



Westman Agricultural Diversification Organization
2019 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 the Fed/Prov. Canada/Manitoba Diversification Centres (CMCDC) based in Carberry and Portage la Prairie. WADO owes its success to the excellent cooperation and participation we receive from the WADO Board of Directors, cooperating land owners, local producers, industry partners and cooperating research institutes. WADO acts as a facilitator and sponsor for many of the Ag Extension events held across the province in conjunction with other Manitoba Agriculture 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 to these organizations.

2019 Industry Partners

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

WADO Directors

WADO functions with a board of directors that assist in communications, activities and project development. The directors are from all across southwest Manitoba and they have a direct connection to farming and agriculture. The directors listed below are those that participated with WADO operations in 2019.

Board member	Location	Southwest Manitoba Agriculture and Resource Development staff members are also part of the WADO board:
Gary Barker-Chairman	Melita	Lionel Kaskiw – Souris
Brooks White	Pierson	Amir Farooq - Hamiota
Ryan Martens	Boissevain	Scott Chalmers - Melita
Kevin Beernaert	Hartney	
Kevin Routledge	Hamiota	
John Finnie	Kenton	
Allan McKenzie	Nesbitt	Board Advisor: Elmer Kaskiw – Shoal Lake
Patrick Johnson	Killarney	
Neil Galbraith	Minnedosa	

Farmer Co-operators 2019 Trial Locations

Cooperator	Allan Brown-Melita	Fred Greig-Reston	Allan Brown-Elva
Soil type	Waskada loam	Ryerson5-Loam-Coatstone Loam2-Tilston1	Lauder5-Souris4 Loamy fine sand

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.

Rachelle McCannell (University of Saskatchewan) and **Pierre Louault** (France) were summer students for 2019. **Chantal Elliott** remained with WADO through the winter to assist with sample analysis and equipment repairs and maintenance. **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.



WADO Staff 2019 (left to right): Chantal Elliott, Leanne Mayes, Justice Zhanda, Rachelle McCannell, Scott Chalmers and Pierre Louault

Got An Idea?

The Westman Agricultural Diversification Organization continually looks for new research project ideas, value-added ideas, 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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scott.chalmers@gov.mb.ca

2019 Weather Report and Data – Melita Area

Table a: Melita 2019 Season Report by Month (normals based on 30-year average)

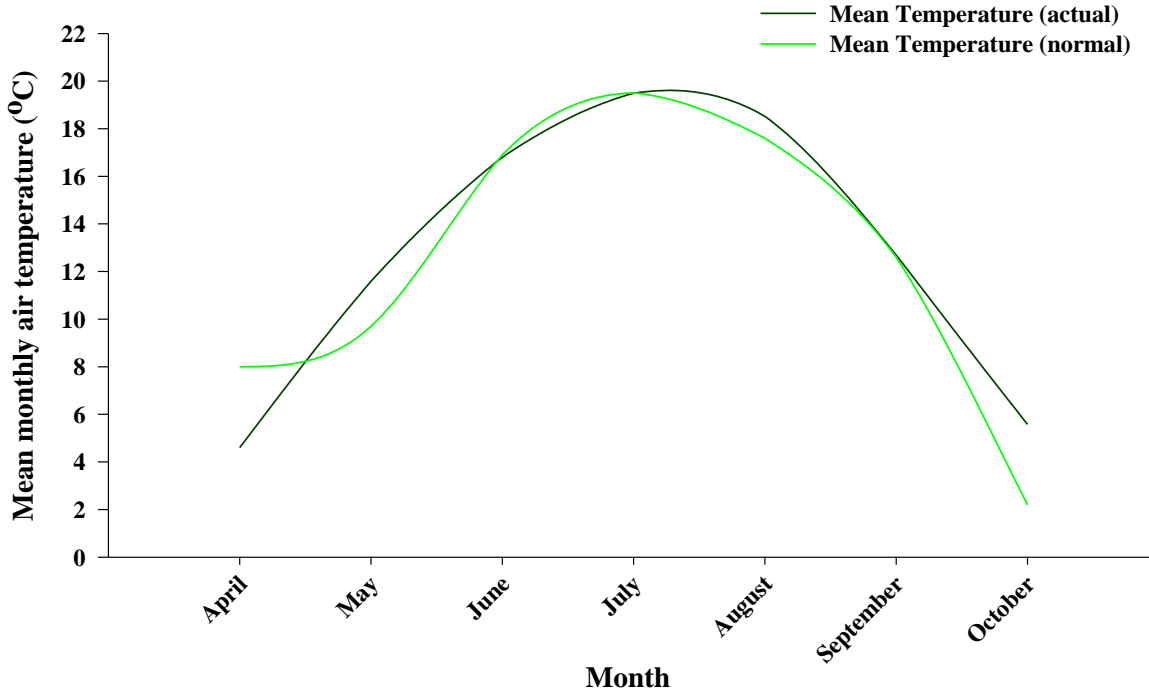
Month	Precipitation (mm)		Temperature °C		Corn Heat Units		Growing Degree Days (>5°C)	
	Actual	Normal	Average	Normal	Actual	Normal	Actual	Normal
April	15	20	8.0	4.6	115	74	55	24
May	15	53	9.7	11.6	307	365	158	205
June	84	101	16.9	16.8	566	583	358	351
July	74	69	19.5	19.5	714	712	450	453
August	100	78	17.6	18.5	620	659	392	415
September	93	35	12.6	12.7	374	369	233	211
October	16	31	2.2	5.6	68	116	29	40

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

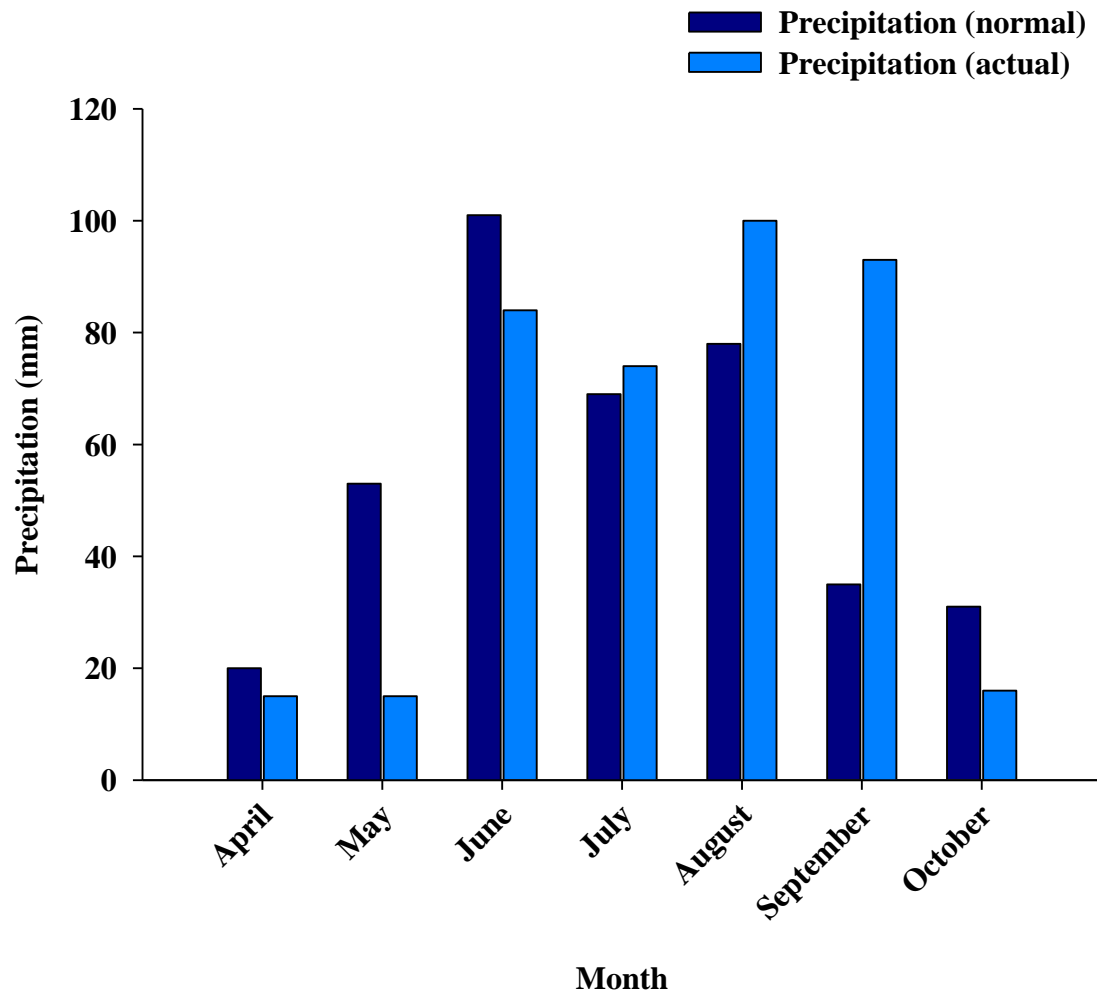
Table b: Season summary April 15 – October 31, 2019

	Actual	Normal	% of Normal
Number of Days	200		
Growing Degree Days _s	1675	1699	99
Corn Heat Units	2764	2878	96
Total Precipitation (mm)	397	387	102

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

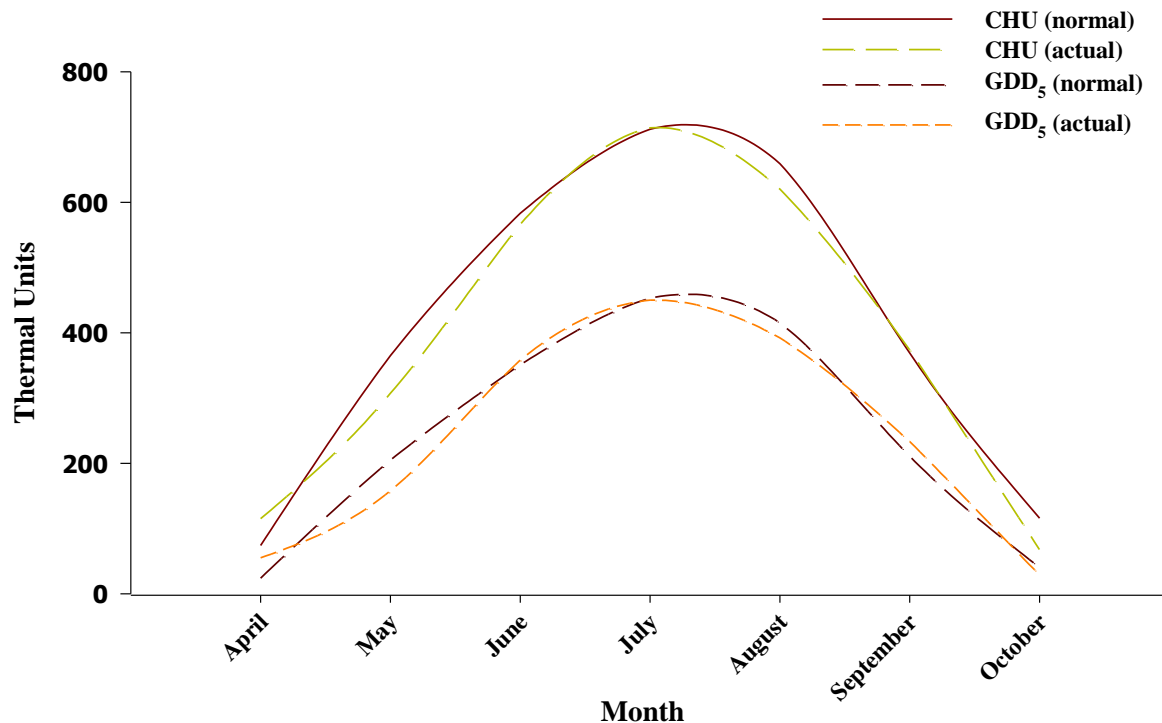


Mean monthly air temperature recorded at Melita from April 15 to October 31 2019



Precipitation (mm) (normal and actual) recorded at Melita between April 15 and October 31 2019

The 2019 growing season was characterised by a drier spring with precipitation less than 20mm in each of the months of April and May, which was below the 30 year normals. The highest amount of 100mm was recorded in August when most crops were few weeks from maturity. Although the total precipitation for the season was slightly above normal, there was uneven distribution throughout the season with 80% of the amounts falling within 1 to 3 days during the months of June, July and August.



CHU and GDD₅ accumulated at Melita from April 15 to October 31 2019

Growing degree days (GDD) are calculated as follows:

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

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

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

above 30°C. Corn heat unit system is a more accurate and consistent crop prediction tool for warm season crops like corn and soybeans. The formula for CHU is illustrated below:

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

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

A good visual of our growing season is illustrated on the 2019 Precipitation Map and the 2019 Corn Heat Unit Map. These can be found at <http://www.gov.mb.ca/agriculture/weather/manitoba-ag-weather.html>.

WADO Tours and Special Events

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

WADO held its annual field day at the main Research site on July 30 2019. Approximately 65 people joined us for lunch and tour of our main plot site NE of Melita. The turnout was slightly lower than in 2018 as a result of many field days occurring around the same time. The annual Field Day is the main way that WADO communicates its activities and we were encouraged to see the participation from producers, fellow researchers and industry partners. The main site showcased many of our variety trials including: wheat, oats, barley, soybeans, peas, narrow row beans, quinoa, flax, hemp, canola and mustard. Also at this site were several trials that were part of the University of Manitoba's research on soybeans and WADO's own research projects on intercropping pea-canola, soybean-flax, winter wheat-soybean, corn-hairy vetch and hemp relay with legumes.

On July 31, WADO and Manitoba Livestock department hosted a Livestock tour and shared our work on Canola-Pea, Corn-Hairy Vetch and Hemp relay intercrops, providing essential information on how these can be integrated into livestock production systems. Close to 70 people, including Livestock industry experts and experienced livestock farmers attended and actively participated during the tour.

We would like to thank the WADO staff, Manitoba Agriculture and Resource Development employees and the guest speakers who made it all happen.



Scott Chalmers participated as a speaker at the following events:

- WADO Annual Field Day – Melita MB, July 30; attendance 65
- Southwest Livestock tour – Melita MB, July 31; attendance 70
- Cover crop workshop – Brandon, November 2019
- Manitoba AgDays in Brandon – 21-24 January 2020
- CropConnect Conference-Winnipeg – 12 & 13 February 2020

Understanding Plot Statistics

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

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

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

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

Grand mean/mean of means is the average of the entire data set. Quite often, it helps gauge the overall yield of a site or trial location. Sometimes 'checks' are used to reference a familiar variety to new varieties

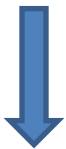
and may be highlighted in grey or simply referred to as 'check' in the results table or summary for the readers' convenience.

Data in all replicated trials at WADO has been analyzed by statistical software from either Agrobase Gen II version 16.2.1, or Minitab 18 software. Coefficient of variation and least significant difference at the 0.05 level of significance was used to determine trial variation and mean differences respectively. At this level of significance, there is less than 5% chance that this data is a fluke when considered significant. For differences among treatments to be significant, the p-value must be less than 0.05. A p-value of 0.001 would be considered highly significant.

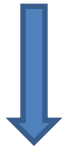
Grain Processing at WADO

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 combine for other grains



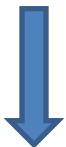
Grain cleaning – depending on specifications by the collaborators, some require uncleaned grain



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



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



Collect sub samples, analyze data and send to collaborators

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

Table 1 summarizes the WADO grown MCVET trial agronomy for each crop type. The table provides extra insight and when combined with the weather summary, provides helpful insight into variety performance especially when compared year to year.

Table 1: Agronomy practices for selected MCVET crops in 2019. Yield data is published in the Seed Manitoba Guide.

Crop**	Pre-Emergence Burnoff	Soil	Seeding	Seeding	Fertilizer Applied	Chemistry	Harvest
	(rate/ac)	Moisture	Date	Depth	(actual lb/ac)	rate/ac	Date
Winter wheat	0.75L Roundup + 21 ml Heat LQ + 0.2L Merge	8" good	10-Sep-18	0.5"	65-35-0-0 + 60N spring	None	16-Aug
Fall rye	0.75L Roundup + 21 ml Heat LQ + 0.2L Merge	8" good	10-Sep-18	0.5"	65-35-0-0 + 60N spring	None	29-Aug
Barley	None	24" good	01-May-19	1"	108-35-20-7-2Zn	Mextrol 0.5L + Puma 150ml	16-Aug
Spring wheat	None	24" good	30-Apr-19	1"	121-35-20-7-2Zn	Mextrol 0.5L + Puma 150ml	20-Aug
Oats	None	24" good	01-May-19	1"	108-35-20-7-2Zn	Mextrol 0.5L + Puma 150ml	20-Aug
Corn	None	good	16-May-19	1.75"	108-35-30-7-2Zn; 60N urea; 80N Agrotain urea	Mextrol 0.4L; Roundup 0.33L	31-Oct
Lentils	None	24" good	08-May-19	1"	7-35-20-7-2Zn	Select 120 ml + Amigo 0.5%; Pounce 54 ml; Lorsban	20-Aug
RR Soybean	Authority 0.1L + Roundup 0.75L + Aim @ 15 ml	fair	13-May-19	1"	7-35-20-7-2Zn	Roundup 0.33 L; Lorsban; Matador 30ml	25-Sep
Conv. Soybean	Authority 0.1L + Roundup 0.75L + Aim @ 15 ml	fair	13-May-19	1"	7-35-20-7-2Zn	Select 120 ml+ Amigo 0.5% ; Basagran 0.91L; Lorsban; Matador 30 ml	23-Sep
Dry Beans	Roundup 0.75L + Rival 0.5L	fair	15-May-19	1.25"	88-35-20-7-2Zn	Arrow 150ml+Xact 0.5%; Basagran 0.91L; Matador 30ml	17-Sep
Peas	Authority 0.1L + Roundup 0.75L + Aim 15 ml	24" good	06-May-19	1.25"	7-35-20-7-2Zn	Select 120 ml + Amigo 0.5% + Pounce 54 ml; Odyssey 17.3g + Merge 0.5%	19-Aug
Sunflower	None	good	16-May-19	1.75"	108-35-30-7-2Zn	Arrow 150 ml + Xact 0.5%; Muster 12g; Assert 0.5L; Superspreader 0.2%; Assure II 0.15L; Matador; Lorsban	22-Oct

****All trials established on oats stubble**

2.0 Evaluating yield potential of new winter wheat varieties

Project duration: 2018-2019

Collaborators: Ducks Unlimited, WesternAg

Objectives

To establish a fertility program suitable for achieving high yield winter wheat on the Prairies.

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. Management practices that can be utilized to improve winter wheat production are; increasing seeding rate and application of starter fertilizer by banding during seeding (Anderson, 2008). Fertility management, in particular nitrogen and phosphorus, remains the integral part of the overall management package aimed at achieving higher yields (Halvorson et al. 1987). 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 per given area without compromising the quality of grain. Morris et al. (2018) suggested the use 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 way that can be availed to producers so as to maximise production.

Materials and Methods

Field trials were established at four locations across Manitoba; Melita, Arborg, Carberry and Roblin in the 2018/2019 growing season. The Melita location was seeded at 0.5" on September 10, 2018 on Waskada loam soil under oat stubble. Preemergence weed control was necessary to ensure a clean seedbed and this was done using 0.75 L ac⁻¹ Glyphosate, 0.021 L ac⁻¹ Heat LQ tank mixed with 0.2 L ac⁻¹ Merge adjuvant. As a preventative measure for fungal diseases such as fusarium head blight (FHB), a spray application was done with Folicur at 0.12 L ac⁻¹ at 75% heading and when 50% of the head had flowers. Treatments were laid out as randomized complete block design in a 2 x 3 factorial (fertility practice x wheat varieties). Wheat varieties used were Gateway, Elevate and Wildfire and 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.

A summary of fertility treatments is presented in Table 2a:

Table 2a: Fertility treatments for Balanced (high yield) and Producer practices

Practice	N	P	K	S
Balanced fertility with 50 % N applied in fall	44-0-0	11-52-0	0-0-60	20-0-0-24
Producer practice with N applied in spring	46-0-0	11-52-0		

Harvesting was done using a Wintersteiger small plot combine on the 19th of August 2019. An IM 9500 NIR grain analyzer was used to determine grain moisture and protein content on dry basis from a 500g subsample of each treatment.

Results

Variety appeared to have influenced wheat yield and protein at 3 of the 4 sites under study in 2019. Elevate and Wildfire varieties had significantly higher yields compared to Gateway at Melita ($P=0.001$) and Arborg ($P=0.036$) while there were no significant differences among varieties at Roblin and Carberry. Although Gateway had lower grain yield, it had significantly higher protein content of 15.8% at Melita, 13.8% at Roblin and 13.5% at Arborg compared to Wildfire and Elevate. Wildfire had significantly higher protein content (15.2%) compared to Elevate (14.4%) at Melita while there were no significant differences between the same varieties at Arborg. There were no significant differences in protein content at Carberry. Balanced application of fertilizer resulted in significantly higher grain yield at Roblin (5031 kg ha⁻¹) and Carberry (4864 kg ha⁻¹) compared to 100% spring applied. Balanced application of fertilizer resulted in significantly higher protein content compared to 100% spring applied fertilizer at Roblin and Arborg. On the other hand, 100% spring applied fertilizer resulted in significantly higher protein than balanced fertilizer application at Carberry. There was a significant interaction between variety and fertilizer on protein content and no influence on wheat yield. An interaction of Gateway variety and balanced fertilizer application resulted in significantly higher protein content (16%) compared to other interactions. Under both fertilizer systems, Elevate resulted in the lowest protein content of 14.4 and 14.5% at Melita (Table 2b). Based on the preliminary results from this study, balanced fertilizer application seemed to a better option to improve wheat yield and protein content at least at two sites but additional site years of study would confirm proper recommendations for use by winter wheat producers.

Table 2b Analysis of variance and mean comparison for wheat yield and protein content at Melita, Roblin, Arborg and Carberry in 2019

		Location							
		Melita		Roblin		Carberry		Arborg	
		Yield kg ha ⁻¹	Protein%	Yield kg ha ⁻¹	Protein%	Yield kg ha ⁻¹	Protein%	Yield kg ha ⁻¹	Protein%
Variety[†]	1	3974a	14.4c	4802	12.6b	4459	13.9	5860a	12.1b
	2	3688b	15.8a	4361	13.8a	4879	13.7	5188b	13.5a
	3	4150a	15.2b	4646	11.4c	4621	13.8	5728a	12.3b
Fert[‡]	1	3901	15.2	4175b	12.2b	4442b	14.3a	5466	12.4b
	2	3974	15.2	5031a	13.0a	4864a	13.4b	5718	12.9a
Var*Fert	1*1	4000	14.5d	4228	12.4	4470	14.5	5823	12.1
	2*1	3682	15.6b	3761	13.5	4662	14.1	5140	13.0
	3*1	4020	15.4bc	4536	10.6	4194	14.2	5434	12.0
	1*2	3948	14.4d	5375	12.7	4449	13.4	5898	12.1
	2*2	3694	16a	4961	14.1	5097	13.3	5235	14.0
	3*2	4280	15.2c	4757	12.3	5047	13.4	6022	12.6
P values	Var	0.001	<0.001	0.574	<0.001	0.524	0.909	0.036	0.001
	Fert	0.324	0.891	0.029	0.003	0.182	0.035	0.212	0.027
	Var*Fert	0.213	0.049	0.441	0.082	0.504	0.933	0.481	0.236
CV%		4	1	16	4			7	4

[†]Variety 1=Elevate, Variety 2=Gateway, Variety 3=Wildfire; [‡]Fert 1=100% Spring applied, Fert 2=Balanced application

References

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doi:10.2134/agronj2017.02.0112

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 is capable of causing significant losses in grain yield, test weight and seed germination. In addition to losses in grain yield, fusarium species produce mycotoxins such as deoxynivalenol (DON) in suitable environments, which compromise grain quality as well as the lives of humans and livestock (Prandini et al. 2008). 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 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 an additional replicate will be added in successive years.

Melita location was established on Waskada loam soil under no till system and on oat stubble. Winter wheat was seeded on 21 September 2018 while spring wheat, barley and durum were seeded on 14 May 2019. Preemergence weed control in winter wheat was done using 0.75 L ac⁻¹ Roundup, 0.021 L ac⁻¹ Heat LQ tank mixed with 0.2 L ac⁻¹ Merge surfactant, while no herbicides were applied as burn off for spring cereals. Post emergence weed control in barley and spring wheat was done using 0.5 L ac⁻¹ Mextrol, 0.15 L ac⁻¹ Puma and 0.48 L ac⁻¹ Axial while only Mextrol and Puma were applied in durum at the same rate.

Fertilizer application for winter wheat was done first at seeding at a rate of 67.7-35-0-0 (N-P-K-S) actual lb ac⁻¹ followed by top dressing with 60 lb ac⁻¹ N in spring. For spring seeded cereals, fertilizer was side banded during seeding at a rate of 108-35-20-7-2Zn (N-P-K-S) actual lb ac⁻¹. Seeding depth for winter wheat was 0.5" while 1" 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 placed 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.



Fusarium Head Blight rating in wheat at Melita, July 2019

Results and Discussion

The research trial is in its first year and progress report will be made available upon completion of the analysis by the collaborators.

References

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4.0 Pepsico - Quaker oats variety evaluation

Project duration: 2018-2019

Collaborators: Pepsico/Quaker/Frito-Lay

Objectives

To evaluate yield of 19 oat varieties under different environments.

Background

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 occurrence of ideal weather conditions favourable for growth and development. Oats production has been on the rise in Canada with an expectation of +15 % to 4 million tonnes 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 suitable for their areas of production.

Materials and Methods

The trial was arranged as randomized complete block design with 19 varieties replicated 4 times on Waskada loam soils in Melita. Plots were established on oats stubble under no till system on the 1st May 2019. All fertilizer requirements were met by side banding during seeding and at a rate of 108-35-20-7-2Zn (N-P-K-S) actual lb ac⁻¹. Fertility application was done based on soil test results and also to meet requirements of the crop. Post emergence weed control was achieved by the application of 0.5 L ac⁻¹ Mextrol tank mixed by error with 0.15 L ac⁻¹ Puma at stage 15 on BBCH scale. The rate of Puma herbicide applied slightly reduced development of oats but full recovery from herbicide injury was observed within 2 weeks of exposure. 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.

Results

Major highlights of this trial were grain yield and disease incidence. Summaries will be available when the trial is finalized.

References

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5.0 La Co-op Fédérée oat variety evaluation

Project duration : 2019

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

Objectives

To determine yield potential of 28 oat varieties in Manitoba.

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. A major component of oats is β -glucans, a soluble fibre, which plays a significant role of lowering cholesterol levels in humans (White, 2000). An increase in the world's populations means more demand for food, feed and fibre, which in turn calls for availability of higher yielding varieties to meet the 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 1st of May 2019 on Waskada loam soils under no till system. A randomized complete block design with 28 treatments (varieties) and 3 replicates was used. Seeds were placed into good moisture conditions at 1" depth using a Seedhawk dual knife air seeder. Fertilizer was side banded at the same time as seeding at a rate of 108-35-20-7-2Zn actual lb ac⁻¹ and this was based on soil analysis results. Post emergence weed control was done using 0.5 L ac⁻¹ Mextrol tank mixed with 0.15 L ac⁻¹ Puma for the control of broad leaf weeds and some grasses. Inclusion of Puma herbicide in the application was an error since oats plots were close to wheat plots but no significant damage was caused due to low rates. 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

2019 results and recommendations will be made available when the trial is finalized.

References

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5.1 Pulse Genetics pea variety evaluation

Project duration: 2018-2019

Collaborators: Pete Giesbrecht, Winkler

Objectives

To evaluate performance of 6 advanced lines compared to registered varieties in the pea growing regions of Southwestern Manitoba and Eastern Saskatchewan.

Background

Pulse Genetics is a small pea breeding company based in Southern Manitoba that started as a dream in a hobby garden 9 years ago. Their goal is to develop yellow and green pea varieties with excellent protein and yield, with an emphasis on premium seed quality. These new lines will exhibit consistent performance over a variety of environments. Selection of appropriate pea varieties should be based on review of many differences that exist among varieties (Schatz, 2009). Apart from yield being the most important selection criteria, traits related to seed quality are increasingly meaningful. Among the varieties and pea lines there exist differences in crude protein and other chemical compounds that determine the nutritional value of the seed. When selecting varieties for production in different areas, farmers do not only consider yield potential, but are also concerned with protein content which is a critical grading criteria when marketing their product. Other important factors for consideration when selecting varieties include market class,

harvest ease, lodging characteristics, maturity and resistant to diseases such as mycosphaerella blight, which is a serious disease that results in severe seed losses (Xue and Warkentin, 2001).

Materials and Methods

The trial was conducted at Melita in South west Manitoba and under no till system. Seven treatments (6 advanced lines and one check 'CDC Meadow') were arranged as randomized complete block design and replicated 3 times. The treatments were inoculated with BASF granular inoculant before seeding on the 3rd of May 2019 to a depth of 1.25". At the time of seeding, soil moisture was reaching approximately 24" in depth, which was adequate to ensure emergence. Fertilizer was side banded at a rate of 7-35-20-7-2Zn actual lb ac⁻¹ during seeding. A burn off herbicide application with 0.1 L ac⁻¹ Authority, 0.75 L ac⁻¹ Glyphosate and 0.015L ac⁻¹ Aim was done 6 days after seeding to ensure control of weeds before peas emergence. Post emergence weeds were controlled by the application of 0.12 L ac⁻¹ Select mixed with 0.5% v/v Amigo adjuvant and 17.3 g ac⁻¹ Odyssey mixed with 0.5% v/v Merge adjuvant at 4 weeks after seeding. Pounce insecticide was applied at a rate of 0.054 L ac⁻¹ as a control measure for cutworm caterpillars during the same period as post emergence herbicide application. Several data were collected for analysis and these included; plant vigor, date of flowering, days to maturity, plant height at maturity, mildew and mycosphaerella blight incidence, lodging, grain yield, thousand kernel weight and protein content of grain on dry basis. The data were analyzed using Minitab 18 and mean separation was done at 5% level of significance.

Results

Results obtained in 2019 showed no significant differences in pea height or mildew and mycosphaerella disease incidence among the seven varieties. Disease incidences recorded were moderate for mycosphaerella and low to moderate for mildew. Days required to reach maturity were significantly different among pea lines and varieties (P=0.016). The earliest maturing variety was Meadow and it required 89 days to reach maturity but this was not significantly different from PG2908, PG2601 and PG3312 that required 89-90 days (Table 5.1a). The late maturing lines (PG3308 and PG6150) required 91 days to reach maturity. Six of the treatments were highly susceptible to lodging (5-7) and this could be a challenge during harvesting and might also result in poor quality of the seed. Treatment PG2601 had significantly lower lodging rating (3) compared to other treatments. This is a desirable characteristic which is considered by most farmers when selecting pea varieties to grow because it may have an impact on yield, quality, disease incidence and harvestability of field peas. There were significant differences in pea

seed yield and the highest yielding treatments were Meadow, PG2908 and PG2601 with 5073, 5141.2 and 5110.2 kg ha⁻¹ respectively. Protein content was also significant and ranged from 22.6% for Meadow to 24% for PG6150.

Table 5.1a Analysis of variance and mean comparison for plant height, mildew, mycosphaerella blight, days to maturity, lodging, seed yield, TKWT and protein content of peas at Melita in 2019

TRT	Variety	Height (cm)	Mildew (1-5)	Mycosphaerella (1-5)	DTM	Lodging (1-9)	Yield kg ha ⁻¹	TKWT (g)	Protein (%)
1	PG3312	84.7	2	2.7	90abc	6ab	4864.2bcd	209.3a	23.7abc
2	PG2601	80.7	2.3	2.3	90abc	3c	5110.2ab	209.5a	23.9ab
3	PG3308	78.0	2.3	2.7	91a	5b	4836cd	204.1a	23.6bc
4	PG6150	86.0	2.7	2.3	91a	7ab	4779.8d	204.2a	24.0a
5	PG2908	88.3	1.3	2.7	89bc	6ab	5141.2a	182.0b	23.1d
6	PG2805	91.3	1	2.3	90ab	7ab	4817cd	206.9a	23.3cd
7	Meadow	82.0	2	2.7	89c	5ab	5073abc	184.8b	22.6e
	CV	6.6	41.8	25.9	0.7	21.7	3.0	2.1	1.0
	P value	0.14	0.238	0.962	0.016	0.011	0.035	<0.001	<0.001

References

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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-Elroy Cober

Objectives

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

Background

Soybean is one of the most important oil and protein source used for both livestock and humans in many countries around the world. The seed quality of soybean is determined by the composition of oil, protein, fatty acids, sugars and minerals, which is also affected by the environment (Bellaloui et al. 2015). For both feed 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 climatic conditions of lower temperatures, shorter growing season and low rainfall. Nevertheless, many soybean varieties of early maturing groups are being developed with a focus on improved protein content (Vollmann et al., 2000).

Materials and Methods

The trial was initiated in 2018 by AAFC and will run until 2023 across Canada at Ottawa, Beloeil, in Ontario, Brandon, Melita, Roblin and Morden in Manitoba, Outlook and Saskatoon in Saskatchewan. In the 2019 growing season in Melita, the trial was arranged as randomized complete block design with 20 treatments (conventional varieties) replicated 4 times on Waskada loam soil. The treatments were inoculated with granular BASF inoculant prior to seeding at a depth of 1" on the 13th of May. Seeding was done under no till system on oats stubble and granular fertilizer blend was side banded at a rate of 7-35-20-7-2Zn (N-P-K-S) lb ac⁻¹ at the same time. Chemical weed control included a burnoff application with a single tank mix of 0.75L ac⁻¹ Roundup, 0.1 L ac⁻¹ Authority and 0.015 L ac⁻¹ Aim and in-season application of 0.91L ac⁻¹ Basagran + 0.12L ac⁻¹ Select and 0.5% v/v Amigo adjuvant in a single tank mix. During the season, Lorsban insecticide was applied to control cutworm while Matador was applied late in the season for the control of grasshopper populations at a rate of 30 ml ac⁻¹. Several observations were made and these included; emergence date (when 50% or more of plant had emerged from each plot), plant height at maturity, days to 50% flowering, days to maturity, harvest date, moisture content at harvest, grain yield and protein content. The data were analyzed by AAFC in Ottawa.

Results and Discussion

Summary results presented in this trial are for 2018 and 2019 growing season.

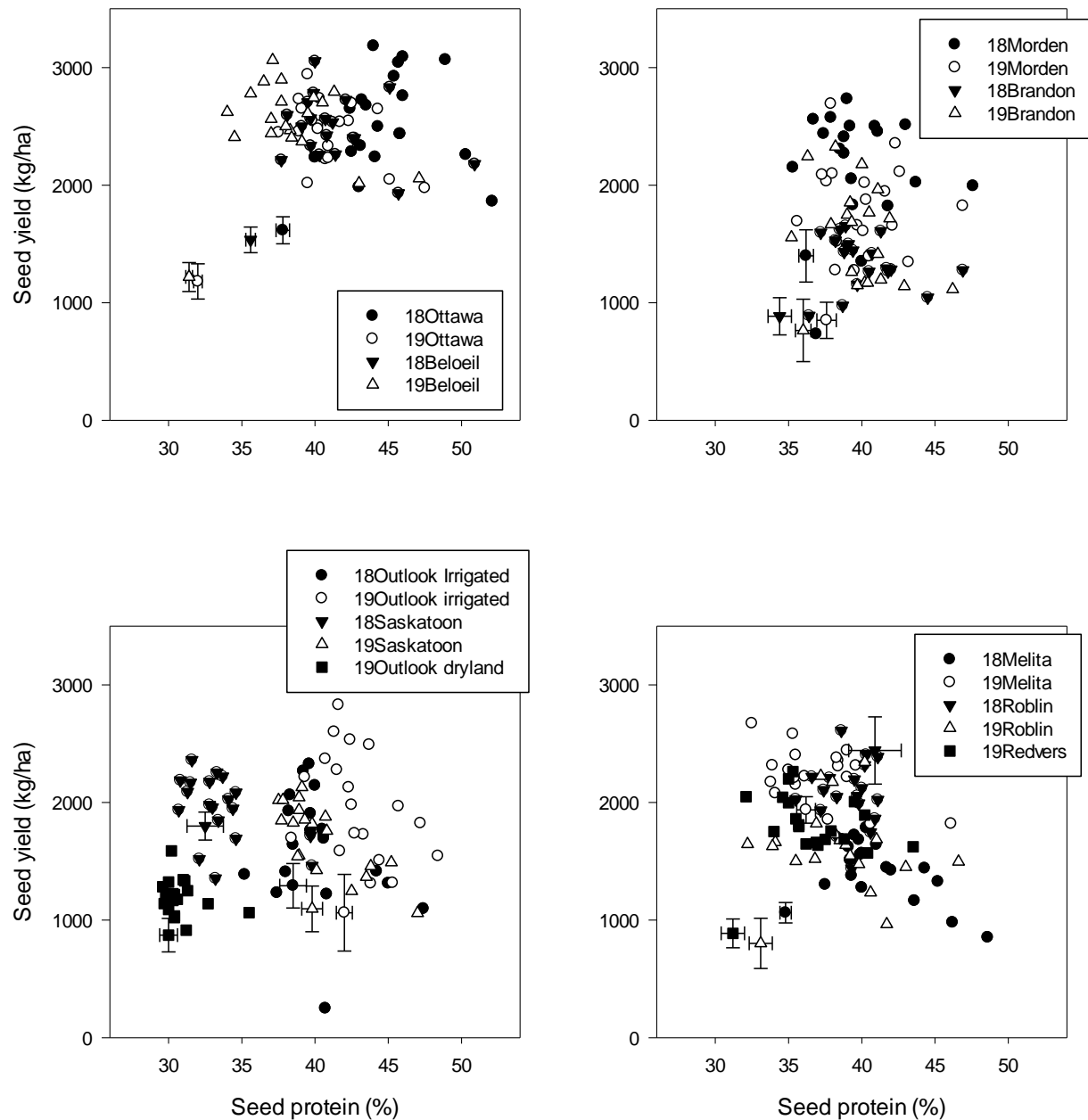


Figure 6a. Seed yield and protein for each site. The error bars are two standard errors and are shown for the non-nodulating line at each location.

At the eastern locations, 2019 was a lower protein year, included for the non-nodulating line. There was a striking difference between 2019 Outlook irrigated and dryland sites.

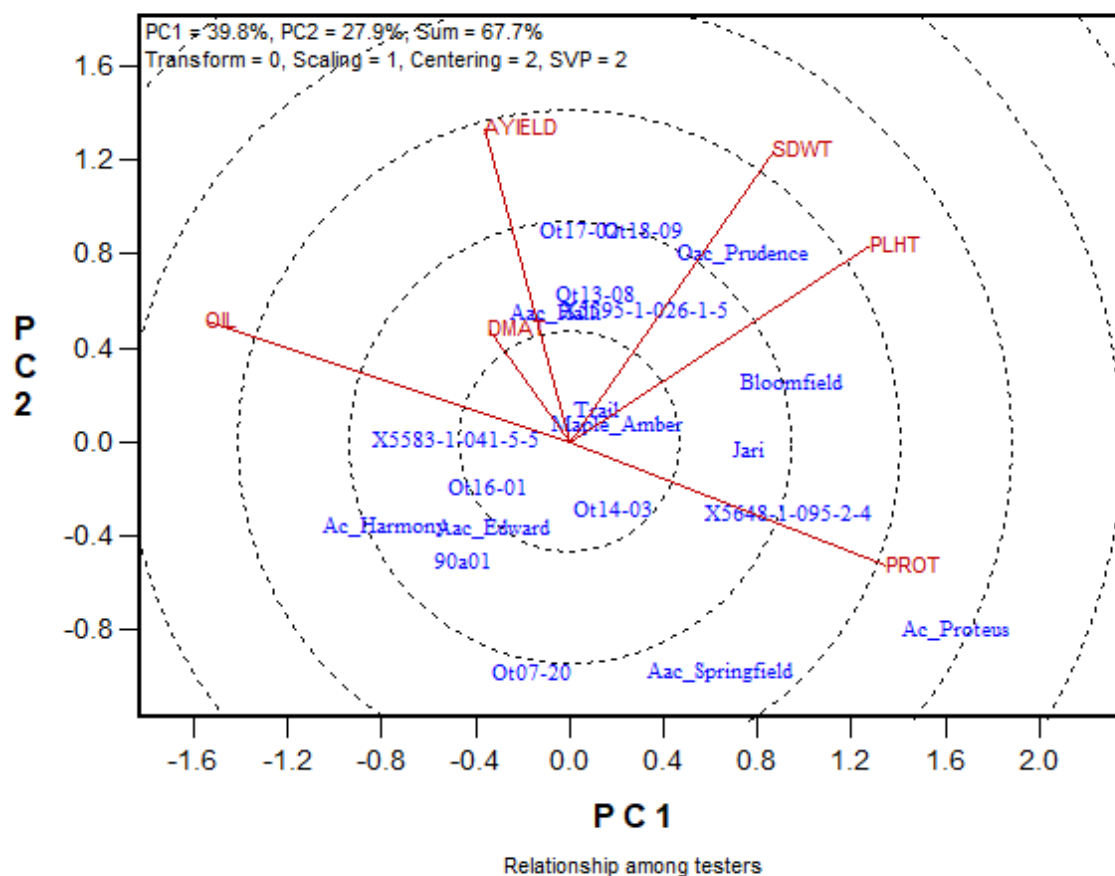


Figure 6b. GGEbiplot for all sites and agronomy data, 2018-2019.

In the biplot, parameters separated with a 180° angle are inversely related, such as protein vs. oil. Parameters at 90° angle are independent, such as seed weight vs. oil or protein. Parameters with a small angle are correlated.

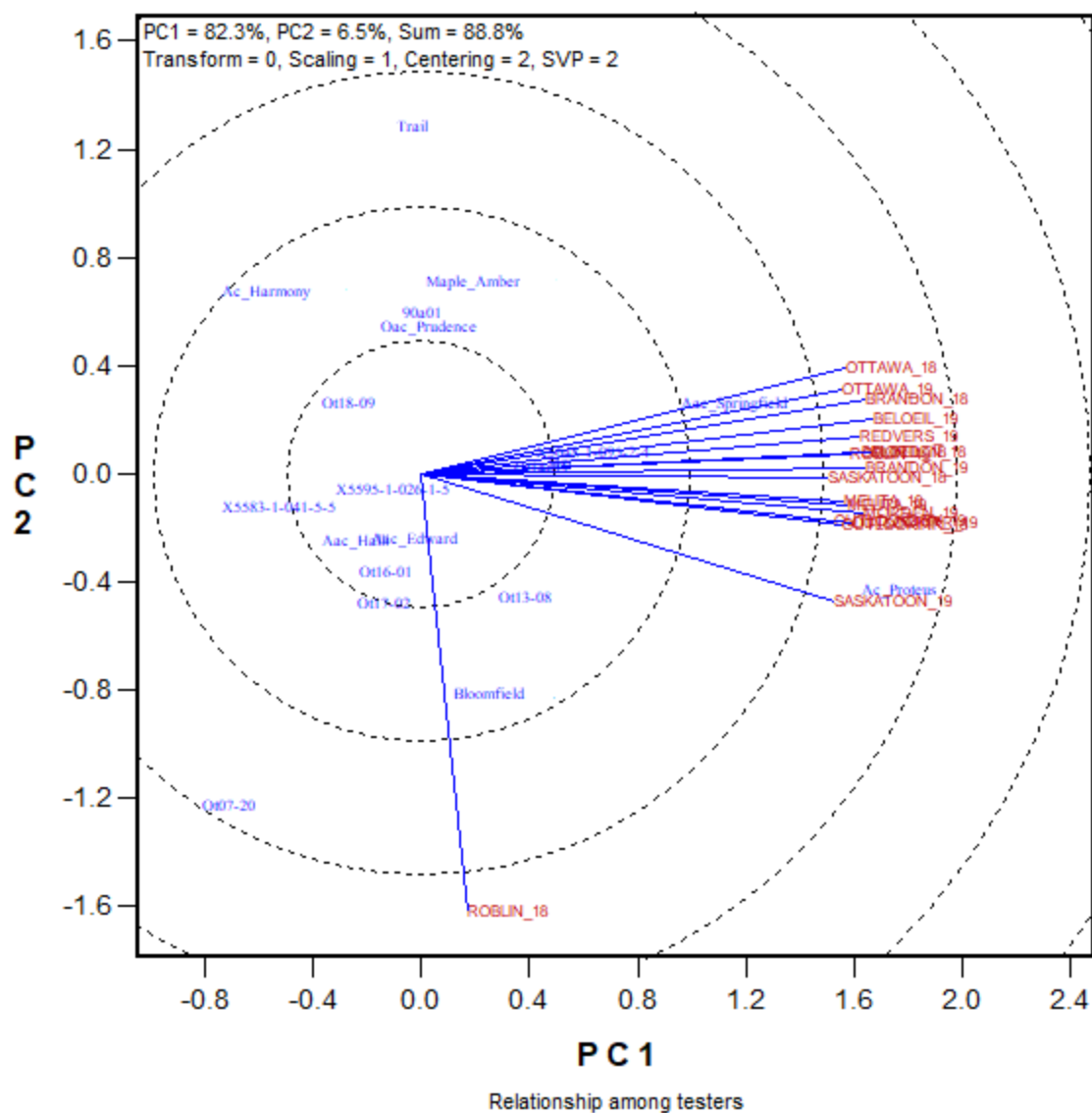


Figure 6c. A genotype by location biplot for seed protein content, 2018-2019.

As seen in Figure 6a, Roblin-2018 had high seed protein for the non-nodulating line (OT07-20) and in this biplot Roblin-2018 is distinct from all other locations. Something different happened at Roblin in 2018. The soil N fertility must have been high.

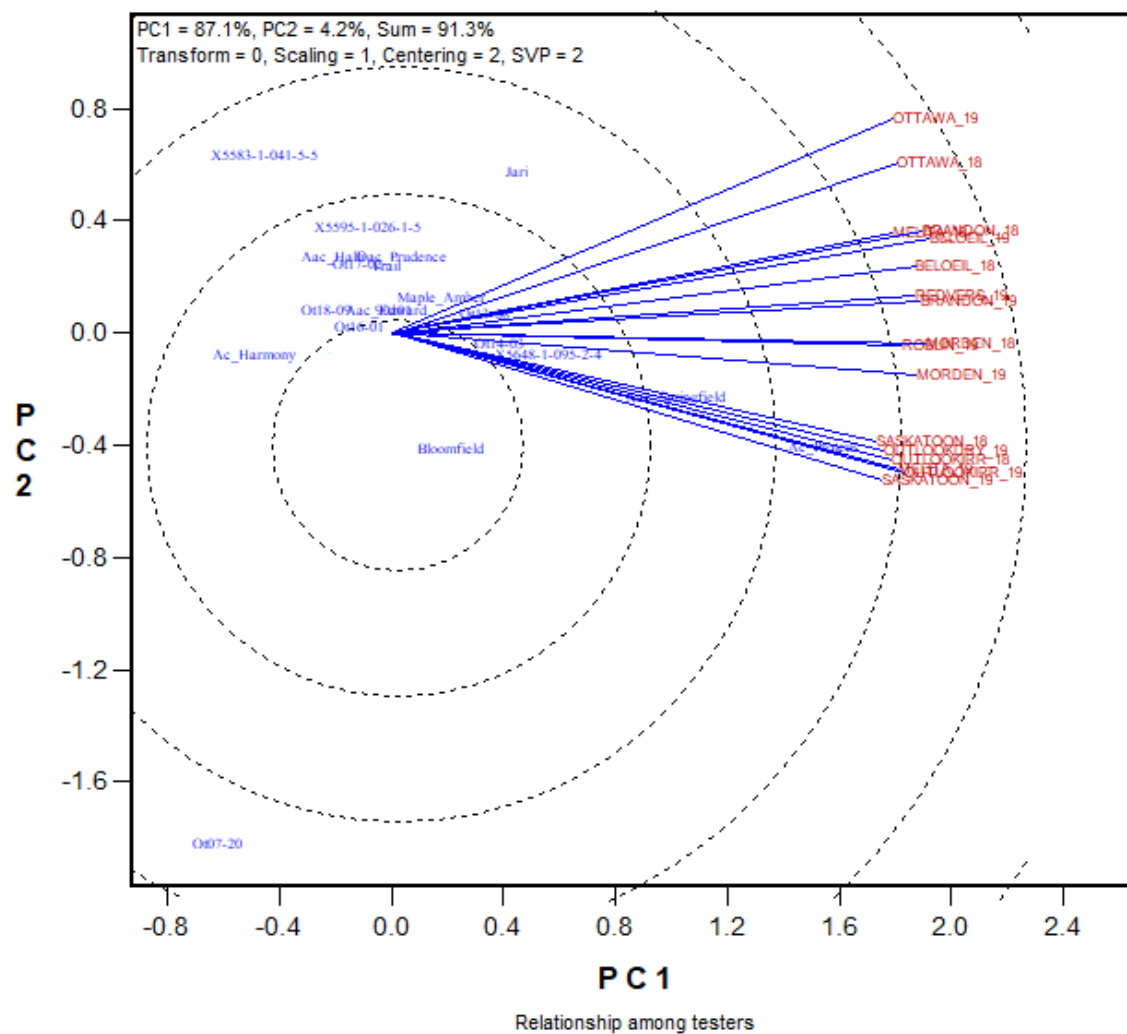


Figure 6d. A genotype by location biplot for seed protein content, 2018-2019 with Roblin-2018 excluded. In this biplot, we see some east-west south-north sorting of locations.

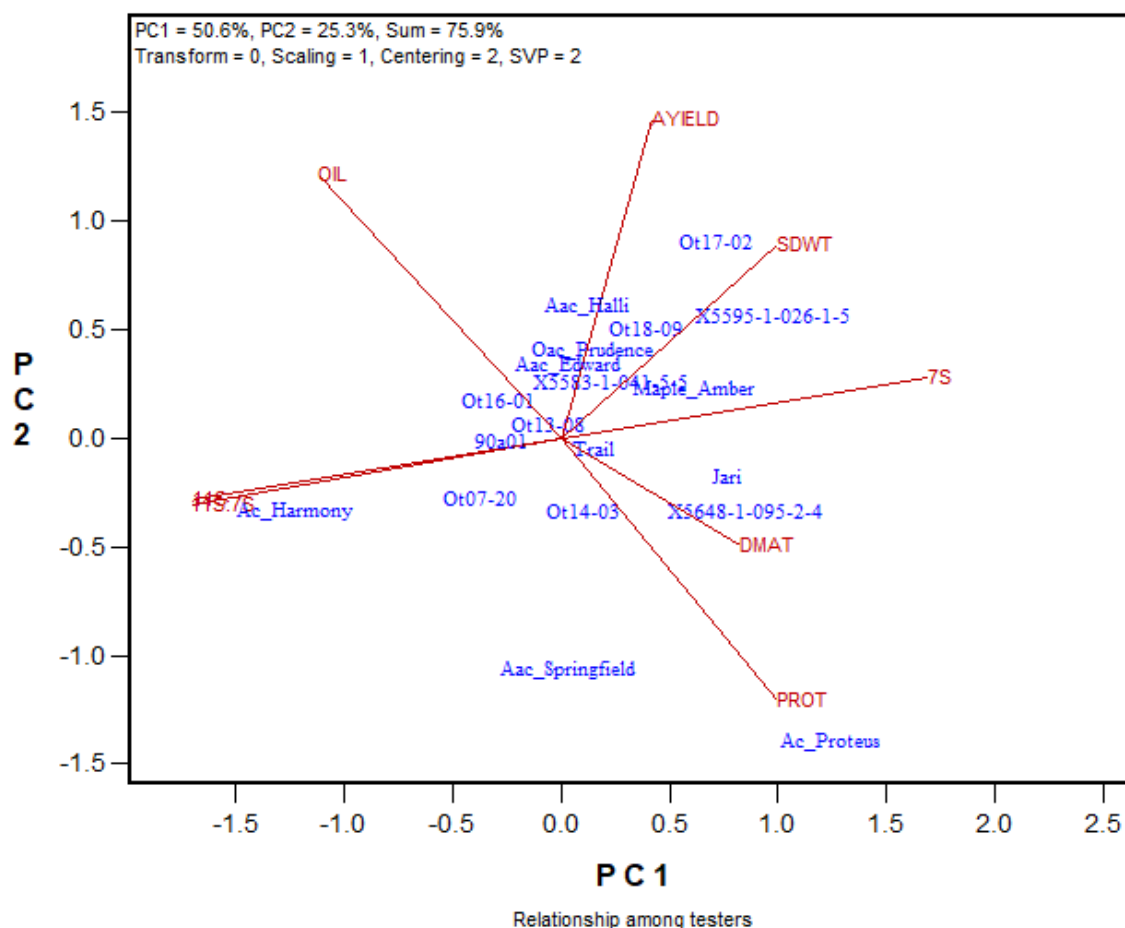


Figure 6e. Soybean protein quality analysis (11S:7S and 11S sit on top of each other) from 2018 grown seed is shown in this biplot.

For the three protein composition traits (11S, 7S and the 11S:7S ratio), there was no location by variety interaction, there was a replication within location effect, and variety effect. The two fractions are inversely related and there is a somewhat negative relationship between protein and 11S. This makes sense if sulphur containing amino acids are limited in soybean which means it may be difficult to combine higher protein with higher 11S:7S ratio. AAC Springfield seems somewhat promising in its combination of higher protein and higher 11S:7S ratio.

References

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7.0 Best Management Practices-flax demonstration

Project duration: 2018-2019

Collaborators: Manitoba Diversification Centres – Melita, Arborg, Roblin and Carberry

Objectives

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

Background

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

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

Flax requires a season length of nearly 110 days and out of these days, 50 are required for the vegetative stage, 25 for flowering and 35 between flowering and maturity. Considering that the Canadian Prairies are characterized by a short growing season, the crop is ideal for production in this region because reaching maturity is assured if seeding is done early (Johnston et al., 2002). Flax seeding dates vary among regions but it is best to establish the crop early, especially during the first week of May in order to ensure full utilization of the growing season in the case of the Prairies that experience an early fall frost. Practices such as nutrient application must be based on soil test results as well as considering the previous crop,

for instance, if the previous crop was an annual legume, nitrogen application must take into consideration nitrogen credits contributed by the legume hence reducing chances of over supplying nutrients to the flax crop (NDSU, 2007). Therefore, this small plot trial was conducted to demonstrate different management approaches to flax production and to recommend best management practices to flax producers.

Materials and Methods

Three farming practises: BMP, Improving and Historic farmer were established as double strip plots with three blocks each. Plots were not randomized. Plots at Melita measured 9 m long x 2.88 m wide. Seeding dates differed depending on the farming practices and agronomic practices were applied as indicated in Table 7a.

Table 7a: Treatment description for Best Management practices of flax at Melita in 2019

Action	Historic Farmer	Improving Farmer	BMP Farmer
Pre-Emergence Herbicide	None	Roundup (full 1L equivalent ac ⁻¹)	Roundup + Authority + Aim
Stubble	Oat	Oat	Oat
Seed Date	31 May 2019	21 May 2019	06 May 2019
Seed Rate	42 lbs ac ⁻¹	56 lbs ac ⁻¹	70 lbs ac ⁻¹
Seed Depth	1 inch.	1 inch.	5/8inch.
Target Fert. (lbs/ac Soil + Applied)		108-35-20-7-2Zn plus 5.0N liquid	108-35-20-7-2Zn (NPKS)
In crop Herbicides	Buctril M	Group 1 + Buctril M	Select 0.12 L ac ⁻¹ + 0.5% v/v Amigo
Fungicide	None	Headline EC	Priaxor at 30% flowering
Desiccant	Swath	Swath	None

Data collected included: plant vigor on a 1 to 5 scale at 3 weeks after seeding, 2 x 1 m plant count at emergence, disease rating, flower and maturity date, grain moisture content and yield. Since treatments were not randomized due to the nature of the demonstration trial, means were determined to appreciate differences in flax management systems.

Results and discussion

Seeding dates differed between sites with Melita seeding all demonstration plots by May 21 while Arborg seeded the last treatment on June 4 (Table 7b). At Arborg, plant density in BMP farmer plots was 323 ppms while the Improving and Historic farmer plots had 332 and 346 ppms, respectively. At Melita, plant density was 500 ppms in BMP farmer plots seeded on 6 May while the Improving farmer, seeded on 13 May, and Historic farmer, seeded on 21 May, had 474 and 248 ppms, respectively. Differences between the two sites could be explained by timing of seeding as well as differences in agro-ecological zones.

Plant height at flowering was 47, 50 and 53 cm for BMP, Improving and Historic farmer plots at Arborg, respectively. This parameter was not measured at Melita. At Arborg, the expectation was that the early seeded demonstration plots would but that was not the case, probably due to unfavorable soil conditions at seeding. Days to reach physiological maturity differed between sites. Although Historic farmer plots were the last to be seeded at Arborg, they required fewer days (84) to reach maturity compared to Improving and BMP farmer plots, which required 92 and 96 days, respectively. On the contrary, Improving farmer plots required 99 days while BMP and Historic farmer plots required 94 and 97 days to reach maturity at Melita, respectively. There were no observed differences in lodging among flax management systems and between the two sites.

At both sites, BMP farmer plots recorded more grain yield compared to Historic and Improving farmer plots. The highest yield was 38 bu ac⁻¹ for BMP while the lowest was 14 bu ac⁻¹ at Melita. At Arborg, grain yield ranged from 27 to 34 bu ac⁻¹. Based on the results from this demonstration trial, Historic farmer practice appear not to be a viable option as a management strategy for flax production as it results in significantly low grain yield as observed at Melita. It would be best for flax producers to consider BMP farmer practice, which involves application of nutrients based on soil tests, early seeding date to maximize on growing season length and effective control of weeds, disease and insect pests, which is all based on scouting.

Table 7b. Seed date, mean plant density, plant height, days to maturity, lodging, plant vigor and yield obtained from 3 flax management practices at Arborg and Melita in 2019

Arborg						
Method	Seed Date	Emergence (ppms)	Plant Height (cm)	DTM	Lodging 1-5	Yield bu ac ⁻¹
Historic farmer	04-Jun	342	53	84	1	27
Improving farmer	22-May	336	50	92	1	31
BMP farmer	15-May	323	47	96	1	34
Melita						
Method	Seed Date	Emergence (ppms)	Plant vigor (1-5)	DTM	Lodging 1-5	Yield bu ac ⁻¹
Historic	21-May	248	3.5	97	1	14
Improving	13-May	474	4.3	99	1	26
BMP	06-May	500	5	94	1	38

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8.0 Determining the optimum seeding window for soybeans in Manitoba

Project duration: 2017-2019

Collaborators: University of Manitoba, MPGA, Kristen MacMillan

Objectives

- The objectives of this study were to determine the optimum seeding window for soybeans across Manitoba growing regions.

Background

Soybean is an important legume crop that contains significant amounts of isoflavone compounds which play a crucial role in human health (Al-Tawaha and Seguin, 2006). Soybean production on the Prairies is mainly limited by the cool short growing season that characterize this region. There is great potential for increasing total area under production but timing of seed establishment is crucial in achieving profitable yields. Traditional recommendations are to plant soybeans when soil temperature has warmed to at least 10°C, which is typically May 15-25 in Manitoba (Manitoba Agriculture). However, farmers have started to seed soybeans earlier (Page et al., 2019) and recent work by Dr. Yvonne Lawley and Cassandra Tkachuk (2017) supports this trend. They evaluated seeding dates across a range of soil temperatures from 6 to 14°C in 2014 and 2015; the earliest seeding dates maximized yield regardless of soil temperature and it was concluded that calendar date is a superior indicator. To update seeding date recommendations across a wider range of environments and using defined calendar dates, this study was initiated at Arborg, Carman, Dauphin and Melita in 2017 and continued through 2019.

Materials and Methods

The experimental design is a split plot RCBD, with seeding window as the main plot and variety as the split plot. The four seeding windows tested were “very early” (7 May), “early” (16 May), “normal” (28 May)

and “late” (7 June). The short season variety S007Y4 and mid-season variety NSC Richer were seeded at 1” depth on oat stubble within each seeding window. Fertilizer was banded during seeding at a rate of 7-35-20-7-22n (N-P-K-S) actual lb ac⁻¹. After seeding the first treatment on May 7, the whole trial area was sprayed with 0.1 L ac⁻¹ Authority, 0.75 L ac⁻¹ Roundup and 0.015 L ac⁻¹ Aim to burnoff weeds before crop emergence. Post emergence herbicide application was done during the season with 0.33 L ac⁻¹ Roundup. Lorsban insecticide was sprayed for the control of cutworm early in the season while Matador was applied at a rate of 0.03 L ac⁻¹ to control grasshoppers late in the growing season. Data collected included; plant count at emergence, days to R1, plant height at maturity, days to maturity, grain yield, green seed count and analysis of oil and protein content. All data were analyzed by the University of Manitoba.



Results and discussion

Final results and recommendations for the Soybean seeding window will be made available during the 2020 growing season.

Acknowledgements

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

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

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Objectives

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

Methods

Field trials were completed during each of three growing seasons (2017, 2018, and 2019) at four locations (Indian Head, Melfort, Scott, and Melita). The treatments were two hybrids (LL versus RR) and four pre-harvest application options plus an untreated control for each hybrid. In 2017, the two hybrids were L233P LL and 45M35 RR. In 2018 and 2019, L233P was replaced with L255PC in hopes that it would be more similar to 45M35 with respect to crop development throughout the season and maturity date. The ten treatments that were evaluated are described in Table 9a below. Timing of the pre-harvest treatments were targeted for 60-75% seed colour change (glyphosate and saflufenacil) or approximately 90% seed colour change (glufosinate ammonium and diquat); however, the actual crop stages varied to some extent due to differences between hybrids, logistic considerations and weather. For all products, excluding glyphosate applied alone (where lower application volumes were permitted but not required), the minimum solution volume was 187 l/ha (20 U.S. gallons per acre). Treatment 7 (RR – glufosinate ammonium) was not included at the 2017-Melfort site due to a misinterpretation of the protocol. Overall, the wide range of environmental conditions combined with a certain amount of variation in treatment application and harvest timing provided a robust evaluation of the treatments.

Table 9a: Treatment list for Canola Pre-harvest Application Study (CARP 2017.9).

Treatment Name	
1) LL – untreated	6) RR – untreated
2) LL – glyphosate (890 g ai/ha) ^z	7) RR – glufosinate ammonium (408 g ai/ha) ^y
3) LL – saflufenacil (50 g ai/ha) ^z	8) RR – saflufenacil (50 g ai/ha) ^z
4) LL – glyphosate (890 g ai/ha) + saflufenacil (50 g ai/ha) ^z	9) RR - glyphosate (890 g ai/ha) + saflufenacil (50 g ai/ha) ^z
5) LL – diquat (40 g ai/ha) ^y	10) RR – diquat (40 g ai/ha) ^y

LL – glufosinate ammonium tolerant; RR – glyphosate tolerant; ^z 60-75% seed colour change; ^y 90% seed colour change

Seeding was generally completed within the first three weeks of May with canola direct-seeded into cereal stubble, target seeding rates ranging from 120-125 seeds m⁻², and row spacing ranging from 24-30 cm. Plot size varied across locations depending on seeding equipment and other site-specific considerations. With the exception of 2017-Melfort where no herbicides were applied, weeds were controlled using registered pre-emergent and in-crop herbicides. At Indian Head and Melita, conventional canola herbicide options (i.e. Edge, Lontrel, Muster, etc.) were utilized while, at Scott and Melfort in 2018 and 2019, each variety was sprayed with its partner in-crop herbicide (i.e. glyphosate or glufosinate ammonium). Insecticides were only applied if necessary while foliar fungicides were applied preventatively to reduce the risks of sclerotinia stem rot at all locations except Melita where no foliar fungicides were applied. Harvest dates varied with site-year; however, all treatments were harvested on the same date for individual hybrids and, in most cases, both varieties were harvested on the same date. The intent was to give the earlier pre-harvest applications (glyphosate and saflufenacil) a minimum of 14 days to affect crop dry-down while also harvesting within 14 days of the later applications (i.e. diquat and glufosinate ammonium); however, actual timings of operations varied. The challenge was to find the right balance between giving the pre-harvest applications enough time to work while also harvesting the plots early enough that treatment effects (i.e. differences in whole plant and seed moisture content) would still be evident. In many cases, this meant harvesting when some plots were still relatively tough/green; however, in some, the canola dried down rapidly and harvest was completed relatively early after the treatment applications (i.e. 10 days at Melita 2019). In other cases, cold, wet late-season weather delayed maturity, treatment applications and harvest; thus diminishing our ability to detect treatment differences (i.e. Melfort 2019).

Various data were collected to provide explanatory background information and assess treatment effects on both plant/seed dry-down and grain quality. As an indicator of overall site establishment and variability, plant densities were estimated by counting plants in two separate 1 m sections of crop row

per plot. These measurements were completed in the spring, after emergence was complete, and the values were converted to plants m^{-2} . Visual stem dry-down ratings were completed prior to harvest where the front and back of each plot was rated on a scale of 0-100 where a rating of 100 indicated that the plants, focusing on the stems, visually appeared to be completely dried down. These values were very subjective and, therefore, of somewhat limited practical value. Whole plant moisture at combining was determined by harvesting all of the above-ground biomass from a minimum of 1 m of crop row within 24 hours of combining, determining both the fresh and dry weights, and calculating percent (wet basis) gravimetric water content $[(\text{fresh weight} - \text{dry weight})/\text{fresh weight}]$. At Indian Head, these samples were collected from unharvested crop rows while, at the other sites, the plots were smaller so samples were collected prior to combining where the entire plot areas were harvested. Seed moisture content was measured in a similar manner and using the same formula as opposed to using electronic meters. The rationale for using gravimetric water content for the seed was that we expected the values to occasionally fall outside of the testable limits of approximately 5.5-15%. While this approach generally worked well, there were cases where the absolute values were unusually low and it appeared that either some drying had occurred between sampling and fresh weight determination or the samples were not completely dried before dry weight determination (i.e. seed moisture and Scott and Melfort in 2017). This was also observed for the whole plant moisture measurements to a certain extent. Seed yields were corrected for dockage and to a uniform moisture content of 10%. Seed weight was determined by counting a minimum of 500 seeds using automated seed counters, weighing the counted seeds to the nearest 0.00 g, and calculating g/1000 seeds. Green seed was assessed by crushing 500 seeds per plot, counting any distinctly green seeds, and converting the values to percent green seed. Daily temperatures and precipitation amounts were compiled from the nearest Environment Canada weather station or Manitoba Agriculture weather stations in the case of Melita site.

Exploratory statistical analyses and basic evaluation of the data confirmed that the results varied by site-year due to factors such as hybrid, weather, timing of operations, and the specific methods/equipment used for plant and seed moisture determination. As such, it was difficult to group site-years in a meaningful manner that would be advantageous over simply analyzing each site-year individually. While this approach creates challenges for summarizing the results in a simple and precise manner, it would be inappropriate to compare values directly across site-years for many variables and misleading to simply average data across sites given the high variability and, at times, contrasting results. Log and arcsine transformations were explored for the percentage data; however, none consistently improved

model convergence and therefore the original, untransformed values were analyzed and summarized for simplicity. Data were analyzed using the Mixed procedure of SAS with the effects of treatment (hybrid x pre-harvest treatment) considered fixed and replicate effects considered random. Individual treatment means were separated using Fisher's protected LSD test. Additional contrasts were used to compare the control treatments to all treated plots (untreated versus treated) and individual pre-harvest herbicide/desiccant products directly to their respective control treatments, averaged across canola herbicide systems where applicable. For the most part, overall treatment effects and differences between individual means were considered significant at $P \leq 0.05$; however, for the contrasts, actual p-values are provided but sites where $P \leq 0.10$ were considered responsive when summarizing and interpreting these results.

Results

Crop establishment:

Plant populations were measured and analyzed for supplemental background information and could not be affected by the pre-harvest herbicide/desiccant applications as these treatments had not yet been applied when the measurements were completed. Overall F-test results are provided with the individual treatment means in Table 9b. Seeding rates were adjusted for seed size and germination with the objective of achieving similar plant populations for both hybrids. Although the overall densities varied widely from site-to-site, the overall F-test was not significant at 10/12 site-years indicating that plant populations were similar regardless of treatment in the vast majority of cases. The exceptions were Indian Head-2017 and Melita-2017 where the responses were mainly due to generally lower plant densities with the RR compared to the LL hybrid.

Visual stem dry down and whole plant moisture content:

At Melita (Table 9c), visual stem dry-down ratings varied in 2017 and 2019 ($P < 0.001$), but not in 2018 where all values were rated as 100% (i.e. completely dried down) and not statistically analyzed. For both RR and LL canola in 2017 and 2019 at Melita, diquat led to the highest visual dry-down ratings. The remaining options generally resulted in intermediate values but the specific results varied to some extent. For whole plant moisture content, treatment effects were highly significant in 2017 and 2019 ($P < 0.001$ -0.032) but only marginally so in 2018 ($P = 0.079$). For LL canola at Melita, diquat provided the most consistent benefit, followed by glyphosate while whole plant moisture content with saflufenacil applied

alone was always similar to the control. For RR canola at Melita, whole plant moisture content values were variable and the only significant effect of interest was a reduction with diquat in 2017.

Seed dry down and yield:

Unlike most agronomy studies, we were not particularly interested in effects on seed yield; however, data were statistically analyzed and summarized nonetheless to provide background information on overall productivity and, in certain cases, the relative harvestability of individual treatments. To be clear, none of the products that were evaluated should impact yield if used according to label directions and harvest is completed within a reasonably timely manner; however, treatment effects did occasionally occur in the current project. Yield differences between hybrids could be reasonably expected but pre-harvest treatment effects would indicate either improper timing (i.e. reduced yield when applied too early) or differences in harvest loss resulting from variation in crop dry-down (i.e. green crop more difficult to feed into combine and thresh. We monitored for pod shattering but no substantial losses or treatment differences were ever noted. At Melita (Table 9d), there was no effect on yield in 2017 or 2018 ($P = 0.070$ - 0.422) but in 2019 the effect was significant ($P = 0.001$). The observed differences at Melita 2019 were difficult to explain and are attributed to a combination of hybrid effects and naturally occurring variability. The overall F-tests indicated treatment effects for seed moisture in 2017 and 2019 ($P = 0.012$ - 0.033) but not 2018 ($P = 0.264$) (Table 9d). Specifically, for LL canola at Melita, the only notable effect on seed moisture content was a significant reduction with diquat in 2019. For the RR canola, both glufosinate ammonium and diquat reduced seed moisture in 2017 but no individual options had a significant impact in either 2018 or 2019.

Seed quality:

Seed size is an important yield component and, similar to what occurs with swathing too early, applying pre-harvest herbicides or desiccants ahead of the recommended crop stage could conceivably lead to smaller seeds and subsequently lower yields. We would not generally expect any such impact when products are applied according to the label recommendations. Results for this variable are presented in Table 9e for Melita.

The other seed quality component that was assessed and potentially expected to be affected by the pre-harvest treatments was distinctly green seed. At Melita (Table 9e), the overall F-test for green seed was significant in all three years ($P < 0.001$ - 0.054) and the specific nature of the treatments was also consistent. In all three years, values for all LL treatments were similar to one another; however, for the RR treatments,

percent green seed was always significantly higher with diquat than either the control or any other pre-harvest options.

Table 9b. Treatment means and tests of fixed effects for plant density at Melita from 2017-2019.
Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test; $P \leq 0.05$).

Treatment ²	2017	2018	2019
----Plant Density (plants m ⁻²)----			
1) LL – Control	37.8 bc	34.7 a	87.6 a
2) LL – Glyphosate	34.7 cd	43.0 a	74.6 a
3) LL – Saflufenacil	43.5 abc	35.2 a	77.2 a
4) LL – Safl + Glyph	56.0 a	40.9 a	80.3 a
5) LL – Diquat	50.8 ab	38.9 a	78.2 a
6) RR – Control	20.7 de	53.9 a	73.6 a
7) RR – Gluf. Amm.	15.0 e	42.0 a	73.1 a
8) RR – Saflufenacil	19.2 e	42.5 a	69.9 a
9) RR – Safl + Glyph	13.0 e	50.8 a	74.6 a
10) RR – Diquat	19.2 e	52.8 a	70.0 a
S.E.M.	5.76	6.16	6.19
LSD ^x	14.25	ns	Ns
Pr > F (p-value)	<0.001	0.230	0.640

²Pre-harvest herbicide/desiccant treatments were not yet applied at the time of these measurements; only differences between hybrids may be logically explained by anything other than background variability and experimental error

Table 9c. Treatment means and tests of fixed effects for final visual stem dry-down ratings and whole plant gravimetric moisture content at Melita, Manitoba. The treatments were pre-harvest/desiccation options for glufosinate ammonium (LL) and glyphosate (RR) tolerant canola. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test; $P \leq 0.05$).

Treatment	MT-2017	MT-2018	MT-2019	MT-2017	MT-2018	MT-2019
	-- Visual Stem Dry-Down Ratings (0-100) ^z --			----- Whole Plant Moisture Content (%) ^y -----		
1) LL – Control	71.3 cd	100	42.5 ef	30.4 a-d	12.2 a	24.4 abc
2) LL – Glyphosate	88.8 ab	100	37.5 f	21.6 d	14.5 a	29.1 a
3) LL – Saflufenacil	71.3 cd	100	37.5 f	31.2 ab	16.2 a	28.5 a
4) LL – Safl + Glyph	83.8 b	100	57.5 cde	25.1 bcd	14.5 a	24.9 ab
5) LL – Diquat	91.3 ab	100	73.8 abc	21.8 cd	9.2 a	15.3 cde
6) RR – Control	67.5 d	100	57.5 cde	36.1 a	8.5 a	16.1 b-e
7) RR – Gluf. Amm.	90.0 ab	100	81.3 ab	28.2 a-d	8.1 a	18.4 cde
8) RR – Saflufenacil	82.5 bc	100	65.0 bcd	33.9 ab	6.2 a	8.7 e
9) RR – Safl + Glyph	86.3 ab	100	52.5 def	30.7 abc	9.2 a	16.8 b-e
10) RR – Diquat	97.5 a	100	85.0 a	26.5 bcd	8.3 a	12.0 de
S.E.M.	5.23	—	6.57	3.06	2.59	0.31
LSD ^x	12.34	—	18.87	8.89	ns	0.91
Pr > F (p-value)	<0.001	—	<0.001	0.032	0.079	<0.001

^zFinal ratings completed at harvest ^yGravimetric water content of above-ground plant material (including grain) at harvest

Table 9d. Treatment means and tests of fixed effects for seed moisture content and yield at Melita, Manitoba. The treatments were pre-harvest/desiccation options for glufosinate ammonium (LL) and glyphosate (RR) tolerant canola. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test; $P \leq 0.05$).

Treatment	MT-2017	MT-2018	MT-2019	MT-2017	MT-2018	MT-2019
	----- Seed Moisture Content (%) ^z -----			----- Seed Yield (kg/ha) ^y -----		
1) LL – Control	8.7 abc	5.0 a	10.0 a	3584 a	2219 a	3060 bc
2) LL – Glyphosate	8.1 bcd	4.9 a	9.4 abc	3496 a	2123 a	2993 cd
3) LL – Saflufenacil	8.2 bcd	5.0 a	9.9 ab	3502 a	2088 a	3065 bc
4) LL – Safl + Glyph	8.5 a-d	5.0 a	9.7 ab	3689 a	2171 a	3140 bc
5) LL – Diquat	8.1 bcd	4.8 a	7.4 d	3648 a	2025 a	2818 d
6) RR – Control	9.5 a	5.0 a	9.0 abc	3613 a	2145 a	3196 bc
7) RR – Gluf. Amm.	7.8 cd	5.1 a	8.0 cd	3524 a	2278 a	3443 a
8) RR – Saflufenacil	9.1 ab	4.9 a	8.5 bcd	3436 a	2248 a	3225 ab
9) RR – Safl + Glyph	8.7 abc	4.8 a	8.9 abc	3304 a	2237 a	3242 ab
10) RR – Diquat	7.5 d	4.9 a	8.2 cd	3577 a	2127 a	3209 bc
S.E.M.	0.43	0.08	0.63	122.4	77.2	92.6
LSD ^x	1.13	ns	1.45	ns	ns	230.7
Pr > F (p-value)	0.033	0.264	0.012	0.070	0.422	0.001

^zGravimetric water content of canola seed at harvest ^yCorrected for dockage and to 10% seed moisture content

Table 9e. Treatment means and tests of fixed effects for seed weight and percent distinctly green seed at Melita, Manitoba. The treatments were pre-harvest/desiccation options for glufosinate ammonium (LL) and glyphosate (RR) tolerant canola. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test; $P \leq 0.05$).

Treatment	MT-2017	MT-2018	MT-2019	MT-2017	MT-2018	MT-2019
	----- Seed Weight (g/1000 seeds) -----			----- Green Seed (%) -----		
1) LL – Control	3.28 a	2.25 b	2.28 b	0.3 bc	0.3 bc	0.1 b
2) LL – Glyphosate	3.21 a	2.27 b	2.21 b	0.1 c	0.3 c	0.4 b
3) LL – Saflufenacil	3.20 a	2.25 b	2.29 b	0.1 c	0.7 ab	0.5 b
4) LL – Safl + Glyph	3.18 a	2.28 b	2.24 b	0.4 bc	0.4 abc	0.2 b
5) LL – Diquat	3.21 a	2.31 b	2.15 b	0.1 c	0.5 abc	0.3 b
6) RR – Control	3.24 a	2.57 a	2.59 a	0.9 b	0.2 c	0.3 b
7) RR – Gluf. Amm.	3.21 a	2.59 a	2.57 a	0.7 bc	0.2 c	0.2 b
8) RR – Saflufenacil	3.27 a	2.57 a	2.64 a	0.5 bc	0.3 c	0.2 b
9) RR – Safl + Glyph	3.27 a	2.58 a	2.60 a	0.2 bc	0.2 c	0.2 b
10) RR – Diquat	3.29 a	2.52 a	2.62 a	1.9 a	0.7 a	1.1 a
S.E.M.	0.073	0.037	0.084	0.24	0.13	0.14
LSD ^x	Ns	0.091	0.153	0.71	0.38	0.42
Pr > F (p-value)	0.864	<0.001	<0.001	< 0.001	0.054	0.004

Table 9f. Selected agronomic information for canola desiccation trial at Melita in 2019

Factor/Operations	Melita, MB 2019
Previous Crop	Oat
Variety	L255PC (LL) / 45M35 (RR)
Pre-emergence Herbicide	None
Seeding Date	May-8
Seeding Rate	125 seeds/m ²
Row spacing	24 cm
Fertility (kg N-P ₂ O ₅ -K ₂ O-S/ha)	121-39-22-8 + 2Zn
In-crop Herbicide	297 ml Centurion/ha + 20 g Muster/ha (Jun-6)
Fungicide	none
Insecticide	198 ml Pounce 384 EC/ha (May-27) 133 ml Pounce 384 EC/ha (Jun-6)
Pre-harvest Applications	All treatments (Aug 13)
Harvest date	Aug-23 (all treatments)

10.0 Linseed Coop Evaluation

Project duration: 2018-2020

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

Funding: Manitoba Flax Growers Association, BASF

Objectives

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

Background

Canada is the world's number 1 producer of flax and its production in North America dates back to the 1800s. Primarily, flax is produced for its fibre or oil, but in Canada, most farmers grow seed flax for oil extraction. Consumption of flax seed by humans has largely increased due to its health benefits of omega 3 oils, high fibre content and presence of anti-carcinogenic compounds known as lignans (Flax Council of Canada, 2015; You et al., 2016). Canadian Flax varieties are mainly developed for improvement of their

oil content and quality. Objectives differ among flax breeding programs but most target to optimize seed yield while maintaining oil content greater than 45%, alpha linoleic acid content greater than 50%, disease resistance, early maturity and resistance to lodging (Hall et al., 2016). Development of flax varieties is a continuing process that makes use of germplasm created by the collaborative efforts of flax breeders and researcher over many years (You et al., 2016). Canadian flax breeding started in the early 1900s, and flax varieties have been released since 1910. Continued development and release of new varieties under varying weather conditions would help expand variety choices by flax farmers as well as increase availability of food, feed and fibre to the ever increasing global population.

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 5/8" depth on May 8th under oats stubble. Fertilizer was banded during seeding at a rate of 108-35-20-7-2Zn actual (N-P-K-S) lb ac⁻¹ following recommendations as per soil test results. Chemical weed control included; 0.1 L ac⁻¹ Authority, 0.75 L ac⁻¹ Roundup and 0.015 L ac⁻¹ Aim applied as a burnoff after seeding and 0.12 L ac⁻¹ Select + 0.5% v/v Amigo adjuvant and 0.91 L ac⁻¹ Basagran applied as post emergence herbicide for control of grasses and some broad leaf weeds.

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

Flax yield data presented are for zone 1 and 3, which are characterized by Black and Grey soils in Western Canada. Zone 1 is considered to have a longer growing season compared to zone 3. Locations in zone 1 included; Melita (MB), Redvers (SK) and Indian head (SK) while zone 3 included; Arborg (MB), Roblin (MB), Vegreville (AB), Melfort (SK) and Codette (SK). Flax seed yield data (Table 10.0) from Melita showed that FP entries yielded more seed compared to checks and SVPG varieties. The highest ranked (1st) variety (FP2594) yielded 3030 kg ha⁻¹ while the lowest ranked (20th) check (AAC Bright) yielded 2560 kg ha⁻¹ in 2019. Overall, seed yield was not much variable as indicated by the low coefficient of variation of 4.4%. Some varieties did not differ in seed yield, for example, CDC Dorado, ND Hammond and FP2589 ranked

13th with 2720 kg ha⁻¹. Check variety CDC Bethune was ranked 11th, similar to SVPG entry AAC Marvelous with 2700.7 kg ha⁻¹. First year entries, FP2590 and FP2593 were both ranked 3rd and yielded 2930 kg ha⁻¹. Similar to Melita results, FP entries were ranked higher compared to SVPG entries and some check varieties at Roblin. Mean seed yield was 520 kg ha⁻¹ lower at Roblin compared to Melita and this could be attributed to differences season length between the two sites. Ranking flax varieties based on seed yield is necessary in selecting varieties that are suitable for production in a given environment. It also aides both breeders in deciding the varieties to consider registering for commercial production of continued breeding.

Table 10.0 Flax yield ('00 kg ha⁻¹) and variety ranking from Melita (Zone1) and Roblin (Zone 3) in 2019

ENTRY	Melita	Ranking†	Roblin	Ranking
Checks	Yield		Yield	
CDC Bethune	27.7	11	22.8	9
AAC Bright	25.6	20	21.2	14
CDC Glas	27	16	19.5	19
SVPG Entries				
CDC Buryu	26.5	18	23.4	8
CDC Dorado	27.2	13	19.3	20
ND Hammond	27.2	13	21.0	15
AAC Marvelous	26.6	17	22.7	12
AAC Prairie Sunshine	27.7	11	21.0	15
CDC Rowland	28.3	8	20.5	17
Topaz	26.5	18	20.5	17
3rd Year Entries				
FP2566	28.6	6	24.4	6
FP2567	27.9	10	22.8	9
FP2573	29.2	5	25.7	2
1st Year Entries				
FP2589	27.2	13	21.9	13
FP2590	29.3	3	24.6	5
FP2591	29.5	2	25.4	3
FP2592	28.2	9	25.2	4
FP2593	29.3	3	25.9	1
FP2594	30.3	1	22.8	9
FP2595	28.5	7	24.2	7
Mean	27.9		22.7	
C.V. %	4.4		8.9	
LSD	2.5		3.92	
No. of Reps	3		3	

†Ranking of flax varieties and lines based on seed yield from highest to the lowest. Arborg results were not included because of high coefficient of variation in 2019.



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11.0 Determining agronomic suitability of European flax (linseed) cultivars in Manitoba

Project Duration: 2018-2019

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

Objectives

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

Background

Flax is a temperate industrial oilseed crop grown mainly in Canada, China and Russia. Currently available genetic resources may accelerate the accomplishment of breeding objectives such as yield, early maturity, disease resistance and seed oil content (Hall et al., 2016). Canadian Prairies produce more than 40% of the world's flax for oil and are the largest exporters of linseed in the world (Irvine et al., 2010; Booker and Lamb, 2012). With the declining popularity of flax as a rotational crop choice in Manitoba, farmers need incentive to grow and increase production area under flax. A longstanding concern is that current flax cultivars are not keeping up with yield advances, similar to gains made in canola, soybeans and to a lesser extent, cereals. This disparity is what encourages a switch away from flax and into higher-yielding, more profitable crops. Flax does have an important role to fill in Manitoba. As a non-host crop for many of the major diseases in western Canada, flax is well suited to break disease cycles and provide a stable, steady return as part of a balanced rotation. With the closure of private breeding programs at Nutrien Ag Solutions, and the public breeding programs at Agriculture and Agri-Food Canada, only a single breeder of flax remains in Canada at the Crop Development Centre. With the introduction and evaluation of European lines, there may be the possibility of a higher yielding cultivar, or a cultivar with more desirable quality characteristics may be found to be well suited to Manitoba's agro-climate.

Materials & Methods

Sites-Melita (WADO), Arborg (PESAI) and Roblin (PCDF)

Experimental Design – Randomized Complete Block Design with three replicates

Treatments – 7 Flax varieties (CDC Bethune, OVB 1001-01, LG Lion, Batsman, LG Aquarius, OVB 0815-02 and Biltstar), all treated identically at each site for fertility and weed control as per PRCO standards for Linseed Co-op testing.

Seeding rate treatment - 40lbs/acre at 5/8" depth, adjusted for individual variety germination %

Stubble Melita-oat/wheat/sunflower, Roblin- oat/barley silage, Arborg-fallow

Soil type Melita (Waskada loam), Roblin (Erickson clay loam), Arborg (heavy clay)

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

Table 11.0a: Applied Agronomy by site

			Fertility (lb/acre)					
Location	Plot Size	Seeding Date	Available	Applied	Herbicides	Spray Date	Desiccation Date	Harvest Date
Arborg	9.12m ²	15-May	104 N 30 P 680 K	50 N 20 P	Curtail M @ 0.8L/acre Centurion @ 0.075L/acre Reglone @ 0.7L/acre	10-Jun	06-Sep	16-Sep
Melita	12.96m ²	06-May	81 N 10 P 192 K	108 N 35 P 20 K	Select @ 0.120L/acre Basagran Forté @ 0.91L/acre	10-Jun 18-Jun	--	29-Aug
Roblin	5.98m ²	21-May	57 N 26 P 450 K	63 N 12 P	(PRE) Glyphosate @ 0.64L/acre + Authority @ 0.18L/acre Assure II @ 0.3L/acre + Basagran Forté @ 0.9L/acre Reglone @ 1L/acre	24-May 10-Jun	17-Sep	24-Sep



European Flax at Flowering phase, July 3rd, 2019 at Melita

Results and Discussion

Yield:

Yield differences were significant between European-origin lines and the Canadian-origin check, CDC Bethune, at only Melita (2018) and Roblin (2019) sites. At Melita in 2018, two European lines produced less yield than CDC Bethune while at Roblin in 2019, CDC Bethune also yielded significantly more than four of the six European lines (Tables 11.0b & c). LG Lion and LG Aquarius were the only European lines to show significant yields similar to CDC Bethune at Melita in 2018 and Roblin in 2019.

Plant height:

All three sites reported significant differences in plant height in 2018, with most lines being significantly shorter than CDC Bethune. However, the number of cultivars statistically differing from the check varied from site to site and year to year (Table 11.0d). Roblin reported significant height differences in 2019, where CDC Bethune was statistically taller than all European-origin cultivars.

Days to Maturity & flowering:

The number of days for flax to reach physiological maturity (75% bolls brown and rattling) at Arborg was similar in both 2018 and 2019. Melita and Roblin experienced a greater number of days required to reach the same flax maturity levels in 2019 than 2018, which may have been a factor of rainfall and environmental differences (Table 11.0e). On average, length of flowering period was longer in 2019 compared to 2018 (Table 11.0f).

Quality:

Shannon Froese at the CDC, Saskatoon, conducted flaxseed quality analysis for the 2018 crop. Results are shown in Table 11g. Higher iodine values are preferred by the industrial use buyers of flaxseed.

Project findings:

Dry and drought-like conditions at the test sites contributed to overall lower yields particularly at Arborg site, as evidenced by low commercial yield across the province according to Manitoba Agricultural Insurance Corporation. Provincial average yields were 26 and 20 bu ac⁻¹ in 2018 and 2019, respectively, compared to the 10-year average of 22 bu ac⁻¹. Rainfall distribution and time of arrival played an important role in crop development, affecting plant height and yield across the three test locations (Tables 11b & c).

Short-stature flax was a result of continued moisture stress, along with overall thinner than ideal stands and the opportunity for weed competition. European flax lines were consistently shorter when compared to CDC Bethune, ranging from 4 to 10 centimeters shorter than check in both years.

Overall days to maturity (DTM) were +1 to -5 days from the 87 DTM CDC Bethune rating in 2018 (Table 11.0e), while in 2019 all European lines took 6 to 9 days longer than the check. Correspondingly, flowering period in European flax cultivars was +1 to -7 days in variance from the average 21 days of CDC Bethune in 2018 (Table 11.0f). In 2019, flowering period lengthened overall and European cultivars ranged from +4 to -1 days against a check variety flowering length of 34 days.

Table 11.0b. Performance of different flax lines in European flaxseed test in 2018

VARIETY	2018 Yield					
	Arborg		Melita		Roblin	
	kg ha ⁻¹	bu ac ⁻¹	kg ha ⁻¹	bu ac ⁻¹	kg ha ⁻¹	bu ac ⁻¹
CDC Bethune (Check)	1675	26.6	2227	35.4 ^{ab}	2057	32.7
OVB 1001-01	1674	26.6	2169	34.5 ^{ab}	1959	31.1
LG Lion	1717	27.3	2314	36.8 ^a	1598	25.4
Batsman	1560	24.8	1973	31.4 ^{cd}	1670	26.5
LG Aquarius	1358	21.6	2156	34.3 ^b	1518	24.1
OVB 0815-02	1362	21.7	2116	33.6 ^{bc}	1565	24.9
Biltstar	1447	23.0	1840	29.3 ^d	1608	25.6
GRAND MEAN	1542	24.5	2114	33.6	1710.71	27.2
CV %	9.1		3.7		14.8	
LSD	-	-	141	2.2	-	-
Sign Diff	No		Yes		No	

Table 11.0c. Performance of different flax lines in European flaxseed test in 2019

VARIETY	Arborg		2019 Yield Melita		Roblin	
	kg ha ⁻¹	bu ac ⁻¹	kg ha ⁻¹	bu ac ⁻¹	kg ha ⁻¹	bu ac ⁻¹
CDC Bethune	2119	33.7	2719	43.2	3616	57.5a
OVB 1001-01	1885	30.0	2798	44.5	3166	50.3bcd
LG Lion	1960	31.2	2704	43.0	3464	55.1ab
Batsman	1933	30.7	2848	45.3	3071	48.8cde
LG Aquarius	1833	29.1	2849	45.3	3302	52.5abc
OVB 0815-02	1913	30.4	2738	43.5	2689	42.8ef
Biltstar	1844	29.3	2758	43.9	2792	44.4def
GRAND MEAN	1927	30.6	2773	44.1	3157	50.2
CV%	7.3		6.0		7.0	
LSD	-	-	-	-	395	6.3
Sign Diff	No		No		Yes	

Table 11.0d. Analysis of variance and mean comparison for flax plant height (cm) in 2018 & 2019

VARIETY	Arborg18	Arborg19	Melita18	Melita19	Roblin18	Roblin19
CDC Bethune	44.0a	44.0	62.0a	57.0	55.3a	64.0a
OVB 1001-01	36.0cd	37.0	51.7b	59.0	55.7a	56.0b
LG Lion	38.0bcd	40.0	51.7b	53.0	46.0b	44.0c
Batsman	40.0abc	37.0	53.3b	58.0	48.0b	50.0bc
LG Aquarius	37.0bcd	38.0	49.3bc	57.0	45.7b	48.0c
OVB 0815-02	36.3cd	35.0	50.0bc	54.0	46.3b	48.0c
Biltstar	41.7ab	39.0	46.0c	49.0	45.3b	49.0c
GRAND MEAN	39.0	38.5	52.0	55.3	48.9	51.1
CV %	6.8		5.9		7.4	7.3
LSD	4.7		5.5		6.4	6.7
Sign Diff	Yes	No	Yes	No	Yes	Yes

Table 11.0e. Mean days to physiological maturity of flax recorded at three sites in 2018 & 2019

Variety	Arborg18	Arborg19	Melita18	Melita19	Roblin18	Roblin19	Average18	Average19
CDC Bethune	95	92	84	92	82	84	87	89
OVB 1001-01	98	91	86	96	81	105	88	98
LG Lion	94	92	85	93	79	106	86	97
Batsman	91	90	84	95	77	101	84	95
LG Aquarius	90	91	83	98	74	102	82	97
OVB 0815-02	91	90	84	99	79	104	85	98
Biltstar	91	92	84	100	76	119	84	104

Table 11.0f. Mean duration of flowering period (days) recorded at three sites in 2018 & 2019

Variety	Arborg18	Arborg19	Melita18	Roblin18	Roblin19	Average18	Average19
CDC Bethune	29	37	22	11	32	21	34
OVB 1001-01	31	39	25	11	34	22	37
LG Lion	20	37	15	10	29	15	33
Batsman	13	39	22	11	33	15	36
LG Aquarius	16	39	17	11	39	15	39
OVB 0815-02	16	39	22	12	34	17	36
Biltstar	16	39	12	13	33	14	36

2019 data not available for Melita

Table 11.0g. Fatty acid and iodine content of 7 flax varieties in 2018

VARIETY	2018 Quality Results							
	OMEGA LEVEL			Ω-9		Ω-6	Ω-3	Ω-9
	FATTY ACID (%)	Palmitic C16:0	Stearic C18:0	Oleic C18:1	Linoleic C18:2	α-Linolenic C18:3	Eicosenoic C20:1	Iodine Value
CDC Bethune		6.00	3.8	18.75	17.5	53.94	0.0	187.57
OVB 1001-01		5.55	5.0	21.17	23.3	44.94	0.1	176.09
LG Lion		6.08	4.1	18.65	14.0	57.15	0.0	189.73
Batsman		6.39	4.2	18.50	14.4	56.39	0.1	188.35
LG Aquarius		5.82	3.8	18.21	15.6	56.53	0.0	190.53
OVB 0815-02		6.59	5.0	18.19	13.9	56.22	0.1	186.71
Biltstar		5.50	5.1	17.52	15.3	56.52	0.1	189.31
GRAND MEAN		5.99	4.4	18.71	16.3	54.53	0.0	186.90

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12.0 Industrial hemp grain and fibre variety evaluation

Project duration: ongoing

Collaborators: Canadian Hemp Trade Alliance

Objectives

To evaluate grain and fibre yield obtained from different hemp varieties in different agro-ecological regions of Canada.

Background

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

Canada started issuing licenses to allow research on industrial hemp in 1994 and new regulations were included in the Canadian Controlled Drugs and Substances Act in 1998 to authorize commercial production of hemp under licensing and control of Health Canada (Cherney and Small, 2016). In Canada, hemp production is more concentrated in Southern Ontario and Quebec but recently, there have been more interest across many provinces as demand for the crop is increasing. The major increase in demand for hemp can be attributed to its many uses, among them; fibre, oilseed and its use in the pharmaceutical industry (De Meijer, 2014; Kaiser et al., 2015). Hemp fiber has high tensile strength and is useful for plastic bio-composites for vehicles, textile, rope, insulation, paper, absorbent and bedding material (Darby et al., 2017). An increase in the interest for production of industrial hemp also means that there is need for producers to effectively select varieties that can perform best in their areas of production. Therefore, there is need for testing available varieties in different agro-ecological regions in order help producers make better decisions. This study seeks to evaluate performance of hemp varieties in relation to grain or fibre yield in varying environmental conditions.

Materials and Methods

The trials were located at Melita, Roblin, Arborg and Carberry in Manitoba. Melita location was established on oat stubble under no till system. The trial was arranged as randomized complete block design with 9 treatments (6 grain and 3 dual purpose varieties) replicated 4 times. Apart from grain and fibre yield, other data collected included; plant counts at 100 % emergence and stem elongation, plant height at maturity, lodging, plant vigor rating, proportion of male to female plants and days to maturity.

Fertility regime and other agronomics related to industrial hemp research at Melita are presented in Table 12a.

Table 12a. Melita site characterization and agronomic practices in 2019

Fertility	N	P	K	S
	lbs/ac			
Soil Test (0-24")	30	8	600	190
Applied	121	35	7	2

Soil Type	Waskada Loam
Legal Land Location	NW 7-4-26 W1
Burnoff	May 23 0.75 L/ac Roundup
Seed Date	May 23 rd
Depth	0.75"
Herbicides Used	Select @ 150ml/ac on 13 June Koril 0.4L/ac spot sprayed on 18 June
Harvest Date Fibre	16 Sep 2019
Harvest Date Grain	17 Sep 2019

Results and Discussion

Hemp fibre yield for trials D and G in Melita were highly variable with coefficient of variation of 21 and 22.7%. In trial D, Petera variety yielded over 3100 kg ha⁻¹ of fibre more than CRS-1 and Altair. In trial G, there were 6 hemp varieties with fibre yield ranging from 5801 kg ha⁻¹ (Judy) to 8960 kg ha⁻¹ (Grandi) (Table 12b). Hemp trials in Melita faced a challenge with respect to fusarium wilt and bird damage that was prevalent and could have resulted in reduced yields.

Table 12b. Industrial Hemp fibre yield obtained from Melita (MB) in 2019

Variety>>	Petera	CRS-1	Altair				C.V	S.E	F.Value	L.S.D
Yield_trial D (kg ha ⁻¹)	11498	8701	8960				21.0	537.5	3.9	2044.1
Variety>>	X59	Judy	CRS-1	Katani	Grandi	CFX-2	C.V	S.E	F.Value	L.S.D
Yield_trial G (kg ha ⁻¹)	8753	8960	7924	6629	5801	7251	22.7	416.1	2.4	2662.1

On average, Altair and Petera varieties yielded significantly more hemp fibre compared to CRS-1 (Table 12c). The lowest CRS-1 fibre yield of 1150 kg ha⁻¹ was observed at Cobden in Ontario while the highest fibre yield of 15365 kg ha⁻¹ was observed at Falher in Alberta for Santhica 70 variety.

Table 12c. Analysis of Variance for Trial D industrial hemp fibre yield obtained from Arborg (MB), Lethbridge (AB), Cobden (ON), St Hugues (QC) and Falher Late (AB)

Name	Arborg MB	Lethbridge AB	Cobden ON	St Hugues QC	Falher Late AB	MEAN
CRS-1	4919b	8029ab	1150c	3075d	-	4293b
Altair	7674a	9704a	1875b	6475b	-	6432a
Petera	7445a	7753ab	2875a	10000a	-	7018a
Silesia	7756a	8910ab	1575b	4800c	10224c	-
Anka	-	7630b	-	-	-	-
Rigel	-	7555b	-	-	-	-
Santhica 27	-	8321ab	-	-	13911ab	-
Santhica 70	-	7943ab	-	-	15365a	-
Earlina	-	-	-	-	9015c	-
C.V	15.9	15.0	12.3	10.8	16.0	9.4
S.E.	276.2	308.3	57.5	163.8	484.1	276.8
L.S.D.	1766.8	1972.7	367.7	1047.9	3097.5	834.3
# stations	1	1	1	1	1	4

There were no significant differences in hemp yield obtained from all varieties at Indian Head. However, at St Hugues, Altair had significantly higher grain yield compared to Petera and CRS-1. Overall, Altair and CRS-1 did not significantly differ in grain yield (Table 12d). Grain yield from St Hugues was close to 3 times higher than that obtained from Indian head probably due to differences in agronomic management as well as weather conditions.

Table 12d. Analysis of Variance for Trial D industrial hemp grain yield obtained from Indian Head (SK) and St Hugues (QC) in 2019

Name	Indian Head SK	St Hugues QC	MEAN
Petera	586a	1459c	1023b
CRS-1	654a	1602bc	1128ab
Altair	680a	2215a	1448a
Silesia	-	2161ab	-
Anka	-	-	-
Rigel	-	-	-
Santhica 27	-	-	-
Santhica 70	-	-	-
Earlina	-	-	-
C.V	13.5	20.0	14.2
S.E.	32.9	92.7	123.1
L.S.D.	157.8	593.3	371.1
# stations	1	1	2

In Trial G, X59 variety ranked 1st in fibre yield at each sites except Lethbridge where it was out yielded by Grandi (Table 12e). Across sites, the highest fibre yield was obtained from X59 but it was not significantly different from Grandi and CRS-1. Furthermore, yield obtained from CFX-2, Katani, CRS-1 and Grandi were not significantly different. Fibre yield from Lethbridge was highly variable compared to other sites.

Table 12e. Analysis of Variance for Trial G industrial hemp fibre yield from Arborg, Indian Head, Lethbridge and Falher in 2019

Name	Arborg MB	Indian Head SK	Lethbridge AB	Falher AB	MEAN
Judy	828c	608bc	468d	728c	658c
CFX-2	1142b	584bc	823abc	1139ab	922b
Katani	1110b	552c	846abc	1235ab	936b
CRS-1	1243ab	700ab	773bc	1143ab	965ab
Grandi	1121b	651bc	975ab	1273ab	1005ab
X59	1390a	793a	751c	1344a	1070a
Earlina	-	-	621 ≠	-	-
C.V	9.0	12.2	17.2	12.6	8.1
S.E.	25.7	20.3	33.2	36.6	37.2
L.S.D.	164.3	129.7	212.1	234.2	112.2
# stations	1	1	1	1	4

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13.0 Performance and adaptation of Quinoa varieties

Project duration: 2017-2019

Collaborators: Percy Phillips-NorQuin

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: PHX16-01, PHX16-02, PHX16-03, PHX16-07, PHX16-08, PHX16-09 and PHX16-10. In Melita, the plots were seeded on the 3rd of May into good soil moisture at a depth of 0.5". Granular blend and liquid fertilizer were side banded at 108-35-20-7-2Zn (N-P-K-S) lb ac⁻¹ during seeding. In-season post emergence weed control was done once using 0.15 L ac⁻¹ Arrow + 0.5% v/v X-Act adjuvant. The major insect pests of concern were stem borer larvae (*Amauromyza karli*), which were controlled four times by alternating a weekly application of Cygon and Matador insecticides at rates of 0.133 L ac⁻¹ and 0.0332 L ac⁻¹ respectively. 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 for comparison of treatments.



**Quinoa at heading stage
(BBCH 80)**

July 2nd 2019, Melita

**Yellowish bottom leaves
showing signs of Downy
mildew**

Results and Discussion

Days required to reach maturity were significantly different and ranged from 129 to 135 among varieties. Late maturity entries such as PHX16-10 which required 134 days to reach maturity also yielded significantly more grain ($P=0.001$) compared to the other varieties. Grain yield ranged from 1882 to 4038 kg ha^{-1} . PHX16-09 had the highest lodging rating of 3 which could have likely caused grain losses resulting in low yield of 1882 kg ha^{-1} . The highest coefficient of variation of grain yield was caused by PHX16-10 entry which had almost double the grain yield compared to the rest of the entries. All treatments showed high vigor especially considering that the rating ranged from 6 to 8 and this was a sign of healthy plants. The variety trial had a few challenges with stem borer larvae that required chemical control more than 3 times during the season. The caterpillar penetrates and feed inside the stem causing severe lodging and eventually reduces grain yield and quality. However, there was better timing of scouting and application of alternating insecticides for better control of the stem borer compared to 2018 growing season.

Table 13.0. Analysis of variance for quinoa lodging, days to maturity, plant vigor, test weight, thousand kernel weight and yield of wheat at Melita in 2019

Entry Name	Trt	Lodging 1-5	DTM	Vigor 1-9	Test weight	TKW	Yield kg ha ⁻¹
PHX16-01	1	2.3bc	132bc	8a	304a	2.0a	2133bc
PHX16-02	2	2.7ab	133b	7ab	306a	1.6b	2780b
PHX16-03	3	2.7ab	129d	6b	305a	2.0a	2138bc
PHX16-07	7	2.7ab	131cd	7ab	305a	2.0a	2261bc
PHX16-08	8	3.0a	132bc	7ab	285b	2.0a	1882c
PHX16-09	9	2.0c	135a	6b	282b	1.9a	2096bc
PHX16-10	10	2.0c	134ab	7ab	290b	2.0a	4038a
	CV	14	1	11	2	7.0	17
	P Value	0.028	<0.001	0.123	<0.001	<0.001	0.001
	LSD (p<0.05)	0.6	2	NS	10	0.2	763

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

Project duration: 2017 - 2019

Collaborators: WADO

Objectives

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

Background

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

Most intercropping systems involve a legume and non-legume crop so as to maximize symbiotic benefits from both crops. In most cases, legume-cereal intercrops result in increased dry matter production and grain yield more than sole crops. When there is a limitation in fertilizer nitrogen, biological nitrogen fixation becomes the major source of nitrogen in mixed cropping systems involving a legume crop (Fujita et al., 1992). The use of legumes that are tolerant to nitrate and whose biological nitrogen fixation is less affected by application of combined nitrogen, may increase the amount of N available for the other component crop without affecting nodulation of the legume itself. When applying nitrogen to legumes, it is important to consider factors such as the source, rate, timing and placement depth, termed the 4R strategy for successful management of nutrients. Research conducted by Takahashi et al. (2012) suggested that deep placement of coated urea at seeding did not depress nodulation resulting in improved soybean growth and increase in seed yield while top dressing with the same fertilizer inhibited nodule activity after R3 stage, and subsequently resulted in low seed yield. In a related study by Laboski

(2006), Agrotain was shown to effectively reduce the conversion of surface applied urea or urea ammonium nitrate to ammonium resulting in increased grain yield due to reduced nitrogen losses. This study therefore seeks to determine the influence of soybean and flax intercrop and whether agrotain inhibitor has any influence on nodulation and seed yield between the component crops.

Materials and Methods

The trial was initiated at Melita in South western Manitoba in 2018 and continued in 2019. The treatments were established on oat stubble on Waskada loam soil under no till system. The trial included 3 crop types (soybean, flax and soy-flax intercrop) and 3 fertilizer types (0 lb N, 60 lb Agrotain N and 60 lb Urea N). These were laid out as randomized complete block design with 9 treatments replicated 3 times. Seeding was done on the 10th of May at a depth of 1" and treatments were applied as indicated in Table 14a.

Table 14a. Treatment description for Soybean-flax intercrop in 2019

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

^aTreatments 7 through 9 involved 2 soybean rows in the middle and 2 flax rows on either side of the soybean rows

All soybean seeds were treated with granular BASF inoculant before seeding and granular fertilizer blend was side banded at a rate of 8-35-40-7-2Zn (N-P-K-S) lb ac⁻¹ during seeding. Preemergence weed control was done by the application of 0.1 L ac⁻¹ Authority, 0.75 L ac⁻¹ Roundup and 0.015L ac⁻¹ Aim soon after seeding. A second chemical weed control application was done at 5 weeks post emergence with 0.12 L ac⁻¹ Select + 0.5% v/v Amigo adjuvant for the control of grasses. There was moderate to high cutworm pressure during the early seedling stages, which warranted the application of Lorsban insecticide at a rate of 0.033 L ac⁻¹. Data collected included: nodule counts (n=10), light interception above and below the canopy, soil moisture content, above ground biomass yield, days to maturity, grain yield and moisture content at harvest. Land equivalence ratio for each cropping system was calculated in Excel before being subjected to statistical analysis. The data were subjected to factorial ANOVA Minitab 18 statistical package for determination of treatment differences. Separation of treatment means was done by using Fisher's LSD at the 5% level of significance.



**Nodule sampling in Soy-flax trial
on July 8th 2019, Melita**

Results and Discussion

Cropping system had a significant influence on yield and other agronomic components of soybean and flax. Yield from soybean monocrop was significantly ($P<0.001$) higher than obtained from an intercrop with flax. Soybean LER ($P<0.001$), height ($P=0.029$) and oil content ($P<0.001$) were also significantly greater in monocrop compared to the intercrop. On the other hand, protein content of soybean was significantly lower ($P<0.001$) in monocrop (39.1%) compared to the intercrop, which had 40% on dry matter basis. Soybean kernel weight based on 100g sample was significantly ($P=0.036$) greater in the intercrop (19.6g) compared to soybean monocrop (19.0g). Similar to soybean, flax monocrop obtained significantly ($P<0.001$) higher yield (1407kg ha^{-1}) compared to the intercrop (901kg ha^{-1}). Land equivalence ratio of flax was significant ($P<0.001$) with monocrop having 1.04 while the intercrop had 0.67. Total yield from soybean monocrop and soybean-flax intercrop was significantly higher ($P<0.001$) than total yield from flax monocrop but there were no significant differences in TLER for the three cropping systems. Fertility had no significant influence on all agronomic parameters except on flax LER. Agrotain and ON application resulted in significantly ($P=0.042$) higher LER compared to Urea application in flax. None of the crop-fertility interactions significantly influenced agronomic components of flax or soybeans in 2019 (Table 14b).

Results from this research show that cropping system is the only factor that influenced grain yield and other agronomic components such as oil and protein content. In particular, mono crop systems of flax and soybean appeared to yield higher than when intercropped. This makes sense considering less interspecific competition that could have arisen in intercrop situations. Lower yields in intercrops could have been due to high competition for nutrients, light and moisture. In 2019, the major factor for lower yield was as a result of low rainfall which was unevenly distributed throughout the season. Furthermore, a long dry spell in the spring meant that the crops depended much on residual moisture from snow melt, which seemed to be inadequate for early crop establishment and fertilizer dynamics. Additional site-years of research may be required in order to account for the influence of varying weather conditions, in this case, rainfall and how these impact fertilizer dynamics in the soil.

Table 14b: Analysis of variance for soybean-flax yield, quality and land equivalence ratio in 2019

Factor			Soybean						Flax			TOTAL Yield Kg ha ⁻¹	Overall T-LER	
			Nodules	Yield	S-LER	Height	Oil	Protein	TKWT	Yield	F-LER			Height
			per plant	Kg ha ⁻¹		Cm	%	%	g/100 seeds	Kg ha ⁻¹		cm		
Crop	Soybean	1	3.0	2808a	1.06a	63a	21.0a	38.1b	19.0b	*	*	*	2808b	1.06
	Flax	2	*	*	*	*	*	*	*	1407a	1.04a	65	1407a	1.04
	Intercrop	3	3.4	843b	0.32b	58b	20.0b	40.0a	19.6a	901b	0.67b	65	1744b	0.99
Fertility	Significant?		No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No
	ON	1	4.4	1703	0.64	63	20.6	38.8	19.3	1215	0.90a	65	1945	1.03
	Agrotain	2	2.8	1767	0.67	60	20.4	39.1	18.9	1197	0.89a	65	1976	1.04
	Urea	3	2.6	2006	0.76	59	20.4	39.3	19.8	1050	0.78b	65	2037	1.03
Interaction	Significant?		No	No	No	No	No	No	No	No	Yes	No	No	No
	Soybean	ON	5.2	2673	1.00	64	21.1	38.2	18.6	*	*	*	2941	1.00
		Agrotain	1.9	2808	1.06	63	21.0	38.0	18.6	*	*	*	2808	1.06
		Urea	1.9	2941	1.13	61	20.9	38.0	19.7	*	*	*	2673	1.13
	Flax	ON	*	*	*	*	*	*	*	1459	1.08	63.7	1459	1.08
		Agrotain	*	*	*	*	*	*	*	1413	1.05	65.0	1413	1.05
		Urea	*	*	*	*	*	*	*	1349	1.00	66.0	1349	1.00
	Intercrop	ON	3.5	734	0.28	55	20.1	39.4	19.9	971	0.72	67.0	1704	1.00
		Agrotain	3.6	725	0.28	62	19.8	40.2	19.2	981	0.73	64.0	1707	1.01
		Urea	3.2	1070	0.40	57	19.9	40.5	19.9	750	0.55	64.3	1820	0.95
Significant?			No	No	No	No	No	No	No	No	No	No	No	
P values	Crop		0.513	<0.001	<0.001	0.029	<0.001	<0.001	0.036	<0.001	<0.001	0.88	<0.001	0.641
	Fertility		0.065	0.437	0.472	0.307	0.662	0.435	0.076	0.067	0.042	0.883	0.861	0.984
	C x F		0.074	0.903	0.957	0.245	0.86	0.214	0.341	0.479	0.367	0.344	0.924	0.835
Coefficient of Variation %			39	23	26	6	2	2	3	10	9	5	18	17

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15.0 Relay crop/intercrop legumes in Hemp Grain Production

Report period: 2019

Project duration: 2017-2019

Collaborators: Hemp Genetics International

Objective

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

Rational

Legume cover crops have many benefits that include; adding nitrogen to the soil, suppression of weeds, control soil erosion, reduce nitrogen leaching and reduce insect pests and disease incidences. Hemp relay cropping systems respond well to conditions where soil moisture is not limited (Canadian Hemp Trade Alliance, 2020). On the Canadian prairies, hemp growers have been investigating the merits of relay cropping legume cover crops in hemp stands. This trial explores the benefits of doing so by studying the effect on hemp grain production and assessing regrowth of relay crops. This is year 3 of performing the trial.

Clovers, hairy vetch, or alfalfa act as a post-harvest cover to compete against weeds, reduce compaction, increase water use and fix nitrogen. In order to achieve nitrogen benefits, legumes must be inoculated with the appropriate bacteria (Martens et al., 2001). The purpose of seeding pea with hemp was to try to increase grain production per acre, as is the case with some farmers who are not into livestock production but want to increase cash returns per unit area (Canadian Organic Growers, 1992). Use of fall rye was to

compete with weeds (both physically and chemically through allelopathy) and then be terminated by a group 1 herbicide.

Materials and Methods

Clovers, alfalfa and rye were hand broadcast after seeding covered small amounts of soil using a garden rake to ensure good seed to soil contact. Peas and vetch were inoculated with granular pea *Rhizobia* inoculant (Nodulator-G Pea/Lentil, BASF) and seeded with the hemp down the same seed shank. A summary of trial site characterization for 2019 is presented below:

Location: Melita; legal land location NW 7-4-26 W1; Waskada Loam

Design: Randomized Complete Block Design; 7 treatments replicated 3 times, plot size 12.96m²

Burn-off: Roundup transorb @ 0.75 L ac⁻¹ applied on May 23rd, 2 days after seeding

Previous crop: Oats

Seed Date: May 21, 2019

Hemp seed depth: 0.75"

Fertilizer: N-P-K-S: 108-35-30-7-2Zn (lbs ac⁻¹)

In Crop Herbicides: Select @ 0.15 L ac⁻¹ June 13, 2019, except on Rye

Hemp Grain Harvest Date: August 30, 2019

Relay Biomass Date: September 20th

Rainfall during trial: 366 mm (108.9 % of normal)

Table 15a. Treatments of relay crops inter-seeded (broadcast or in seed row) with hemp and their respective variety and seeding rate (lbs ac⁻¹).

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

Various data collected included crop emergence count sampled at 2 x 1 m rows per plot for both hemp and relay treatment to determine plant density, hemp crop height measured at maturity, kernel weight for hemp based on 500 seed count and grain yield for hemp and field pea. Soil moisture was measured to a depth of 6" in each plot using a hand held HydraSense II unit. In order to determine differences in soil

nitrogen levels among treatments, a composite sample was obtained from 3 sub samples and sent for laboratory analysis. Nitrate tests were done in fall to determine concentration of nitrates in forages. Data were subjected to a two-way analysis of variance (ANOVA) using Minitab 18 statistical software to determine if means were significantly different. Mean separation was conducted using Fisher's LSD at the 5% level of significance.

Results and Discussion

There were no significant differences observed among treatments in hemp plant density and plant height. Forage yield was significantly ($P<0.001$) high in hairy vetch + hemp relay (3041 kg ha^{-1}) compared to other intercrop options. On the other hand, forage yields were not significantly different in sweet clover + hemp, alfalfa + hemp and red clover + hemp treatments (Table 15b). There were also no significant differences in hemp kernel weight regardless of the relay crop system involved. Hemp yield obtained from pea + hemp was significantly high ($P=0.023$) compared to other hemp relay systems but was not different from hemp check. The probable cause for higher yield in the pea + hemp intercrop could have been due to higher nitrogen fixing ability of pea compared to other legumes. Pea and hemp seemed to complement each other in an intercrop when considering the combined yield of 248 kg ha^{-1} , which was significantly higher ($P<0.001$) than other treatments. Organic matter content measured was similar for the check, sweet clover + hemp, alfalfa + hemp, hairy vetch + hemp, and pea + hemp but was significantly higher than red clover + hemp treatment ($P=0.021$). Overall, the organic matter content ranged from 3.27 to 3.73 and had coefficient of variation of 4%.

Table 15b. Analysis of variance and mean comparison for hemp and legume plant density, height, forage yield, hemp TKWT, hemp yield, total yield and organic matter content at Melita in 2019

Description	Hemp ppms	Hemp ht-cm	Legume ppms (summer)	Legume ppms (fall)	Forage Yield Kg ha^{-1}	Hemp TKWT	Hemp Yield kg/ha	extra	total yield kg/ha	O.M
Hemp (Check)	70	145.0	*	*	*	4.94	129ab		129bc	3.67a
Sweet Clover + Hemp	58	150.7	5	16	141b	4.82	113bc		113bc	3.63ab
Alfalfa + Hemp	68	144.7	19	30	328b	5.03	95c		95bc	3.63ab
Red Clover + Hemp	58.7	141.0	5	51	286b	4.37	97bc		97bc	3.27c
Hairy Vetch + Hemp	79.33	143.0	58	*	3041a	4.27	89c		89c	3.73a
Pea + Hemp	77.3	140.7	36	*	*	3.85	147a	100.8	248a	3.6ab
Fall Rye + Hemp	78	144.7	18	*	*	4.59	105		105bc	3.4bc
CV	33	6			16	14	17		17	4
P value	0.824	0.866			<0.001	0.333	0.023		<0.001	0.021

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16.0 Intercropping corn and hairy vetch

Project duration: 2018-2020

Collaborators: WADO

Objectives

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

Background

Corn and hairy vetch intercrop provides a 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

The trial was arranged as split plot design with 10 treatments and 3 replicates. Seeding onto oat stubble took place on May 14th. Corn was seeded at a depth of 1.5" with a four row Wintersteiger corn planter while hairy vetch was seeded at 0.75" with a seed hawk dual knife air seeder. Granular fertilizer blend was applied during hairy vetch seeding by banding method at a rate of 116-35-20-7-22Zn (N-P-K-S) lb ac⁻¹. Herbicide treatments were applied using a Co² sprayer, ensuring thorough rinsing between treatments to avoid contamination. Corn-hairy vetch treatments are described in the table below.

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

Percent hairy vetch injury was assessed weekly for 3 weeks after application of herbicide treatments. Wet weeds biomass was collected from 2 x 1 m² 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 m² sampling areas from each plot. Due to severe deer and raccoon damage, at least 20 corn cobs were harvested manually from each plot and placed in air driers before running them through the combine. Grain yield data was converted to output per plot before being subjected to statistical analysis. These 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

The highest percentage (50%) of hairy vetch injury as a result of herbicide treatment was observed when roundup was applied at 0.5 L ac⁻¹ in a tank mix with 0.5 L ac⁻¹ Mextrol but this was not significantly different from a treatment of 0.33 L ac⁻¹ roundup (43%) applied at V3 and V8 stages of corn (Table 16b). Compared to other treatments, applications of 0.2 L ac⁻¹ roundup, 0.5 L ac⁻¹ roundup and 0.5 L ac⁻¹ roundup + 0.4 L

ac⁻¹ Koril at V3 resulted in significantly lower hairy vetch herbicide injury ranging from 10 to 18% (Figure 16a). Overall, herbicide injury on hairy vetch appeared to increase with an increase in the application rate of roundup and was reduced with lower rates or tank mixture of roundup and Koril. Split application of 0.33 L ac⁻¹ roundup at V3 and V8 stages of corn resulted in the same amount of injury with the application of 1 L ac⁻¹ at V3 on hairy vetch. A change in the application rate of roundup from 0.75 L ac⁻¹ to 1 L ac⁻¹ at V3 stage of corn did not result in any significant change in herbicide injury to hairy vetch (Table 16b; Figure 16a). There were no significant differences in weed biomass regardless of the herbicide treatment and timing of application.

Herbicide treatment significantly influenced corn stalk + cob (SC) biomass and total corn stalk + cob and hairy vetch biomass ($P < 0.001$) but did not influence hairy vetch (HV) biomass. The application of 0.75 L ac⁻¹ roundup at V3 in the control corn resulted in 19 122 kg ha⁻¹ stalk + cob dry matter, which was significantly higher compared to other treatments (Table 16b; Figure 16b). The lowest stalk + cob biomass (12 822 kg ha⁻¹) was recorded in the control corn + hairy vetch sprayed with 0.91 L ac⁻¹ Basagran and hand weeded. Corn stalk + cob biomass was also not significantly different for herbicide applications 0.2, 0.5, 0.75, and 1 L ac⁻¹ round up and 0.5 L ac⁻¹ roundup + 0.5 L ac⁻¹ Mextrol 450 at V3 stage of corn development. With respect to corn stalk + cob biomass alone, producers have a wide choice in the roundup application rates that they can use to ensure minimal damage to hairy vetch while maximizing biomass yield that they can use for their livestock. In this case there could be a benefit of lower input costs through use of lower application rates of between 0.2 and 0.5 L ac⁻¹ than using higher rates and achieve the same amount of biomass. Total SC + HV biomass was significantly higher when 0.75 L ac⁻¹ roundup was applied at V3 compared to control corn (0.75 L ac⁻¹ roundup), control hairy vetch (0.91 L ac⁻¹ Basagran), Control corn + hairy vetch (hand weed + 0.91 L ac⁻¹ Basagran) and 0.2 L ac⁻¹ but was not significantly different from the other treatments.

Corn grain yield was significantly higher in the control corn (0.75 L ac⁻¹ roundup) and 0.33 L ac⁻¹ roundup split at applied at V3 and V8 compared to other treatments. The least grain yield was obtained from hand weeded corn-hairy vetch + 0.91 L ac⁻¹ Basagran (7 980 kg ha⁻¹) and treatment applied with 1 L ac⁻¹ roundup at V3 (8 506 kg ac⁻¹). Overall, grain yield from different treatments ranged from 7 980 to 10 630 kg ac⁻¹. These results suggest that farmers could reap more benefits in selecting round up application rates of 0.33 L or 0.5 L ac⁻¹ at V3 because they result in lower herbicide injury to vetch, increased corn stalk and cob biomass and increased corn grain yield in corn-hairy vetch cropping systems. Similar results were obtained in the 2018 growing season, where application of 0.5 L ac⁻¹ roundup was considered to be effective.

Table 16b. Analysis of variance for hairy vetch herbicide injury, weed biomass and dry matter biomass for corn stalk + cob, grain yield and hairy vetch in 2019

Factor	% Hairy Vetch injury			Wet weeds kg ha ⁻¹	Dry Matter Biomass kg ha ⁻¹			
	1WAA†	2WAA	3WAA		Stalk + Cob (SC)	Grain Yield	Hairy Vetch (HV)	Total SC + HV
Control corn, 0.75L ac ⁻¹ Roundup at V3	0	0	0e	305	19122a	10630a	*	19122c
Control hairy vetch, 0.91L ac ⁻¹ Basagran	*	*	*	217	*	*	8000	8000d
Control corn + hairy vetch hand weed + 0.91L ac ⁻¹ Basagran	*	*	*	38	12822d	7980e	6667	19489c
0.2L ac ⁻¹ Roundup at V3	25	23	10d	213	14893c	9014cd	4800	19693bc
0.5L ac ⁻¹ Roundup at V3	30	42	18d	210	16318bc	9094bcd	4267	20585abc
0.75L ac ⁻¹ Roundup at V3	37	45	32c	174	16047bc	9668bc	7200	23247a
1L ac ⁻¹ Roundup at V3	43	57	40bc	374	15730bc	8506de	5600	21330abc
0.33L ac ⁻¹ at V3 and V8	33	55	43ab	25	17111b	9964ab	5333	22445abc
0.5L ac ⁻¹ Roundup + 0.4L ac ⁻¹ Koril (tank mixed)-V3	35	43	17d	98	16808b	9277bcd	4800	21608abc
0.5L ac ⁻¹ Roundup +0.5L ac ⁻¹ Mextrol 450 (tank mixed)-V3	47	75	50a	128	15519bc	9563bc	7467	22986ab
Significant?			Yes	No	Yes	Yes	No	Yes
P-Value			<0.001	0.608	<0.001	0.001	0.344	<0.001
R-sqr			0.95	0.34	0.83	0.78	0.41	0.88
C.V. (%)			20	119	6	6	35	10

†WAA = weeks after application, P values are based on 95% confidence level

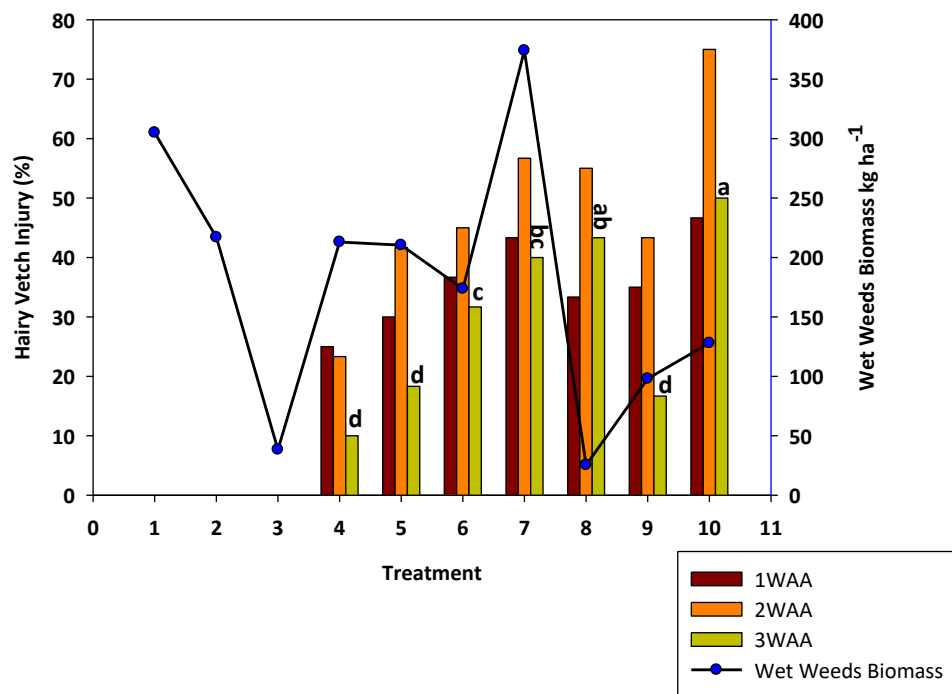


Figure 16a Hairy vetch % injury and wet weed biomass after applying herbicide treatments in 2019

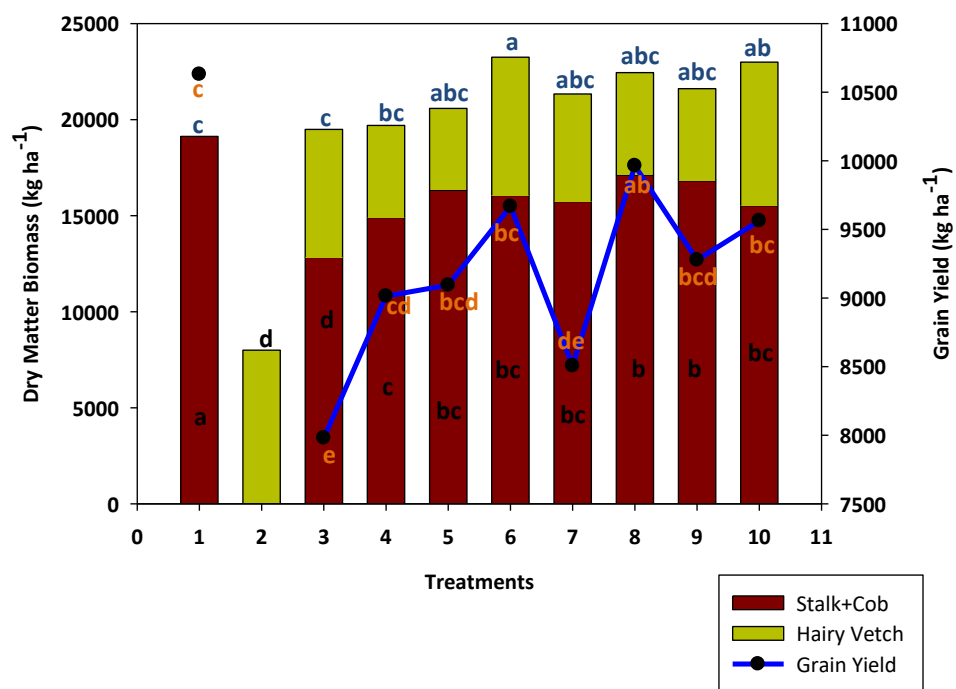


Figure 16b Dry matter biomass of stalk + cob, hairy vetch and corn grain yield in 2019

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

Project duration: 2018-2019

Collaborators: WADO

Objectives

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

Background

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

Research conducted by Szumigalski and Van Acker (2006) showed that pea-canola intercrop systems resulted in consistent land equivalent ratios for grain nitrogen yield and this suggests that intercrops, in particular, pea-canola could be useful for improving nitrogen use efficiency on per land area basis. Apart from pea-canola intercrop, alfalfa-canola can also be another option. Incorporation of a perennial pasture crop may aid in improving productivity and nutrient use efficiency as well as reducing disease incidence

(Sheaffer and Seguin, 2008). Furthermore, strip-intercropping canola with alfalfa has been shown to enhance biological control of diamond back moth, a common insect pest in canola (Tajmiri et al., 2017). Including alfalfa as a relay crop in a pea-canola intercrop would leave alfalfa to continue to grow in fall after harvesting and it can provide hay the following growing season. This study therefore seeks to evaluate the impact of intercrops involving pea, canola and alfalfa relay crop as best management tools for improving productivity and control fungal diseases.

Materials and Methods

The trial was initiated at Melita in Southwestern Manitoba in 2018. Eight treatments were arranged as randomized complete block design (split-plot) and replicated 3 times. In 2019, the plots were seeded onto oats stubble on May 9th at a depth of 0.75". Alfalfa seed was broadcasted by hand, raked in and rolled afterwards to improve seed to soil contact for improved emergence. Granular fertilizer blend was side banded for all treatments during seeding and application rates of 100-35-20-7-2Zn (N-P-K-S) lb ac⁻¹. Liquid nitrogen was not applied on peaola and pea treatments. Granular (BASF) pea inoculant was applied to pea and peaola treatments to account for atmospheric nitrogen fixation. Post emergence chemical weed control included the use of 0.15 L ac⁻¹ Select + 0.5% v/v Amigo adjuvant and 17.3 g ac⁻¹ Odyssey + 0.5% v/v Merge adjuvant. Early in the growing season, there were incidences of crucifer flea beetles which were controlled by a single spray application of 0.08 L ac⁻¹ Pounce. The same insecticide was also used to control blister beetles at about 8 weeks after seeding. At 50% flowering stage of canola, Lance fungicide was applied at 100g ac⁻¹, with a follow up application a week later. Apart from grain yield and alfalfa biomass, other data collected included emergence counts for each crop type, flowering dates for canola and peas, pod clearance for peas, aphid populations at full pod in peas and rating of mycosphereella disease. The data were analyzed using Minitab 18 with significant differences determined by Fisher's LSD at the 5% level of significance. Treatment materials are presented below:

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

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



Results and Discussion

Monocrop peas significantly ($P<0.001$) yielded more than pea intercropped with canola or alfalfa by more than 50%, which also translated to a significantly ($P<0.001$) higher Land Equivalent Ratio (LER) (1.02) for the pea monocrop compared to the intercrop systems (0.38 and 0.39). Pea grain yield and LER from peaola and peaolafalfa cropping systems were not significantly different while canola monocrop system recorded above 40% more grain yield compared to mixed cropping systems. Whereas the combined yield analysis of pea and canola resulted in pea monocrop yielding significantly ($P<0.001$) more grain than other cropping systems, the Total Land Equivalence Ratio (TLER) was not significantly different. Total yield from peaola and peaolafalfa were significantly higher ($P<0.001$) by over 500 kg ha^{-1} compared to canola while pea had the highest at 4258 kg ha^{-1} (Table 17a).

There was a significant ($P=0.027$) fungicide application effect on pea grain yield resulting in 141 kg ha^{-1} more yield and 0.03 higher ($P=0.026$) LER compared to pea treatments that were not sprayed with a fungicide during the season (Table 17a). With respect to canola response to fungicide application, there were no significant differences in grain yield or LER. Furthermore, there were no significant interactions between cropping system and fungicide with respect to grain yield and LER. Overall, the variability of grain yield data and LER was low and less than 10%.

Table 17a. Analysis of Variance for Pea and Canola yields and Land Equivalence Ratios

Factor		Pea		Canola		Total Pea & Canola		
		Yield	PLER ¹	Yield	CLER ²	Yield	TLER ³	
		Kg ha ⁻¹		Kg ha ⁻¹		Kg ha ⁻¹		
Crop	Pea	4258 a†	1.02 a	-	-	4258 a	1.02	
	Canola	-	-	3000 a	0.98 a	3000 c	0.98	
	Peaola	1623 b	0.39 b	1922 b	0.63 b	3545 b	1.01	
	Peaolalfa	1608 b	0.38 b	2030 b	0.66 b	3638 b	1.05	
	Significant?	Yes	Yes	Yes	Yes	Yes	No	
Fungicide	check -	2426 b	0.58 b	2313	0.75	3554	1.00	
	Fungicide +	2567 a	0.61 a	2321	0.76	3666	1.03	
	Significant?	Yes	Yes	No	No	No	No	
C x F	Pea	-	4182	1.00	-	-	4182	1.00
		+	4333	1.04	-	-	4333	1.04
	Canola	-	-	-	3070	1.00	3070	1.00
		+	-	-	2930	0.95	2930	0.95
	Peaola	-	1600	0.38	1835	0.60	3435	0.98
		+	1646	0.39	2008	0.65	3654	1.05
	Peaolalfa	-	1495	0.36	2035	0.66	3530	1.02
		+	1722	0.41	2024	0.66	3746	1.07
	Significant?		No	No	No	No	No	No
	P values	Crop	<0.001	<0.001	<0.001	<0.001	<0.001	0.100
Fungicide		0.027	0.026	0.906	0.919	0.076	0.139	
C x F		0.375	0.359	0.192	0.191	0.142	0.149	
R-square		0.998	0.998	0.98	0.98	0.97	0.79	
Coefficient of Variation %		4	4	6	6	4	4	

PLER¹ = Pea Land Equivalence Ratio, CLER² = Canola Land Equivalence Ratio, TLER³ = Total Land Equivalence Ratio, †Figures with the same letter within the same column are not significantly different

Table 17b clearly shows that peaolalfalfa cropping system resulted in significantly ($P < 0.001$) higher pod height at 61 cm compared to peaola at 57 cm ($P < 0.001$) and pea monocrop at 46 cm ($P < 0.001$). Other variables such as disease severity, thousand kernel weight (TKW) and aphid infestation were not significant regardless of the factor considered in the analysis. This means that none of the cropping systems, fungicide treatments or interactions of these had a significant influence on disease severity, TKW or aphid populations on peas.

Table17b. Analysis of Variance for Disease, Aphids, Pod height and thousand kernel weight in peaola intercrop

Factor			Pea Disease	Aphids	Pod HT	TKWT Pea	TKWT Can
			0-9 (9 severe)	# plant ⁻¹	cm	g 1000 ⁻¹	g 1000 ⁻¹
Crop	Pea	-	1.3	0.4	46 c	179	-
	Canola	-	-	-	-	-	3.28
	Peaola	-	1.3	0.1	57 b	181	3.39
	Peaolalfa	-	1.5	0.3	61 a	185	3.46
	Significant?		No	No	Yes	No	No
Fungicide	check	-	1.5	0.2	55	181	3.36
	fungicide	+	1.2	0.3	55	183	3.42
	Significant?		No	No	No	No	No
C x F	Pea	-	1.4	0.4	45	178	-
		+	1.1	0.5	47	180	-
	Canola	-	-	-	-	-	3.28
		+	-	-	-	-	3.42
	Peaola	-	1.5	0.1	57	181	3.35
		+	1.1	0.0	57	182	3.43
	Peaola Alfalfa	-	1.4	0.1	62	183	3.40
		+	1.5	0.4	60	186	3.47
	Significant?		No	No	No	No	No
P values	Crop		0.506	0.114	<0.001	0.141	0.074
	Fungicide		0.189	0.518	0.938	0.305	0.065
	C x F		0.366	0.464	0.347	0.866	0.340
R-square			0.80	0.70	0.97	0.79	0.89
Coefficient of Variation %			23	92	4	2	2

Although there were significant differences in net income among different cropping systems, none were positive. Figure 17a shows that in 2019 cropping systems, net losses were recorded for each of the four cropping systems. Peaola cropping system had a significantly lower net loss of (CAD\$13.33) compared to pea monocrop and peaolalfa which had net losses of (CAD\$60.12) and (CAD\$48.08) respectively. Net negative income of (CAD\$32.78) for canola monocrop was not significantly different from the other cropping systems.

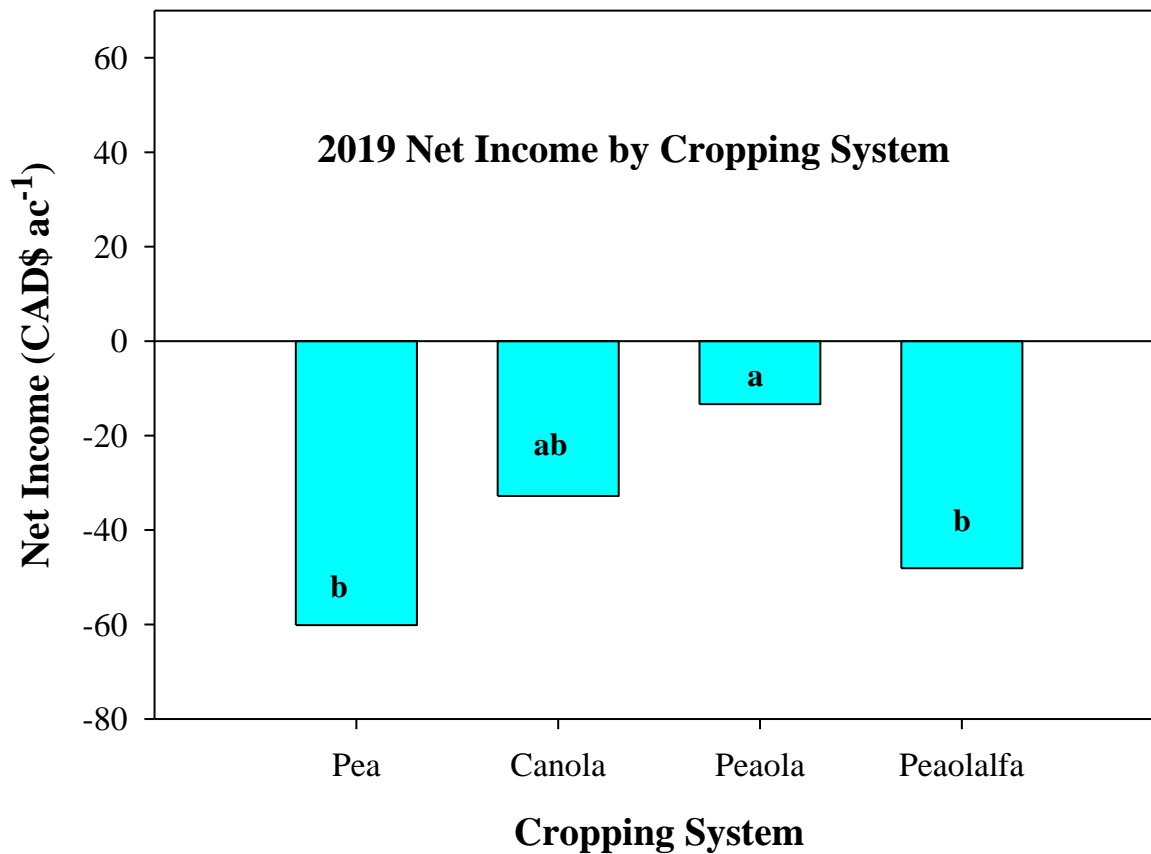


Figure 17a Net Income obtained from different cropping systems at Melita in 2019

An economic analysis on the interaction of cropping system and fungicide resulted in significantly positive net income only for peaola treatment with CAD\$11.27 compared to other treatments that had net negative incomes. Economic losses from pea, canola and peaolalfalfa with fungicide application were not significantly different. Highest economic losses at (CAD\$85.99) were obtained from pea monocrop with a fungicide application. On the other hand, economic losses from pea with no fungicide, peaola with fungicide and peaolalfalfa with no fungicide were significantly lower than other cropping systems except for peaola with no fungicide (Figure 17b).

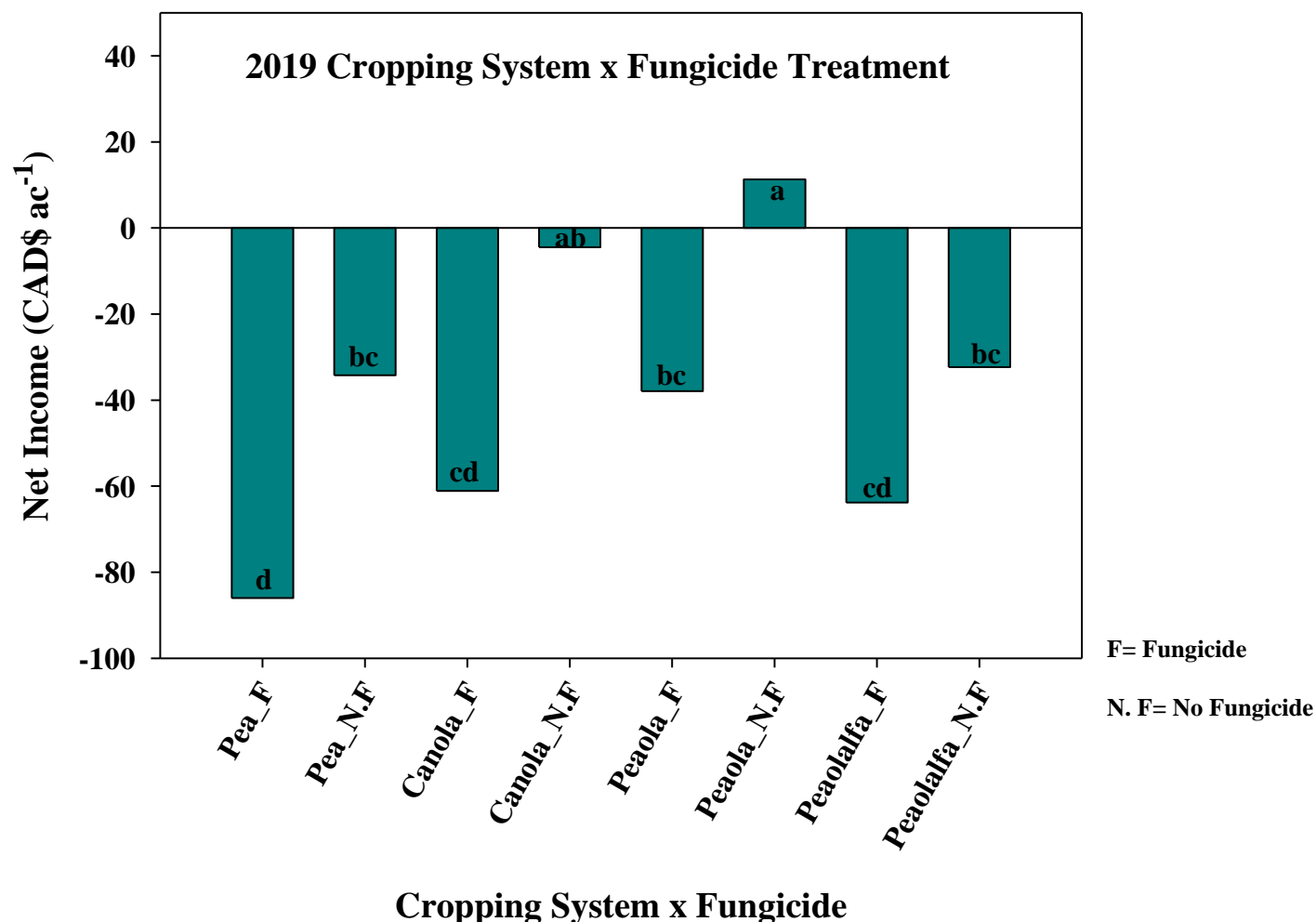


Figure 17b Net income recorded for cropping system x fungicide interaction at Melita in 2019

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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 Agrifood Canada, Brandon

Objectives

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

Materials and Methods

The trials were established at Melita in 2019 except for AFOO Barley that was a continuation from 2018 season. The layout was serpentine arranged as randomized complete block design with 3 replicates. Seeding occurred early on the 2nd and 3rd May under no till system and on oat stubble. A seeding depth of 1" was achieved on Waskada soil moisture reaching 24" and this was adequate for barley emergence within 7 days. Fertilizer blend was side banded during seeding with a seed hawk dual knife air seeder at 108-35-20-7-2Zn (N-P-K-S) actual lb ac⁻¹. Weed control was done between 4 and 6 leaf stage by the application of 0.5 L ac⁻¹ Mextrol and 0.15 L ac⁻¹ Puma. Grain yield was the major data component collected, but other components included plant height at heading, heading and maturity dates and lodging. All data were analyzed by Agriculture and Agrifood Canada in Brandon.

Results and Discussion

The trials for advanced barley yield tests are still ongoing and combined results will be published at a later date. Collaboration of this trial is between Agriculture and Agrifood Canada and WADO.

19.0 Dry bean variety trial – Agriculture and Agri-food Canada

Project duration: 2019-

Collaborator: Anfu Hou Ph.D., Agriculture and Agrifood Canada, Morden MB

Objectives

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

Background

Dry bean is grown in regions of the world that typically experience soil moisture deficits such as the Canadian Prairies during the growing season (Nleya et al., 2001). Development and release of new varieties require extensive screening and testing at different locations over many years in order to find

appropriate varieties to grow in specific ecological regions (Saindon and Schaalje, 1993). Well proven performances of these varieties will enable dry bean producers to select varieties that suit their needs. Therefore, there is need to evaluate different varieties in different environments for potential yield and agronomic characteristics before they can be recommended for different production areas on the Prairies. Among other parameters, dry bean producers are also interested in pod height, disease resistance, days to maturity and nitrogen fixation capacity (Wilker et al., 2019).

Materials and Methods

The trial was established in Melita in 2019. The trial was laid out as randomized complete block design with twenty treatments in 3 blocks. Land preparation involved harrowing to spread oat straw evenly across the plots for ease of seeding and crop emergence. Seeds were placed at 1.25" under no till system on May 14 and fertilizer placement was side banded at the same time. Fertilizer application rates were 88-35-20-7-2Zn (N-P-K-S) actual lb ac⁻¹ based on soil test results obtained from AGVISE laboratory. An application of 0.75 L ac⁻¹ Roundup tank mixed with 0.5 L ac⁻¹ Rival was done a week after seeding but before emergence of beans. Another chemical weed control application was done in-season using 0.91 L ac⁻¹ Basagran and 0.15 L ac⁻¹ Arrow + 0.5% v/v X-Act surfactant for control of broad leaf weeds and grasses respectively. Grasshoppers were controlled with an application of 0.03 L ac⁻¹ Matador as the infestation was high enough to cause significant yield losses. Reglone was applied at 0.5 L ac⁻¹ + 0.25 L LI700 100 L⁻¹ of spray solution at maturity to dry immature green material and late weeds before harvest. Various agronomic data recorded include emergence date, pod clearance, lodging characteristics, flowering date, maturity date and grain yield. The data were analyzed by AAFC in Morden.

Results and Discussion

Dry bean variety trial data was analyzed without distinguishing dry bean market classes. Dry bean plant height had a wide range among the treatments and Azuki BC-26 was the shortest (25 cm) while W11-08-1-2-3-11 was the tallest and measured 61 cm (Table 19a). Although treatments differed in plant height, there were no significant differences in pod height. As expected and due to differences in genetic makeup, days to maturity varied among treatments with the early maturing treatment requiring 97 to 101 days while late maturing treatment (Azuki BC-26) required 120 days to reach maturity. Azuki BC-26 was the shortest treatment but yet required significantly more days to mature compared to other treatments. The genetic makeup of the treatment (Azuki BC-26) could be involving a stay green gene that allows the plant to continue to manufacture food for eventual compensation on seed yield. Dry bean seed yield varied between 1299 kg ha⁻¹ (Azuki BC-26) to 2268 kg ha⁻¹ (W12-32-2-2-1-4). Seventeen of the treatments were

concentrated between 1801 to 2268 kg ha⁻¹ while the other 3 (Azuki BC-26, Envoy-check and Etna) obtained non-significant seed yield of 1299, 1385 and 1486 kg ha⁻¹ (Table 19a). High seed weight was associated with high seed yield for most treatments. However, although Azuki BC-26 had the lowest seed yield of 1299 kg ha⁻¹, its seed weight of 17.6g was not significantly different from most of the treatments including L13BM650, which had the same seed weight but significantly different seed yield of 2059 kg ha⁻¹.

Table 19a. Analysis of variance and mean comparison for dry bean plant height, pod height, days to maturity, seed yield and seed weight at Melita in 2019.

Trt	Name	Type†	Plant_ht cm	Pod_ht cm	DTM	Yield kg/ha	Sdwt
4	Blackstrap	BK	48bcd	6	97f	2208ab	19.4df
14	W11-08-1-1-2	BK	60a	6	106bc	2120abc	20.1d
11	L13BM650	BK	47bcd	6	99f	2059abcd	17.6hi
9	W11-02-1-5-2	BK	55ab	2	107b	2018abcd	19.6d
19	W11-08-1-2-3-11	BK	61a	7	105bc	1934bcdf	17.6hi
10	W11-02-1-3-2	BK	54abc	2	107b	1926bcdf	19.0df
13	W11-08-1-1-1	BK	54abc	8	104bcd	1921bcdf	19.1df
3	CDC Jet (check)	BK	55ab	7	105bcd	1823cdf	18.3fhi
18	W13-15-02-1-3-1	NA	45cd	3	98f	2079abcd	18.0hi
17	W11-18-1-2-1-6	NA	54ab	5	105bc	1947bcd	16.0j
16	W11-15-1-2-2-5	NA	41	3	106bc	1862cdf	18.0hi
2	Portage (check)	NA	45d	3	98f	1846cdf	17.6hi
5	S09-27C	NA	55ab	7	103bcd	1801df	18.7fhi
15	W11-20-1-11-3	NA	54abc	2	98f	1694f	18.5fhi
12	W11-20-1-11-2	NA	44d	2	103cd	1647fh	18.8fh
1	Envoy (check)	NA	47bcd	7	101df	1385hi	18.5fhi
6	CR10875	CR	47bcd	5	105bc	2059abcd	47.2a
8	Etna	CR	37d	1	105bc	1486hi	45.7b
7	Azuki BC-26	AZ	25f	1	120a	1299i	17.6hi
20	W12-32-2-2-1-4	PT	42d	2	100df	2268a	30.1c
		CV	11	71	2	10	3
		LSD					
		(p<0.05)	9	NS	3	300	1.2
		P value	<0.001	0.078	<0.001	<0.001	<0.001

†Analysis used does not distinguish varieties within market classes

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20.0 Swath Canola Variety Trial

Project duration: 2017-

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 impact negatively on 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 at Melita was arranged as randomized complete block design with 23 treatments (varieties) replicated 4 times. Canola was directly seeded into oat stubble under no till system on the 9th of May 2019. A seeding depth of 0.5" was achieved and fertilizer side banded at 116-35-20-7-22n (N-P-K-S) actual lb ac⁻¹. Soil moisture content was good to a depth of 24". Flea beetles were controlled by the application of Pounce insecticide 3 times at 0.08 L ac⁻¹, 0.074 L ac⁻¹ and 0.054 L ac⁻¹ on May 27, May 29 and June 6

respectively. Herbicide application was based on treatments as follows: 0.12 L ac⁻¹ Select + 0.5% v/v Amigo surfactant, 0.33 L ac⁻¹ Roundup Transorb, 17.3 g ac⁻¹ Odyssey + 0.5% v/v Merge surfactant and 1.35 L ac⁻¹ Liberty Link. Swathing was done on August 13 and 20 when plots exhibited >60% seed color change. 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

2019 results available at www.canolaperformancetrials.ca or Seed Manitoba 2020 Variety Selection and Growers Source Guide pp 47-48.

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21.0 Straight Cut Canola Variety Trial

Project duration: 2017-

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 at Melita was 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 onto oat stubble at 0.5" on the 8th of May. Chemical control for weeds and insecticides was similar to the Swath Canola Variety trial.

Results and Discussion

2019 results available at www.canolaperformancetrials.ca or Seed Manitoba 2020 Variety Selection and Growers Source Guide pp 47-48.

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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 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

In 2019, the trials were conducted at Melita and Reston locations in Southwestern Canada. The experimental design was randomized complete block design with 11 treatments replicated 4 times. These locations differed in soil type, with the former characterized by Waskada loam while the later was characterized by Ryerson5loam-Coatstoneloam2-Tilstoneloam1 soils. Melita site was established on oat stubble while Reston plots were on flax stubble. Land preparation involved harrowing to evenly spread plant residues at both sites. Due to high weed density at Reston, application of 1.5 l ac⁻¹ Roundup and 0.65 L ac⁻¹ Rival was done before seeding while the Melita site did not require a burnoff. Seeding was done on the 8th of May at Melita at 0.5" while Reston was seeded on the 17th of May at 0.75". Soil moisture content was lower at Reston hence the difference in seeding depth with Melita. Fertilizer was side banded during seeding at a rate of 108-35-20-7-2Zn (N-P-K-S) lb ac⁻¹ in Melita while 7-35-20-7-2Zn lb ac⁻¹ was applied at seeding in Reston followed by top dressing with 120 lb ac⁻¹ N in the form of Urea. Post emergence chemical weed control involved the use of 0.12 L ac⁻¹ Select mixed with 0.5% v/v Amigo surfactant. In addition to this tank solution, 0.5 L ac⁻¹ 28-0-0 (Urea) was applied at Reston to improve efficacy on weeds. Flea beetles were sprayed twice with 0.074 L ac⁻¹ Pounce at both. Before harvesting Reston site, an application of 0.65 L ac⁻¹ Reglone, 0.5 L ac⁻¹ Roundup and 0.5% v/v LI700 was done as a desiccant to dry mustard stems and kill late weeds. Melita site was swathed and left to dry before harvesting. Data collected included maturity date, plant height at maturity, days to flowers and grain yield.

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/>.

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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 established in Melita and Reston in Southwestern Manitoba in 2019. Six treatments were laid out as randomize complete block design and replicated 3 times. The soil type and seeding dates at both sites were the same as for Yellow Mustard trial. All fertilizer requirements were met during seeding,

ensuring application of 108-35-20-7-2Zn (N-P-K-S) actual lb ac⁻¹ by banding method. In addition to the herbicides applied in Yellow Mustard trial, 8 g ac⁻¹ + 0.2% v/v Prosurf was applied to the Juncea (*B. juncea*) trial at both locations. Flea beetles were controlled the same way as in the Yellow Mustard trial. Preharvest operations of swathing and desiccation were done the same way as Yellow Mustard trial. Various data collected included plant height at maturity, flowering date, days to maturity, severity of lodging, green seed count, and grain yield.



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/>.

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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 trial (Pea-Oats-Canola-Wheat-Flax-Mustard)

Project duration: 2019-2021

Collaborators: Manitoba Pulse & Soybean Growers Association - Daryl Domitruk

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 on flax stubble at Reston (Legal: SE 11-7-27 W1) and on wheat stubble at Elva (Legal: SE 26-3-28 W1), in Southwestern Manitoba. Soil type at Reston site was Ryerson5Loam-CoatstoneLoam2-TilstonLoam1 while Elva site was Lauder5-Souris5-Loamy Fine Sand soils. A randomized complete block design with 11 treatments and 4 replicates was used at each site. Reston site was seeded on May 17th while Elva site was seeded on June 3rd at a depth of 0.75". Fertilizer was applied together with the inoculant during seeding at 8-35-20-7-2Zn (N-P-K-S) lb ac⁻¹ for Reston site and 7-30-0-0 (N-P-K-S)

lb ac⁻¹ for Elva site. Both sites were sprayed with 0.75 L ac⁻¹ Roundup, 0.1 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, and 0.1 L ac⁻¹ Select in all treatments except cereals at Reston. Flea beetles were controlled using 0.074 L ac⁻¹ Pounce at Reston while 0.033 L ac⁻¹ Matador was applied for grasshopper control at Elva. 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. 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 mycosphereella, 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.



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 1.22 and higher TLER ($P<0.0001$) at 2.05 compared to other intercrop options at Reston. There were no significant yield differences in other pea intercrop options (Table 24a). At Elva, the highest partial pea yield (2405 kg ha^{-1}) obtained from a mustard intercrop was not significantly different from wheat or canola intercrops but was significantly higher ($P=0.002$) than pea yield obtained from oats and flax plots. Partial pea land equivalence ratio for pea followed the same pattern as yield with mustard intercrop having 0.76 pea LER which was significantly ($P=0.001$) higher than oats and flax. The TLER for the mustard intercrop was not significantly different from other treatments except flax which had the lowest at 0.94 compared to 1.27 ($P=0.022$) for the former (Table 24b). Results from Roblin in Table 24c, indicate that there were no significant differences partial pea yield, LER or TLER regardless of the intercrop option.

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

Trt	Crop	Yield (kg ha^{-1})			LER		
		Sole	Crop-IC	Pea-IC	Partial Sole	Partial Pea	TLER
1	Pea	531	*	*	1.00	*	1.00d
2,7	Flax	2463	1681	306b	0.64	0.58b	1.22cd
3,8	Oat	4328	4323	344b	1.01	0.66b	1.67ab
4,9	Wheat	3865	3177	322b	0.83	0.61b	1.44bcd
5,10	Canola	3735	3070	656a	0.82	1.22a	2.05a
6,11	Mustard	2034	1651	401b	0.80	0.76b	1.56bc
P value		0.001			0.001		<0.0001
CV		23			23		13

Table 24b. Analysis of variance for yield, partial LER and TLER for Elva MultiCrop

Trt	Crop	Yield (kg ha^{-1})			LER		
		Sole	Crop-IC	Pea-IC	Partial Sole	Partial Pea	TLER
1	Pea	3301	*	*	1.00	*	1.00ab
2,7	Flax	1865	909	1479bc	0.49	0.45bc	0.94b
3,8	Oat	4173	3390	1079c	0.83	0.35c	1.17ab
4,9	Wheat	2220	1302	1920abc	0.59	0.62ab	1.21ab
5,10	Canola	2602	1255	2258ab	0.51	0.71ab	1.22ab
6,11	Mustard	1318.4	666	2480a	0.51	0.76a	1.27a
P value		0.002			0.001		0.022
CV		22			20		12

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

Trt	Crop	Yield (kg ha ⁻¹)			LER		
		Sole	Crop-IC	Pea-IC	Partial Sole	Partial Pea	TLER
1	Pea	939	*	*	1.00	*	1.00a
2,7	Flax	1386	347	869a	0.31	0.87a	1.18a
3,8	Oat	6794	4753	371a	0.71	0.43a	1.15a
4,9	Wheat	4505	2325	371a	0.52	0.44a	0.95a
5,10	Canola	4451	2071	1691a	0.44	1.98a	2.42a
6,11	Mustard	2142	1286	956a	0.61	1.07a	1.68a
P value		0.101			0.072		0.115
CV		81			79		55

LER=Land equivalence ratio, TLER=Total land equivalence ratio, IC=Intercrop

In 2019, the percentage change in crop emergence and weed biomass was not significantly different at any of the three sites regardless of the intercrop combination. There was no evidence on whether one intercrop had an advantage over the other in suppressing weeds. These results suggest the need for additional site years of data to determine an appropriate intercrop option that producers can use as an alternative integrated weed control strategy in their areas of production (Table 24d-24f).

Table 24d. Analysis of variance for crop emergence and weed biomass for Reston MultiCrop in 2019

Trt	Crop	Final Emergence ppms			% Change Emergence			Weeds (g/m ²)	
		Sole	Crop-IC	Pea-IC	Sole	Crop-IC	Pea-IC	Sole	Pea-IC
1	Pea	77	*	*	13	*	13a	2193	*
2,7	Flax	469	190	41	4	19	13a	920	1274a
3,8	Oat	204	108	29	3	7	28a	1011	1636a
4,9	Wheat	247	106	38	7	3	15a	1302	1756a
5,10	Canola	71	36	33	3	0	29a	893	1026a
6,11	Mustard	33	22	37	0	3	17a	1991	1691a
P value		0.534			0.094		0.094		
CV		83			83		33		

Table 24e. Analysis of variance for crop emergence and weed biomass for Elva MultiCrop in 2019

Trt	Crop	Final Emergence ppms			% Change Emergence			Weeds (g/m ²)	
		Sole	Crop-IC	Pea-IC	Sole	Crop-IC	Pea-IC	Sole	Pea-IC
1	Pea	85	*	*	9	*	9a	120	*
2,7	Flax	353	196	41	4	11	10a	53	66a
3,8	Oat	240	129	39	7	7	9a	79	25a
4,9	Wheat	270	133	45	0	5	13a	16	43a
5,10	Canola	77	47	41	16	13	5a	182	59a
6,11	Mustard	86	42	42	6	20	9a	90	40a
P value		0.942			0.083		0.083		
CV		113			113		73		

Table 24f. Analysis of variance for crop emergence and weed biomass for Roblin MultiCrop in 2019

Trt	Crop	Final Emergence ppms			% Change Emergence			Weeds (g/m ²)	
		Sole	Crop-IC	Pea-IC	Sole	Crop-IC	Pea-IC	Sole	Pea-IC
1	Pea	66	*	*	17	*	17a	93.8	*
2,7	Flax	153	65	49	41	42	14a	274	115a
3,8	Oat	102	84	29	47	15	39a	21.5	81a
4,9	Wheat	99	86	38	51	36	14a	25.75	32.8a
5,10	Canola	58	24	49	35	28	21a	91	35.25a
6,11	Mustard	31	24	48	22	26	0a	123.5	96a
P value		0.127						0.681	
CV		100						114	

Whereas protein content (21.6 to 22.4%) was not significantly different among different intercropping systems, there were significant ($P<0.0001$) differences in pea splits at Reston. Pea splits were lowest in oats intercrop (3.5g 500 seeds⁻¹) compared to pea monocrop and flax intercrop that had 9.4 and 11.2g 500 seeds⁻¹). At Elva, pea splits were lowest (0.1g 500 seeds⁻¹) in oats compared to pea monocrop with 1.8g 500 seeds⁻¹ ($P=0.02$). Pea splits in other intercrop options were not significantly different from pea splits in oats and pea monocrop. Pea protein content at the same site was significantly ($P=0.014$) lower in canola intercrop (21.5%) compared to oat and wheat intercrop (22.5%). Although there were no significant differences in pea splits at Roblin, there was a significant ($P=0.029$) difference in protein content with mustard intercrop recording 26.5% compared to 22.3% for the wheat intercrop. Compared to other sites, Roblin recorded higher protein content with a range of 22.3 to 26.5% compared to 21.5 to 22.5% across all intercrop options in 2019 (Table 24g).

Table 24g. Analysis of variance for pea splits and protein content at 3 MultiCrop sites in 2019

Trt	Crop	Reston		Elva		Roblin	
		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	9.4ab	22.4a	1.8a	22.2ab	5.8a	24.5ab
2,7	Flax	11.2ab	22.1a	0.4ab	21.8ab	7.8a	24.8ab
3,8	Oat	3.5c	22.3a	0.1b	22.5a	5.1a	23.1ab
4,9	Wheat	5.1c	21.9a	1.7ab	22.5a	8.8a	22.3b
5,10	Canola	5.7bc	22.3a	1.4ab	21.5b	3.5a	23.7ab
6,11	Mustard	7.3abc	21.6a	1.1ab	21.7ab	6.8a	26.5a
P value		<0.0001	0.193	0.02	0.014	0.211	0.029
CV		26	2	65	2	47	6

Net revenue obtained from different cropping systems was significantly different ($P < 0.0001$ at Reston and Elva, and $P = 0.001$ at Roblin). At Reston, pea sole crop had the lowest net revenue of (CAD\$248) compared to the other cropping systems that had positive net revenues (Table 24h). There appeared to be significantly higher net revenues when pea was intercropped with oat, canola or mustard than pea sole crop. On the other hand, net revenue obtained from intercropping pea with flax, oat or wheat was not significantly different (Table 24h). With respect to Elva site, net revenue obtained from pea sole crop and pea intercrop with flax, oats or wheat was significantly lower than that obtained from pea-canola or pea-mustard, which had the highest net revenues (Table 24i). Negative net revenues in pea sole crop, pea-flax and pea-wheat were obtained at Roblin while pea-oats, pea-canola and pea-mustard recorded the highest net revenues (Table 24j). These results provide some insight on viable options that farmers can select from as a way of spreading risks on the farm. Higher revenue from pea intercropping systems involving mustard or canola could be one of the options that farmers can consider probably due to a better symbiotic relationship between the component crops. This study is still ongoing and with additional site-years, a better understanding of component crop dynamics is assured so as to allow farmer to make informed decisions concerning suitable cropping systems.

Table 24h. Economic analysis for Reston MultiCrop in 2019

Trt	Crop	Economics					
		Sole-CROP	IC – CROP	Gross Revenue		Net Revenue	
				Sole	IC	Sole	IC
1	Pea	303	*	55	*	(248)	(248)c
2,7	Flax	289	325	499	373	210	48b
3,8	Oat	292	318	425	461	134	142ab
4,9	Wheat	308	316	387	352	79	36b
5,10	Canola	328	339	732	669	404	329a
6,11	Mustard	317	336	689	601	372	265a
P value		<0.0001					
CV		28					

Table 24i. Economic analysis for Elva MultiCrop in 2019

Trt	Crop	Economics					
		Sole-CROP	IC – CROP	Gross Revenue		Net Revenue	
				Sole	IC	Sole	IC
1	Pea	303	*	343	*	40	40bc
2,7	Flax	289	325	378	338	89	13c
3,8	Oat	292	318	410	445	118	127ab
4,9	Wheat	308	316	223	330	(86)	14bc
5,10	Canola	328	339	510	481	182	141a
6,11	Mustard	317	336	446	483	129	147a
P value		<0.0001					
CV		52					

Table 24j. Economic analysis for Roblin MultiCrop in 2019

Trt	Crop	Economics					
		Sole-CROP	IC – CROP	Gross Revenue		Net Revenue	
				Sole	IC	Sole	IC
1	Pea	303	*	98	*	(206)	(206)b
2,7	Flax	289	325	281	161	(8)	(164)b
3,8	Oat	292	318	667	506	376	187a
4,9	Wheat	308	316	451	272	143	(44)ab
5,10	Canola	328	339	872	581	544	242a
6,11	Mustard	317	336	725	535	408	199a
P value		0.001					
CV		411					

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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 (Legal: SE 11-7-27 W1) on Ryerson5Loam-CoatstoneLoam2-TilsonLoam1 soil in 2019. Nine treatments were arranged as randomized complete block design with 4 replicates. Prior to seeding, weed control was done by the application of 1.5 L ac⁻¹ Roundup and 0.65 L ac⁻¹ Rival. Seeding occurred on the 17th of May at a depth of 0.75" together with side banding of fertilizer at 8-35-20-7-22Zn (N-P-K-S) actual lb ac⁻¹. Due to high weed density in the plots, post emergence application

with 0.12 L ac⁻¹ Select + 0.5% v/v Amigo was done twice, with Urea (28-0-0) at 1.5 L ac⁻¹ added in the tank mix of the second application. Flea beetles were controlled once using 0.074 L ac⁻¹ Pounce insecticide. Prior to harvesting, Roundup, Reglone + LI700 were applied as desiccants at 0.5 L ac⁻¹, 0.65 L ac⁻¹ and 0.5% 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 Chatteron) for DNA assessment of severity of fusarium root rot, aphanomyces, mycosphaerella and powdery mildew.

Results and Discussion

Preliminary results for pea and canola or yellow mustard intercrop showed no significant differences in emergence counts at 2 to 3 weeks after emergence and at flowering (table not shown). In the first year of the study, various diseases: fusarium root rot, aphanomyces, powdery mildew and mycosphaerella were identified from each of the plots but there were not significant differences in diseases incidence between different cropping systems based on field ratings. However, a PCR analysis established significantly lower ($P=0.049$) aphanomyces copies in pea-mustard ratios 50:50 and 30:70 compared to the 70:30 and pea-canola 30:70 ratios (Table 25b). Based on the same analysis, there were no significant differences in aphanomyces copies from pea sole crop, pea-mustard 70:30, pea-canola 50:50 and 30:70 ratios. The most important observation to note was the presence of aphanomyces, which causes serious economic losses in pea. Cropping system did not seem to influence pea protein content and percentage of pea splits. However, weed biomass significantly ($P=0.001$) decreased with a change in cropping system (Table 25a). Results from this study show that pea monocrop harbors more weeds compared to any cropping system involving yellow mustard or canola. This could be chemical compounds produced by brassicas that suppress or outcompete weeds.

Table 25a. Analysis of variance for weeds, protein content and splits in a pea-canola-mustard intercrop at Reston in 2019

Treatment Description	Weeds per sqm		Pea %	
	Biomass g	Number	Protein	Splits
Pea	726a [†]	1275	22.3	2.1
Mustard	423b	1156	-	-
Canola	389b	700	-	-
Pea:Mustard 70:30	287b	1350	22.4	2.4
Pea:Mustard 50:50	416b	844	21.9	2.4
Pea:Mustard 30:70	323b	856	21.8	3.1
Pea:Canola 70:30	346b	1038	22.3	2.6
Pea:Canola 50:50	353b	838	21.5	2.1
Pea:Canola 30:70	311b	863	21.6	2.0
P value	0.001*	0.413	0.063	0.897
CV	94	44	2	54

[†] Values with the same letter within the same column are not significantly different

Table 25b. Analysis of variance for pea diseases from field ratings and PCR analysis of root diseases in a pea-canola or mustard intercrop at Reston in 2019, data observed July 24, 2019.

Treatment Description	Field Rated Diseases*				PCR Analysis of Root Diseases (Copies per µL)			
	<i>Fusarium</i> sp. (root)	<i>Aphano</i> (root)	<i>P.</i> <i>Mildew</i> (plant)	<i>Myco.</i> (plant)	<i>Aphano</i>	<i>F.</i> <i>redolens</i>	<i>F.</i> <i>avenaceum</i>	<i>F. solani</i>
Pea	4.6	2.4	2.1	1.6	251abc	18	13	31
Mustard	-	-	-	-	-	-	-	-
Canola	-	-	-	-	-	-	-	-
Pea:Mustard 70:30	4.6	2.6	2.4	1.3	295ab	14	10	41
Pea:Mustard 50:50	4.6	2.3	2.2	0.9	180c	14	3	35
Pea:Mustard 30:70	4.4	2.8	2.9	0.9	182c	14	10	19
Pea:Canola 70:30	4.9	2.7	2.4	1.1	203bc	12	12	30
Pea:Canola 50:50	5.1	2.5	2.9	1.0	230abc	12	3	25
Pea:Canola 30:70	5.0	2.6	2.9	1.0	320a	20	5	32
P value	0.943	0.755	0.204	0.057	0.049	0.725	0.084	0.809
CV	21	16	23	29	28	55	71	66

* Field Rating scales: *Fusarium* and *Aphanomyces* rated at 1-7 scale (1=no disease, 7=dead), *P. mildew* and *Mycosphaerella* at 0-9 scale (0=no disease, 9=dead) Xue-Wang Scale.

Pea grain yield from pea monocrop and pea: mustard (70:30) were the highest and significantly ($P<0.001$) different from pea: mustard at both 50:50 and 30:70 ratios. This suggests that a producer can be better off adopting a 70:30 pea-mustard cropping system and not only achieve similar yields to pea monocrop but also benefit from biological weed control due to inclusion of mustard in the cropping system. Grain yield for mustard was not significantly different regardless of the cropping system under consideration.

The same cropping systems that resulted in higher yields had significantly higher LER for pea ($P<0.001$) and the total land equivalence ratio was significantly high ($P<0.084$) for a pea-mustard cropping system with a 70:30 seeding ratio (Table 25c; Figure 25a). A higher LER ratio translates to higher economic returns as a result of maximum utilization of available land area.

Table 25c: Analysis of variance for yield and land equivalence ratio of pea-mustard intercrop at Reston in 2019

Treatment	Pea yield Kg ha ⁻¹	Mustard yield Kg ha ⁻¹	P-LER	M-LER	TLER†
Pea	1144a	*	1.00a	*	1.00
Mustard	*	931a	*	1.00a	1.00
Pea: Mustard 70: 30	987a	714a	0.873a	0.774a	1.647a
Pea: Mustard 50: 50	655b	774a	0.589b	0.834a	1.423b
Pea: Mustard 30: 70	509b	849a	0.448b	0.914a	1.362b
P-value	< 0.001	ns	<0.001	ns	0.084
CV%	18	14	13	14	10

†LSD for TLER at 90% CI, all other means at 95% CI

Similar to pea-mustard, grain yield and LER of pea in monocrop were not significantly different from that obtained from pea-canola at seeding ratio on 70:30. There were also no significant differences in pea grain yield and LER when 70:30 and 50:50 (pea: canola) seeding rates were used. However, a pea-canola seeding ratio of 30:70 resulted in significantly ($P<0.001$) lower pea yield of 525 kg ha⁻¹ and compared to other cropping systems. Canola yield and LER were significantly ($P<0.001$) high in canola monocrop and pea-canola seeded at 30:70 compared to the 50:50 and 70:30 cropping systems. Canola yield and LER from 50:50 (pea: canola) cropping system were significantly ($P<0.001$) greater than that recorded in the 70:30 cropping system. Total LER was significantly ($P=0.053$) high in pea-canola cropping systems with 70:30 and 50:50 seeding rates compared to other cropping systems. The high LER in these cropping systems implies that producers can benefit more in returns with this intercropping combination than when they consider monocrop of either pea or canola (Table 25d; Figure 25b). Although this trial is only in its first year, it is clear that diversification results in sustainability and producers can have a wide range of choices to select from while still realizing economic returns.

Table 25d. Analysis of variance for yield and land equivalence ratio of pea-canola intercrop at Reston in 2019

Treatment	Pea yield Kg ha⁻¹	Canola yield Kg ha⁻¹	P-LER	C-LER	TLER†
Pea	1144 a	*	1.00 a	*	1.00
Canola	*	1742 a	*	1.00 a	1.00
Pea: Canola 70: 30	977 ab	1201 c	0.877 ab	0.698 c	1.575 a
Pea: Canola 50: 50	840 b	1394 b	0.755 b	0.808 b	1.563 a
Pea: Canola 30: 70	525 c	1670 a	0.458 c	0.968 a	1.426 b
P-value	< 0.001	< 0.001	<0.001	< 0.001	0.053
CV%	14	8	12	7	5

†LSD for TLER at 90% CI, all other means at 95% CI

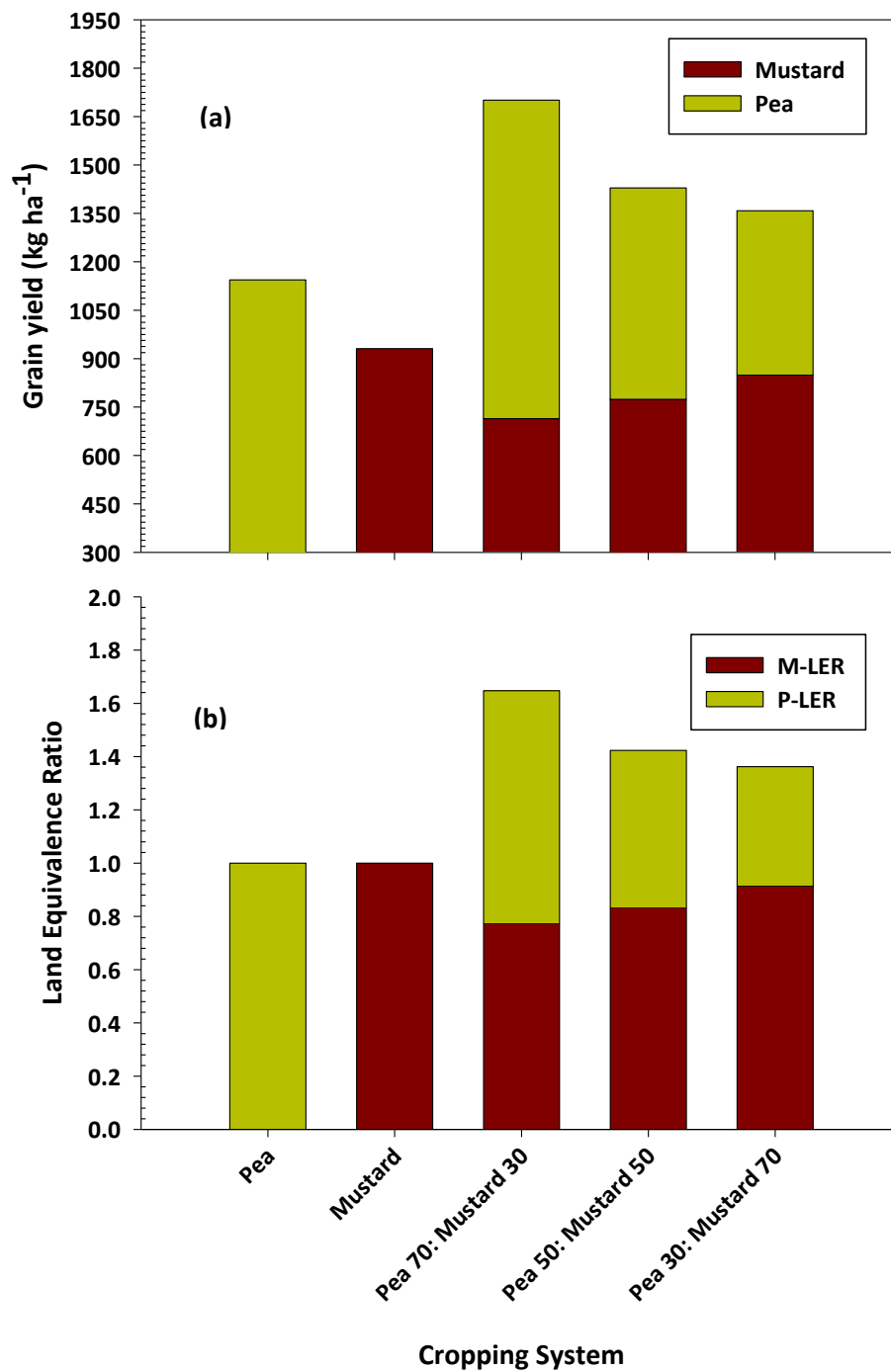


Figure 25a: Grain yield (a) and land equivalence ratio (b) for pea-mustard intercrop at Reston in 2019

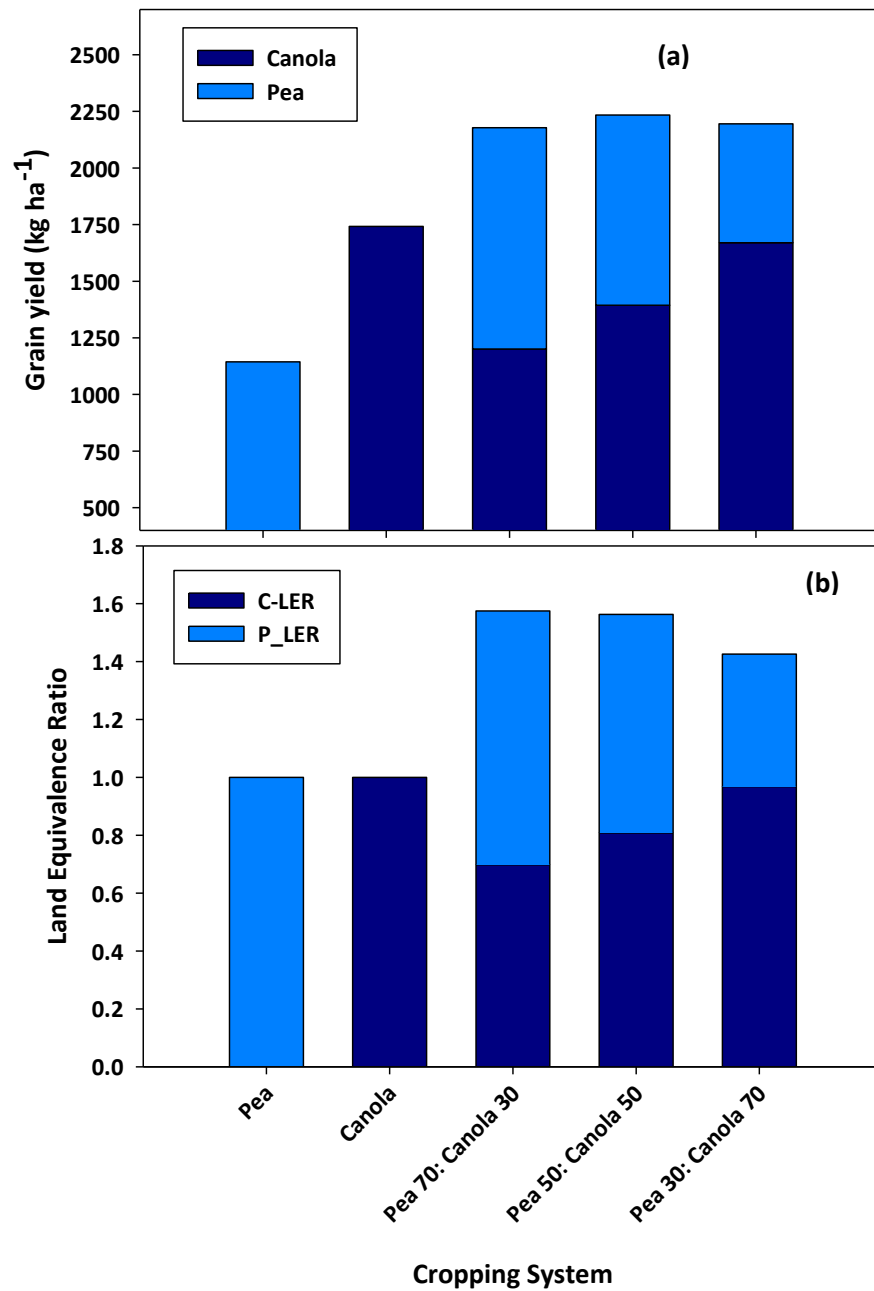


Figure 25b. Grain yield (a) and land equivalence ratio (b) for pea-canola intercrop at Reston in 2019

Pea-Canola-Mustard intercrop harvest at
Reston, August 20 ,2019



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26.0 Winter Wheat-Soybean Intercrop

Project duration: 2019

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 established in fall 2018 at Melita and arranged as randomized complete block design with 8 treatments replicated 3 times. Seeding of winter wheat was done on oats stubble in fall followed by soybean early in spring as per treatment layout. Preseeding herbicides were applied in fall as burnoff using 0.75 L ac⁻¹ Roundup, 0.021 L ac⁻¹ Heat LQ and 0.2 L ac⁻¹ Merge adjuvant. Top dressing was applied on May

23rd as per protocol. Post emergence weed control in soybean was done using 0.33 L ac⁻¹ Roundup on June 24th. Cutworm and grasshoppers in soybean were controlled using Lorsban and Matador at 0.03 L ac⁻¹ respectively. Various data collected included plant counts at emergence, date to growth stage 30 of wheat, flowering dates, soybean nodule count per plant, head count, days to maturity, wheat lodging score, plant height at maturity, test weight and yield. 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. Treatment materials are presented in Table 26a.

Table 26a. Treatment materials for winter wheat- soybean trial in 2018/19

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	16 000 ppa 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



Soybean seeded into winter wheat on May 10 2019 at Melita

Results and Discussion

Table 26b presents findings from the winter wheat- soybean trial in 2018/19 growing season. Treatment 5 (winter wheat-soybean with 16000 plants ac⁻¹ and 100% fall N) had significantly (P=0.011) more heads m⁻¹ compared to other treatments. The mean number of heads for this treatment was 110.5 compared

to 75.67 for treatment 8 (winter wheat monocrop with 250 plants m⁻² and 100% spring applied N). Wheat yields (row) for treatments 3, 4 and 5 were significantly ($P<0.0001$) higher than treatments 6, 7 and 8. Land equivalence ratio for wheat (field) was significantly higher for treatment 4 (1.0571) compared to treatment 3 (0.9146) and 5 (0.9153). Total land equivalence ratio for wheat and soybean was also significantly higher for treatment 4 compared to treatment 3 and 5. Treatment 3 received 50% N in fall, 50% N in spring and 234g ac⁻¹ agrotain but did not have significant differences in LER with treatment 5 which received 100% N in fall only. Treatment 5 recorded an average of 10.633 nodules per plant, which was significantly ($P=0.057$) more than treatments 1 (4.633 nodules), 2 (3.5 nodules) and 4 (6.37 nodules). These results suggest contrasting outcomes in whether or not applying all nitrogen requirements in fall, spring or split application with or without agrotain has benefits in winter wheat-soybean intercropping system. It is important to note that results from this study are only from the first year of the study but there seem to be promising data that could be useful to producers interested in pursuing winter wheat-soybean intercropping systems as an alternative to improve soil health and maximum utilization of land. Additional site years are required in order to make recommendations on whether producers should pursue this cropping system under Prairies weather conditions

Table 26b: Analysis of variance for winter wheat-soybean intercrop agronomic performance in 2019

Trt	Height Cm	WhHeads m ⁻¹	TestWt 500g ⁻¹	WhYield kg ha ⁻¹		WhLER (field)	SoYield kg ha ⁻¹	SoLER	TOTAL LER	SoNodules plant ⁻¹	SoEmerg plants m ⁻¹
1	*	*	*	*	*	*	2230	*	*	4.633c	17
2	*	*	*	*	*	*	2717	*	*	3.5c	10
3	58	86.17b [†]	367	4756a	3171	0.9146b	204	0.074	0.989b	9.23ab	14
4	57	93ab	369	5244a	3496	1.0571a	152	0.057	1.114a	6.37bc	21
5	55	110.5a	373	4816a	3211	0.9153b	198	0.070	0.9851b	10.633a	9
6	54	77.17b	371	3508.3b	3508	*	*	*	*	*	*
7	54	80.33b	368	3462.1b	3462	*	*	*	*	*	*
8	51	75.67b	365	3311b	3311	*	*	*	*	*	*
P values by Treatment											
1,2,3,4,5 3,4,5,6,7,8 3,4,5 1,2 6,7,8	0.151	0.011	0.114	<0.0001	0.537 0.505 0.640	0.058	0.590	0.672	0.089	0.057 0.404 0.486	0.430

[†]Values sharing the same letter within the same column are significantly different. WhHeads= wheat heads, TestWt=test weight, WhYield=wheat yield, WhLER= wheat land equivalence ratio, SoYield= soybean yield, SoLER= soybean land equivalence ratio, SoNodules= soybean nodules, SoEmerg= soybean emergence. P values significant at alpha 0.1 level.



Winter wheat-soybean
intercrop at WADO 2019

References

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27.0 Prairie Mountain Hops 2019 Farm Report

Cooperator: Randy and Lyn Tye

Introduction

Hops (*Humulus lupulus* L.) are viney plants that have flowering structures called cones (loosely termed the “hops” of the plant used as a bittering and aroma flavor additive to beer and have been used for centuries as a natural preservative. The crop attracts many pests and diseases, thereby requiring effective integrated pest management in order to achieve higher yield and quality. Knowledge of biology and environmental conditions in which they thrive provides crucial information required for pest management.

WADO continued their partnership with Prairie Mountain Hops (PMH) farm in 2019 providing advice on various aspects including; fertility management, pest management, scouting, and various other tasks.

PMH is located several miles south of Boissevain MB. It was established in 2017 with 2.5 acres of plants (approx. 2500 plants). In 2019, PMH increased its production area by more than 100% to 5.5 acres (5500 plants) and still plan to meet a target of 15 acres in the near future. Eight varieties of hops were established and these are; Centennial, Cascade, Willamette, Comet, Chinook, Mount Hood, Nugget and Brewers Gold.

Hop production requires very high input costs including labor and pesticides but high returns following successful crop management are assured due to high demand on the market.

Seasonal Management

Zonal soil tests were conducted in early spring and recommended application rates were designed to address nutrient deficiency in the soil and to meet requirements by hops (Table 27a). Fertilizer application was done by broadcasting and fertigation methods.

Table 27a Zonal (high and low slope) soil test results and recommended application rates for 2019

Soil Test - South Field (4 acres)							Soil Test - North Field (2.5 acres)						
N*	P	K	S	Zn	B	Cu	N*	P	K	S	Zn	B	Cu
lb ac ⁻¹	Ppm	ppm	lb ac ⁻¹	ppm	ppm	ppm	lb ac ⁻¹	ppm	ppm	lb ac ⁻¹	ppm	ppm	ppm
175	17.5	257	70	1.57	0.5	0.625	35	15	260	108	2.065	0.6	0.65
Recommended application rate (lb ac ⁻¹)							Recommended application rate (lb ac ⁻¹)						
80	30	20	15	1	2	2	160	30	20	15	1	2	2
Total Available (lb ac ⁻¹)							Total Available (lb ac ⁻¹)						
325	65	534	85	4.14	3	3.25	209	60	540	123	5.13	3.2	3.3

*N will mineralize 1.4 times the soil test value over the season

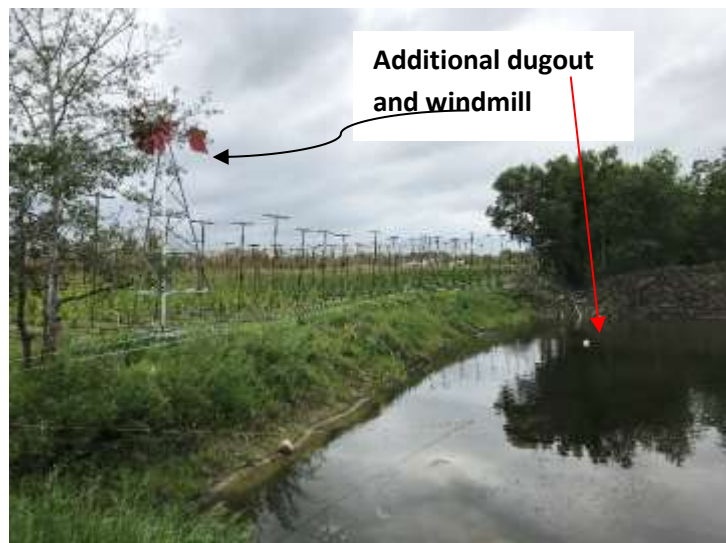
Dates of occurrence of different developmental stages of the varieties differed by less than 5 days, for instance; 1st shoot emergence occurred between May 10th and 18th and burr development was observed during the week of July 16th to 20th. Bine training was done on June 5th and 6th. Other activities conducted during the season included mowing weeds between rows and trimming excess shoots. Chemical weed control around hops plants using Aim herbicide on June 15th.

During the 2019 season there were significant number of two-spotted spider mites and these were controlled by the application of Agmite insecticide on August 15th. Spider mites are of economic importance as a result of their ability to transmit viral disease and also reduce hop yield, hence controlled must be initiated timely so as to avoid possible yield losses from occurring. There were no major cases of aphids that warranted control in 2019 compared to 2018. Aphid population did not warrant any action by use of chemicals probably due to presence of predatory lady bugs. A few plants with downy mildew were rogued and destroyed to prevent spread of the disease to healthy plants. No further downy mildew development was apparent for the rest of the season.

Rainfall, subsoil moisture and temperature was below normal for April 15- September 11 in 2019 for PMH for the majority of the summer. May and late August were cooler than normal contributing to below normal Growing Degree Days (GDD). GDD accumulations for the area between April 1 and September 11 was 1349 (normal 1528) at base 5°C [Data sourced from Manitoba Agriculture Ag-Weather Program, Boissevain location]. Subsoil and rainfall moisture was limited in June and July until the last few days in August and September when the rains began. Total rainfall was 316 mm, normal being 319 mm. Due to the lack of seasonal rainfall during peak cone development, irrigation was implemented. Total amount of supplemental irrigation water applied in 2019 was 132 000 imp. gallons, with each plant receiving 24 gallons during cone development.

An additional dugout was excavated on property to be used as a secondary water source when the primary dugout was low. The primary dugout (photo) was also excavated deeper for greater water capacity. A windmill aerator was installed to reduce algae bloom within this dugout.

Update



Similar to the 2018 harvested crop, marketing of hops was directly to craft brewers. In addition, they managed to supply orders for seedling purchases that they had pre-sold for all their hop production obtainable for the 2019 season.

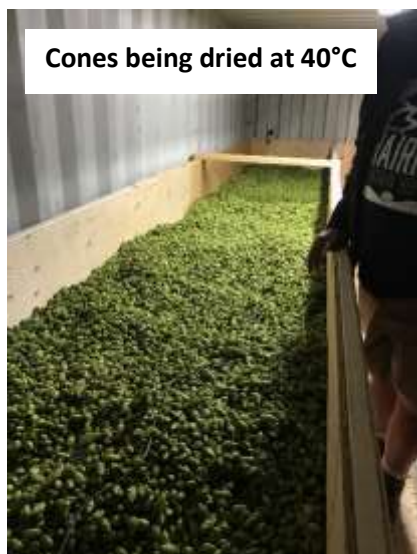
Hop Harvest

Comet and Cascade appeared to be the most vigorous and bountiful plants, while Centennial appeared to be the poorest vigor, slow to grow and have reduced performance. The farm could have used more rainfall to boost yields mid summer.

Harvest began September 5th starting in order of Cascade, then Centennial, Willamette, Chinook, Brewers Gold, Comet then finally Nugget on September 20th. Harvest begins as crew cut bines at the bottom and the top of the strings, then lay the bines in a cart. Bines are brought to and fed into the cone harvester. Then staff remove branches and leaves from the cones. The cones are then dumped into driers set to 40°C with forced air aeration. Once dry the cones are pelletized and stored until ready to package and ship to customers.



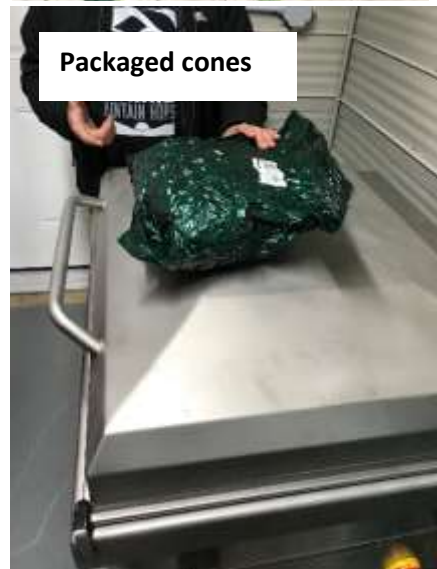
Cone harvester
separating leaves and
branches from cones



Cones being dried at 40°C



Pelletized cones



Packaged cones

Hop Variety Yields

Four of the varieties; Cascade, Willamette, Centennial and Comet were in their 2nd year of production while Chinook, Nugget and were in their first year of production. The top 3 highest yielders were Cascade>Comet>Chinook with 0.98, 0.93 and 0.85 lb plant⁻¹ respectively. Although Chinook variety was in its first year of production, it managed to produce 0.45 and 0.34 lb plant⁻¹ more hops than Centennial and Willamette varieties respectively (Table 27b). Approximately 3768 lb of hops were harvested and sold from 5.5 acres (5500 plants) with an average of 0.69 lb produced per plant in 2019.

Samples were sent to Commodity Lab Vancouver in British Columbia and analyzed either as pellets or dry cones to determine their quality. The parameters of concern were alpha acid, beta acid, hops storage index and total oil content. Alpha acid content ranged from 3.2 to 10.6% while beta acid content ranged from 3.4 to 6.6%. Nugget variety had the highest alpha acid content while Willamette had the lowest. Although Willamette variety had the lowest beta acid content, it had the highest hops storage index (HSI) of 0.29 while one of the dry cone samples of Comet variety had the lowest HSI of 0.2. Total oil content ranged from 0.8 to 1.9 ml 100g⁻¹ hops sample and the lowest were recorded on Brewer gold and Chinook varieties (Table 27c).

Hops Production and Quality Analyses Summaries for 2019

Table 27b. Hops production summary for 2019

Variety	Production year	Acres* grown	Total yield (lbs)	Yield (dry) lbs ac ⁻¹	No. producing plants	Av. yield lbs plant ⁻¹
Cascade	2	1.20	1180	983	1200	0.98
Willamette	2	0.75	385	513	750	0.51
Centennial	2	1.55	621	401	1550	0.40
Comet	2	1.00	925	925	1000	0.93
Chinook	1	0.25	212	848	250	0.85
Brewers Gold	1	0.25	160	640	250	0.64
Nugget	1	0.50	285	570	500	0.57
Totals		5.50	3768	685	5500	0.69

*Total acres grown in 2019 increased by more than 100% from 2.5 acres in 2017

Table 27c. Hops quality analyses for acids, HSI and oil content for different varieties in 2019

Variety	Sample form	Analysis date	α -Acids %	β -Acids %	HSI [†]	Oil ml 100g ⁻¹
Brewers Gold	Pellet	30-Sep-19	5.6	4.5	0.24	0.8
Cascade	Pellet	27-Sep-19	5.6	6.6	0.24	0.9
Centennial	Pellet	30-Sep-19	7.4	3.9	0.25	1.5
Centennial	Pellet	27-Sep-19	7.1	3.9	0.26	1.9
Chinook	Pellet	08-Oct-19	9.7	3.7	0.25	0.8
Comet	Dry cone	30-Sep-19	8.3	4.9	0.2	1.9
Comet	Pellet	08-Oct-19	8.1	4.7	0.26	1.9
Nugget	Pellet	08-Oct-19	10.6	5.4	0.25	1.7
Williamette	Pellet	27-Sep-10	3.2	3.4	0.29	1.0

[†]Hops Storage Index- measure of alpha and beta acids degradation during storage. α and β Acids analyzed using ASBC Hops-6a method. HSI analyzed using ASBC Hops-12 method. Total oils analyzed using ASBC Hops-13 method.



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