbicide application with 0.5 L ac^{-1} Roundup tank mixed with 0.015 L ac^{-1} Aim was done prior to seeding. Seeding was done on the 1st of June using a 6-row dual knife air seeder set at a depth of ¾". Fertilizer application was done by side banding during seeding at 100-35-20-8-2 (N-P-K-S-Zn) actual lb. ac^{-1}. Post emergence weed control was done by spraying 0.81 L ac^{-1} Tundra using a side-by-side ATV on the 15th of June. The plots were harvested on the 19th and 20th of August with the same equipment used for Western Coop hulless oats. Data collection and sampling was also similar to the Western Coop hulless oats trial (Section 19.0).

Results and Discussion

Results from this study are for publication by Agriculture and Agri-Food Canada and will be shared when available.

References

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

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

19.0 Western Coop Hulless Barley evaluation

Project duration: Ongoing
Collaborator: Ana Badea-AAFC Brandon

Objectives

- Evaluation of yield potential and agronomic characteristics of hulless barley

Background

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

Materials and Methods

The trial was conducted on Newstead loam soils under no-till cropping system at Melita in 2020. The previous 2 years had soybean and spring wheat in rotation followed by barley in the current season. Experimental design used was a randomized complete block design with 15 treatments (varieties) replicated 3 times. Land preparation only involved harrowing of spring wheat crop residue to avoid interference with seeding equipment. Seeding occurred on the 19th of May using a dual knife air seeder set at a depth of 5/8”. Fertilizer was side banded during seeding at 100-35-20-8-2 (N-P-K-S-Zn) actual lb. ac^{-1}. This was followed by preemergence weed control using 0.5 L ac^{-1} Roundup tank mixed with 0.015 L ac^{-1} Aim on the 21st of May. In-crop weed control was achieved by the application of 0.81 L ac^{-1} Tundra in 10 gal. ac^{-1} spray volume using boom sprayer mounted on a side-by-side ATV on the 4th of June. Data collected for all plots during the season included heading date, plant height at maturity, maturity date and lodging assessment at a scale of 1 to 9. The plots were harvested on the 11th of August using a Wintersteiger small plot combine equipped with an H2 Harvest Master which recorded grain yield, moisture content and test weight during harvesting. Composite samples of each entry were assessed for dirty test weight, as kg per hectoliter taken on the unclean sample, clean test weight taken on the cleaned sample, kernel weight in grams per 1000 seed count and plump percentage using a 5.5/64” sieve for a minimum of 100g of seed sample. Additional observations such as disease load on a 1 to 9 scale and general visual rating of the plots on a 1 to 9 scale were also necessary. In all rating cases, 1 referred to poor while 9 referred to excellent crop. Composite samples of 1.5 kg from each entry/treatment were sent to Agriculture and Agri-Food Canada for further malting and food quality assessment.

Results and Discussion

Results from this study are proprietary and can be made available through by Agriculture and Agri-Food Canada (Dr. Ana Badea).

References

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

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

20.0 Swath Canola Variety Trial

Project duration: Ongoing
Collaborators: Canola Council of Canada, Haplotec

Objectives:

- Evaluate performance of commercial swath canola seed varieties currently available to farmers on the Prairies

Background

Canola is an oil seed crop that has been grown in Canada since the 1940's with close to 5 million seeded hectares annually before the start of the new millennium (Statistics Canada, 1999). Swathing or windrowing is a preferred harvest method for canola and many other crops because it can accelerate maturity and reduce effects of uneven seed ripening thereby minimizing seed loss due to pod shelling (Thomas, 2003; Vera et al., 2007). In the case of the Canadian Prairies which experience early frost, swathing has been reported to protect the maturing crop from untimely frost and hail and reduce harvesting problems caused by late weeds undergrowth or crop regrowth. Furthermore, swathing has also been reported to reduce cases of black leg disease which could negatively impact the crop quality and yield (Vera et al., 2007). Canola farmers need to be aware of the appropriate stage at which they should swath their crop because premature swathing can reduce yield, test weight, protein and oil content and can also cause chlorophyll retention in the embryo. This is associated with loss in seed grade and increased oil processing costs for removal of chlorophyll.

Materials and Methods

The trial was conducted on Newstead loam soils at Melita in 2020. A randomized complete block design with 23 treatments (varieties) replicated 4 times was used. Land preparation only involved harrowing to evenly spread wheat straw from the previous season. Plots were seeded on the 12th of May at 0.5" depth and using a 6-row dual knife air seeder. Basal fertilizer was side banded through the air seeder at the time of seeding at 125-35-20-8-2 (N-P-K-S-Zn) actual lb. ac^{-1}. There were no preemergence herbicides applied but in-crop weed control was achieved by the application of 0.33 L ac^{-1} Roundup and 1.35 L ac^{-1} Liberty link on June 3rd and 17.3 g ac^{-1} Odyssey on June 4th. Flea beetles were controlled three times, starting on

May 26th, 28th and June 8th using Pounce insecticide at 0.063 L ac^{-1} and 0.07 L ac^{-1}, respectively. Applications in May were done at the cotyledon stage of development. Swathing was done on the 9th of August followed by harvesting 10 days later. Grain yield and moisture content were measured during harvest by an H2 Harvest Master system to ensure data accuracy. Data collected included plant height at swathing, days to maturity (planting to swath date), lodging at maturity, seed yield and moisture content off combine.

Results and Discussion

2020 results for small plot trials are available at www.canolaperformancetrials.ca or Seed Manitoba 2021 Variety Selection and Growers Source Guide pp 53-57.

References

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Thomas, P. 2003. Canola Growers Manual. Canola Council of Canada. Winnipeg, MB.

Vera, C. L., Downey, R. K., Woods, S. M., Raney, J. P., McGregor, D. I., Elliott, R. H. and Johnson, E. N. 2007. Yield and quality of canola seed as affected by stage of maturity at swathing. *Canadian Journal of Plant Science* **87: 13–26.**

21.0 Straight Cut Canola Variety Trial

Project duration: Ongoing
Collaborators: Canola Council of Canada, Haplotec

Objectives

- To evaluate performance of straight cut canola seed varieties currently available to farmers on the Prairies.

Background

Straight combining canola can save producers time, fuel costs and wear of equipment but this practice is rare on the Canadian Prairies owing to the risks of substantial yield losses due to shattering. Generally, shattering losses from straight cutting canola outweigh yield benefits compared to swathing or windrowing (Watson et al., 2007). In addition to high yielding canola varieties, producers are also interested in shatter resistance, which results in reduced yield losses if straight combining is used. Previous studies have shown that direct combining of older canola varieties resulted in highly variable seed losses of up to 25% especially when strong winds occurred prior to seed ripening and harvest (Price et al., 1996; Gan et al., 2008; Irvine and Lafond, 2010). However, continuous breeding of shatter resistant varieties is underway and they need to be tested under Prairie conditions to enable farmers to select the ones that are appropriate for their needs.

Materials and Methods

The trial was conducted at Melita and arranged as randomized complete block design with 12 treatments (varieties) replicated 4 times. Among the treatments were Liberty Link and Roundup Ready canola varieties. Land preparation only involved harrowing and no tillage practices were done. Seeding was done into spring wheat stubble at 0.5" on the 12th of May. Chemical control for weeds and insecticides was similar to the Swath Canola Variety trial (Section 20.0).

Results and Discussion

2020 small plot trial results are available at www.canolaperformancetrials.ca or Seed Manitoba 2021 Variety Selection and Growers Source Guide pp 53-57.

References

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Irvine, B. and Lafond, G. P. 2010. Pushing canola instead of windrowing can be a viable alternative. *Canadian Journal of Plant Science* **90: 145-152**

Price, J. S., Hobson, R. N., Neale, N. M. and Bruce, D. M. 1996. Seed losses in commercial harvesting of oilseed rape. *Journal of Agricultural Engineering Research* **65: 183-191.**

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22.0 Yellow Mustard (*Sinapis alba*) Variety Trial

Project duration: 2018-2023
Collaborators: Mustard21 Canada, Saskatchewan

Objectives

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

Background

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

Materials and Methods

Trials were conducted at Melita and Reston in 2020 and laid out as randomized complete block design with 11 treatments replicated 4 times at each site. These locations differed in soil type, with the former characterized as Newstead loam while the later was characterized as Ryerson5loam-Coatstoneloam2-Tilstoneloam1 soils. The Melita site was established on spring wheat stubble while Reston was on roundup ready canola stubble. Land preparation involved harrowing to evenly spread plant residues at both sites. Initial seeding was done on the 15th of May at Reston and reseeding on the 5th of June as a result of severe damage by flea beetles. Melita site was seeded on the 19th of May and flea beetle damage did not warrant reseeding. At both sites, the seeding depth was 0.5" and fertilizer was side banded during seeding at 10-35-20-8-2 and 100-35-20-8-2 (N-P-K-S-Zn) actual lb. ac^{-1} at Reston and Melita, respectively. The Reston site was top dressed with 100 lb. ac^{-1} N using urea source (46-0-0) on the 22nd of May but there appeared to be high volatility after application. Additional fertilizer application with 60 lb. ac^{-1} N was done on the 5th of June as a result of under application during initial seeding at Reston. Preemergence weed control was done by the application of 0.5 L ac^{-1} Roundup, 0.015 L ac^{-1} and 0.65 L ac^{-1} Rival twice at Reston (as a result of reseeding) and once at Melita before seeding. In-crop weed control was done by the application of 0.1 L ac^{-1} Arrow for grasses at Reston and Melita. During early crop establishment, there were high infestations of flea beetles which required spraying two times with 0.07 L ac^{-1} Pounce insecticide on the 8th and 12th of June at Reston and three times, on May 28, June 8 and June 12, at Melita. Follow up applications were justified because the insects reemerged within 3 days after the initial control was done. Prior to harvesting at Melita, Reglone was applied at 0.65 L ac^{-1} as a desiccant to facilitate drying of stems and control of late weeds. There were no desiccants applied at Reston. The plots were harvested on the 17th and 19th of August after they had reached 95% harvest maturity overall at Melita and Reston, respectively. Data collection included maturity date, plant height at maturity, days to flowers and grain yield. Completed raw data were sent to the collaborator for statistical analysis and publication.

Results and Discussion

Photo: Yellow Mustard variety trial at Melita in 2020

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

References

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

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

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

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23.0 Juncea Mustard/Oriental Mustard (*Brassica Juncea)* Variety Trial

Project duration: 2017-2023
Collaborators: Mustard21 Canada

Objectives

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

Background

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

Materials and Methods

The trials were conducted at Melita and Reston under the same environment as the yellow mustard trial in 2020. Nineteen treatments (varieties) were laid out as randomize complete block design and replicated 4 times. The soil type and seeding dates were the same as for yellow mustard trial at Melita and Reston. Fertilizer application rates, dates and methods were the same as the yellow mustard trial for both locations (Section 22.0). Preemergence herbicides used were similar to the ones used on yellow mustard but post emergence herbicides differed. At Reston, a tank mix of 0.2 L ac^{-1} Assure II + 8 g ac^{-1} Muster and Prosurf surfactant, and 0.15 L ac^{-1} Select + 1% v/v X-Act were applied while 0.1 L ac^{-1} Arrow and 12 g ac^{-1} Muster were applied at Melita. In future, Prosurf surfactant will not be used with the same herbicide combination used at Reston because it resulted in poor control of green foxtail weeds. Desiccation was done using 0.65 L ac^{-1} Reglone + 0.25% LI700 adjuvant in 20 gal. ac^{-1} spray volume at least a week prior to harvest at both sites. Data collection objectives were similar to yellow mustard trial.

Results and Discussion

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

References

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

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

24.0 Multi-Crop Intercrop evaluation (Pea-Oats-Canola-Wheat-Flax-Mustard)

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

Objectives

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

Background

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

Materials and Methods

The trials were established at Reston, Melita and Roblin in 2020. Soil tests were conducted to determine nutrient status before seeding at all sites (Table 24(I)). A randomized complete block design with 11 treatments and 4 replicates was used at each site. Reston site was seeded on May 15th then reseeded on the 29th due to severe damage by flea beetles while Melita site was seeded on May 8th at a depth of 0.75”.

Fertilizer was applied together with the inoculant during seeding at 10-35-20-8-2 (N-P-K-S-Zn) lb. ac^{-1} at Reston and 9-35-20-8-2 (N-P-K-S-Zn) lb. ac^{-1} at Melita. Differences in N application rates were due to differences in soil test results at both sites. Reston and Melita received 0.5 L ac^{-1} Roundup + 0.015 L ac^{-1} Aim, 0.08 L ac^{-1} Authority + 0.65 L ac^{-1} Rival in flax, pea and mustard, and 0.65 L ac^{-1} Rival in canola plots soon after seeding to burnoff weeds. Additional herbicide application was done as post emergence control with 17.3 g ac^{-1} Odyssey in pea-canola and peas, 0.1 L ac^{-1} Arrow in pea-flax-mustard, 0.91 L ac^{-1} Basagran in wheat and flax-pea, and 0.1 L ac^{-1} Select in all treatments except cereals at Melita. At Reston, post emergence herbicides applied were 0.91 L ac^{-1} Basagran tank mixed with 0.1 L ac^{-1} Arrow in flax or flax-pea, 17.3g Odyssey + 0.1L ac^{-1} Arrow in pea or pea-canola, 0.5 L ac^{-1} Axial + 0.283 L ac^{-1} in wheat or wheat-pea and 8 g ac^{-1} Muster + 0.2 L ac^{-1} Assure II + 0.5% Prosurf in canola. Flea beetles were controlled initially at V1 stage using 0.063 L ac^{-1} Pounce followed up by a second application at Melita while Reston required three applications of the same product to effectively control the insect pests. Desiccant products applied at Reston before harvest were 0.65 L ac^{-1} Reglone + 0.5 L ac^{-1} + 0.5% v/v LI700 surfactant + 0.5 L ac^{-1} Roundup ensuring spray volume of 20-gal ac^{-1} while 0.5 L ac^{-1} Roundup + 0.042 L ac^{-1} Heat LQ was applied at Melita. Summary of site description and agronomy as well as weather information are presented in Table 24(II). Various data were collected and these included plant counts at emergence and flowering, weed counts at flowering, flowering date, grain yield, percentage of pea splits, percentage of pod shatter, test weight and protein content. Disease severity data collected was for mycospharella, powdery mildew, rust, sclerotinia and fusarium wilt. Data were analyzed using Minitab 18 and means were separated using Fisher's LSD at the 5% significance level.

Table 24(I): Soil test results and nutrients applied by site in 2020

Soil Test:

Nutrient Location	N kg ha^{-1}	P ppm	K Ppm	S kg ha^{-1}	Zn ppm	Organic Matter (%)	pH
Melita	38	7	327	81	0.71	2.8	7.9
Reston	77	18	224	404	1.23	4.8	7.3
Roblin	82	65	649	168	N/A	4.6	7.8

Applied:

Nutrient	N	P	K	S	Zn
Location	kg ha^{-1}				
Melita	10	39	22	9	2
Reston	10	39	22	9	2
Roblin	3	22	0	0	0

Table 24(II) Site characterization and agronomic description in 2020

Location	Reston, MB	Melita, MB	Roblin, MB
Legal Land Location	SE 11-7-27 W1	SE 26-3-27 W1	NE 20-25-28 W1
Soil Series	Ryerson Loam	Newstead Loam	Erickson Clay Loam
Previous Crop	RR Canola	Spring wheat	Silage Barley
Field Preparation	Harrowed, No-till	Harrowed, No-till	Harrowed, No-till
Pre-Emergent Herbicides	Glyphosate all, Authority + Rival on Flax Pea Mustard; Rival in Canola plots after seeding	Glyphosate all, Authority + Rival on Flax Pea Mustard; Rival in Canola plots after seeding	Glyphosate
Soil Moisture at Seeding	Good	Excellent	Excellent
Seed Date	May/29	May/08	May/19
Seed Depth (inch)	0.75	0.75	0.75
Herbicides	Basagran, Arrow, Odyssey, Axial, Muster + Assure ll	Odyssey, Arrow, Basagran	None used
Insecticides	Pounce x 3 - flea beetles	Pounce x 2 -flea beetles	None
Desiccation	Reglone-August 25	Roundup- August 10	Reglone
Harvest Date	Aug/31	Aug/19	Sep/24
Combine Settings			
Rotor	800	800	800
cleaning fan	930	930	930
rotor-concave space	10 mm (3 mm flax)	10 mm (3 mm flax)	10 mm
Growing Season Report (May 1 - Aug 31, 2020)			
Precipitation (mm)	211	166	239
Normal (mm)	259	262	265
Growing Degree Days	1270	1303	1349
Normal GDDs	1248	1249	1302

Results and Discussion

Peas intercropped with canola yielded significantly ($P<0.001$) more grain resulting also in significantly higher partial pea LER ($P<0.001$) at 1.19 and higher TLER ($P<0.0001$) at 2.01 compared to other intercrop options at Reston. Similar trends were observed in 2019. Peas intercropped with flax resulted in significantly low grain yield of 101 kg ha^{-1} and low partial and TLER at the same site (Table 24a). In 2020, Reston yields were markedly low owing to low seasonal rainfall compared to normal, presence of diseases as discussed in the Pea-Mustard-Canola study (Section 25.0) and reseeding on the 29th of May as a result of severe crop damage by flea beetles. Contrasting results were obtained from Melita, with the highest partial pea yield of 3072 kg ha^{-1} obtained from a flax intercrop but this was not significantly different from pea yield obtained from mustard (3027 kg ha^{-1}) or canola (2745 kg ha^{-1}) intercrops. Pea yield from oat intercrop was the lowest at 1501 kg ha^{-1}, more than 100% lower than pea-mustard intercrop option (Table 24b). Partial pea land equivalence ratio followed the same pattern as yield with pea-flax, pea-canola and pea-mustard having 0.62, 0.55 and 0.61, respectively. Just like in 2019, TLER for pea-mustard (1.30) intercrop was not significantly different from other treatments except pea-flax and pea-wheat intercrops which had 1.07 (P=0.001) (Table 24b). Results from Roblin in Table 24c, show significant (P=0.001) differences in partial pea intercrop yield. There appeared to be significant pea yield benefits for intercrops involving canola or mustard compared to oats, which recorded pea yield reduction of 1567 kg ha^{-1} compared to pea yield in the canola option. This was a significant shift from 2019, where no significant differences were observed among different intercrop combinations. Partial pea LER was significantly higher (P=0.001) in pea-canola (0.79), pea-flax (0.54) and pea-mustard (0.58) compared to pea-flax intercrop which had 0.31. Overall, TLER for intercrops at Roblin was lower than Melita and Reston in 2020 (Table 24 a, b and c). In 2020, there were no significant differences observed in final crop emergence or weed biomass at all locations (Table 24 d, e, f).

There were no significant differences in split peas obtained from different intercrop options at all locations based on a 500g pea sample. Throughout all intercropping options, split peas were estimated at 1 to 2.5% for each sample selected in 2020. Protein content of peas was not significantly different at either Melita or Reston and ranged from 23.6 to 24.5% at both locations. However, there were significant (P=0.035) differences in pea protein content in pea sole crop (23.8%) compared to pea-oat intercrop (22.7%) at Roblin during the 2020 season (Table 24g). All other intercrop options were not significantly different from pea sole crop.

Significant differences were observed in net revenue realized from different pea intercrop options at all locations. Notable at Reston was the negative net revenue of -$282 for pea sole crop while significantly (P<0.001) higher revenues were obtained from pea-mustard ($713) and pea-oat ($633). Inclusion of flax, wheat or canola generated significantly less net revenue compared to mustard or oat but was a better option than pea alone due to positive revenues of $142, $334 and $391, respectively at Reston in 2020 (Table 24h). At Melita, there was no significant benefit of including oat or mustard in a pea intercropping system compared to pea sole crop because of similar net revenues of $213, $199 and $231 for pea sole, pea-oat and pea-mustard, respectively. On the other hand, pea-wheat and pea-flax had significantly (P<0.001) low net revenue of $72 and $122, respectively. Therefore, based on Melita results for 2020 alone, inclusion of flax or wheat may not be a best option for the producer considering other alternatives like oat or mustard (Table 24i). At Roblin, pea-oat intercrop had a net revenue of $214, which was the highest but was not significantly different from revenue obtained from pea-wheat, pea-canola and pea-mustard (Table 24k). However, pea-flax and pea sole had significantly (P=0.001) low net revenue of -$80 and $39, respectively, compared to other intercrop options. This implies that, selection of pea-flax intercrop could result in significant losses by the producer under Roblin conditions in 2020.

Table 24a. Analysis of variance for yield, partial LER and TLER at Reston MultiCrop in 2020

Trt	Crop	Yield (kg/ha)			LER		
		Sole	Crop-IC	Pea-IC	Partial Sole	Partial Pea	TLER
1	Pea	206	-	-	1.00	-	1.00**c**
2,7	Flax	2680	2252	101**c**	0.87	0.50**c**	1.37**bc**
3,8	Oat	8830	8951	162**b**	1.06	0.80b**c**	1.86**a**
4,9	Wheat	8051	6305	171**b**	0.79	0.86**b**	1.64**ab**
5,10	Canola	4385	3604	236**a**	0.82	1.19**a**	2.01**a**
6,11	Mustard	3886	3042	182**ab**	0.79	0.90**ab**	1.69**ab**
	P value			**<0.001**		**<0.001**	**<0.001**
	CV			**14**		**16**	**13**

Table 24b. Analysis of variance for yield, partial LER and TLER for Melita MultiCrop in 2020

Trt	Crop	Yield (kg/ha)			LER		
		Sole	Crop-IC	Pea-IC	Partial Sole	Partial Pea	TLER
1	Pea	4970	-	-	1.00	-	1.00**b**
2,7	Flax	1406	630	3072**a**	0.45	0.62**a**	1.07**b**
3,8	Oat	4240	3463	1501**c**	0.83	0.30**c**	1.14**ab**
4,9	Wheat	2416	1449	2330**b**	0.61	0.47**b**	1.07**b**
5,10	Canola	1847	1099	2745**ab**	0.59	0.55**ab**	1.14**ab**
6,11	Mustard	1080	744	3027**a**	0.69	0.61**a**	1.30**a**
	P value			**<0.001**		**<0.001**	**0.001**
	CV			**11**		**11**	**7**

Table 24c. Analysis of variance for yield, partial LER and TLER for Roblin MultiCrop in 2020

Trt	Crop	Yield (kg/ha)			LER		
		Sole	Crop-IC	Pea-IC	Partial Sole	Partial Pea	TLER
1	Pea	3298	-	-	1.00	-	1.00a
2,7	Flax	2592	306	1763abc	0.12	0.54abc	0.66b
3,8	Oat	5515	4090	1011c	0.74	0.31c	1.05a
4,9	Wheat	4485	2404	1378bc	0.54	0.42bc	0.96a
5,10	Canola	3292	1020	2578a	0.32	0.79a	1.11a
6,11	Mustard	2255	668	1908ab	0.28	0.58ab	0.86ab
	P value			**0.001**		**0.001**	**0.002**
	CV			**21**		**21**	**13**

Table 24d. Analysis of variance for final crop emergence counts and weed biomass at Reston in 2020

Trt	Crop	Final Emergence ppms			Weeds (g/m2)	
		Sole	Crop-IC	Pea-IC	Sole	Pea-IC
1	Pea	91	-	45 (adj)	486.0	-
2,7	Flax	381	205	37	548.0	387.0
3,8	Oat	190	112	32	726.0	661.0
4,9	Wheat	192	110	34	90.80	255.8
5,10	Canola	54	32	39	168.3	98.00
6,11	Mustard	51	22	34	809.0	308.8
	P value			**0.112**		**0.177**
	CV			**17.9**		**29**

Table 24e. Analysis of variance for final crop emergence counts and weed biomass at Melita in 2020

Trt	Crop	Final Emergence ppms			Weeds (g/m2)	
		Sole	Crop-IC	Pea-IC	Sole	Pea-IC
1	Pea	49	-	25 (adj.)	41	-
2,7	Flax	240	101	36	136	45
3,8	Oat	177	110	28	40	76
4,9	Wheat	165	71	28	8	25
5,10	Canola	54	38	32	67	127
6,11	Mustard	54	36	21	47	41
	P value			0.164		0.982
	CV			26.5		43

Table 24f. Analysis of variance for final crop emergence counts and weed biomass at Roblin in 2020

Trt	Crop	Final Emergence ppms			Weeds (g/m2)	
		Sole	Crop-IC	Pea-IC	Sole	Pea-IC
1	Pea	58	-	29 (adj.)	71.4	-
2,7	Flax	227	86	38	92.3	265
3,8	Oat	119	92	30	51.1	107
4,9	Wheat	170	91	36	70	67
5,10	Canola	50	20	48	14.7	81.5
6,11	Mustard	28	16	29	85.3	52.4
	P value			0.215		0.41
	CV			32.9		30

Table 24g. Analysis of variance for pea splits and protein content at Melita, Reston and Roblin in 2020

		Reston		Melita		Roblin	
Trt	**Crop**	**Pea splits g/500 seeds**	**Pea protein % DM basis**	**Pea splits g/500 seeds**	**Pea protein % DM basis**	**Pea splits g/500 seeds**	**Pea protein % DM basis**
1	Pea	14a	24.2	6.6	23.6	11.2	23.8a
2,7	Flax	3c	23.6	6.5	23.8	10.1	23.1ab
3,8	Oat	7bc	24.2	4.6	24.5	9.0	22.7b
4,9	Wheat	9ab	23.6	10.0	24.4	12.2	23.6ab
5,10	Canola	12a	23.8	6.8	23.5	12.0	22.9ab
6,11	Mustard	11ab	23.8	9.8	24.4	12.1	23.3ab
	P value	**<0.001**	0.766	0.081	**0.012**	0.202	**0.035**
	CV	**22**	**3.4**	**36**	**1.8**	**18**	**2**

Table 24h. Economic analysis for Reston MultiCrop in 2020

		Economics					
Trt	**Crop**	**Sole-COP**	**IC – COP**	**Gross Revenue**		**Net Revenue**	
				Sole	**IC**	**Sole**	**IC**
1	Pea	303	-	21	-	(282)	(282)**d**
2,7	Flax	289	325	544	467	254	142**c**
3,8	Oat	292	318	922	951	630	633**a**
4,9	Wheat	308	316	807	650	498	334**bc**
5,10	Canola	328	339	859	731	532	391**b**
6,11	Mustard	317	336	1315	1049	998	713**a**
	P value						**<0.001**
	CV						**28**

Table 24i. Economic analysis for Melita MultiCrop in 2020

		Economics					
Trt	**Crop**	**Sole-COP**	**IC - COP**	**Gross Revenue**		**Net Revenue**	
				Sole	**IC**	**Sole**	**IC**
1	Pea	303	-	519	-	213	213**ab**
2,7	Flax	289	325	285	447	(4)	122**cd**
3,8	Oat	292	318	443	517	151	199**ab**
4,9	Wheat	308	316	242	387	(66)	72**d**
5,10	Canola	328	339	362	501	34	161**bc**
6,11	Mustard	317	336	366	566	49	231**a**
	P value						**<0.001**
	CV						**18**

Table 24j. Economic analysis for Roblin MultiCrop in 2020

		Economics					
Trt	**Crop**	**Sole-COP**	**IC - COP**	**Gross Revenue**		**Net Revenue**	
				Sole	**IC**	**Sole**	**IC**
1	Pea	303	-	343	-	39	39**bc**
2,7	Flax	289	325	526	245	236	(80)**c**
3,8	Oat	292	318	576	532	284	214**a**
4,9	Wheat	308	316	449	384	141	68**abc**
5,10	Canola	328	339	645	468	317	128**ab**
6,11	Mustard	317	336	763	424	446	89**ab**
	P value						**0.001**
	CV						**94**

Data collection from the Multi-crop intercrop trial at Melita in 2020

Multi-crop intercrop trial at an advanced stage at Reston in 2020

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25.0 Pea-Canola-Mustard Intercrop

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

Objectives

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

Background

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

Materials and Methods

The trial was established in Reston on Ryerson5Loam-CoatstoneLoam2-TilsonLoam1 soil in 2019 and the same location was utilized for the 2020 field study. Nine treatments were arranged as randomized complete block design with 4 replicates. Prior to seeding, weed control was done by the application of 0.5 L ac^{-1} Roundup, 0.015 L ac^{-1} Aim and 0.65 L ac^{-1} Rival as a burnoff. Initial seeding occurred on the 15th of May and reseeding on May 17th at a depth of 0.75” together with side banding of fertilizer at 10-35-20-8-

2 (N-P-K-S-Zn) actual lb. ac^{-1}. Reseeding was necessary due to severe damage by flea beetles. A second burn off herbicide application was done after reseeding using 0.5 L ac^{-1} Roundup and 0.015 L ac^{-1} Aim in a single tank mix. In crop weed control was done using 17.3 g ac^{-1} Odyssey + Merge adjuvant + 0.1 L ac^{-1} Arrow on peas and pea-canola while 0.1 L ac^{-1} Arrow + X-Act adjuvant was applied on mustard and pea-mustard treatments on 20 June. Flea beetles were controlled three times using 0.07 L ac^{-1} Pounce insecticide. Persistent presence of these insects justified the number of applications on the treatments in 2020. Prior to harvesting, Roundup and Reglone + LI700 adjuvant were applied as desiccants at 0.5 L ac^{-1}, 0.65 L ac^{-1} and 0.25% v/v respectively. Data collected included plant counts at 3 weeks after emergence, weed biomass at pod stage of peas, grain yield, protein content and percentage of pea splits at harvest. Samples of pea plants were sent to the laboratory (AAFC Lethbridge, Dr. Syama Chatterton) for DNA analysis of severity of fusarium root rot, Aphanomyces, mycospharella and powdery mildew.

Results and Discussion

Results from 2020 study showed no significant differences in weed biomass, protein content or split pea percentage across all intercrop systems. There were also no significant differences in severity of Aphanomyces, downy mildew or mycospharella among the treatments. However, significant (P=0.028) differences were observed in observed in fusarium root rot in peas (Table 25a). Pea: Mustard (70:30) had the highest fusarium rating (3.0) while the lowest rating was for Pea: Canola (50:50). Similar results were obtained in the first year of the study implying that, at this seeding ratio, canola might have a suppression effect on fusarium root rot severity when intercropped with pea.

There were no significant differences in grain yield when either canola or mustard were used in different seeding ratios with peas in 2020 (Table 25b and c). In the pea-mustard intercrop, there were no significant differences in partial LER compared to the control. However, TLER showed significantly higher ratio of 2.488 for pea: mustard (50:50) compared to the 70:30 (2.023), 30:70 ratios (1.958) and the control (1.00) (Table 25b). Pea: Canola (70:30) and (50:50) had significantly higher partial pea LER compared to the control (Figure 25b). The 30:70 (pea: canola) was not significantly different from the control and 50:50 seeding ratio. Combined LER showed pea: canola (70:30 and 50:50) with similar results but significantly different higher than the 30:70 and control in 2020. Overall, pea: canola options resulted in higher TLER compared to pea: mustard options with the former having as high as 3.27 TLER for the 70:30 seeding ratio while the latter had 2.488 as the highest TLER for the 50:50 seeding ratio (Table 25b and c, Figure 25a). Crop emergence counts were not significantly different at any of the growth stages in 2020 (Table 25d).

Table 25a. Analysis of variance for weeds, protein content, splits % and disease ratings in a pea-canola-mustard intercrop at Reston in 2020

Treatment	Weeds		Pea		Disease ratings			
	Biomass g m$^{2-2}$	#s m$^{2-2}$	Protein %	Splits %	Fusarium	Aphano	Mildew	Mycospharella
Pea	161	307	23.3	3.4	2.1b**c**	3.9	0.25	2.4
Mustard	122	241	*	*	*	*	*	*
Canola	91	244	*	*	*	*	*	*
Pea: Mustard 70:30	183	166	22.2	3.6	3.0**a**	4.1	0.25	2.725
Pea: Mustard 50:50	89	202	22.7	3.4	2.6**ab**	4.2	0.25	2.575
Pea: Mustard 30:70	200	159	22.7	4.1	2.1**bc**	3.9	0.15	2.6125
Pea: Canola 70:30	81	299	22.8	3.2	2.3**bc**	3.9	0.375	2.638
Pea: Canola 50:50	48	236	23.3	3.2	1.8**c**	3.4	0.325	2.475
Pea: Canola 30:70	118	218	23	3.6	2.3**bc**	4.4	0.25	2.375
P value	0.616	0.52	0.075	0.828	**0.028**	0.334	0.216	0.393
CV %	94	47	2	27	**18**	14	43	10

Table 25b: Analysis of variance for yield and land equivalence ratio of pea-mustard intercrop at Reston in 2020

Description	Pea yield	Mustard yield	Land Equivalence Ratio		
	Kg ha^{-1}	Kg ha^{-1}	Pea	Mustard	Total
Pea	311a	*	1.000	*	1.000
Mustard	*	1735a	*	1.000	1.000
Pea: Mustard 70:30	283a	1550a	1.091	0.932	2.023**b**
Pea: Mustard 50:50	376a	1660a	1.506	0.9819	2.488**a**
Pea: Mustard 30:70	232a	1595a	1.019	0.9389	1.958**b**
P value	0.463	0.635	0.188	0.819	**0.051***
CV	41	13	29	12	**12**

*Significant at P=0.1

Table 25c. Analysis of variance for yield and land equivalence ratio of pea-canola intercrop at Reston in 2020

Description	Pea yield	Canola yield	Land Equivalence Ratio		
	Kg ha^{-1}	Kg ha^{-1}	Pea	Canola	Total
Pea	311	-	1.000**c**	-	1
Canola	-	2367	-	1	1
Pea: Canola 70:30	519.8	2361	2.186**a**	1.084	3.270**a**
Pea: Canola 50:50	469	2397	1.762**ab**	1.129	2.892**a**
Pea: Canola 30:70	335.5	2493	1.318**bc**	1.156	2.473**b**
P value	0.172	0.948	**0.057***	0.792	**0.099***
CV	34	15	35	21	15

*Significant at P=0.1

Table 25d: Analysis of variance for crop emergence counts and percentage changes in emergence in pea, mustard and canola at Reston in 2020

	Crop Emergence Counts					
Description	**Pea at 2-3WAE**	**Pea at Flower**	**% Pea Change**	**Brassica at 2-3WAE**	**Brassica at Flower**	**% Brassica Change**
Pea	87	81	0.0869	*	*	*
Mustard	*	*	*	51	48	0.0929
Canola	*	*	*	53	50	0.0788
Pea: Mustard 70:30	56	47	0.1572	23	23	0.0694
Pea: Mustard 50:50	46	33	0.2611	22	27	0.0313
Pea: Mustard 30:70	24	18	0.244	33	32	0.1333
Pea: Canola 70:30	51	43	0.1297	11	11	0.1
Pea: Canola 50:50	38	35	0.1535	27	26	0.0371
Pea: Canola 30:70	24	21	0.1381	37	39	0.0357
P value	**-**	**-**	0.632	-	-	0.926
CV			88			172

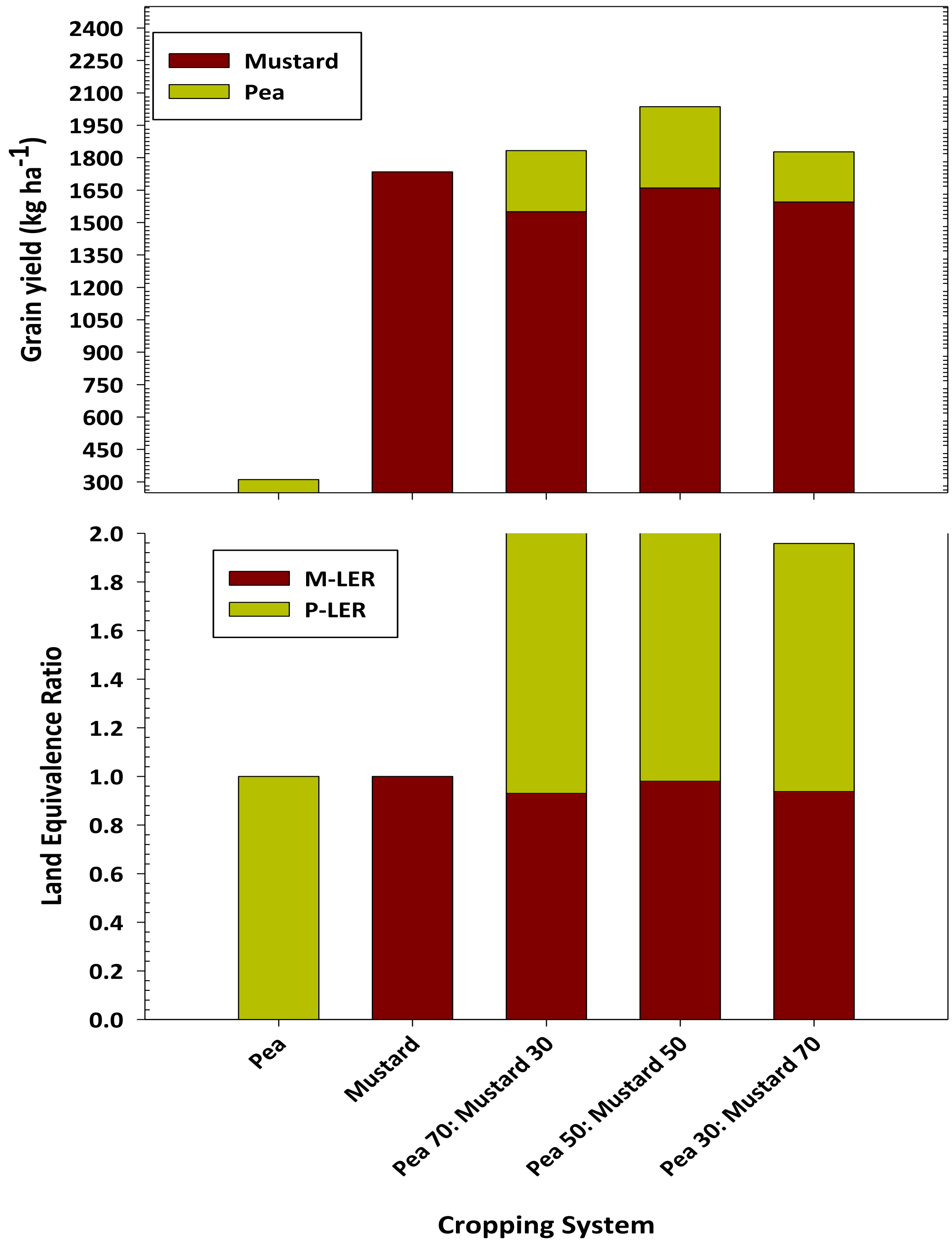

Figure 25a: Grain yield (a) and land equivalence ratio (b) for pea-mustard intercrop at Reston in 2020

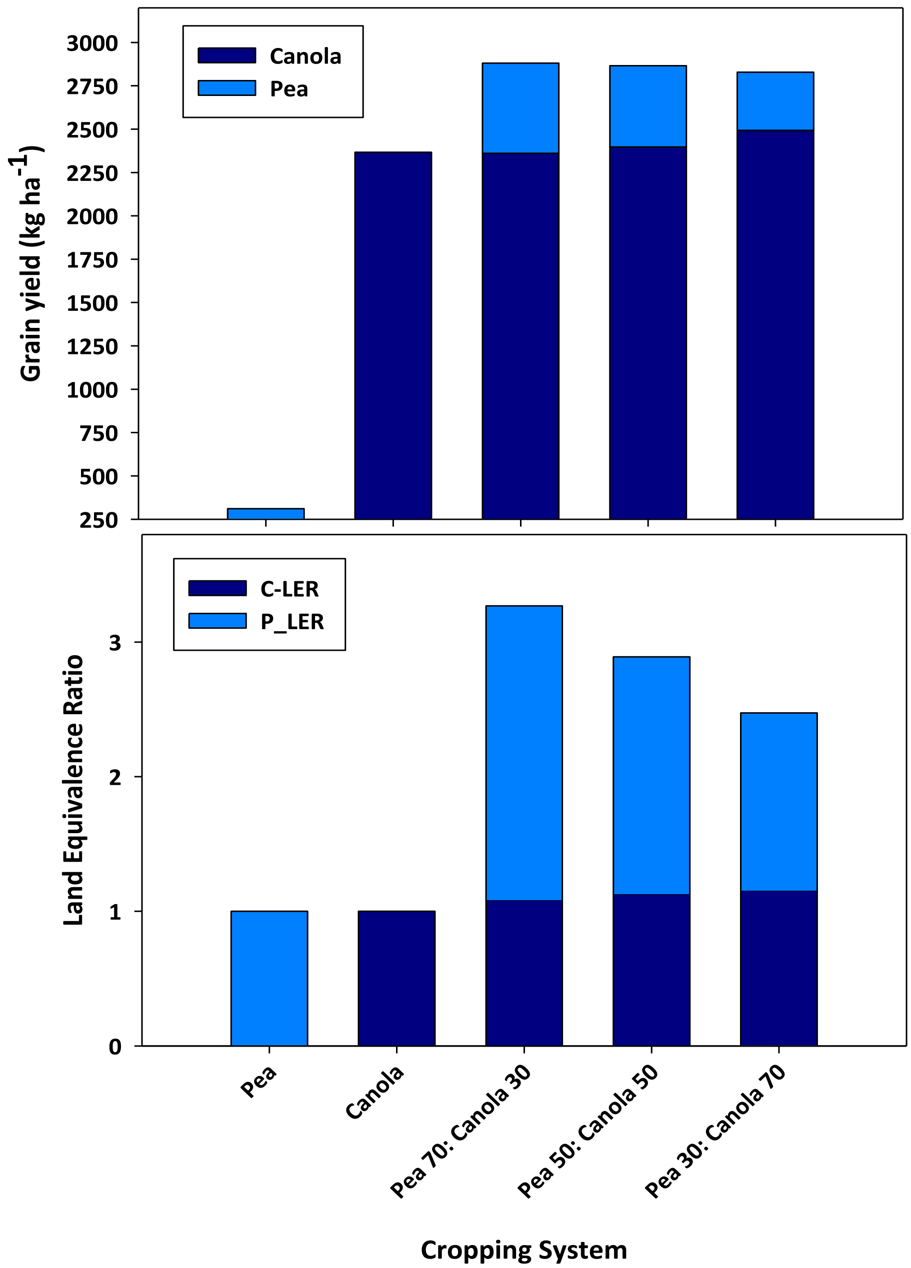

Figure 25b. Grain yield (a) and land equivalence ratio (b) for pea-canola intercrop at Reston in 2020

Conclusions:

In 2020, significant increase in TLER in pea on 50:50 (pea: mustard) was observed but at 90% confidence interval. There were also significant increases in partial pea LER compared to the control treatment and within intercrops and TLER on 70:30 and 50:50 (pea: canola) at the same confidence interval. A weak correlation of fusarium disease rating to pea LER (but not yield) existed in mustard plots with a coefficient of -0.591 and R-square of 34.9%. Canola appeared to be a better option in reducing disease in pea probably because it helps funnel water away from pea roots, thus keeping the soil microclimate drier and not conducive for disease development. It was also noted that pea yield dropped as mustard populations increased and this might have been due to increased competition for resources such as nutrients, sunlight and moisture. Compared to 2019, there was an increase in disease impact on peas yield resulting in 311 kg ha^{-1} in 2020 while 2019 yielded 1144 kg ha^{-1}. This could have been due to the influence of weather elements which exacerbated disease development in 2020, for example, 55 mm rainfall and 210 GDDs were recorded between May 15 and June 30 in 2019 while 118 mm rainfall and 533 GDDs were recorded during the same period in 2020. Therefore, the current year could have provided more conducive environment for root diseases development that was in turn reflected in pea yield. Results from this study are inconclusive across the whole trial citing larger coefficient of variance across all variables. Further research would be necessary in order to come up with recommendations that producers can use for their intercropping systems.

Pea-canola-mustard intercrop trial at Reston in 2020

Pea root and soil sampling for Aphanomyces and Fusarium root rot by WADO staff at Reston in 2020

Pea disease rating for Fusarium root rot and Aphanomyces in pea-mustard and pea-canola intercrop trials at Reston in 2020

Healthier (left) and diseased (right) pea roots sampled at Reston in 2020

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26.0 Winter Wheat-Soybean Intercrop

Project duration: 2019-ongoing
Collaborators: WADO

Objectives

- To evaluate agronomic performance of relay soybean in winter wheat
- To determine if different nitrogen management systems (100% in fall vs 50% in fall and 50% in spring) affect soybean nodule development

Background

Selection of a cropping system depends of several interrelated climatic, agronomic and economic factors. Compared to monocrop, intercrop systems involving a legume usually result in more benefits such as residual nitrogen, biological control of pests and diseases, weed suppression, improvement of soil organic matter and control of soil erosion. Based on timing and design of crop species, intercropping can be divided into several categories: mixed, strip, row and relay (Goldmon, 1991). Relay intercropping is where a second crop is planted into land area already occupied by the first crop such that the two species overlap for a portion of the same growing season. In Canada, winter wheat is usually seeded by mid-September (fall) and insurance seeding cut off dates depending on the region or zone. Soybean is seeded in May and is initially slow in growth and development compared to wheat as a result of cooler soil temperatures in spring. Performance of wheat and soybean in an intercrop system is largely influenced by the time of interplanting the soybean crop (Khokhar and Jeffers, 2001). Successful relay cropping of soybean is dependent on a range of factors that include: variety attributes, row spacing, soil conditions at planting and during the growing season, soil moisture availability and fertility (Goldmon, 1991). Various fertility management systems can be utilized in wheat and soybean with some producers preferring application of nitrogen in fall while conservative producers opt for split application in fall and spring to account for fertilizer losses. Another concept that measures the success of an intercrop is Land Equivalence ratio, which is a measure of the yield obtained from an intercrop in relation to yield obtained from the monocrop (Mead and Willey, 1980; Delmar, 1994). This study seeks to address possible benefits of winter wheat-soybean intercropping system with respect to yield, nodulation and land equivalence ration.

Materials and Methods

The trial was conducted at Melita in 2019/2020 on Ryerson5Loam/Regent5Loam soil series. Eight treatments (Table 26a) were laid out as randomized complete block design and replicated 3 times. Preemergence weed control was done by the application of 0.5 L ac^{-1} Roundup tank mixed with 0.015 L ac^{-1} Aim in 10 gal. ac^{-1} spray volume. As part of the treatments, winter wheat was seeded on 16 September 2019 in fall and under high soil moisture conditions. Winter wheat received 58 lb. ac^{-1} monoammonium phosphate ($NH_4H_2PO_4$) while soybean received 10-35-20-8-2 (N-P-K-S-Zn) (actual lb. ac^{-1}) as basal dressing. Soybean seeds were inoculated before being seeded the following spring on 21 May 2020 at a seeding depth of 1" and growth stage 30 of winter wheat. Fertilizer top dressing rates were based on the protocol for the trial (Table 26a). In-crop weed control was done in appropriate treatments using a tank mix of 0.2 L ac^{-1} Achieve + 0.91 L ac^{-1} Basagran + 1% v/v Turbocharge in 10 gal. ac^{-1} spray volume on the 25th of May and 0.33 L ac^{-1} Roundup with a hand sprayer at V2 stage of soybean on the 22nd of June. Various data collected included plant counts at emergence, date to growth stage 30 of wheat, flowering dates, soybean nodule count per plant on July 30, head count, days to maturity, wheat lodging score, plant height at maturity, test weight and yield. Wheat harvesting was done on the 30th of July ensuring harvesting of 4 inner rows (by a combine) for sole crop and 2 inner rows (by hand) for intercrops. These data were analyzed using Minitab 18 and means separated by Fisher's LSD at 10% level of significance. Interaction plots were also examined between soybean and wheat.

Table 26a. Treatment materials for winter wheat- soybean trial in 2019/2020

TRT #	Treatment description	Plant population	Fertility N in row of winter wheat	Spring Application
1	Soybean row crop	16 000 ppa in row	Inoculant	No
2	Soybean solid seeded	18 000 ppa	Inoculant	No
3	Winter wheat-Soybean	16 000 ppa in row	50% Fall, 50% Spring	254 g Agrotain WW
4	Winter wheat-Soybean	16 000 ppa in row	100% Spring	508 g Agrotain WW
5	Winter wheat-Soybean	16 000ppa in row	100% Fall	No
6	Winter wheat mono	250 p m^{-2} in row	100% Fall	No
7	Winter wheat mono	250 p m^{-2} in row	50% Fall, 50% Spring	380 g Agrotain
8	Winter wheat mono	250 p m^{-2} in row	100% Spring	805 g Agrotain

Results and Discussion

There were severe damages by wild animals in soybean plots and grain yield data could not be used for analysis in 2020. Furthermore, severe drought stress from low rainfall and high competition by wheat did not translate to meaningful results that can be recommended to producers. Further studies under ideal conditions will be considered in future.

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27.0 Exploring high rates of nitrogen on the effects of oat production

Project duration: 2020 (1 year)
Collaborators: WADO-Melita, Manitoba Agriculture & Rural Development-John Heard

Objectives:

- Assess oat under a nitrogen ramp for agronomic characteristics; yield and quality parameters
- Determine yield response thresholds for nitrogen application in oat production

Background

Throughout the past 20 years, the oat milling industry has been transformed and shifted from the Midwestern United States to Western Canada, where it has emerged as a major Canadian export crop (May et al., 2020). As a result of its transformation from a domestic to an export crop, there has been a significant rise in total seeded area for oats. A shift in oat seeded area from 1.259 million hectares in 2018 to 1.459 million hectares in 2019 was observed in Canada with close to 90% of the total area seeded in Western Canada (Sask Crop Insurance, Alberta Ag Financial Services Corp., Manitoba Agricultural Services Corporation and BC Crop Insurance, 2019). Continued research in oat has led to improved production practices, providing producers with motivation to increase production. Like any other crop, oats require sufficient amounts of nitrogen to boost yield and quality of the crop. General nitrogen recommendations in oats vary depending on the previous crop, with the maximum recommended application being 101 kg ha^{-1} (Manitoba Agriculture). However, soil sampling and analysis is the best tool to determine optimal nitrogen application rates, as residual soil nitrogen differs and there cannot be blanket recommendations across different production areas. For this reason, this study seeks to assess oat yield and quality parameters under different nitrogen application rates and determine the economic thresholds for nitrogen application in oat production. Results obtained from this study will be useful for oat producers as they continue to improve oat production trends in their respective areas of production and in Canada at large. Only one site year of data will be summarized in this report, and therefore it should only be used as a reference rather than a recommendation.

Materials and Methods

The field research was conducted at Melita (Newstead loam) in Southwest Manitoba under dry land no-till conditions in 2020. Land preparation only involved harrowing to evenly spread spring wheat residues from the previous season. Plots were arranged at randomized complete block design with 8 treatments replicated 3 times. Plots were seeded on May 7th using a SeedHawk dual knife air seeder with 6 shanks on 24 cm row spacing. Fertilizer was side banded approximately 19 mm beside and below the seed using a separate opener from the seed. Seed was placed 16 mm below ground. The variety of oat used in the project was CDC Summit seeded at 225 plants m^{-2}. Soil tests (AgVise Laboratories, Northwood, ND) were conducted and results (Table 27a) utilized to determine baseline residual nitrogen values for which total nitrogen treatments would be determined (soil + applied nitrogen).

Table 27a. Spring soil test results for Newstead loam soil at Melita site in 2020

Soil Test							
pH	OM	N 0-6" (kg ha^{-1})	N 6-24" (kg ha^{-1})	N-(N1+N2) (kg ha^{-1})	P-O (ppm)	K (ppm)	Ca (ppm)
7.8	3.4	14	10	24	14	440	4564
Mg (ppm)	**S 0-6" (kg ha^{-1})**	**S 6-24" (kg ha^{-1})**	**Zn (ppm)**	**Salt1**	**Salt2**	**CEC meq**	
506	11	81	1.04	0.25	0.22	28.16	

Spring soil test results showed 24 kg ha^{-1} existing soil nitrogen, and 10 kg ha^{-1} nitrogen was banded with basal granular fertilizer application at seeding, bringing soil nitrogen content at the trial site to 34 kg ha^{-1}. Basal fertilizer was banded at seeding at 39-22-9-2 (P-K-S-Zn) actual kg ha^{-1}. Granular fertilizer forms included monoammonium phosphate infused with ammoniums sulfate and zinc oxide (NPSZ, Koch, Fertilizer Co., Western Canada), and Zinc Sulfate. At seeding, UAN (28-0-0) nitrogen application was banded at variable rates from 0 (check) to 142 kg ha^{-1}. Preemergence weed control was done soon after seeding using 1.66 L ha^{-1} Roundup transorb tank mixed with 0.037 L ha^{-1} Aim. A follow up in-crop weed control was done using 1.24 L ha^{-1} Mextrol 450 about four weeks after seeding. No fungicide was applied. Roundup transorb and Heat LQ were applied at 1.24 L ha^{-1} and 0.10 L ha^{-1}, respectively, as desiccants on oats on the 10th of August, one week prior to harvesting. Data collected from the trial included crop emergence (ppms), days to maturity, lodging rate, and leaf disease rating using McFadden scale. NDVI (Normalized Difference Vegetative Index) values were determined using drone (SenseFly) NIR reflectance data taken at the flag leaf stage of oat, processed by Pix4D software (version 4.4.12) and viewed and sampled on ESRI's ArcMap program (version 10.6). NDVI values were based on the average of three 1 m^2 equivalent samples per plot on a 1:300 ratio map. SPAD meter (Spectrum Technologies Inc.) readings were based on 3 samples. Finally grain yield, test weight (Avery), percent protein content (dry matter basis) and seed weight. All data were subjected to a two-way analysis of variance (ANOVA) using Minitab 18 and mean separation was done using Fisher's LSD at the 5% level of significance.

Results and Discussion

There were no differences in emergence or maturity among N application rates used (Table 27b). Even stands among all treatments indicates that risk of fertilizer burn was low using the Seedhawk dual knife side banding system. Lodging rating based on a 1 to 5 scale was significantly different (P=0.001) among N application rates used. Low soil + applied N (34, 54 and 62 kg ha^{-1}) resulted in low lodging rates whereas high N application rates (114, 136 and 176 kg ha^{-1}) resulted in significantly higher lodging rates compared to the control. There were unexplained similarities in lodging rate between the control (34 kg ha^{-1} N) and 156 kg ha^{-1} soil + applied N treatments. Without considering this anomaly in lodging response, the data clearly shows an increase in lodging rate resulting from an increase in nitrogen application. Excess application of nitrogen often results in disproportionate weight between plant heads and stems, resulting in weak stems that cannot support the weight of the plant. There is need to balance nitrogen application rate with crop nitrogen requirements in order to reduce chances of lodging, which can cause significant harvest issues leading to yield losses in some cases.

Leaf diseases were significantly higher (P=0.040) in the control and 54 kg ha^{-1} treatments compared to soil + applied nitrogen treatments of 136, 156 and 176 kg ha^{-1}. On the other hand, soil + applied N treatments between 62 and 176 kg ha^{-1} did not show significantly different mean leaf disease ratings in oats. It is a possibility that nitrogen deficiency symptoms displayed in oat plots, particularly among low N treatments, were misattributed to leaf disease. This misattribution would have increased mean leaf disease ratings and potentially created a treatment effect where one was not present, so the direct impact of nitrogen rate on leaf disease incidence is not clear from this data. Generally, increase in nitrogen application results in healthier plants with lower susceptibility to diseases, but other factors such as lodging and economic returns need to be considered when determining optimal nitrogen application rates.

It was also evident in this trial that NDVI (P=0.005) and SPAD meter readings (P=0.003) increased with increase in nitrogen rate. These methods could be used as predictors to yield potential, for example, prior to harvest. However, soil + applied N levels beyond 92 kg ha^{-1} did not significantly increase NDVI or SPAD meter readings, meaning a soil + applied N level of 92 kg ha^{-1} provided optimum benefits to oats in this respect.

Table 27b. Analysis of variance for oat emergence, days to maturity, lodging, leaf disease, NDVI and SPAD reading of oats at Melita in 2020.

Soil + Applied Nitrogen (kg ha $^{-1}$)	Mean Emergence (ppm)	DTM (Days)	Lodging (1 to 5)	Leaf Disease (1 to 11)	NDVI (0 to 1)	SPAD Reading (n=10)
34	309	87	2**c**	6**ab**	0.729**c**	47**d**
54	269	87	2**c**	6**a**	0.753**bc**	51**bcd**
62	273	87	2**c**	5**abc**	0.753**bc**	50**cd**
92	293	87	3**bc**	5**bc**	0.774**ab**	54**abc**
114	308	87	4**a**	5**abc**	0.777**ab**	56**a**
136	293	87	3**ab**	4**c**	0.790**a**	56**a**
156	268	87	2**c**	4**c**	0.775**ab**	55**ab**
176	316	87	4**a**	4**c**	0.778**ab**	58**a**
P value	**0.110**	**0.328**	**0.001**	**0.040**	**0.005**	**0.003**
Significant	**No**	**No**	**Yes**	**Yes**	**Yes**	**Yes**
CV	**8**	**1**	**20**	**13**	**2**	**5**

Letters beside values indicate relationship to other treatment values. Values with differing letters indicate a significant difference between treatments. Similar letters indicate no significant difference.

There were significant differences in grain yield (P<0.001) and test weight (P=0.015) of oats between treatments (Table 27c). An increase soil + applied nitrogen resulted in a proportional increase in yield of oats from 34 to 136 kg N ha^{-1}, followed by a decrease in yield at 156 and 176 kg N ha^{-1}. Therefore, the optimum soil + applied nitrogen level in oats was 136 kg ha^{-1} (Figure 27a), beyond which no further gain in yield response was attained. Test weight values obtained for oats in this trial indicate that all treatments would be graded as No.3 CW, which requires a minimum weight of 51 kg hL^{-1}. Typically, the higher the nitrogen rate the lower the test weight, and this was evident with soil + applied N levels between 92 kg ha^{-1} and 176 kg ha^{-1} having significantly lower test weight values compared to the check (34 kg N ha^{-1}). The overall low test weight values in this study suggest poor conditions during grain fill across all treatments. Environmental stresses, such as moisture and temperature stress, during oat grain fill could have impacted nutrient uptake, production and transportation resulting in lower test weights (Walsh and Walsh, 2020).

Grain protein content increased significantly (P<0.001) with increase in nitrogen rate. Soil + applied nitrogen levels between 34 and 62 kg N ha^{-1} had a protein content range of 8.9 to 9.0%, while increasing soil + applied N to 92 and 114 kg ha^{-1} significantly increased protein content to 9.7 and 10.1%, respectively. Strong response of grain protein content to high nitrogen levels (136, 156, and 176 kg ha^{-1}) was observed in this study, as protein content in these treatments was significantly higher (10.7 to 11%) than treatments with lower soil + applied nitrogen levels. From an economical point of view, an oat producer should only apply nitrogen to a maximum of 136 kg ha^{-1} if current fertilizer prices warrant the need to obtain high grain protein content, as any extra N application would result in a reduction in revenue. There were no differences in seed weight among nitrogen treatments.

Table 27c. Analysis of variance for nitrogen (N) rate vs yield, seed weight, protein content and seed weight of oats at Melita in 2020.

Soil + Applied Nitrogen (kg ha^{-1})	Yield (kg ha^{-1})	Test Wt. (kg hL^{-1})	Yield (bu ac^{-1})	Protein (%)	Seed Weight (g/500 seeds)
34	4019**f**	50.6**a**	88.3**f**	8.9**c**	19.3
54	4301**ef**	49.9**abc**	96.0**ef**	9.1**c**	18.7
62	4551**e**	50.3**ab**	100.8**e**	9.0**c**	18.8
92	5165**d**	49.6**bcd**	115.7**d**	9.7**b**	19.4
114	5492**cd**	49.3**cd**	124.1**c**	10.1**b**	19.1
136	6087**a**	49.6**bdc**	136.6**a**	10.8**a**	18.4
156	5645**bc**	49.5**bcd**	127.0**bc**	10.7**a**	18.4
176	5927**ab**	49.1**d**	134.4**ab**	11.0**a**	17.4
P value	**<0.001**	**0.015**	**<0.001**	**<0.001**	**0.161**
Significant	**Yes**	**Yes**	**Yes**	**Yes**	**No**
CV	**4**	**1**	**4**	**2**	**5**

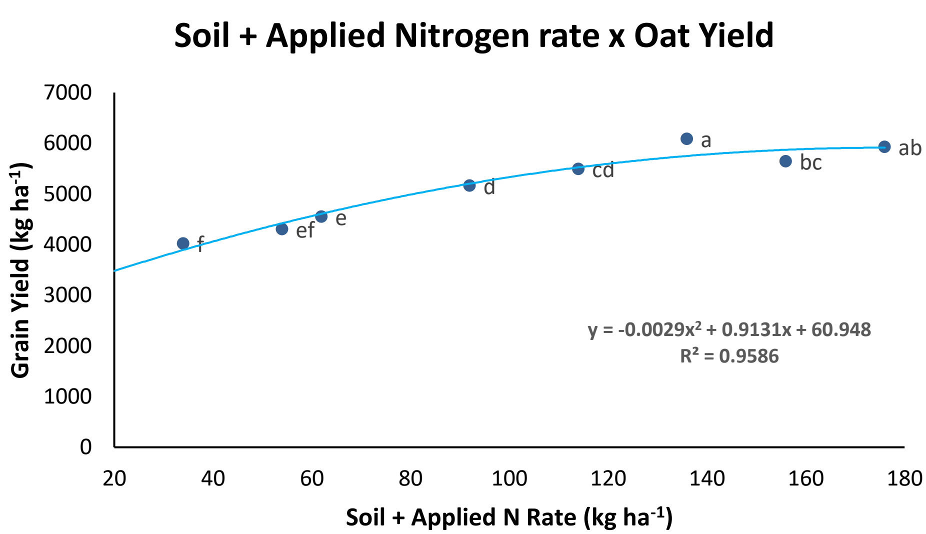

Figure 27a. Response of oat grain yield to various levels of soil + applied Nitrogen (kg ha^{-1}) at Melita in 2020. Values followed by the same letter indicate no significant difference.

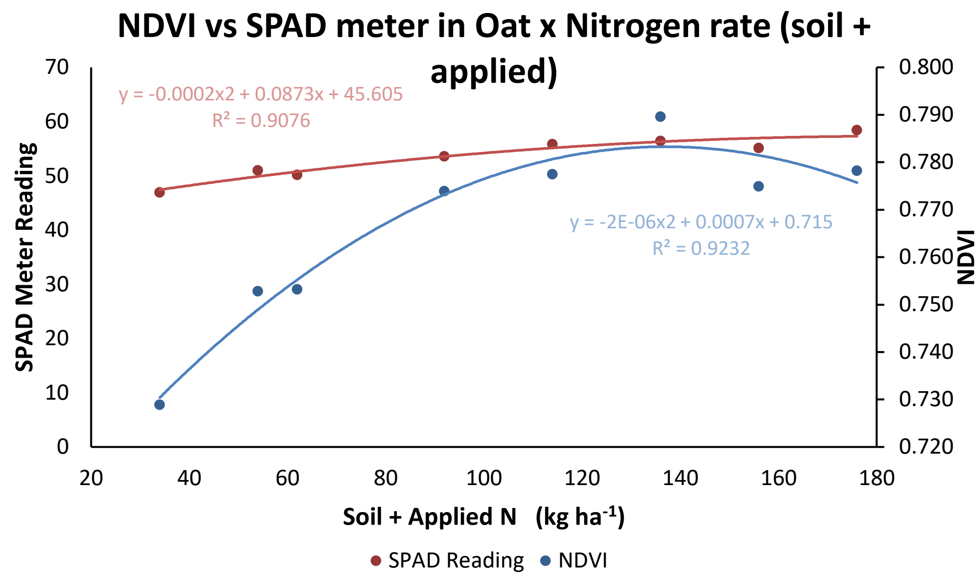

Figure 27b. Effect of increasing soil + applied nitrogen (kg ha^{-1}) on NDVI and SPAD meter readings in oats at Melita in 2020.

Pearson correlation analysis on raw yield, NDVI and SPAD reading data revealed significant correlations between NDVI reading and yield (R^2 = 0.58), as well as SPAD reading and yield (R^2 = 0.62) [Table 27d]. This correlation indicates that NDVI and SPAD readings could be useful for yield prediction in oat crops, though these correlations are on the weaker side given the R-squared values. Significant correlation between NDVI and grain protein content (R^2 = 0.53), as well as SPAD reading and grain protein content (R^2 = 0.60) was also observed. When N application rates are plotted against NDVI and SPAD values (Figure 27b) the NDVI response curve is similar to that of the yield response, peaking at 136 kg ha^{-1} nitrogen, while SPAD meter readings peaked at 176 kg ha^{-1} nitrogen. Visually, NDVI readings illustrate a similar peak response to nitrogen rate as yield, while this peak is less apparent in the SPAD reading curve.

Table 27d: Pearson correlations between NDVI to protein, NDVI to yield, SPAD meter readings to protein and SPAD to yield in oats at Melita in 2020.

Contrast	df	Pearson r value	R-squared	P value	Equation
NDVI to Protein	23	0.728	0.53	<0.001	Protein = - 8.113 + 23.55 NDVI
NDVI to Yield	23	0.763	0.58	<0.001	Yield (kg ha^{-1}) = - 12343 + 22831 NDVI
SPAD to Protein	23	0.772	0.60	<0.001	Protein = 1.732 + 0.1534 SPAD
SPAD to Yield	23	0.790	0.62	<0.001	Yield (kg ha^{-1}) = - 2610 + 145.2 SPAD

Conclusion

In this trial, yield and quality parameters were assessed for oats grown with various levels of nitrogen to determine the yield response and other agronomic parameters for nitrogen application in Western Canadian oat production operations. Oat yield was greatest when oats were grown with nitrogen levels of 136 kg ha^{-1}. Protein content of oats was also optimized under 136 kg N ha^{-1} conditions, as no significant gain in protein content was realized with an increase in nitrogen levels. Leaf disease severity and NDVI/SPAD readings did not improve significantly at total nitrogen levels greater than 62 kg ha^{-1} and 92 kg ha^{-1}, respectively, but higher nitrogen levels did not adversely affect either parameter. Significant adverse effects were observed on oat lodging at nitrogen levels greater than 92 kg ha^{-1}, and on oat test weight at nitrogen levels greater than 62 kg ha^{-1}. So, while oat yield and protein content may be optimized at 136 kg ha^{-1} total nitrogen, growers should be aware of potential test weight and lodging trade-offs at this nitrogen level. The 2020 Prairie Oat Growers Association Oat Growers Manual recommends 109 -131 kg ha^{-1} total nitrogen for optimal oat yield, while Manitoba Agriculture recommends a blanket nitrogen application of 101 kg ha^{-1} when seeding into stubble (Prairie Oat Growers Association, 2020; Manitoba Agriculture). The optimal nitrogen level for oat production demonstrated here is greater than both of these recommendations, and provides more insight into the economic thresholds of oat production in the Canadian prairies, and the potential yield advantage of new varieties available. This expanded insight is useful to Western Canadian oat producers as they work to continually improve oat production trends in Canada.

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28.0 Management Practices for high yielding spring wheat

Project duration: 2020-ongoing
Collaborators: PCDF-Roblin, PESAI-Arborg, CMCD-Carberry, WADO-Melita, Anne Kirk

Objectives:

- To quantify the yield benefits of intensive management practices in spring wheat and to determine if these practices provide the same benefits to a variety of cultivars.

Background

Canadian Western Red Spring (CWRS) wheat cultivars are increasingly high yielding, and may require specific management practices to achieve their yield potential. A study looking at rates of yield gain in CWRS cultivars found that yields rose 0.67% per year between the early 1990's and 2013 (Thomas and Graf 2014). Higher yielding CWRS cultivars may require specific management practices in order to achieve their yield potential.

In order to improve wheat yield potential, management practices such as seeding rates, nitrogen rates, fungicides and plant growth regulators need to be considered. Among these factors, nitrogen is the most important limiting factors of wheat growth, protein content and yield (Lacolla et al., 2019). Additionally, disease prevention, especially fungal disease, is an important aspect that needs to be considered when maximum yields need to be obtained. Targeting higher yields often means increasing N rates, which brings with it the increased risk of lodging. Plant growth regulators are another tool that wheat producer to inhibit stem elongation, which reduces the overall plant height and this helps to reduce lodging (Clark and Fedak, 1977; Belchim Crop Protection Canada, 2020) and maintain yield (Strydhorst et al., 2017). The PGR Manipulator (chlormequat chloride) is registered for use in Canada but more information about this PGR is needed as response depends on crop type and cultivar, application timing, and weather conditions.

Currently, available wheat varieties have low to moderate resistance to fungal diseases and producers prefer to use a combination of diseases resistance by the varieties as well as spraying fungicides to reduce losses that may occur. Fungicides to control FHB and leaf diseases are commonly used on spring wheat in Manitoba. Ransom and McMullen (2008) reported yield increases of 6-44% with foliar fungicide use, with the greatest increases occurring when susceptible cultivars were grown under high disease pressure. Wheat varieties respond differently to these management practices but the aim is to find the best alternative for maximum grain yield and quality. Therefore, this study seeks to determine grain yield benefits of different management practices and how they affect performance of spring wheat varieties being tested.

Materials and Methods

The trial was conducted at Melita on Newstead loam soil under no till system in 2020. The plots were laid out as randomized complete block design with 20 treatments (4 varieties x 5 management practices) replicated 3 times. The treatments used were as follows:

- CWRS Varieties:
  - AAC Brandon
  - AAC Cameron VB
  - AAC Viewfield
  - Cardale
- Management practices:
  - Standard (100 lb./acre N, no PGR, no fungicide)
  - Additional N to target higher yields (150 lb./acre)
  - PGR (Manipulator applied at BBCH 31 to 32)
  - Fungicides (application at flag leaf and anthesis)
  - Advanced (150 lb./acre N, Manipulator, two fungicide applications)

The plots were seeded at a depth of 5/8" using a dual knife air seeder to achieve 280 plants m^2 on the 7th of May. Fertilizer application was done by banding at variable nitrogen rates based on management practice and at 35-20-8-2 (P-K-S-Zn) actual lb. ac^{-1}. On the same day, preemergence weed control was achieved by the application of 0.67 L ac^{-1} Roundup tank mixed with 0.015 L ac^{-1} Aim in 10 gal. ac^{-1} spray volume. Post emergence weed control was done using 0.81 L ac^{-1} Tundra about a month after seeding. Treatments requiring plant growth regulator application were sprayed with 0.73 L ac^{-1} Manipulator on the 15th of June. Fungicide application was done on specific treatments based on the protocol using 0.15 L ac^{-1} Headline on the 3rd of July. Prior to harvesting, the plots were desiccated using 0.5 L ac^{-1} Roundup and 0.042 L ac^{-1} Heat LQ on the 10th of August. Observations made during the season included; plant height at maturity, lodging rating on a 1 to 9 scale, grain yield and protein content. Raw data tables were sent to the collaborators for analysis.

Results and Discussion

Results from all Roblin, Melita, Arborg and Carberry for 2019 and 2020 are summarized in this section.

Plant Height

The four cultivars included in this study varied in plant height, with AAC Cameron VB being the tallest at all sites and AAC Viewfield being the shortest (data not shown).

There were no significant height differences between management practices at the Roblin site in both years of the study. At the locations where there were height differences between management practices, the PGR reduced height relative to the standard and additional N treatments (Figure 1 and 2). Compared to standard management, the addition of a PGR reduced plant height by 6, 5, and 2 cm at Arborg, Carberry, and Melita, respectively in 2018 (Figure 1). In 2020, the additional of a PGR reduced plant height by 7, 4, and 8 cm compared to the standard treatment at Arborg, Carberry, and Melita, respectively.

There was a significant interaction between management and cultivar at Arborg in 2018, but not in any other site years. This significant interaction indicates that not all cultivars had the same height response to management. Response to the PGR varied for the four cultivars, with no significant difference between standard management and the addition of the PGR for AAC Brandon. The height difference between the standard management treatment and the PGR treatment for AAC Cameron and AAC Viewfield were 4 and 6 cm, respectively. AAC Viewfield, the shortest variety, had a 13 cm height difference between the standard and PGR treatments (Figure 3).

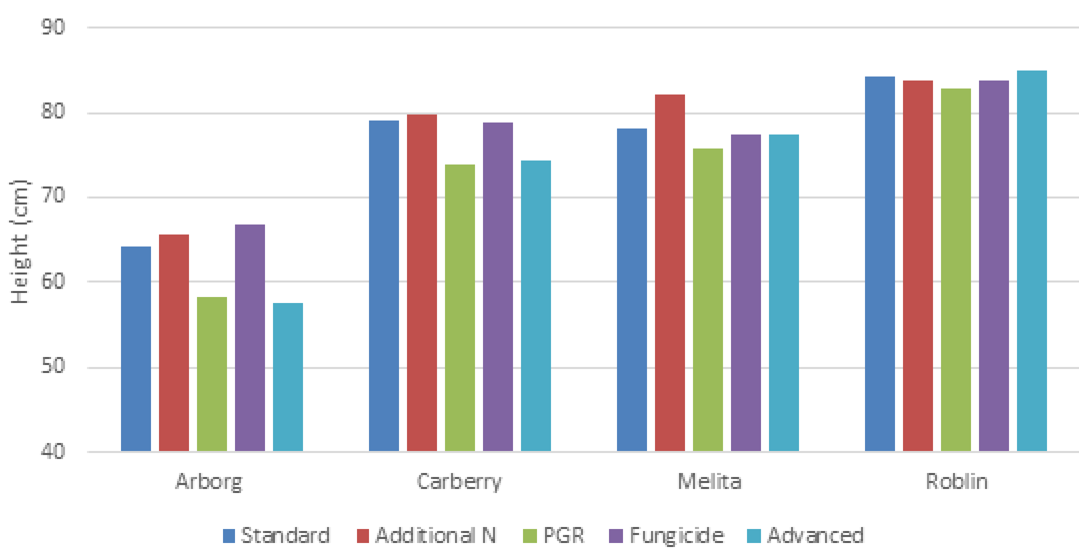

Figure 1. Height (cm) of the five treatments averaged across cultivars at Arborg, Carberry, Melita, and Roblin in 2018. Letters above the bars show statistically significant differences. Treatments within the same site with the same letter are not significantly different (P<0.05).

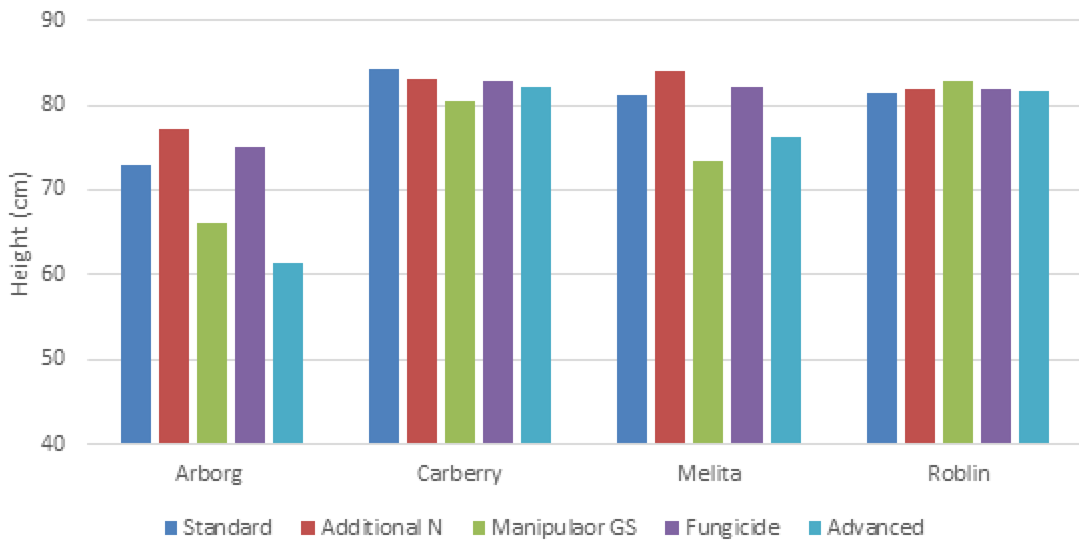

Figure 2. Height (cm) of the five treatments averaged across cultivars at Arborg, Carberry, Melita, and Roblin in 2020. Letters above the bars show statistically significant differences. Treatments within the same site with the same letter are not significantly different (P<0.05).

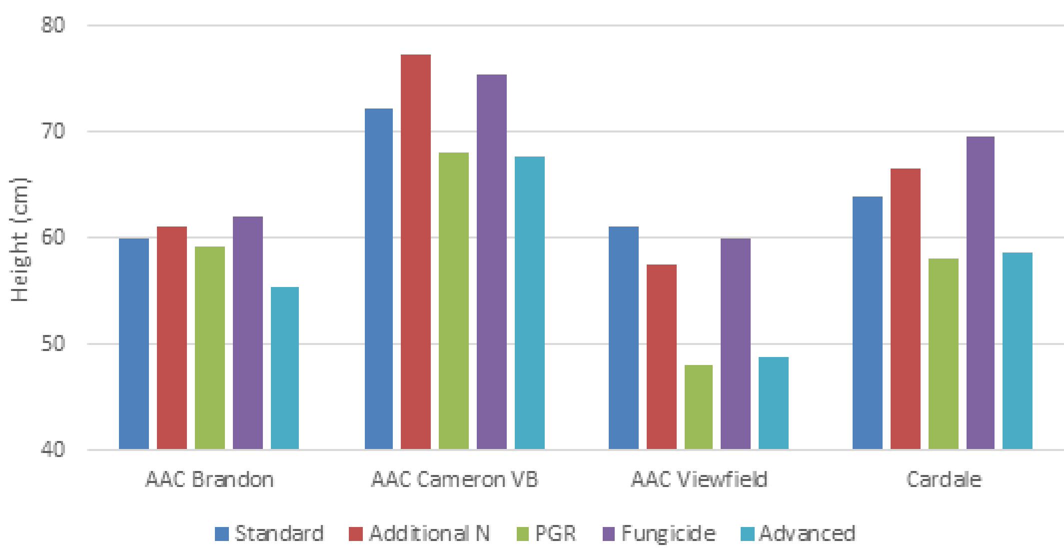

Figure 3. Height (cm) of the five treatments for each cultivar at Arborg 2018. Letters above the bars show statistically significant differences. Bars with the same letter are not significantly different (P<0.05).

Yield and lodging

There were no significant differences in lodging at any of the sites in 2018 and 2020.There was also no significant yield difference between cultivars at any of the sites in 2018 and 2020. Yield differences between management treatments were significant at Arborg and Melita in 2018 (Figure 4) and Arborg, Carberry and Melita in 2020 (Figure 5). Yield was not reported at Roblin in 2020. There was no significant interaction between cultivar and management in either year, indicating that the cultivars had similar yield responses to the management treatments (data not shown).

At Arborg and Melita 2018, the additional N and advanced management treatments yielded significantly more than the other three treatments, indicating that the additional 50 lb/acre of N resulted in a yield advantage (Figure 4). In 2020, the results were less clear. Compared to the standard treatment, additional N resulted in a significant yield increase at Arborg. Both additional N and fungicides resulted in a significant yield increase compared to standard at Melita, but the advanced treatment was highest yielding overall (Figure 5). Overall, additional N resulted in a yield increase in four of seven site years, and fungicides resulted in a yield increase in one of seven site years.

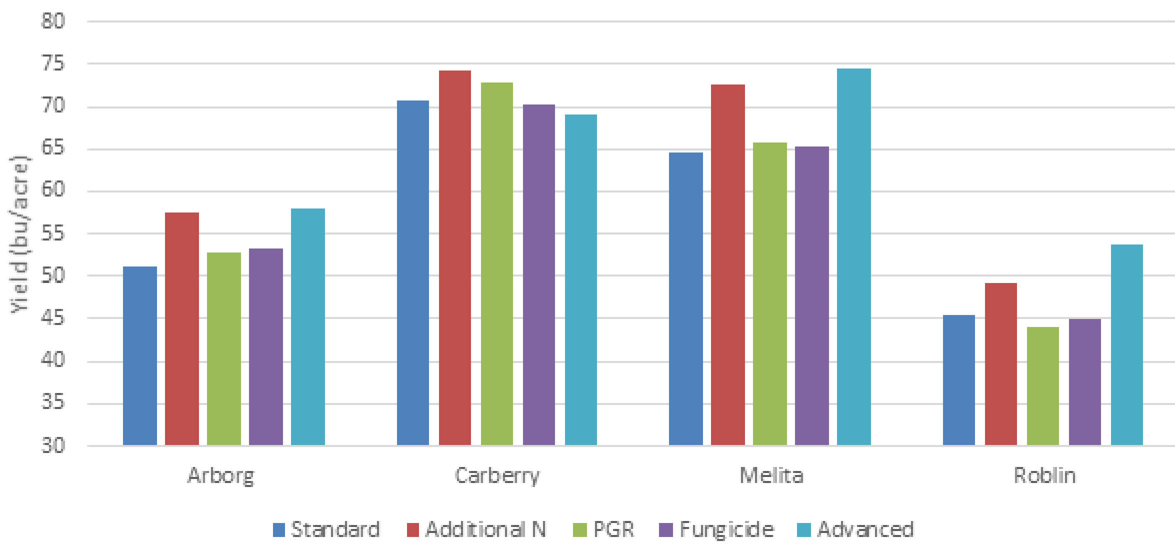

Figure 4. Yield (bu/ac) of the five treatments averaged across varieties at Arborg, Carberry, Melita, and Roblin 2018. Letters above the bars show statistically significant differences. Treatments within the same site with the same letter are not significantly different (P<0.05).

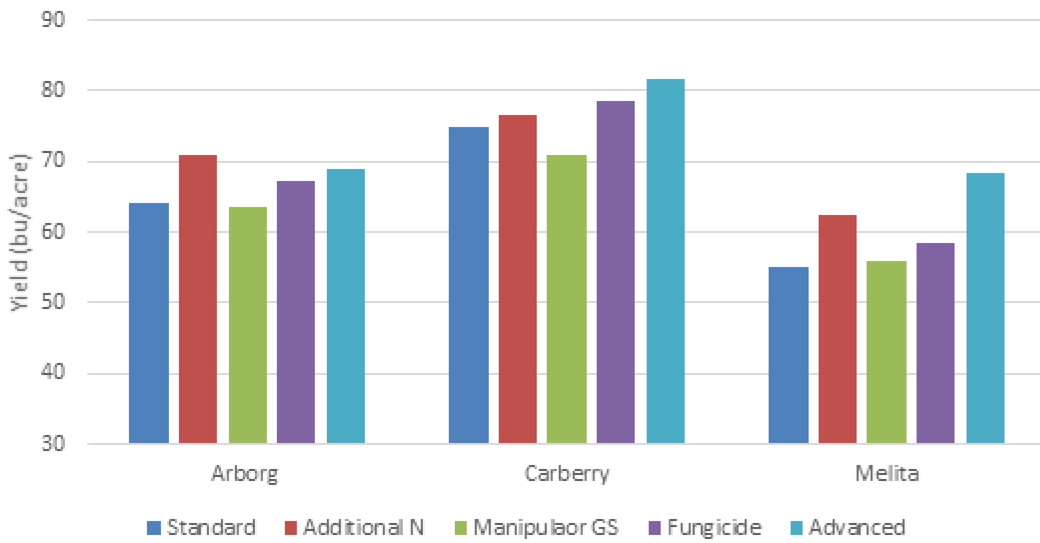

Figure 5. Yield (bu/ac) of the five treatments averaged across varieties at Arborg, Carberry, and Melita 2020. Letters above the bars show statistically significant differences. Treatments within the same site with the same letter are not significantly different (P<0.05).

Protein

Protein was measured on composite samples; therefore, results were not statistically analyzed. Of the management practices studied, treatments with higher N rates had the highest protein concentrations at most locations. Protein contents were similar between management treatments at Melita 2020 and Roblin 2018 (Table 28.0).

Table 28.0 Protein content (%) for different high yielding spring wheat varieties across 4 locations (Arborg, Melita, Carberry and Roblin) in 2018 and 2020

	Arborg		Carberry		Melita		Roblin
	2018	2020	2018	2020	2018	2020	2018
	----------------------Protein %----------------------						
Variety							
AAC Brandon	14.3	12.2	15.9	15.1	12.0	12.3	11.6
AAC Cameron VB	13.9	12.0	16.2	14.6	12.1	11.3	11.0
AAC Viewfield	13.5	11.4	15.0	15.7	11.8	11.8	10.4
Cardale	14.1	12.4	17.1	16.1	12.3	12.7	11.5
Management							
Standard	13.2	11.5	15.7	15.3	11.7	11.9	11.3
Manipulator	13.2	11.3	15.7	15.2	11.4	11.7	11.0
Fungicide	13.0	12.0	15.9	15.4	11.5	11.7	11.0
Additional N	15.3	12.4	16.4	15.4	12.9	12.7	11.3
Advanced	15.1	12.8	16.6	15.6	12.9	12.3	11.1

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29.0 Grain Corn Hybrid Trials at Melita

Project duration: Ongoing
Collaborators: MCVET, Manitoba Crop Alliance, WADO

Objectives:

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

Background

The grain corn hybrid trials were tested and the data donated by the Manitoba Corn Committee. The data presented is for one year only. Use with caution. A target plant population of 32,000 plants per acre was used. Yields are corrected to 15.5% moisture content. Moisture content is measured at harvest. The Manitoba Corn Committee publishes the annual results with all the yearly data in their brochure, which is available by calling the MCA office. The brochure is also available on the MCA website: www.mbcropalliance.ca. Each company assigns acorn heat unit (CHU) rating to each of their hybrids[1] (Table 29.0). The CHU rating is the measure of relative maturity and is one criterion for choosing a hybrid suitable to your growing region. [2]The Canadian Seed Trade Association (CSTA website provides a database for corn hybrids available in Canada, available at https://seedinnovation.ca/corn-hybrids-database. Information provided includes technology, brand name and refuge requirements.

Table 29.0 Grain corn variety evaluation trials yield at Melita in 2020

CHU[1] Rating	Hybrid	*Trait[2](s)*	Company	YIELD (bu/ac)	Moisture (%)	Days to Silking	Bushel Wt. (lbs/bus)
2000	P7005AM	YGCB/HX1/LL/RR2	Pioneer	122	11.9	67	57.6
2000	PS 2142RR	RR2	PICKSEED	112	16.6	68	56.2
2025	DKC21-36RIB	VT2P	DEKALB	146	15.4	68	55.8
2025	A3993G2 RIB	VT2P	PRIDE Seeds	120	15.1	67	56.6
2025	TH4072 RR	RR2	Thunder Seed	129	11.9	68	53.9
2050	PV 60172RR	RR2	Proven Seed	137	15.0	69	55.1
2050	P7202AM	YGCB/HX1/LL/RR2	Pioneer	136	12.5	67	54.1
2050	P7211AM	YGCB/HX1/LL/RR2	Pioneer	128	11.1	68	53.2
2050	NSC EXP73	VT2PRIB	NorthStar Genetics	129	12.8	67	55.6
2050	TH7673 VT2P	VT2P	Thunder Seed	106	17.6	67	57.0
2100	DKC24-06RIB	VT2P	DEKALB	136	17.5	70	54.9
2100	P7417R	RR2	Pioneer	134	12.8	68	52.6
2100	P7455R	RR2	Pioneer	140	15.9	69	52.7
2100	NS 72-521	VT2PRIB	NorthStar Genetics	116	15.1	68	55.2
2100	TH6875 VT2P	VT2P	Thunder Seed	121	16.8	68	52.5
2100	CP1440VT2P/RIB	VT2P	CROPLAN	122	12.2	68	53.4
2100	E44H12R	VT2P	Maizex Seeds	110	15.7	69	55.6
2125	P7417AM	YGCB/HX1/LL/RR2	Pioneer	134	12.9	70	53.2
2125	PS 2210VT2P RIB	GENVT2P	PICKSEED	120	13.6	72	50.6
2150	DKC26-40RIB	VT2P	DEKALB	132	17.9	69	55.7
2150	P7527AM	YGCB/HX1/LL/RR2	Pioneer	143	19.3	70	49.1
2150	A4414RR	RR2	PRIDE Seeds	107	18.0	68	55.7
2150	HZ 1265	Agrisure GT	Horizon Seeds	123	15.9	68	56.3
2150	MZ 1340DBR	VT2P	Maizex Seeds	139	15.8	68	55.3
2175	PV 61276RIB	VT2P	Proven Seed	138	16.7	70	54.6
2200	PV 61177SRR	RR2	Proven Seed	131	26.5	70	48.9
2200	A4323G2 RIB	VT2P	PRIDE Seeds	134	13.8	67	56.3
2200	HZ 1451	Agrisure 3120 EZR	Horizon Seeds	112	16.8	69	52.7
2200	TH6977 VT2P	VT2P	Thunder Seed	132	17.1	69	52.8
2250	TH6079 VT2P	VT2P	Thunder Seed	146	20.8	69	51.8
2250	CP1725RR	RR	CROPLAN	124	12.3	70	52.2
2300	CP2123VT2P/RIB	VT2P	CROPLAN	137	11.5	70	52.5
			Site Average	127	15.4	69	54.0
			CV	6.98	6.82	1.57	1.31
			Sign Diff	Yes	Yes	Yes	Yes
			LSD	15	1.7	2	1.2
			Planting Date	**May 20, 2020**			
			Harvest Date	**October 8, 2020**			

References

Manitoba Crop Alliance; www.mbcropalliance.ca

https://seedinnovation.ca/corn-hybrids-database

30.0 Confectionary and Oil Sunflower variety trial in Manitoba

Collaborators: Manitoba Crop Alliance, WADO

Project Duration: Ongoing

Objectives:

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

Background

Sunflower varieties were tested and data donated by the Manitoba Crop Alliance (MCA). All confectionary sunflowers varieties listed are susceptible to sclerotinia and sunflower rust strains present in Manitoba (Table 30a and b). Genetic resistance to verticillium wilt is rated as moderately susceptible to moderately resistant for all sunflower varieties presented. Oil Sunflower markets - include bird food, oil crush and de-hull. Variety selection become more important when trying to capture de-hull markets. Choose varieties with better de-hull ratio, larger size and higher test weight (Table 30e). Plant population and environment will contribute greatly to the final product.

Materials and Methods

All agronomy conducted on sunflower trial is summarized together with other MVCET trials at Melita in Table 1a of this report.

Table 30a Description of Confectionary sunflower varieties from 2020

		Genetic	Site	Yield	Maturity	Height	2020 Seed Sizing (%) ²		
Company	**Hybrid**	**Traits ¹**	**Years**	**% Check**	**(days to R9)**	**(inches)**	**>22/64**	**>20/64**	**<20/64**
Nuseed Americas	6946 DMR	DM	28	100	0	0	19	36	45
Nuseed Americas	Panther DMR	DM	36	100	0	-2	69	23	8
Experimental lines tested/proposed for registration in Canada									
CHS	RH1121	Conventional	3	121	2	5	72	19	9
CHS	RH208-EX	ExSun	3	114	4	1	63	24	13
MCA	EX 35957	ExSun	3	123	-4	4	72	20	8
MCA	EX 40057	ExSun	3	108	0	2	69	22	9
MCA	EX 57101	ExSun	3	109	0	4	73	20	7
	CHECK CHARACTERISTICS								
	6946DMR		**28**	**3114**	**122**	**67**			
			Site-years	**lb/ac**	**days**	**inches**			

1 Genetic traits include CL = Clearfield tolerance; ExSun = Express tolerance; DM = Downy Mildew Resistance.

2 Totals may not add to 100% due to rounding; information based off two sites at Elm Creek and Rossendale.

Table 30b Description of Oil sunflower varieties from 2020

Company	Variety	Herbicide/Disease Tolerance [1]	Site Years	Yield (% check)	Maturity[2] (+/- check)	Height (inches)	% Oil	Oil Type[3]	Test Weight[4]
Corteva	P63HE60	ExSun / DM	14	96	-2	0	44.9	HO	32.5
Corteva	P63ME70	ExSun / DM	19	100	0	0	44.6	NS	30.1
Corteva	P63ME80	ExSun / DM	17	95	1	0	48.4	NS	31.6
Nuseed Americas	N4H302 E	ExSun	8	88	-3	1	44.4	HO	29.5
Nuseed Americas	N4HM354	CL / DM	14	104	-1	-4	47.6	NS	33.7
Nuseed Americas	Talon	ExSun	17	97	-3	-4	42.5	NS	28.9
Experimental lines tested/proposed for registration in Canada									
Corteva	PH_experimental	ExSun	2	105	-1	4	43.8	HO	27.1
CHS	8D310CL	CL	2	106	2	2	39.6	CO	25.0
Nuseed Americas	N5LM307	CL / DM	4	103	-2	-7	41.8	CO	27.6
WinField United	CP432E	ExSun	2	107	-3	0	43.1	NS	27.5
WinField United	CP455E	ExSun	2	112	2	1	44.1	HO	26.9
WinField United	CP4909E	ExSun	2	98	-1	-3	44.9	HO	29.4
	CHECK CHARACTERISTICS								
	P63ME70		19 site years	3236 lb/ac	124 days	69 inches			

1 Genetic traits include CL = Clearfield tolerance; ExSun = Express tolerance; DM = Downy Mildew Resistance.
2 Physiological maturity for sunflower is R9, where the bracts on the head are almost completely brown.
3 Oil Type include NS=NuSun; HO=High Oleic; CO = ConOil
4 Test weights reported in lbs per Avery (Canadian) bushel.

Table 30c Confectionary sunflower yield, maturity, seed size and test weight for Elm Creek and Melita sites in 2020

Hybrid	Elm Creek Yield (lb/ac)	Elm Creek Maturity[1] (days to R9)	Elm Creek 2020 Seed Sizing (%) [2] >22/64	Elm Creek >20/64	Elm Creek <20/64	Elm Creek Test Wt. (lb/bu A)	Melita Yield (lb/ac)	Melita Maturity[1] (days to R9)	Melita 2020 Seed Sizing (%) [2] >22/64	Melita >20/64	Melita <20/64	Melita Test Wt. (lb/bu A)
6946 DMR	2106	119	4	31	66	23.7	2729	139	24	30	46	26.0
Panther DMR	2219	118	58	30	12	20.7	2647	140	47	36	17	26.9
Experimental lines being tested/proposed for registration in Canada												
EX 35957	2749	119	58	30	12	23.9	3271	135	61	23	16	24.8
EX 40057	2148	123	48	36	16	24.3	3345	135	55	27	18	25.7
EX 57101	2419	119	57	32	11	19.6	3020	141	84	7	8	21.1
RH1121	2325	124	55	31	15	22.3	3633	140	76	14	9	22.4
RH208-EX	2368	125	47	32	22	21.1	3303	141	68	18	13	22.4
Site Average	2333	121				22.2	3135	139				24.2
CV%	8.5						10.7					
Sign Diff	No						No					
LSD (0.05)	--						--					
Planting Date	21-May						20-May					
Harvest Date	06-Oct						13-Oct					

Table 30d Confectionary sunflower yield, maturity, seed sizing and test weight for Rossendale site in 2020

	Rossendale					
	Yield	Maturity*	2020 Seed Sizing (%) ²			Test Wt.
Hybrid	(lb/ac)	(days to R9)	>22/64	>20/64	<20/64	(lb/bu a)
6946 DMR	2482	126	34	41	25	21.9
Panther DMR	2471	119	80	15	5	21.9
Experimental lines being tested/proposed for registration in Canada						
EX 35957	2525	119	86	10	4	20.5
EX 40057	2438	125	91	7	2	20.8
EX 57101	2521	124	89	8	4	17.8
RH1121	2915	127	90	8	3	19.9
RH208-EX	2683	130	79	17	5	18.7
Site Average	2577	124				20.2
CV%	5.4					
Sign Diff	Yes					
LSD (0.05)	264					
Planting Date	22-May					
Desiccation Date	--					
Harvest Date	07-Oct					

1 Physiological maturity for sunflowers is R9, where the bracts on the head are almost completely brown. **2** Totals may not add to 100% due to rounding

Table 30e Oil sunflower yield, maturity, test weight and oil content for Elm Creek and Rossendale in 2020

	Elm Creek					Rossendale				
Hybrid	Yield (lb/ac)	Moisture (%)	Maturity[1] (days to R9)	Test Wt[2] (lb/bu)	Oil (%)	Yield (lb/ac)	Moisture (%)	Maturity[1] (days to R9)	Test Wt[2] (lb/bu)	Oil (%)
N4H302 E	2293	8.4	119	28.1	44.9	1923	10.8	119	23.1	43.9
N4HM354	2540	7.0	118	31.5	48.7	2595	13.5	126	28.3	46.4
Talon	2518	7.3	119	27.9	44.7	1990	12.9	119	20.5	40.3
P63HE60	2133	7.1	123	28.8	45.0	2136	12.9	123	27.2	44.8
P63ME70	2275	9.6	125	26.9	46.0	2361	10.2	126	23.2	43.2
P63ME80	2223	6.9	119	29.2	47.7	2404	14.1	128	26.6	49.0
Experimental lines being tested/proposed for registration in Canada										
8D310CL	2450	8.8	126	26.4	39.6	2454	12.4	128	23.5	39.6
PH_experimental	2286	6.7	123	29.4	43.8	2603	10.9	126	24.8	43.7
N5LM307	2633	9.2	117	27.3	41.3	2456	14.2	126	21.7	42.3
CP432E	2309	6.9	119	29.0	42.5	2655	11.1	126	26.0	43.7
CP455E	2424	8.6	125	28.7	44.2	2776	13.9	130	25.1	43.9
CP4909E	2388	7.3	123	31.2	45.2	2178	14.0	126	27.6	44.6
Site Average	2373	7.8	121	28.7	44.5	2377	12.5	125	24.8	43.8
CV%	6.2					5.5				
Sign Diff	Yes					Yes				
LSD (0.05)	250					294				
Planting Date	21-May					22-May				
Desiccation Date	--					--				
Harvest Date	06-Oct					07-Oct				

1 Physiological maturity for sunflowers is R9, where the bracts on the head are almost completely brown. 2 Totals may not add to 100% due to rounding

References

Manitoba Crop Alliance www.mbcropalliance.ca

31.0 Influence of iQ granular starter (3-4-3) pelleted chicken manure on canola emergence safety and seed yield

Project duration: 2020
Collaborators: Canadian Agronomics Inc. (Tim Dyck - Elie)
Location: **Melita**

Objectives

- Evaluate effectiveness of iQ granular starter chicken manure fertilizer on canola emergence potential and seed yield.

Background

Animal manures are regarded as valuable sources of plant nutrition in cropping systems and also play a significant role in soil amendment through addition of organic matter (Schoenau and Davis, 2006). Chicken manure, in particular, contains about 1.1% nitrogen and relatively low proportions of phosphorus, potassium, calcium and other naturally occurring micronutrients that can be utilized to improve plant growth and soil health with less impact on the environment compared to conventional fertilizers. However, low nutrient proportions in chicken manure imply that bulky amounts will need to be applied in order to meet crop demands hence the need to apply them together with synthetic fertilizers to reduce the large quantities. Significant yield responses to nutrients in animal manure have been reported in field trials in western Canada (Olson et al., 1998; Mooleki et al., 2004). In many cases, part of the yield response to animal manure application, particularly liquid or pelleted manure, maybe as a result of enhanced availability of other nutrients such as phosphorus, copper and zinc when soil availability of these elements is limiting (Qian and Schoenau, 2000; Qian et al., 2003). Therefore, addition of animal manure can make significant contribution to crop and soil health by increasing accessibility of nutrients in the soil, improve porosity and organic matter. Furthermore, animal manure also improves the rhizosphere and enhances nutrient uptake through chemical and microbial means, which in turn impacts positively on yield and crop quality (Whalen et al.,2000). In Manitoba, much of animal manure sources come from cattle and pigs in either solid or liquid form. There has not been much research on the use of chicken manure on a large scale, which prompted this research to explore the potential influence of chicken manure on canola yield and quality. This study will explore starter fertilizer, iQ granular, 3-4-3, (N-P-K), which has proved to be extremely beneficial in canola production in Canada. Top quality raw materials are used in the composting process of this fertilizer, which is high in calcium, carbon and other naturally occurring minerals essential for crop and soil health.

Materials and Methods

The trial was arranged as randomized complete block design with 4 chicken manure (iQ granular starter 3-4-3) treatments replicated 4 times at Melita. The plots were harrowed first before planting in order to evenly spread wheat straw from the previous crop. Seeding was done on the 12th of May using a dual knife Seed Hawk air seeder at 0.5'" depth. The 4 chicken manure treatments were applied during seeding in rows at 0, 25, 50 and 100 lb. ac^{-1}. Conventional fertilizer was banded during seeding at 125-35-20-8-2 (N-P-K-S-Zn) actual lb. ac^{-1} with a combination of UAN, MAP, ammonium sulfate and zinc sulfate granular products. Post emergence weed control was done using 17.3 g ac^{-1} Odyssey + 5% v/v Merge adjuvant and 0.1 L ac^{-1} Arrow one week apart. During the season there were incidences of flea beetles, which were controlled by the 3 applications (up to V5) of 0.063 L ac^{-1} Pounce 384 EC insecticide. The plots were swathed on the 12 of August and left to dry for approximately 2 weeks prior to harvesting. Various data were collected during the season and these included; plant counts at emergence, lodging percentage, plant height, seed yield, seed weight and protein and oil content. These parameters were necessary to differentiate the impact of chicken manure on canola production. All data were analyzed using Minitab 18 and mean separation was done using Fishers LSD at 0.05 significance level.

Results and Discussion

There were no significant differences observed in average emergence, plant height, days to maturity, lodging, seed weight, distinct green seed and protein content of canola regardless of different iQ starter application rates used including the check, which did not receive any starter chicken manure (Table 31.0). The high coefficient of variation in average canola emergence (37.7%) could have been due to seed placement variation during the seeding process, however, stands were generally consistent between plots overall. Seed yield from the control treatment, with no iQ starter fertilizer, was not significantly different from treatments that received 25 and 100 lb. ac^{-1}. Surprisingly, application of 50 lb. ac^{-1} iQ starter fertilizer resulted in significantly lower yield (56.61 bu ac^{-1}) compared to the control (61.6 bu ac^{-1}) treatment. There were also no significant differences in canola seed yield when 25 and 50 lb. ac^{-1} iQ starter fertilizer was applied to different treatments at Melita. Oil content was similar in 0, 25 and 50 lb. ac^{-1} treatments but was significantly lower (50.3%) in 100 lb. ac^{-1} iQ starter treatment compared to the control (50.9%) (0 lb. ac^{-1}) and 25 lb. ac^{-1} (51.0%). Other trials across the Manitoba province noted by Canadian Agronomics Ltd showed response to iQ granular product when placed with seed using disc style opener compared to Melita site which used knife style openers (personal comm. Tim Dyck, Canadian Agronomics, 2020)

Environmental conditions at Melita such as low overall rainfall, compared to normal, may have contributed to the lack of response to iQ granular starter fertilizer in canola.

Organic manures are classified as slow-release fertilizers, which might explain the outcome of no significant differences in canola seedling emergence even with significant differences in the rates applied.

Table 31.0 Analysis of Variance for chicken manure influence on canola emergence, plant height, maturity, lodging, yield, protein and oil content at Melita in 2020

Chicken Manure (iQ starter) rates (lb ac^{-1})	Average Emergence ppms	Plant height cm	DTM	Lodge (1-5)	Yield (kg/ha) corr. 10%	bu/ac	Seed weight g/1000	Distinct green seed %	Protein Content %	Oil content %
0 (check)	11.3	136.0	90.8	2.0	3456	61.57**a**	3.6	0.0	17.9	50.85**a**
25	9.4	127.0	91.0	1.8	3307	58.9**ab**	3.6	0.3	17.8	51.03**a**
50	19.9	135.3	90.5	2.0	3178	56.61**b**	3.6	0.0	18.0	50.68**ab**
100	19.3	128.3	91.0	2.3	3427	61.05**a**	3.5	0.5	18.5	50.25**b**
Grand Mean	**14.9**	**131.6**	**90.8**	**2.0**	**3342**	**59.5**	**3.58**	**0.2**	**18.0**	**50.7**
CV%	**37.7**	**5.9**	**0.9**	**20.4**	**3.8**	**3.80**	**2.54**	**183.3**	**2.3**	**0.6**
P Values	0.056	0.298	0.776	0.436	**0.046**	**0.046***	0.467	0.194	0.165	**0.030***

***Fishers LSD at p=0.05 level of significance**

Results from this trial are inconclusive considering that seed yield was highest in the control with no iQ starter fertilizer compared to other treatments that received significant amounts of the product during seeding. There was no change in canola emergence among treatments despite the product being seed placed and no seed burn was observed. Further field studies are necessary to compare side-by-side treatments using hoe versus disc openers in which, the latter may provide more detectable response.

Arial view of chicken manure treated canola at Melita in 2020

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