PCDF

Parkland Crop Diversification Foundation

2020 ANNUAL REPORT

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Introduction

The Parkland Crop Diversification Foundation (PCDF) is located in Roblin, in the Parkland region of Manitoba and has a close liaison with Manitoba Agriculture and Resource Development (ARD). PCDF works alongside three other Diversification Centres in the province: Manitoba Horticulture Productivity Enhancement Centre (MHPEC) in Carberry, Prairies East Sustainability Agricultural Initiative (PESAI) in Arborg, and Westman Agricultural Diversification Organization (WADO) in Melita.

The Parkland Crop Diversification Foundation owes its success to excellent cooperation with ARD, the PCDF board of directors, producers, industry and cooperating research institutions.

The 2020 season was full of hard work and dedication from the staff to execute all the research activities that came with an ambitious project list. A thank you goes out to James Frey and all the staff: Jessica Frey, Brooklyn Bartel and Mackenzie Kozak.

Funding is essential for the Parkland Crop Diversification Foundation's everyday activities to occur. This year PCDF received core funding and support from the Canadian Agricultural Partnership (CAP) and Agriculture Sustainability Initiative (ASI) programs, as well as from trial cooperators, producers, and members of the local community. PCDF is always open to project ideas and learning about the production concerns of local producers, so please feel free to contact us with any project proposals. For project submissions or additional information, please refer to the Contact info supplied on this website.

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Parkland Industrial Hemp Growers
Pepsi-co/Quaker Oats
Saskatchewan Pulse Growers
Saskatchewan Variety Performance Group
University of Manitoba
University of Saskatchewan

Meteorological Data

Table 1: Roblin 2020 Season Report by Month (based on 30-year average)

Month	Precipitation		Corn Heat Units		Growing Degree Days	
	Actual	Normal	Actual	Normal	Actual	Normal
April	16	24	67	33	26	7
May	17	45	310	321	171	172
Jun	111	73	518	530	322	314
Jul	69	71	665	645	406	392
Aug	43	56	607	587	376	354
Sep	11	53	249	292	148	163
Oct	19	26	59	42	30	11

Information gathered from Manitoba Agriculture Growing Season Report website at https://web43.gov.mb.ca/climate/SeasonalReport.aspx

Table 2: Roblin 2020 Season Summary April 1 – October 31

	Actual	Normal	% of Normal
Number of Days	214	-	-
Growing Degree Days	1481	1415	98
Corn Heat Units	2372	2452	97
Total Precipitation	280	350	80

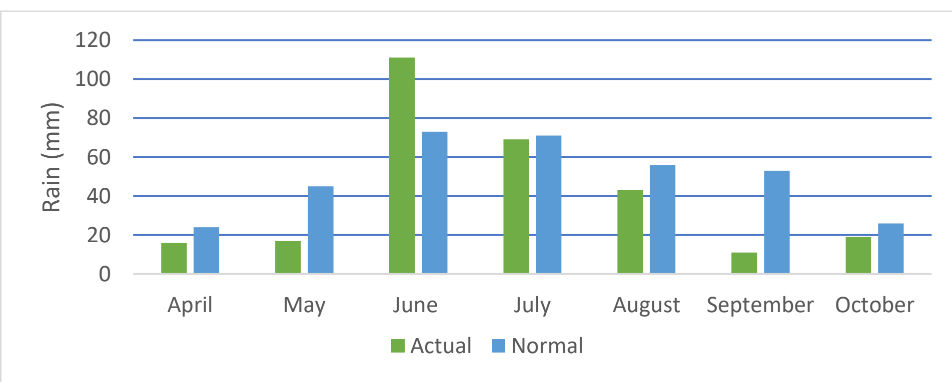

Figure: Roblin 2020 Precipitation by Month April - October

Extension Activities

The Manitoba Diversification Centres participated in Ag Days at the Keystone Centre in Brandon

Table 1: PCDF 2020 Extension Activities

Name	Medium	Date	Location
Ag Days	Booth	January	Brandon
Ag in the Classroom	School presentations	March	Swan River, Benito
Extension Videos	Online video	N/A	PCDF plots

Online videos (https://mbdiversificationcentres.ca/videos/)

Cooperator	Organization	Video Title
Aaron Beattie	University of Saskatchewan, Crop Development Centre	Oat Breeding
Martin Entz	University of Manitoba	Critical Lows: Phosphorous in Organic Systems
		Manure Application in Organic Systems
		Organic Nutrient Study at Libau, MB
		Phosphorous: Long-term Management for Organics
		Phosphorous: Transitioning to Organic
		Rock Phosphate in Prairie Organic Systems
Donovan Friesen	Farmer, Roblin	Turning Pea Crop Failure into Success
John Gavloski	Entomologist, Manitoba Agriculture and Resource Development	Pollinators Part 1: Bees
		Pollinators Part 2: Flies
		Pollinators Part 3: Butterflies and Moths
		Pollinators Part 4: Beetles
		Pollinators and Pest Control
		Pollinators and Spraying
		Pollinators and Tillage
Elmer Kaskiw	Agronomist, Ducks Unlimited	Ducks Unlimited Overview
		Why Winter Wheat?
Jeffrey Kostuik	Hemp Genetics International	Cannabinoids
		Hemp: Environmental Damage
		Hemp: Fertility
		Hemp: Field Selection
		Hemp: Harvest Management
		Hemp: Pest Management
		Hemp: Seeding
		Hemp: Variety Selection
Rhéal Lafrenière	Apiarist, Manitoba Agriculture and Resource Development	Beekeeping for Pollination
		Buying a Honeybee Colony
		Honey Production with Specialty Crops
		Inside a Honeybee Colony
		Intro to Beekeeping
		Marketing Honey From Specialty Crops
		Overwintering Honeybees

PCDF Field Trials

Plot information		**Equipment**
At seeding:	9m x 1.2m	5-Row Fabro Disc Seeder
Trimmed:	5m x 1.2m	Plot Sprayer
Plot Area:	$10.8m^2$	Wintersteiger Plot Combine
Alleyways:	2m	

Manitoba Crop Variety Evaluation (MCVET) Trials

Manitoba Crop Variety Evaluation Trials (MCVET) facilitates variety evaluations of many different crop types in this province. The purpose of MCVET trials is to grow both familiar (checks or reference) and new varieties side by side in a replicated manner in order to compare and contrast various variety characteristics such as yield, maturity, protein content, disease tolerance, and many others.

During 2020, PCDF did variety evaluations for winter wheat, fall rye, oat, barley, fababean, pea and flax. Yearly data is collected, combined, and summarized in the *Seed Manitoba Guide*. Hard copies are available at most Manitoba Agriculture and agriculture industry offices.

Table 1: 2020 MCVET Trials*

Crop type	# of plots	Site
Barley	27	Roblin
Oats	24	Roblin
Flax	27	Roblin
Fababean	72	Roblin
Fall Rye	15	Roblin
Winter Wheat	24	Roblin
Total plots	189	

* See *Seed Manitoba Guide* or visit websites *www.seedinteractive.ca* or *www.seedmb.ca*.

Table 2: Summary of 2020 PCDF Trials

Crop Type	Collaborators	Purpose	# Plots
Barley	Saskatchewan Variety Performance Group	Variety trial	81
Barley, durum, spring wheat, and winter wheat	University Manitoba	Validate fusarium headblight (FHB) risk model	40
Barley	PCDF	Compare yield and in-crop characteristics for barley grown after (a) green manure grazed by livestock, (b) green manure not grazed, and (c) no green manure	12
Canola and wheat	University of Manitoba	Year 1 establishment (2020-2023)	48
Canola	PCDF	Compare yield and in-crop characteristics for barley grown after (a) green manure grazed by livestock, (b) green manure not grazed, and (c) no green manure	12

Corn	Agricultural and Agri-Food Canada	Variety trial	90
Corn	Agricultural and Agri-Food Canada	Corn nursery	500
Cover Cropping	PCDF	Cover crop species evaluation: Pea, oat, millet, turnip, Italian ryegrass, chicory, pre-mixed purchased blend	24
Flax	Linseed Coop	Variety trial	60
Flax	BASF, MFGA	Herbicide trial	27
Fruit Demonstration	PCDF	Sour cherry and haskap	10
Hemp	Canadian Hemp Trade Alliance	National Industrial Hemp Variety Evaluation Trials	44
Hemp	EnterraFrass Canada	Rates and applications of organic insect frass formulated for use in plant growth	20
Hemp	Montra Crop Science	Organic acids and soil health	12
Hops	PCDF	Year 3 of hopyard	24
Intercropping	PCDF	Barley-clover intercrop	15
	PCDF	Canola-clover intercrop	15
	PCDF	Oat-clover intercrop	15
	PCDF	Wheat-chicory intercrop	15
	PCDF	Wheat-clover intercrop	15
	PCDF	Wheat-lupin intercrop	15
	PCDF	Wheat-phacelia intercrop	15
	PCDF	Hemp-cereal intercrop mixes for silage production	48
	PCDF	Pea-cereal intercrop mixes for silage production	44
	Manitoba Diversification Centres	Row orientations involving fababean, peas, flax, and buckwheat	15
	Manitoba Diversification Centres	Peas intercropped with flax, oat, canola mustard and spring wheat	21
Oats (organic)	Agricultural and Agri-Food Canada	Evaluation of new oat lines being developed for organic production	75
Oats (organic)	University of Manitoba	Variety trial	72
Soybean (six-year crop rotation)	PCDF	Year 3 of a 6-year rotation: Seeded on the 2019 Wheat Nitrogen Ramp	28
Soybean	Agriculture and Agri-Food Canada	Assessment of soy protein by variety	80

Soybean	Sask Pulse Growers	Assessment of soy protein by variety	84
Spring wheat	PCDF	Compare yield and in-crop characteristics for barley grown after (a) green manure grazed by livestock, (b) green manure not grazed, and (c) no green manure	12
Spring wheat	Parkland Coop	Variety trial	30
Spring wheat	Saskatchewan Variety Performance Group	Variety trial	171
Spring wheat (organic)	University of Manitoba	Participatory Plant Breeding program	66
Spring wheat	ARD	Evaluate management practices for high yielding spring wheat	126
Winter wheat	Ducks Unlimited	Evaluate management practices for high yielding winter wheat	18

Table 3: 2020 PCDF Exclusive Trials

Crop Type	Collaborators	Number of Plots
Oat	University of Saskatchewan	108
Oat	Pepsi-Co/Quaker Oats	76
Oat	Murphy et al, Inc	348

Table 4: 2020 Field Scale Collaboration

Crop Type	Collaborator	Area
Intermediate Wheat Grass	Ted Hawryluk	Approx. 2 ac

Table 5: 2020 PCDF Discontinued Trials

Crop Type	Collaborators	Purpose	Number of Plots
Intercropping – Pea Quinoa	Tamarack Farms	Evaluation of seeding rates	18
Quinoa	Phillex	Variety trial	21
Teff	PCDF	Teff evaluation	15

Canola Disease Surveys

Summary of Surveys
In 2020, PCDF provided support for the Canola Disease Surveys conducted by Manitoba Agriculture and Resource Development (ARD). PCDF surveyed seven farmers' fields in the Roblin area. The following summary and results for 2018 and 2019 are from the ARD website:

Canola is an economically important crop produced in Manitoba, but continued profitability relies on management of pest, such as diseases. Annual disease surveys of canola crops give valuable information on distribution in the province and impact of farming practices on incidence and severity. Results from disease surveys help farmers, agronomists and researchers prioritize where future research is needed and provides early warning about new diseases or varietal resistance/pesticide failure. Annual canola disease surveys have been occurring in Manitoba since 1971 with collaboration from Agriculture and Agri-Food Canada (AAFC), Manitoba Agriculture and Resource Development (ARD).

Results of the 2019 (& 2018) Canola Disease Surveys:

2019 Fields Surveyed (165)	Sclerotinia	Blackleg		Aster Yellows	Fusarium Wilt	Clubroot		Alternaria Pod Spot
		Stem	Basal			Plant	Soil	
% Prevalence	25	47	68	6	18	<1	-	12
Mean Severity	2	-	1.4	-	-	-	-	-
Reference: Survey of canola diseases in Manitoba in 2019. *Can. Plant Dis. Surv. In press*								
2018 Fields Surveyed (180)	Sclerotinia	Blackleg		Aster Yellows	Fusarium Wilt	Clubroot		Alternaria Pod Spot
		Stem	Basal			Plant	Soil	
% Prevalence	36	54	73	5	5	0	-	16
Mean Severity	1.9	-	1.5	-	-	-	-	-
Reference: Survey of canola diseases in Manitoba in 2018. *Can. Plant Dis. Surv.* 99:175-178								

Summary of 2020 activities (adapted from David Kaminski, Field Crop Pathologist, ARD)
Oilseed Specialist Dane Froese took on the overall organization for 2020. The workload was spread among ARD (132 fields), Canola Council (17 fields) and AAFC-Brandon (20 fields). In total, 169 fields were surveyed, representing approximately 1% of Manitoba's cultivated canola acres. The main diseases of long-term interest are Blackleg and *Sclerotinia* (aka. stem rot). Surveyors collected 116 stem samples to test blackleg and/or Verticillium stripe. They also collected 151 pod samples to check for bacterial pod spot, a disease that has not been documented in Manitoba so far. The survey found clubroot in only one of the 169 fields surveyed, and not in any of the fields surveyed by PCDF.

Barley Trials

SVPG 2-Row Barley Variety Trial

Project duration: May 2020 – August 2020
Objectives: Evaluate 2-row barley varieties for the Saskatchewan Variety Performance Group
Collaborators: Mitchell Japp, Saskatchewan Agriculture

Background
The Saskatchewan Variety Performance Group (SVPG) conducts variety trials to evaluate important varieties. Find the [2020 Saskatchewan Seed Guide]() here.

Results
The yield results (bu/ac) for the Roblin site are shown in Figure 1

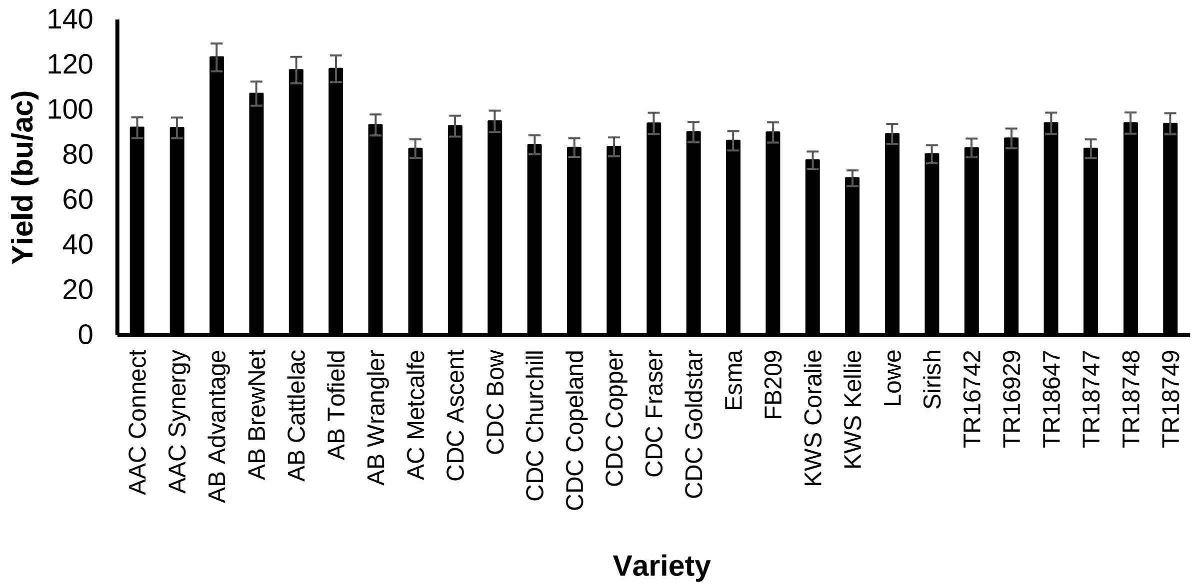

Figure 1: 2-Row barley yields by entry (bu/ac)

The results for barley yield differ statistically by treatment (Table 1). Treatments not marked with the same letter are statistically different from other treatments.

Table 1: Summary of statistical information for wheat and lupin yield

Entry												
AB Advantage	A											
AB Tofield	A											
AB Cattlelac	A	B										
AB BrewNet		B	C									
TR18747			C	D								
TR18748			C	D	E							
TR18749				D	E	F						
CDC Bow				D	E	F	G					
TR18647				D	E	F	G	H				
CDC Fraser				D	E	F	G	H				

AB Wrangler				D	E	F	G	H	I			
CDC Ascent				D	E	F	G	H	I			
AAC Connect				D	E	F	G	H	I			
AAC Synergy				D	E	F	G	H	I			
CDC Goldstar					E	F	G	H	I	J		
FB209					E	F	G	H	I	J		
Lowe						F	G	H	I	J		
TR16929						F	G	H	I	J	K	
Esma						F	G	H	I	J	K	
CDC Churchill							G	H	I	J	K	
CDC Copper								H	I	J	K	
CDC Copeland									I	J	K	
TR16742									I	J	K	
AC Metcalfe									I	J	K	
Sirish										J	K	
KWS Coralie											K	L
KWS Kellie												L
CV (%)	14.4											
LSD (0.05)	537.8											

Materials and methods

Experimental Design: Random Complete Block Design
Entries: 27 varieties
Seeding: May 12
Harvest: Aug 21

Data collected Date collected
Yield: Oct 21
Moisture: Oct 21

Agronomic info
Previous year's crop: Barley Silage
Soil Type: Erickson Loam Clay
Landscape: Rolling with trees to the east
Seedbed preparation: Heavy harrowed

Table 1: Fertility Information

	Available	Added	Type
N	66 lb/ac	58 lb/ac	46-0-0
P	47 ppm	15 lb/ac	11-52-0-0

Corn Trials

Agriculture Agri-Food Canada Corn Variety Evaluation

Project duration: May 2020 – November 2020
Objectives: To develop and release early maturing cold tolerant corn inbreds with emphasis on the 1800-2000 CHU market.
Collaborators: Lana Reid PhD – AAFC Research Scientist Ottawa Research and Development Centre
Manitoba Corn Growers Association

Background and findings

The objective will be achieved using conventional corn breeding methodology enhanced by double haploid inbred production and specialized screening techniques for cold tolerance and disease resistance. The trial is being conducted at sites across five Canadian provinces. The anticipated impact of developing earlier maturing, cold tolerant corn will expand the acreage of corn production in Canada. This project is part of a long-term, multi-site study led by Lana Reid. Lana Reid and team will make research findings available at the conclusion of the project.

Materials and methods

Experimental Design: Random Complete Block Design
Entries: 30 varieties
Seeding: May 20
Harvest: Oct 14

Data collected Date collected
Yield: Oct 27
Moisture: Oct 27

Agronomic info
Previous year's crop: Barley Silage
Soil Type: Erickson Loam Clay
Landscape: Rolling with trees to the east
Seedbed preparation: Direct-seed

Table 1: Fertility Information

	Available	Added	Type
N	71 lb/ac	121 lb/ac	46-0-0
P	50 ppm	15 lb/ac	11-52-0-0
K	556 ppm	N/A	N/A

Table 2: Pesticide Application

Crop stage	Date	Product	Rate	
Pre-emerge	May 26	Heat	28	g/ac
		Round-up	645	ml/ac
In crop	Jul 27	Sortan IS	30	g/ac

Agriculture Agri-Food Canada Corn Nursery

Project duration: May 2020 – October 2020
Objectives: To develop and release early maturing cold tolerant corn inbreds with emphasis on the 1800-2000 CHU market.
Collaborators: Lana Reid PhD – AAFC Research Scientist Ottawa Research and Development Centre
Manitoba Corn Growers

Background and project findings

The objective will be achieved using conventional corn breeding methodology enhanced by double haploid inbred production and specialized screening techniques for cold tolerance and disease resistance. The trial is being conducted at sites across five Canadian provinces. The anticipated impact of developing earlier maturing, cold tolerant corn will expand the acreage of corn production in Canada. This project is part of a long-term, multi-site study led by Lana Reid. Lana Reid and team will make research findings available at the conclusion of the project.

Materials and methods

Experimental Design: 500 row observation nursery
Entries: 500
Seeding: May 20
Harvest: Oct 14

Data collected — Date collected
Tasseling Date: Jul 23 – Aug 18
Silking Date: Jul 21 – Aug 22
Ear Formation: Aug 4 – Aug 26

Agronomic info
Previous year's crop: Barley Silage
Soil Type: Erickson Loam Clay
Landscape: Rolling with trees to the east
Seedbed preparation: Direct-seed

Table 1: Fertility Information

	Available	Added	Type
N	71 lb/ac	121 lb/ac	46-0-0
P	50 ppm	15 lb/ac	11-52-0-0
K	556 ppm	none	N/A

Table 2: Pesticide Application

Crop stage	Date	Product	Rate
Pre-emerge	May 26	Heat	28 g/ac
		Round-up	645 ml/ac
In crop	Jul 27	Sortan IS	30 g/ac

Cover Cropping Trials

The Effect of Grazing and Non-grazing of Annual Green Manures on Following Crops (Year 2)

Project duration: May 2019 – October 2020
Objectives: To evaluate the use of an annual green manure crop for grazing by livestock and to provide fertility for the following crop (2019); and to evaluate the performance of three annual field crops after a green manure crop, with and without grazing (2020).
Collaborators: PCDF

Background
The use of green manure crops to provide nitrogen is well-understood in organic agriculture. One of the barriers to adoption of green manures is that there is no "harvestable" product and no income from that year. Research conducted by the Natural Systems Agriculture laboratory at the University of Manitoba has demonstrated that grazing the green manure by livestock can kill the crop, providing an alternative to terminating the crop with tillage. Further, grazing results in large amounts of available N in the soil. Follow-up research by the Natural Systems Agriculture laboratory demonstrated that there was no significant difference in the year-2 crop yield for grazed and ungrazed treatments. The results for that research suggest that there is no yield decrease associated with grazing a green manure.

Results
2019
The current study established a green manure crop on May 14, 2019. Half of the green manure crop was swathed (to terminate the crop) and intensively grazed by sheep on August 19, and the other half was mowed. Both areas were disked in October, after a killing frost. Table 1 shows seeding rates and costs for the green manure blend. The feed test for the green manure at the time of grazing is shown in Table 2, with cattle feed requirements shown in Table 3.

Table 1: Green manure blend by species, rate and description

Species	Rate (lb/ac)	$/ac	Description
Pea (4010 forage)	40	8.33	Cool season legume; forage type
Oat (Haymaker)	30	7.02	Cool season grass; forage/hay type
Japanese millet	3	5.37	Warm season grass
Italian ryegrass	2	4.38	Cool season grass; limited over-wintering ability
Persian clover	2	8.38	Cool season legume; slow establishment
Chicory	0.5	4.79	Short-lived perennial broadleaf; deep taproot
Turnip	0.3	1.44	Cool season broadleaf; good frost tolerance
Feed beet	0.7	4.19	Cool season broadleaf; quick leaf regrowth
Common vetch	2	5.58	Cool season legume; shade tolerant
Phacelia	0.5	2.50	Warm season broadleaf; attracts pollinators
	Total $/ac	51.98	

Table 2: Feed test results for 2019 green manure (August 19) compared to animal feed requirements*

% Crude Protein	% TDN	Ca	P	Mo	Cu	Fe	Mn	Zn
11.60	68.96	0.69	0.18	0.34	3.80	161.72	0.34	14.06

 

Figure 1: (a) green manure before grazing; (b) sheep on swathed green manure.

Table 3: Cattle feed requirements*

	% Crude Protein	% TDN
	8.21	58.86
Mature cows		
Mid gestation	7	50-53
Late gestation	9	58
Lactating	11-12	60-65
Replacement heifers	8-10	60-65
Breeding bulls	7-8	48-50
Yearling bulls	7-8	55-60

* Developed by Elisabeth Nernberg (ARD).

Figure 2: Green manure after grazing

The biomass yield was 9,745.9 lb/ac (hay-dry), or 6.5 1500-lb round bales per acre. The stocking rate for animals was 195 sheep per acre for 5 days. This equals 39 animal units (1 animal unit = 1000 lb animal).

2020

Barley, canola and spring wheat were seeded on May 15, 2020 on the 2019 site (Table 4). Fertilizer was added to all treatments to ensure even fertility levels (Tables 6-8). The relatively low nitrogen levels for the green manure treatments are based on the soil test, conducted in early May 2020, and does not take into account the nitrogen contained in the plant and animal manure residues. The trial design is shown in Figure 4.

Table 4: 2020 treatments

Green manure (2019)	Crop seeded (2020)		
Yes, grazed	Barley	Canola	Wheat
Yes, not grazed	Barley	Canola	Wheat
No green manure	Barley	Canola	Wheat

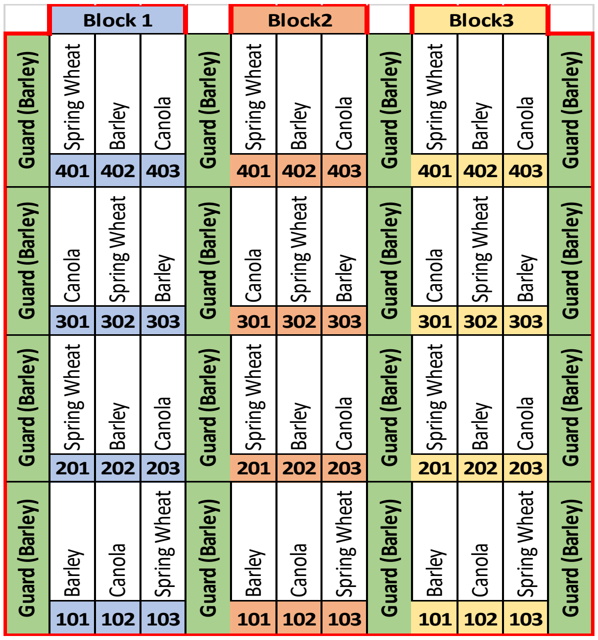

Figure 4: Plot design, showing (a) block 1, no green manure; (b) cover crop, grazed; (c) cover-crop, non-grazed

The trial design does not allow for results within each treatment to be compared across the treatments. That is, although the crops are replicated and randomized within each block, the treatments are not randomized across blocks. For this reason, the results provide suggestions about treatment effects, but do not provide statistically meaningful comparisons.

Table 5: Comparison of average yields (bu/ac), test weight and % CV by treatment

Crop	Treatment	Average Yield (bu/ac)	Average Test Weight	Yield % CV
Barley	No green manure	101.4	51.8	9.8
Barley	Green manure, grazed	100.3	51.7	10.0
Barley	Green manure, not grazed	106.4	55.4	9.4
Canola	No green manure	48.1	46.2	20.7
Canola	Green manure, grazed	46.0	46.7	21.7
Canola	Green manure, not Graze	47.8	46.0	20.9
Spring Wheat	No green manure	56.7	57.2	17.6
Spring Wheat	Green manure, grazed	73.5	58.2	13.6
Spring Wheat	Green manure, not grazed	67.5	58.3	14.8

The comparison of yields suggests that the differences between crop yields across treatments are small. This supports the research findings of the Natural Systems Agriculture laboratory. Note that the percent CV (that is, differences between replications of the same treatment) is high for canola. The higher percent CV for canola is due to challenges in establishment (including dry conditions at emergence and flea beetle pressure), resulting in uneven stand across replications.

Observations

The cost of the seed blend for forage is high relative to simpler cereal-only annual forages, such as barley planted for green feed (estimated at $16.88/ac in the MB Agriculture Cost of Production). However, some green manure species can provide extended in-season grazing, reducing pressure on perennial pastures. Strategic inclusion of these species in a green manure mix can improve its application to grazing. Other management options for green manures and livestock include swath or bale grazing, which can extend grazing into the winter months, reducing feeding and yardage costs. In future years, other benefits to soil characteristics, moisture infiltration and retention, and crop performance may be observed.

Materials and methods

Experimental Design: Random Complete Block Design (3 separate, non-comparable blocks)
Entries: 3 crops, 4 replications per block
Seeding: May 15
Harvest: Sep 11

Data collected Date collected
Yield: Sep 11
Moisture: Sep 11
Previous year's crop: Cover crop blend
Soil Type: Erickson Loam Clay
Landscape: Rolling with trees to the east
Seedbed preparation: Heavy harrowed

Table 6: Fertility Information, No Cover Crop

	Available	Barley Added	Canola Added	Wheat Added	Type
N	42 lb/ac	82 lb/ac	112 lb/ac	147 lb/ac	46-0-0
P	23 ppm	15 lb/ac	10 lb/ac	15 lb/ac	11-52-0-0
K	249 ppm	-	-	-	N/A
S	38 lb/ac	-	-	-	N/A

Table 7: Fertility Information Cover Crop, Grazed

	Available	Barley Added	Canola Added	Wheat Added	Type
N	60 lb/ac	64 lb/ac	94 lb/ac	129 lb/ac	46-0-0
P	18 ppm	15 lb/ac	15 lb/ac	18 lb/ac	11-56-0-0
K	257 ppm	-	-	-	N/A
S	34 lb/ac	-	-	-	N/A

Table 8: Fertility Information Cover Crop, Non-Grazed

	Available	Barley Added	Canola Added	Wheat Added	Type
N	79 lb/ac	45 lb/ac	75 lb/ac	110 lb/ac	46-0-0
P	22 ppm	15 lb/ac	10 lb/ac	15 lb/ac	11-52-0-0
K	257 ppm	-	-	-	N/A
S	18 lb/ac	-	-	-	N/A

Cover Crop Species Evaluation

Project duration: May 2020 – August 2020
Objectives: To identify the biomass and nutritional contributions of cover crop species to a pea-oat mixture.
Collaborators: PCDF

Background
The use of cover crops is gaining popularity among Manitoba farmers. The Manitoba Agriculture and Resource Development (ARD) website provides information on the many benefits to growing cover crops. Previous research at PCDF has examined the benefits of growing a green manure mixture that included cover crops for use with livestock grazing (see "The Effect of Grazing and Non-grazing of Annual Green Manures on Following Crops - Year 2"). A question arising from that research is how specific cover crop species contribute to the green manure mixture, both in terms of biomass and nutritional properties. This trial examined the biomass and nutritional contributions of different cover crop species to a pea-oat mixture. Biomass yield was taken from each plot, and a composite sample for each treatment was submitted for a feed test. Additionally, pea-oat grain yield was calculated for each plot.

Results
The average wet and dry biomass yield (t/ac) for each treatment is shown in Figure 1. The treatments, with seeding rates, are presented in Table 1.

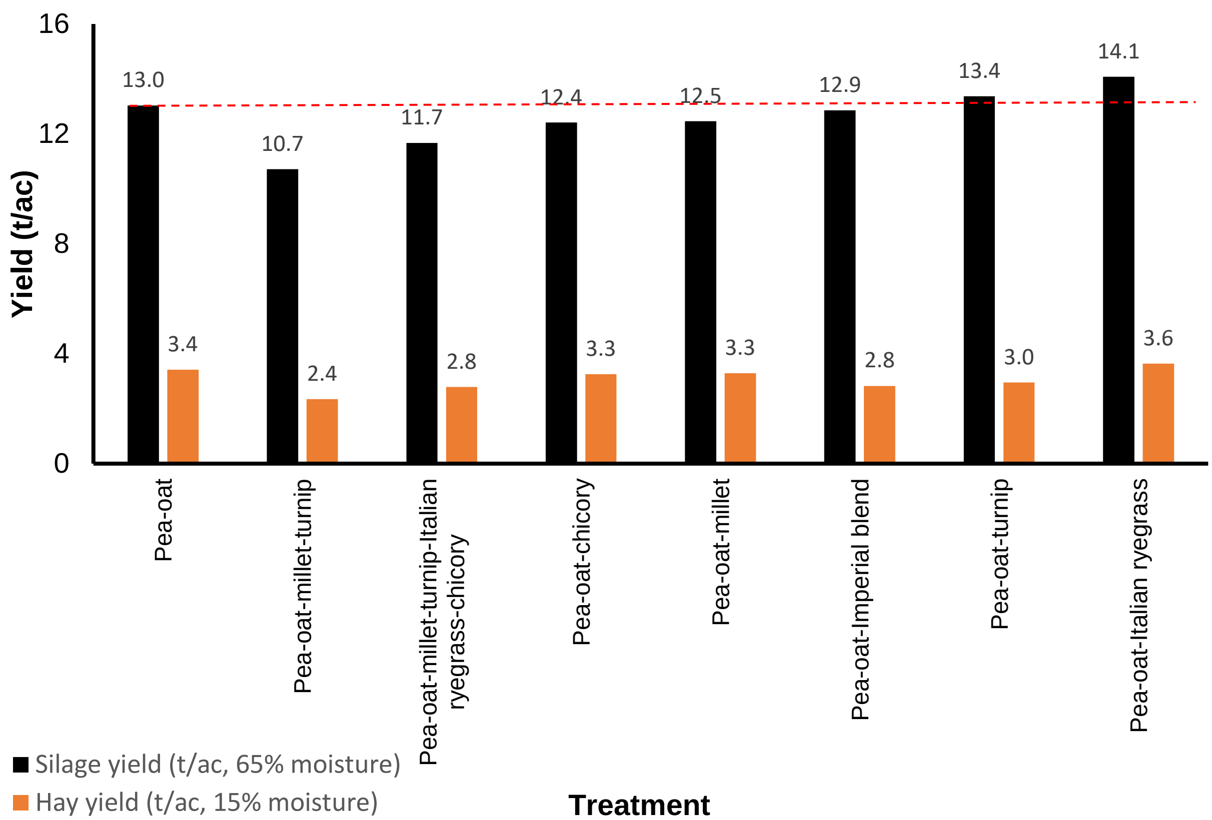

Figure 1: Biomass yield, silage (65% moisture, t/ac) and hay (15% moisture, t/ac), by treatment (red dashed line shows pea-oat only yield for comparison)

Table 1: Treatment seeding rates

Treatment	lbs per acre							$/acre
	Pea	Oat	Millet	Turnip	Italian ryegrass	Chicory	Blend	
Pea-Oat*	40	30						15.35
Pea-Oat-Millet	40	30	6					26.09
Pea-Oat-Turnip	40	30		3				29.75
Pea-Oat-Italian Ryegrass	40	30			5			26.30
Pea-Oat-Chicory	40	30				3		44.09
Pea-Oat-Millet-Turnip	40	30	6	3				40.49
Pea-Oat-Millet-Turnip-Italian Ryegrass-Chicory	40	30	6	3	2	1		54.45
Pea-Oat-Blend**	40	30					11	51.98

* Pea = 4010 Forage, Oat = Haymaker

** Blend = millet, Italian ryegrass, Persian clover, chicory, turnip, feed beet, common vetch, phacelia

The feed values for each treatment are shown in Table 2.

Table 2: Feed values for biomass by treatment compared to animal feed requirements*

Entry	% Crude Protein	% TDN	Ca	P	Mg	K
Pea-Oat	11.22	59.40	0.54	0.23	0.21	2.19
Pea-Oat-Millet	10.32	60.30	0.41	0.25	0.18	2.21
Pea-Oat-Turnip	11.73	61.79	0.56	0.25	0.19	2.25
Pea-Oat-Italian Ryegrass	9.89	62.47	0.44	0.25	0.17	2.18
Pea-Oat-Chicory	9.99	62.43	0.37	0.25	0.16	2.19
Pea-Oat-Millet-Turnip	10.61	59.47	0.44	0.25	0.18	2.24
Pea-Oat-Millet-Turnip-Italian Ryegrass-Chicory	11.00	62.06	0.52	0.26	0.19	2.30
Pea-Oat-Blend	10.37	76.23	0.45	0.25	0.17	2.35
Animal feed requirements						
Mature cows						
Mid gestation	7	50-53				
Late gestation	9	58				
Lactating	11-12	60-65				
Replacement heifers	8-10	60-65				
Breeding bulls	7-8	48-50				
Yearling bulls	7-8	55-60				

* Animal feed requirements developed by Elisabeth Nernberg (ARD).

Oat and pea grain yield for each treatment is shown in Table 3.

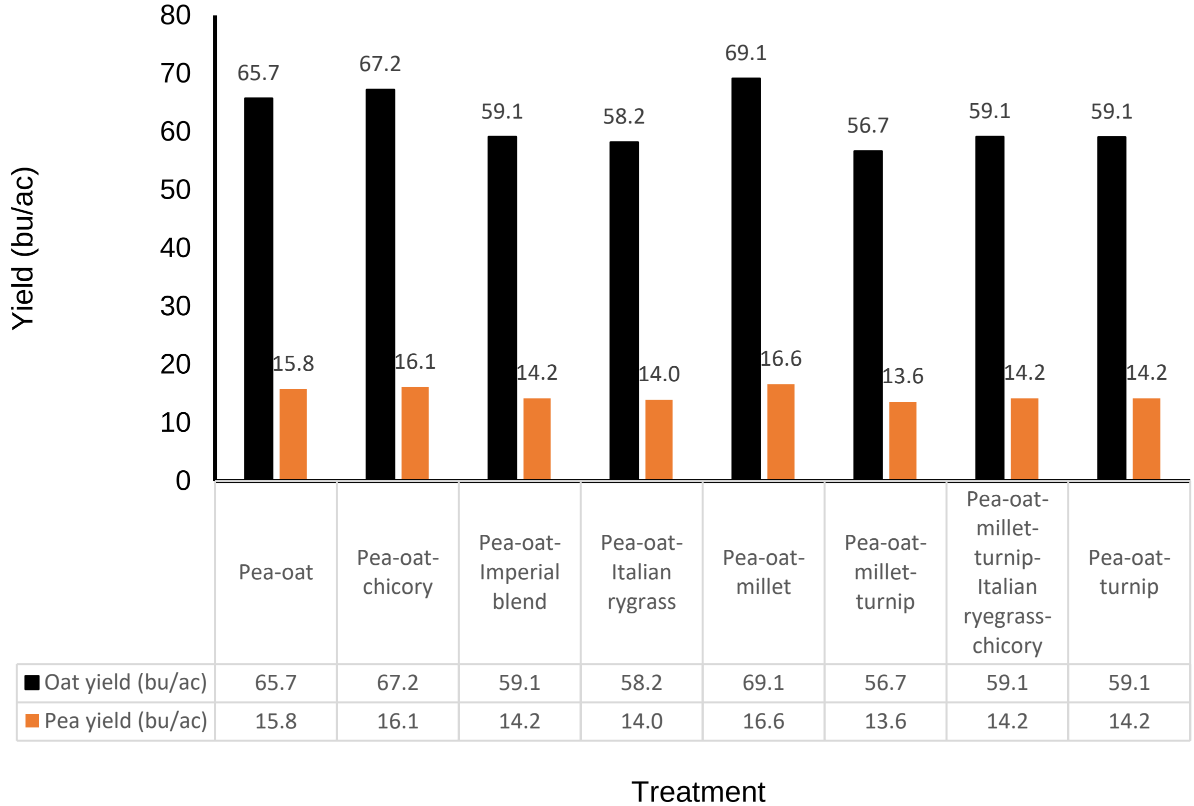

Figure 2: Grain yield (bu/ac) for oat and pea by treatment

The statistical information for biomass yield and grain yield are summarized in Table 3.

Table 3: Summary of statistical information for biomass yield and grain yield.

Treatment	Biomass Yield		Statistical Significance (Biomass, Silage and Hay)*	Oat yield (bu/ac)	Pea yield (bu/ac)	Statistical Significance (Oat and Pea Yield)*			
	Silage (t/ac)	Dry hay (t/ac)							
Pea-Oat	13.0	3.4	A	65.7	15.8	A			
Pea-Oat-Millet	12.5	3.3	A	69.1	16.6	A	B		
Pea-Oat-Turnip	13.4	3.0	A	59.1	14.2	A	B	C	
Pea-Oat-Italian Ryegrass	14.1	3.6	A	58.2	14.0		B	C	D
Pea-Oat-Chicory	12.4	3.3	A	67.2	16.1		B	C	D
Pea-Oat-Millet-Turnip	10.7	2.4	A	56.7	13.6		B	C	D
Pea-Oat-Millet-Turnip-Italian Ryegrass-Chicory	11.7	2.8	A	59.1	14.2			C	D
Pea-Oat-Blend	12.9	2.8	A	59.1	14.2				D
CV (%)	16.0			9.8	9.8				
LSD (0.05)	3.63			8.23	1.98				

* Treatments not marked with the same letter are statistically different from other treatments.

Observations

The trial results show that including more cover crop species in a mixture did not significantly affect overall biomass yield for silage or hay. However, feed test values indicate that including leafy cover crop species (especially the blend of millet, Italian ryegrass, Persian clover, chicory, turnip, feed beet, common vetch and phacelia) increases the percentage of total digestible nutrients (%TDN). The increased %TDN is likely the result of the higher proportion of tender, leafy material in the mixture. Including cover crops in a mixture may be useful for producers targeting a high-quality feed ration. However, the overall cost of seed per acre is higher for mixtures including cover crops as compared to the pea-oat only treatment.

An area for further research arising from this study is to look at the potential for establishing cover crops in-season that will provide producers with good grazing or forage opportunities in the following year. For example, chicory does not produce large amounts of biomass in the establishment year, but can be an excellent crop for livestock in future years. The advantages in subsequent years might justify the higher seeding costs in the establishment years.

Materials and methods

Experimental Design: Random Complete Block Design
Entries: 8 Treatments, 3 replications
Seeding: May 25
Harvest: Sep 22

Data collected — Date collected
Oat heading date: Jul 18
Pea flowering date: Jul 19 – 23
Vigor: Jul
Stand: Jul
Grain yield: Sep 22
Moisture: Sep 22
Biomass wet weight: Aug 12
Biomass dry weight: Sep 15

Agronomic info
Previous year's crop: Barley Silage
Soil Type: Erickson Loam Clay
Landscape: Rolling with trees to the east
Seedbed preparation: Heavy harrowed

Figure 3: Pea-oat mixture at oat booting stage

Table 2: Fertility Information

	Available	Added	Type
N	61 lb/ac	-	N/A
P	47 ppm	15 lb/ac	11-52-0-0
K	393 ppm	-	N/A

Flax Trials

CDC Linseed Flax Coop Variety Evaluation

Project duration: May 2020 – September 2020
Objectives: To evaluate pre-registration varieties for the Linseed Coop.
Collaborators: Helen Booker – University of Saskatchewan Plant Sciences Flax Breeder
Ken Jackle – Crop Development Centre Flax Breeding Program

Background
The trial was conducted in partnership with Helen Booker and the Prairie Recommending Committee for Oilseeds (PRCO). For further information, contact Ken Jackle: ken.jackle@usask.ca.

Results
The mean yields by named and unnamed varieties are shown in Table 1. Statistical differences for yield are shown in Figure 1. Summary statistics for the test are shown in Table 2.

Table 1: Mean yield by variety (named and unnamed)

Variety (FP2500s)	Yield (bu/ac)	Variety (FP2600s)	Yield (bu/ac)	Variety (Named)	Yield (bu/ac)
FP2573	47.4	FP2600	46.0	AAC Bright	42.0
FP2591	48.1	FP2601	43.5	AAC Marvelous	57.5
FP2592	52.1	FP2602	42.8	AAC Prairie Sunshine	46.7
FP2596	40.5	FP2603	40.3	CDC Bethune	43.2
FP2597	47.7	FP2604	45.4	CDC Dorado	37.3
FP2598	44.4	FP2605	40.3	CDC Glas	46.3
FP2599	46.2			CDC Rowland	49.0

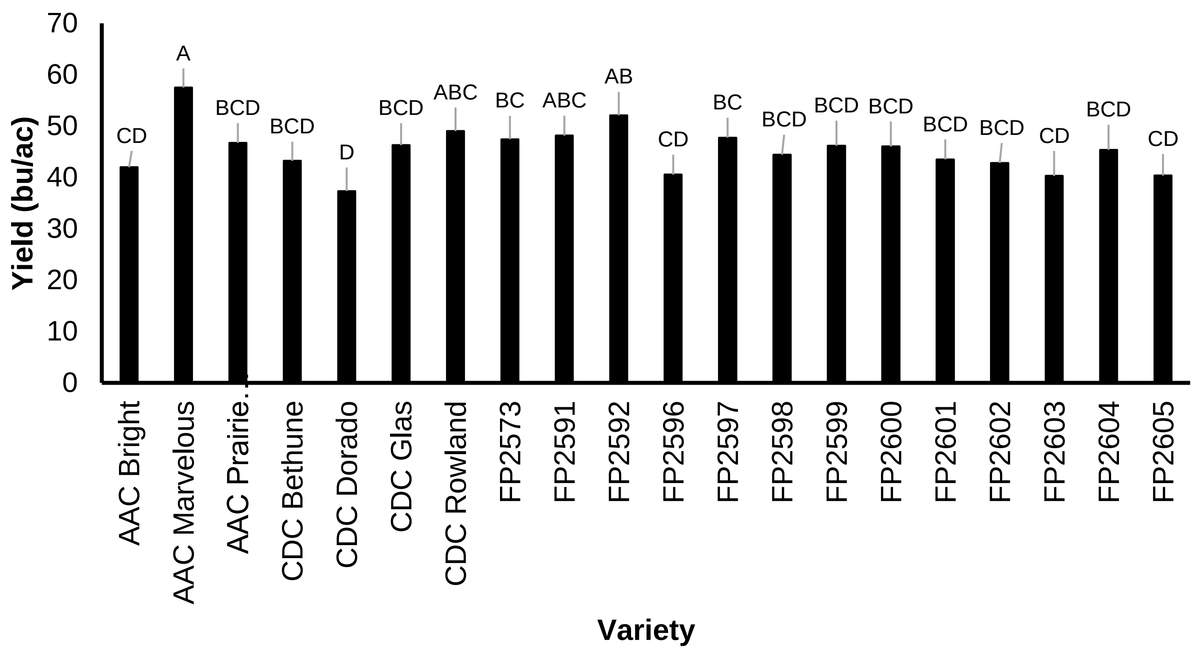

Figure 1: Statistical differences for yield by variety. Columns not connected by the same letters are significantly different.

Table 2: Summary statistics for test

Mean (bu/ac)	45.35
CV (%)	12.1
LSD (.05)	9.48

Materials and methods

Experimental Design:	Random Complete Block Design
Entries:	20
Seeding:	May 26
Harvest:	Sep 16

Data collected	Date collected
Height:	Aug 15
Determinate Habit:	End of August
Dry down Habit:	End of August
Maturity:	End of August
Lodging:	Sep 16
Yield:	Sep 16
Moisture:	Sep 16

Agronomic info

Previous year's crop:	Barley Silage
Soil Type:	Erickson Loam Clay
Landscape:	Rolling with trees to the east
Seedbed preparation:	Heavy harrowed

Table 3: Fertility Information

	Available	Added	Type
N	58 lb/ac	62 lb/ac	46-0-0
P	71 ppm	10 lb/ac	11-52-0-0
K	513 ppm	-	

P banded with seed; N side-banded

Flax Herbicide Evaluation

(Adapted from a report by Justice Zhanda, WADO)

Project duration: May 2020 - Sept 2020

Objectives: To compare the efficacy of Authority (standard treatment) to Armezon (experimental treatment) for crop and weed efficacy, and to observe any safety concerns with herbicide combinations.

Collaborators: Jeannette Gaultier BASF
Eric Fridfinnson MFGA
Scott Chalmers, WADO
Nirmal Hari, PESAI

Background

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

Table 1: List of Weeds controlled by Armezon, Authority, Mextrol, Koril and Select

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

C – Control

S – Suppress

TG – Top growth

Adapted from 2019 Manitoba Crop Protection Guide

Materials and methods

The trial was conducted at Melita, Roblin and Arborg in Manitoba, as randomized complete block design with nine herbicide treatments replicated three times. Table 2 shows herbicide treatments. Table 3 summarizes herbicide formulation and treatment description. Ratings for phytotoxicity on flax were taken at two and four after treatment while herbicide injury on weeds was only assessed at two weeks after treatment. Additional data were collected for flax height at 2 weeks after treatment, flax count at four weeks after treatment, top weed species names, weed density at flowering, seed yield and moisture content.

Table 2: Treatments

	RoundUp (Pre-emerge)	Authority (Pre-emerge)	Armezon + Merge	Mextrol 450	Koril	Select + Amigo
1	X					
2	X					
3	X	X				
4	X		X			
5	X	X	X			
6	X	X		X		X
7	X	X			X	X
8	X		X	X		X
9	X		X		X	

Table 3: Herbicide formulation and treatment description for flax herbicide trial in 2020

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

Table 4: Spraying information for Arborg, Melita and Roblin site in 2020

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

Agronomic information

Variety:	Neela seeded @ 60lb/ac
Seeding:	May 27
Harvest:	Sep 23
Treatments:	9
Yield:	Sep 23
Moisture:	Sep 23
Previous year's crop:	Barley Silage
Soil Type:	Erickson Loam Clay
Landscape:	Rolling with trees to the east
Seedbed preparation:	Tilled once and then harrowed

Table 5: Fertility Information

	Available	Added	Type
N	66 lb/ac	54 lb/ac	46-0-0
P	47 ppm	10 lb/ac	11-52-0-0
K	612 ppm	-	-

N side banded; P banded with seed

Results and discussion

Roblin

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

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

Table 5: GLM Analysis of variance for weed injury, weed density, flax emergence, crop injury, crop height and crop yield at Roblin in 2020

Treatment	**Weed Injury (%) 2WAA**	**Weed Density ppm at flower**	**Flax Emergence ppm**	**Crop Injury (%)**		**Crop Height (cm) 2WAA**	**Crop Yield (kg/ha)**
				2WAA	**4WAA**		
1. UTC (no weeding)	*	51	155	*	*	39abc	3097
2. UTC (Hand weeded check)	*	*	149	*	*	44a	1939
3. Authority (pre-seed)	73a	53	134	0b	0b	40ab	2976
4. Armezon (in crop)	8c	72	136	0b	0b	35bcd	4041
5. Authority + Armezon	5c	52	158	3b	0b	37abcd	3141
6. Authority + [Mextrol + Select (in crop)]	5c	60	150	3b	0b	31cd	3110
7. Authority + [Bromoxynil + Select (in crop)]	5c	41	157	2b	0b	30d	3013
8. Armezon + Mextrol + Select	5c	68	146	47a	22a	16e	2418
9. Armezon + Bromoxynil + Select	43b	62	180	3b	1b	33bcd	2864
P value (treatment)	**0.001**	0.573	0.794	**<0.001**	**0.014**	**<0.001**	0.320
Coefficient of Variation	33	10	21	85.8	196.2	14	29
MSE	2.351	0.03	1001.7	0.0056	0.005	24.002	759257
GM	4.671	1.77	150	0	0.034	34	2954

Melita

At Melita, there were significantly (P=0.005) more weed injury percentages with herbicide combinations than single herbicide treatments (Table 6). A combination of Armezon + Bromoxynil + Select caused higher weed injury percentages compared to other herbicide treatments. Higher weed injury percentages for combination treatments involving Authority were probably as a result of adequate rainfall for herbicide activation following application of treatments. Herbicide combinations also caused significant (P=0.004) reduction in weed densities compared to Armezon or Authority applied alone.

Overall, weed density was lower at Melita compared to Arborg and Roblin, which could be due to site specific differences. It is also important to note that although Armezon (in-crop) application alone caused little injury on weeds and flax than when applied in combination with other herbicides at 2WAA, it did not have a negative impact on flax height compared to combination herbicides. Crop injury recovery was observed at 4 WAA of combination herbicides involving Armezon, which explains the ability of flax to recover in the short term after herbicide treatment. Flax emergence was not significantly different at Melita but the plant stand was more than 300% better than Roblin across all herbicide treatments. This was probably due to differences in soil moisture at crop establishment between the two sites. There were no significant differences in flax seed yield across all treatments and the yields were lower than at Roblin site overall.

Table 6: GLM Analysis of variance for weed injury, weed density, flax emergence, crop injury, crop height and crop yield at Melita in 2020

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

Arborg

Weed injury percentage was significantly (P<0.001) high among all combination treatments including Armezon applied in-crop and ranged from 60% to 87% compared with Authority (pre-seed) that only caused 10% injury (Table 7). Treatments 6, 8 and 9 had best weed control with 80, 87 and 85% weed injury at 2 WAA, respectively. It is possible that efficacy of Authority was low as a result of low rainfall within 2 of application of the herbicide. Authority applications require a moderate rainfall of between 10 to 20 mm or equivalent irrigation within 10 to 14 days for proper activation. During the 2-week period from application of Authority, Arborg site only received 3.8 mm rainfall (https://web43.gov.mb.ca/Climate), which was not adequate for activation of the herbicide and could explain the reason why there was only 10% weed injury. Weed density measured at flowering was significantly (P=0.037) different at Arborg. The ideal herbicide option was considered to be the one with the lowest weed density after herbicide treatment relative to other options under consideration. In this regard, weed density was significantly lower in Authority + [Mextrol + Select (in-crop)] (11 ppms) and Armezon + Mextrol + Select (15 ppms). Similar pattern in crop injury recovery as with Melita and Roblin was observed at Arborg with initially high injury percentages at 2 WAA followed by significant (P=0.007) recovery at 4 WAA. Crop height was also significantly (P<0.001) reduced in combination herbicide options especially treatment 8 and 9 that included Armezon + Mextrol + Select and Armezon + Bromoxynil + Select, respectively. Flax plants in these treatments were more than 50% shorter compared to the non-weeded check at 2 WAA. Perhaps Bromoxynil and Mextrol components influenced the reduction in flax height. Flax seed yield was significantly (P<0.001) high in combination herbicides that had Armezon in the mixture and was comparable to the hand weeded check. Overall, flax yield ranged from 1889 kg ha^{-1} to 3553 kg ha^{-1}, with the lowest being the non-weeded check as expected. Although it caused significantly high percentage in weed injury during the first 2 WAA, the MCPA component in Mextrol with Armezon + Mextrol +Select appeared to have reduced flax seed yield. Probably application rates of the Mextrol component might need to be revised to reduce the impact on yield but not compromising on weed control.

Table 7: GLM Analysis of variance for weed injury, weed density, flax emergence, crop injury, crop height and crop yield at Arborg in 2020

Treatment	Weed Injury (%) 2WAA	Weed Density ppm at flower	Flax Emergence ppm	Crop Injury (%)		Crop Height (cm) 2WAA	Crop Yield (kg/ha)
				2WAA	4WAA		
1. UTC (no weeding)	*	96a	264	*	*	42ab	1889e
2. UTC (Hand weeded check)	*	*	313	*	*	47a	3553a

3. Authority (pre-seed)	10b	93ab	293	8	12ab	35bc	2217de
4. Armezon (in crop)	60a	109a	304	13	13ab	20d	2574cd
5. Authority + Armezon	67a	104ab	317	13	7c	32c	3198ab
6. Authority + [Mextrol + Select (in crop)]	80a	11c	279	12	6c	46a	3007bc
7. Authority + [Bromoxynil + Select (in crop)]	78a	68abc	315	17	8bc	22d	3052b
8. Armezon + Mextrol + Select	87a	15bc	315	28	15a	17d	2944bc
9. Armezon + Bromoxynil + Select	85a	70a	277	23	13ab	19d	3116ab
P value (treatment)	**<0.001**	**0.037**	0.29	0.242	**0.007**	**<0.001**	**<0.001**
Coefficient of Variation	12	17	10	15.2	25.7	13	10
MSE (mean square error) for CV calculations	0.946	0.104	876.200	0.010	0.001	18.620	75721.000
GM	8.061	1.839	300.306	0.645	0.100	32.360	2813.144

<u>Combined site results</u>

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

Table 8: GLM Combined (Melita, Arborg and Roblin) Analysis of variance for weed injury, weed density, flax emergence, crop injury, crop height and crop yield in 2020

Treatment	**Weed Injury (%) 2WAA**	**Weed Density ppm at flower**	**Flax Emergence ppm**	**Crop Injury (%)**		**Crop Height (cm) 2WAA**	**Crop Yield kg/ha**
				2WAA	**4WAA**		
1. UTC (no weeding)	*	57	320	*	*	39ab	2486
2. UTC (Hand weeded check)	*	*	333	*	*	42a	2667
3. Authority (pre-seed)	37	53	315	3c	4b	37abc	2568
4. Armezon (in crop)	25	67	336	4c	4b	31bcd	2997
5. Authority + Armezon	39	54	316	9bc	2b	34abcd	3034
6. Authority + Mextrol + Select (in crop)	54	25	309	12bc	2b	36abc	2869
7. Authority (pre-seed) + Bromoxynil + Select (in crop)	58	38	336	9bc	3b	28cde	2889
8. Armezon (pre-seed) + Mextrol + Select (in crop)	54	29	322	39a	15a	20e	2653
9. Armezon + Bromoxynil + Select (in crop)	74	46	327	21b	8ab	25de	2835
P value (treatment)	0.647	0.058	0.821	**0.003**	**0.023**	**0.004**	0.876
P value (Site)	0.22	0.202	0.159	0.291	0.208	<0.001	0.392
P value (Site x Treatment)	**0.015**	0.075	0.481	0.056	0.082	0.007	**0.048**

Weed summary

Weed species composition differed across the 3 sites under study in 2020 (Table 9). Arborg had predominantly redroot pigweed in treatments 1, 2, 4 and 8 while lambsquarters was only present in treatment 1 and 2. At Melita, biennial wormwood was predominant in treatments 1, 3, 4 and 6 while volunteer wheat appeared in more than 50% of the treatments. At Roblin, volunteer canola was predominant in all treatments followed by green foxtail.

Table 9: Summary of four major weeds (ranked as most to least) by site after herbicide treatment at flower stage in 2020

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

Key (Table 9)

RRP – Redroot pigweed	C – volunteer canola	D – Dandelion	WB – Wild Buckwheat
LQ – Lambsquarters	BW – Biennial Wormwood	WO – Wild Oat	K – Kochia
VW – Volunteer Wheat	CT – Canadian Thistle	GF – Green foxtail	SP – Shepherd's purse

Conclusions

Interestingly there were no flax injuries with Authority + Mextrol option but Armezon in combination with Mextrol caused injuries. Based on these preliminary findings, this combination should be avoided in real farm situations unless if further studies with reduced applications rates of Mextrol can prove otherwise. Armezon on its own did not seem to show crop injury, but it stunted the height of flax, which could reduce seed yield. Arborg was the only site that showed yield loss based on herbicide use in general. At this site, Armezon showed yield loss both in sole use, and in combination with Mextrol. The study will be conducted again in 2021 before recommendations can be made available for registration of Armezon in flax. There might be need to consider reducing Mextrol application rates when used in combination with Armezon in order to address crop injury concerns.

References

Berglund, D. R. and Zollinger, R. K. 2007. Flax Production in North Dakota. North Dakota Extension Service, North Dakota State University 58105: A-1038.

Kurtenbach, M. E., Johnson, E. N., Gulden, R. H., Dugiud, S., Dyck, M. F., Willenborg, C. J. 2019. Integrating Cultural Practices with Herbicide Augments Weed Management in Flax. *Agronomy Journal* 111 (4): 1904-1912**.** https://doi.org/10.2134/agronj2018.09.0593.

FHB Risk Model University of Manitoba – Barley, Durum, Spring Wheat, Winter Wheat

Project duration: September 2019 – August 2020
Objectives: To increase understanding of resulting Fusarium Head Blight (FHB) infection for spring and winter wheat, barley and durum based on the current model.
Collaborators: Manasah Mkhabela PhD., Research Associate University of Manitoba Soil Science

Background
Farmers need improved decision-making tools in order to assess the local risk of Fusarium Head Blight (FHB). Better tools would improve judgement on whether or not to use fungicide and how to time application. The project recognizes that the current model for predicting the presence of FHB is insufficient and is gathering data across the province for different treatment plans using both known fusarium resistant and fusarium susceptible varieties.

This project design centred on learning more about how spore density in the air at specific times of plant maturation affected FHB infection. The specific window of interest is during flowering and up to five days before flowering.

Results
Grain samples sent away to analyze for grading, fusarium species assessment, and mycotoxin analysis. PCDF will post a link when this report is available.

Materials and methods
Entries: 3 varieties for each winter wheat, spring wheat and barley; 1 variety for durum
Seeding: Winter wheat seeded 09.12.19; barley, spring wheat and durum seeded 05.15.20
Harvest: Aug 19, 2020

Table 1: Varieties in 2020 FHB Trial

Winter Wheat	Spring Wheat	Barley	Durum
Moats	AAC Elie	CDC Copeland	Strongfield
AAC Gateway	AAC Brandon	AAC Connect	
Emerson	Muchmore	AAC Synergy	

Data collected	Date collected
Plant Counts:	Three leaf stage (and spring emergence for winter wheat)
Plant Staging:	Weekly staging beginning at late booting through late flowering
Spore Traps:	Beginning just before winter wheat flowering spanning five weeks and covering all cereals flowering
FHB sampling:	18-21 days after flowering – Enumeration of FHB afflicted kernels per head in a given sample size of fifty heads per plot
Heights:	Aug 5
Yield:	Aug 19
Moisture:	Aug 19

Agronomic info
Previous year's crop: Barley Silage
Soil Type: Erickson Loam Clay

Landscape: Rolling with trees to the east
Seedbed preparation: Tilled once and then harrowed

Table 2: Fertility Information for Barley, Wheat, and Durum

	Available	Added for Barley	Added for Wheat	Added for Durum
N	71 lb/ac	53 lb/ac	118 lb/ac	118 lb/ac
P	50 ppm	10 lb/ac	10 lb/ac	10 lb/ac
K	556 lb/ac	-	-	-

Table 3: Fertility Information for Winter Wheat

	Available	Added
N	39.1	96
P	75.5	15
K	132.0	-

N side banded; P banded with seed

Table 4: Herbicide Application

Crop stage	Date	Product	Rate
Pre-emerge	Sep 12	RoundUp	0.67 L/ac
	May 26	Axial	0.5 L/ac
		Prestige XC	0.18 L/ac
In-crop Spring Cereals	Jun 22	Prestige XC-A	0.17 L/ac

Hemp Trials

National Hemp Variety Field Trials

Project duration: May 2020 – October 2020
Objectives: To evaluate industrial hemp varieties for the National Hemp Variety Field Trials coordinated by the Canadian Hemp Trade Alliance
Collaborators: Canadian Hemp Trade Alliance
Manitoba Horticulture Productivity Enhancement Centre (MHPEC)
Parkland Crop Diversification Foundation (PCDF)
Prairies East Sustainable Agricultural Initiative (PESAI)
Westman Agricultural Diverification Organization (WADO)
PI, James Frey (Manitoba Agriculture and Resource Development)

Background

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

Results

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

Table 1: Grain yield by variety (lb/ac)

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

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

Table 2: Fibre yield by variety (lb/ac)

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

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

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

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

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

Table 4: Agronomic characteristics by variety

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

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

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

Materials and methods

Experimental Design: Random Complete Block Design
Entries: 7 grain entries and 11 dual purpose entries, 4 replications
Seeding: May 22
Fibre Harvest: Aug 28
CBD Harvest: Aug 28
Grain Harvest: Sep 17

Table 5: Summary of hemp varieties by site

Variety	PESAI	PCDF	MPHEC	WADO
Grain				
X59		X	X	X
Katani		X		X
Grandi		X		X
CRS-1 (check)		X	X	X
Picolo		X	X	X
Dual Purpose				
Vega	X	X		X
Altair	X	X		X
CRS-1	X	X		X
Petera	X	X		X
CFX-2		X		X
Research				
NWG 2730	X	X	X	X

Table 6: Data collected

Emergence date	Stem elongation plant counts	Grain yield	Fibre wet yield	Lodging
Mortality plant counts	Height	Grain moisture	Fibre dry yield	Cannabinoid content

Agronomic info (Roblin)

Previous year's crop:	Barley Silage
Soil Type:	Erickson Loam Clay
Landscape:	Rolling with trees to the east
Seedbed preparation:	Heavy harrowed

Table 7: Fertility Information (Roblin)

	Available	**Added**	**Type**
N	63 lb/ac	57 lb/ac	46-0-0
P	62 ppm	20 lb/ac	11-52-0-0
K	698 ppm		

Table 8: Herbicide Application (Roblin)

Crop stage	**Date**	**Product**	**Rate**
Pre-emerge	May 22	Roundup	0.64 L/ac
No in-crop			

EnterraFrass Canada Hemp

Project duration: May 2020 – October 2020
Objectives: To evaluate the use of four frass formulations for hemp fertility management
Collaborators: Conner Entz, EnterraFrass Canada

Background

EnterraFrass is a fertilizer product derived from frass, the solid excreta of black soldier fly larvae. The larvae feed upon traceable, recycled food. The frass has 3% nitrogen content, as well as other nutrient and biological properties, and can have applications in organic farming contexts. Learn more about EnterraFrass here.

Results

The yield results for hemp grain are shown in Figure 1.

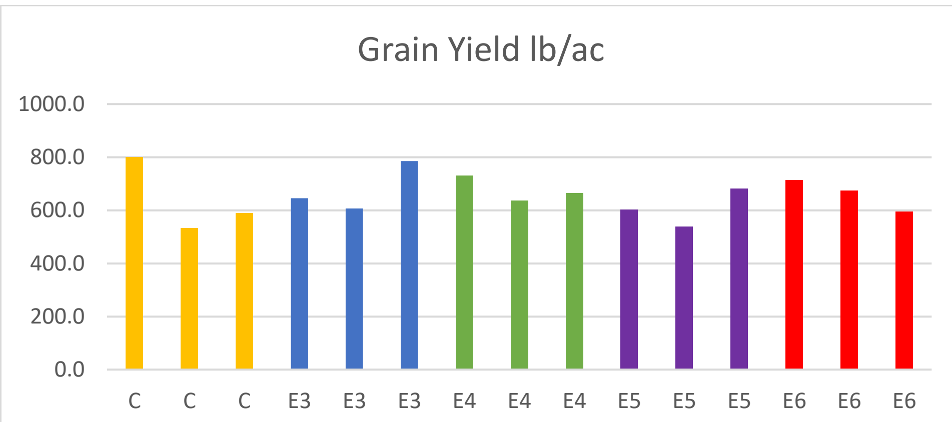

Figure 1: Grain yield (lb/ac). (C = Control [Composted turkey manure]; E3:E6 = frass formulations)

CBDA content is shown in Figure 2. Cannabinoid analysis was done with an Orange Photonics Legacy LightLab cannabis analyzer, which uses chromatography and spectroscopy to determine the content for six major cannabinoids. Table 1 describes the cannabinoids measured by the LightLab unit. The tests for this trial were calibrated to provide cannabinoid results above a 0.3% threshold. This means that any cannabinoids below 0.3% may have been present, but were not detected by the cannabis analyzer.

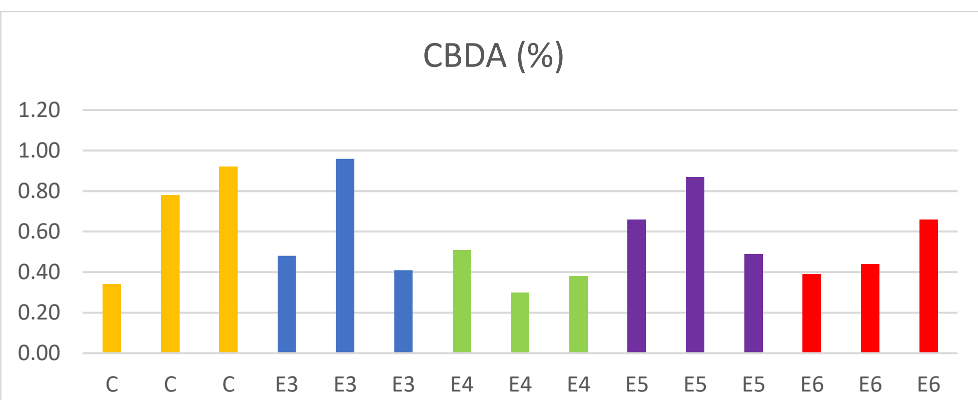

Figure 2: CBDA content by treatment (%)

Table 1: Description of cannabinoids measured by the Orange Photonics Legacy LightLab*

Cannabinoid Short name	Cannabinoid Full name	Description	Note
THCA	Tetrahydrocannabinolic Acid	The acidic form of THC	By Canadian law, THC content for hemp must be below 0.3 %
Delta-9 THC	Delta-9 Tetrahydrocannabinol	The psychoactive, neutral form of THC	
Total Potential Delta-9 THC		Total potential Delta-9 THC if the sample is completely decarboxylated	
Total THC		The sum of THCA and Delta-9 THC	
CBDA	Cannabidiolic Acid	The acidic form of CBD.	
CBD	Cannabidiol	The neutral form of CBDA	Formed by the decarboxylation of CBDA; CBD is non-psychoactive
CBN	Cannabinol	Formed from the breakdown of Delta-9 THC	
CBGa	Cannabigerolic acid	Precursor molecule that is transformed by enzymatic processes into THCA and CBDA	

* Descriptions for cannabinoids are adapted from the Orange Photonics manual

Grain yield and CBDA content do not differ statistically by treatment (Table 2). The percent CV for both grain yield is good for hemp (<20%, the threshold used by the Canadian Hemp Trade Alliance to accept or reject trial results), meaning that the results can be taken with confidence. However, the percent CV for CBDA is high and exceeds the threshold for confidence, meaning that the results may not accurately represent the effects of the treatments.

The results indicate that the different frass formulations can be used effectively to provide fertility to a hemp crop. There is no indication that frass increases or reduces hemp grain yield or CBDA.

Table 2: Summary of statistical information for grain and CBDA yield

Entry	Hemp yield (lb/ac)	CBDA content (%)	Statistical significance: Grain yield and CBDA content*
Control	606.3	0.68	A
Entry 1 (E3)	642.7	0.62	A
Entry 2 (E4)	670.4	0.40	A
Entry 3 (E5)	599.6	0.67	A
Entry 4 (E6)	550.1	0.50	A
CV (%)	13.8	38.5	

* Treatments not marked with the same letter are statistically different from other treatments.

Materials & Methods

Experimental Design:	Random Complete Block Design
Variety:	CRS-1
Entries:	5 treatments x 3 replications
Seeding:	Jun 24
Harvest:	Sep 17
Control fertility:	6% composted turkey manure pellets
Frass entries:	3% frass pellets

Data collected	Date collected
Emergence:	Jul 1
Plant Counts:	Jul 1
Vigor:	Aug 5
Disease:	Aug 5
CBD Sampling:	Aug 28
Yield:	Oct 1
Moisture:	Dec 1

Agronomic info

Previous year's crop:	Barley Silage
Soil Type:	Erickson Loam Clay
Landscape:	Rolling with trees to the east
Seedbed preparation:	Heavy harrowed

Table 3: Fertility Information

	Available	Added	Type
N	63 lb/ac	57 lb/ac	46-0-0
P	62 ppm	20 lb/ac	11-52-0-0
K	698 ppm		

Table 4: Herbicide Application

Crop stage	Date	Product	Rate
Pre-emerge	Jun 24	RoundUp	0.64 L/ac
In-crop	Jul 10	Bromoxynil	0.4 L/ac
		Centurion	0.15 L/ac

Montra Crop Science Hemp

Project duration: May 2020 – October 2020
Objectives: To evaluate the effect of organic acid products applied to hemp crops
Collaborators: Kevin Shale, Montra Crop Science

Background
Montra Crop Science provides organic plant and soil amendments. The current project is designed to examine effect of Montra products, BR-X and VX-8, on hemp yield and cannabinoid content. Find out more about Montra Crop Science here.

Results
The yield results for hemp grain are shown in Figure 1.

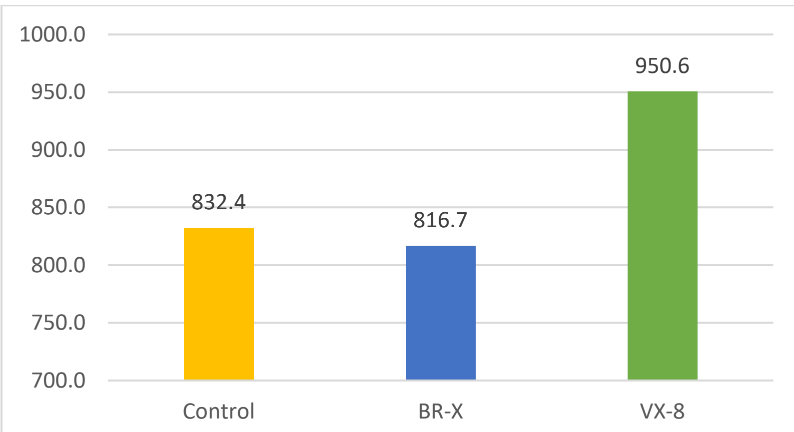

Figure 1: Grain yield (lb/ac).

CBDA content is shown in Figure 2. Cannabinoid analysis was done with an Orange Photonics Legacy LightLab cannabis analyzer, which uses chromatography and spectroscopy to determine the content for six major cannabinoids. Table 1 describes the cannabinoids measured by the LightLab unit. The tests for this trial were calibrated to provide cannabinoid results above a 0.3% threshold. This means that any cannabinoids below 0.3% may have been present, but were not detected by the cannabis analyzer.

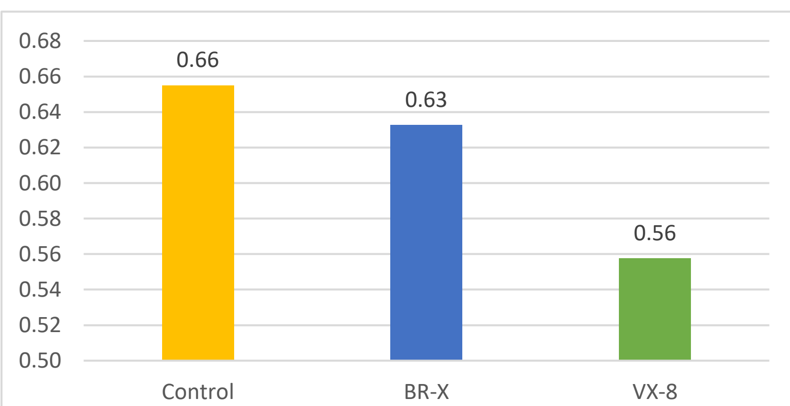

Figure 2: CBDA content by treatment (%)

Table 1: Description of cannabinoids measured by the Orange Photonics Legacy LightLab*

<table>
<tr><th>Cannabinoid
Short name</th><th>Cannabinoid
Full name</th><th>Description</th><th>Note</th></tr>
<tr><td>THCA</td><td>Tetrahydrocannabinolic Acid</td><td>The acidic form of THC</td><td rowspan="4">By Canadian law, THC content for hemp must be below 0.3 %</td></tr>
<tr><td>Delta-9 THC</td><td rowspan="2">Delta-9 Tetrahydrocannabinol</td><td>The psychoactive, neutral form of THC</td></tr>
<tr><td>Total Potential Delta-9 THC</td><td>Total potential Delta-9 THC if the sample is completely decarboxylated</td></tr>
<tr><td>Total THC</td><td></td><td>The sum of THCA and Delta-9 THC</td></tr>
<tr><td>CBDA</td><td>Cannabidiolic Acid</td><td>The acidic form of CBD.</td><td></td></tr>
<tr><td>CBD</td><td>Cannabidiol</td><td>The neutral form of CBDA</td><td>Formed by the decarboxylation of CBDA; CBD is non-psychoactive</td></tr>
<tr><td>CBN</td><td>Cannabinol</td><td>Formed from the breakdown of Delta-9 THC</td><td></td></tr>
<tr><td>CBGa</td><td>Cannabigerolic acid</td><td>Precursor molecule that is transformed by enzymatic processes into THCA and CBDA</td><td></td></tr>
</table>

* Descriptions for cannabinoids are adapted from the Orange Photonics manual

Grain yield and CBDA content do not differ statistically by treatment (Table 2). The percent CV for both grain yield and CBDA are high, but less than 20%, which is the threshold used by the Canadian Hemp Trade Alliance to accept or reject trial results.

Table 2: Summary of statistical information for grain and CBDA yield

Entry	Grain yield (lb/ac)	CBDA content (%)	Statistical significance: Grain yield and CBDA content*
Control	832.4	0.66	A
BR-X	816.7	0.63	A
VX-8	950.6	0.56	A
CV (%)	20.2	38.5	

* Treatments not marked with the same letter are statistically different from other treatments.

Materials & Methods

Experimental Design:	Random Complete Block Design
Variety:	Katani
Entries:	3 treatments x 4 replications
Seeding:	Jun 4
Harvest:	Sep 17

Table 3: Treatments

Treatment	At seeding	At Herbicide Application
1	Control	No product
2	Montra BR-X (wet) Soil-applied at 2 L/ac	Montra MX-3 Foliar applied
3	Montra VX-8 (dry) Soil-applied at 13.2 lb/ac	Montra MX-3 Foliar applied

Data collected	Date collected
Emergence:	Jun 11-12
Plant Counts:	Jul 1
Vigor:	Aug 5
Disease:	Aug 5
CBD Sampling:	Aug 28
Yield:	Oct 1
Moisture:	Dec 1

Agronomic info	
Previous year's crop:	Barley Silage
Soil Type:	Erickson Loam Clay
Landscape:	Rolling with trees to the east
Seedbed preparation:	Heavy harrowed

Table 4: Fertility Information

	Available	Added	Type
N	58 lb/ac	131 lb/ac*	46-0-0
P	71 ppm	15 lb/ac**	11-52-0-0
K	513 ppm		

* Side-banded
** In-row

Table 5: Herbicide Application

Crop stage	Date	Product	Rate
Pre-emerge	Jun 8	RoundUp	0.64 L/ac
In-crop	Jun 24	Brotex	0.40 L/ac
		Centurion	0.15 L/ac
		Decis	0.15 L/ac
		Montra MX-3	1.00 L/ac

Intercropping Trials

Intercropping: Barley-Cover Crop (Year 1)

Project duration: May 2020 – September 2020
Objectives: To evaluate intercropping potential for barley and cover crops
Collaborators: PCDF

Background

The Manitoba Agriculture and Resource Development (ARD) website states that producers may plant cover crops to minimize wind and water erosion. Cover crops can play an important role after low-residue crops, such as potatoes, or in spring as a new crop is establishing. Another import function is to immobilize excess nutrients, especially nitrogen, and prevent losses. Additionally, cover crops can help to trap snow, enhancing moisture conditions in spring.

Despite these benefits, the limited growing season before or after another crop can make establishing cover crops a challenge. A common practice is to establish a cover crop in-season, with a cash crop. This trial examined the effect of establishing four cover crops with barley (Table 1).

Results

The data presented here are for Year 1 of a two-year study. Figure 1 shows barley yield (bu/ac) by treatment. The yields do not differ significantly by treatment (Table 1), indicating that seeding a cover crop with barley did not affect barley yield.

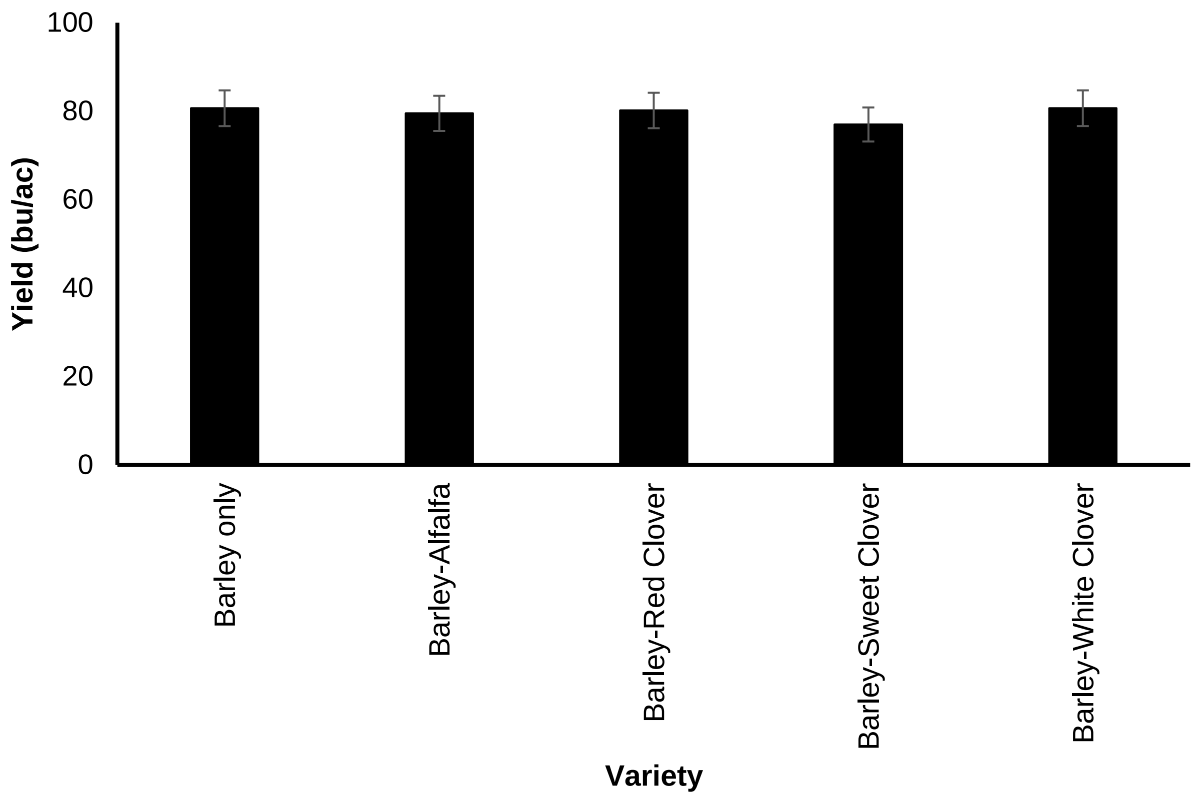

Figure 1: Barley yield (bu/ac) by treatment.

Table 1: Summary of statistical information for barley yield

Treatment	Yield (bu/ac)	Statistical significance*
Barley only	80.7	A
Barley-Alfalfa	79.5	A
Barley-Red Clover	80.2	A
Barley-Sweet Clover	77.0	A
Barley-White Clover	80.7	A
CV (%)	5.6	
LSD (0.05)	9.17	

Observations

Cover crop biomass was not collected, but qualitative assessments of the cover crops after harvest suggest that the treatments all established well. The barley was cut about 18-20" above the ground, and the loose straw was removed from the field so that the undamaged cover crop could continue to grow for the remainder of the season. Additionally, the longer stubble will trap more snow during the winter, providing better protection for the crop. Year 2 of the study will look at the winter survival and spring growth of the cover crop.

No herbicides were applied to the crop. Limited herbicide options are available for barley-cover crop intercrops, and the close proximity of the plots (and danger of spray drift) made it more feasible to hand-weed the plots. On a field-scale, careful field selection and pre-emergence herbicide application would be crucial to the establishment of a successful intercrop. Consult a herbicide guide or dealer to determine the best herbicide option for each intercrop.

Materials and methods

Experimental Design: Random Complete Block Design
Barley variety: CDC Austenson
Treatments: 5
Replications: 3
Seeding: May 22
Harvest: Sep 11

Table 2: Treatments (crops by lb/ac)

	Barley	Red Clover	White Clover	Sweet Clover	Alfalfa
Treatment 1	105 lb/ac	-	-	-	-
Treatment 2	105 lb/ac	10lb/ac	-	-	-
Treatment 3	105 lb/ac	-	5lb/ac		
Treatment 4	105 lb/ac	-	-	5lb/ac	-
Treatment 5	105 lb/ac	-	-	-	18lb/ac

Data collected Date Collected
Emergence: Barley: May 24, Cover crop: May 27-30
Barley Heading: Jul 12-13
Stand rating: Jul
Vigor Rating: Jul

Yield:	Sep 11
Moisture:	Sep 11

Agronomic info

Previous year’s crop:	Barley Silage
Soil Type:	Erickson Loam Clay
Landscape:	Rolling with trees to the east
Seedbed preparation:	Heavy harrowed

Table 3: Fertility Information

	Available	Added	Type
N	61 lb/ac	63 lb/ac	46-0-0
P	47 ppm	15 lb/ac	11-52-0-0
K	393ppm	-	
Cover crops inoculated; no herbicide applied (hand weeded)			

Intercropping: Canola-Cover Crop (Year 1)

Project duration: May 2020 – September 2020
Objectives: To evaluate intercropping potential for canola and cover crops
Collaborators: PCDF

Background
The Manitoba Agriculture and Resource Development (ARD) website states that producers may plant cover crops to minimize wind and water erosion. Cover crops can play an important role after low-residue crops, such as potatoes, or in spring as a new crop is establishing. Another import function is to immobilize excess nutrients, especially nitrogen, and prevent losses. Additionally, cover crops can help to trap snow, enhancing moisture conditions in spring.

Despite these benefits, the limited growing season before or after another crop can make establishing cover crops a challenge. A common practice is to establish a cover crop in-season, with a cash crop. However, producers do not commonly establish cover crops with canola. This trial examined the effect of establishing four cover crops with canola (Table 1).

Results
The data presented here are for Year 1 of a two-year study. Figure 1 shows canola yield (bu/ac) by treatment. The yields do not differ significantly by treatment (Table 1), indicating that seeding a cover crop with canola did not affect canola yield.

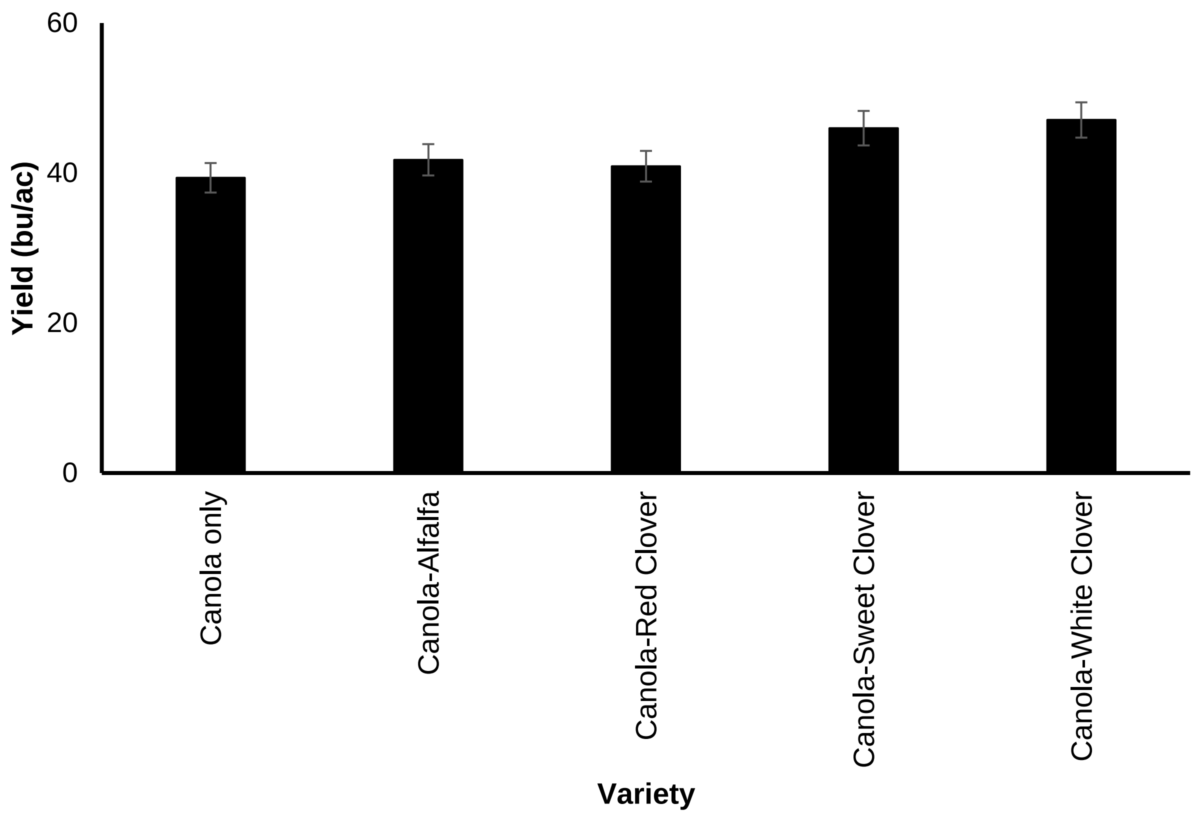

Figure 1: Canola yield (bu/ac) by treatment.

Table 1: Summary of statistical information for canola yield

Treatment	Yield (bu/ac)	Statistical significance
Canola only	39.4	A
Canola-Alfalfa	41.8	A
Canola-Red Clover	40.9	A
Canola-Sweet Clover	46.0	A
Canola-White Clover	47.1	A
CV (%)	12.8	
LSD (0.05)	9.79	

* Treatments not marked with the same letter are statistically different from other treatments.

<u>Observations</u>

Cover crop biomass was not collected, but qualitative assessments of the cover crops after harvest suggest that the treatments all established moderately well. The canola was cut about 18-20" above the ground, and the loose straw was removed from the field so that the undamaged cover crop could continue to grow for the remainder of the season. Additionally, the longer stubble will trap more snow during the winter, providing better protection for the crop. Year 2 of the study will look at the winter survival and spring growth of the cover crop.

No herbicides were applied to the crop. Limited herbicide options are available for canola-cover crop intercrops, and the close proximity of the plots (and danger of spray drift) made it more feasible to hand-weed the plots. On a field-scale, careful field selection and pre-emergence herbicide application would be crucial to the establishment of a successful intercrop. Consult a herbicide guide or dealer to determine the best herbicide option for each intercrop.

Materials and methods

Experimental Design: Random Complete Block Design
Canola Variety: Clearfield
Treatments: 5
Replications: 3
Seeding: May 22
Harvest: Sep 11

Table 2: Treatments by seeding rate (lb/ac)

	Canola	Red Clover	White Clover	Sweet Clover	Alfalfa
Treatment 1	5 lb/ac	-	-	-	-
Treatment 2	5 lb/ac	10lb/ac	-	-	-
Treatment 3	5 lb/ac	-	5lb/ac		
Treatment 4	5 lb/ac	-	-	5lb/ac	-
Treatment 5	5 lb/ac	-	-	-	18lb/ac

Data collected	Date Collected
Emergence:	Canola: May 24-25, Clover: May 28-30
Canola Flowering:	Jul 4-6
Stand rating:	Jul
Vigor Rating:	Jul
Yield:	Sep 11
Moisture:	Sep 11

Agronomic info	
Previous year's crop:	Barley Silage
Soil Type:	Erickson Loam Clay
Landscape:	Rolling with trees to the east
Seedbed preparation:	Heavy harrowed

Table 3: Fertility Information

	Available	Added	Type
N	61 lb/ac	93 lb/ac	46-0-0
P	47 ppm	10 lb/ac	11-52-0-0
K	393ppm	-	

Cover crops inoculated; no herbicide applied (hand weeded)

Intercropping: Oat-Cover Crop (Year 1)

Project duration: May 2020 – September 2020
Objectives: To evaluate intercropping potential for oat and cover crops
Collaborators: PCDF

Background
The Manitoba Agriculture and Resource Development (ARD) website states that producers may plant cover crops to minimize wind and water erosion. Cover crops can play an important role after low-residue crops, such as potatoes, or in spring as a new crop is establishing. Another import function is to immobilize excess nutrients, especially nitrogen, and prevent losses. Additionally, cover crops can help to trap snow, enhancing moisture conditions in spring.

Despite these benefits, the limited growing season before or after another crop can make establishing cover crops a challenge. A common practice is to establish a cover crop in-season, with a cash crop. This trial examined the effect of establishing four cover crops with oats (Table 1).

Results
The data presented here are for Year 1 of a two-year study. Figure 1 shows oat yield (bu/ac) by treatment. The yields do not differ significantly by treatment (Table 1), indicating that seeding a cover crop with oats did not affect oat yield.

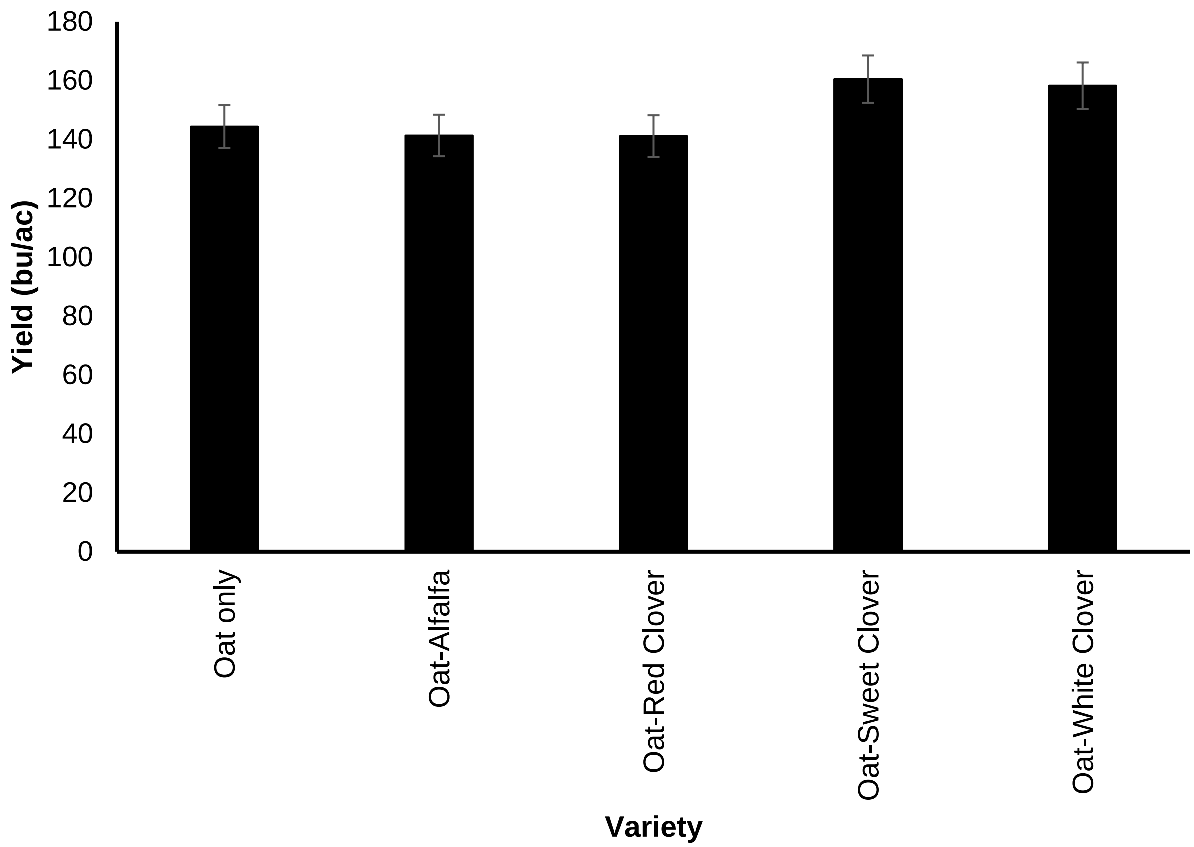

Figure 1: Oat yield (bu/ac) by treatment.

Table 1: Summary of statistical information for barley yield

Treatment	Yield (bu/ac)	Statistical significance
Oat only	144.4	A
Oat-Alfalfa	141.4	A
Oat-Red Clover	141.2	A
Oat-Sweet Clover	160.5	A
Oat-White Clover	158.2	A
CV (%)	10.7	
LSD (0.05)	28.61	

* Treatments not marked with the same letter are statistically different from other treatments.

Observations

Cover crop biomass was not collected, but qualitative assessments of the cover crops after harvest suggest that the treatments all established well. The oats were cut about 18-20" above the ground, and the loose straw was removed from the field so that the undamaged cover crop could continue to grow for the remainder of the season. Additionally, the longer stubble will trap more snow during the winter, providing better protection for the crop. Year 2 of the study will look at the winter survival and spring growth of the cover crop.

No herbicides were applied to the crop. Limited herbicide options are available for oat-cover crop intercrops, and the close proximity of the plots (and danger of spray drift) made it more feasible to hand-weed the plots. On a field-scale, careful field selection and pre-emergence herbicide application would be crucial to the establishment of a successful intercrop. Consult a herbicide guide or dealer to determine the best herbicide option for each intercrop.

Materials and methods

Experimental Design: Random Complete Block Design
Oat Variety: AC Summit
Treatments: 5
Replications: 3
Seeding: May 22
Harvest: Sep 11

Table 2: Treatments by seeding rate (lb/ac)

	Oat	Red Clover	White Clover	Sweet Clover	Alfalfa
Treatment 1	105 lb/ac	-	-	-	-
Treatment 2	105 lb/ac	10lb/ac	-	-	-
Treatment 3	105 lb/ac	-	5lb/ac		
Treatment 4	105 lb/ac	-	-	5lb/ac	-
Treatment 5	105 lb/ac	-	-	-	18lb/ac

Data collected	Date Collected
Emergence:	Oat: May 24-25, Clover: May 27-30
Stand rating:	Jul
Vigor Rating:	Jul
Yield:	Sep 11
Moisture:	Sep 11

Agronomic info	
Previous year's crop:	Barley Silage
Soil Type:	Erickson Loam Clay
Landscape:	Rolling with trees to the east
Seedbed preparation:	Heavy harrowed

Table 3: Fertility Information

	Available	Added	Type
N	61 lb/ac	59 lb/ac	46-0-0
P	47 ppm	10 lb/ac	11-52-0-0
K	393ppm		

Cover crops inoculated; no herbicide applied (hand weeded)

Intercropping: Spring Wheat-Clover (Year 1)

Project duration: May 2020 – September 2020
Objectives: To evaluate intercropping potential for Wheat and clovers
Collaborators: PCDF

Background
The Manitoba Agriculture and Resource Development (ARD) website states that producers may plant cover crops to minimize wind and water erosion. Cover crops can play an important role after low-residue crops, such as potatoes, or in spring as a new crop is establishing. Another import function is to immobilize excess nutrients, especially nitrogen, and prevent losses. Additionally, cover crops can help to trap snow, enhancing moisture conditions in spring.

Despite these benefits, the limited growing season before or after another crop can make establishing cover crops a challenge. A common practice is to establish a cover crop in-season, with a cash crop. This trial examined the effect of establishing four cover crops with wheat (Table 1).

Results
The data presented here are for Year 1 of a two-year study. Figure 1 shows wheat yield (bu/ac) by treatment. The yields do not differ significantly by treatment (Table 1), indicating that seeding a cover crop with wheat did not affect wheat yield.

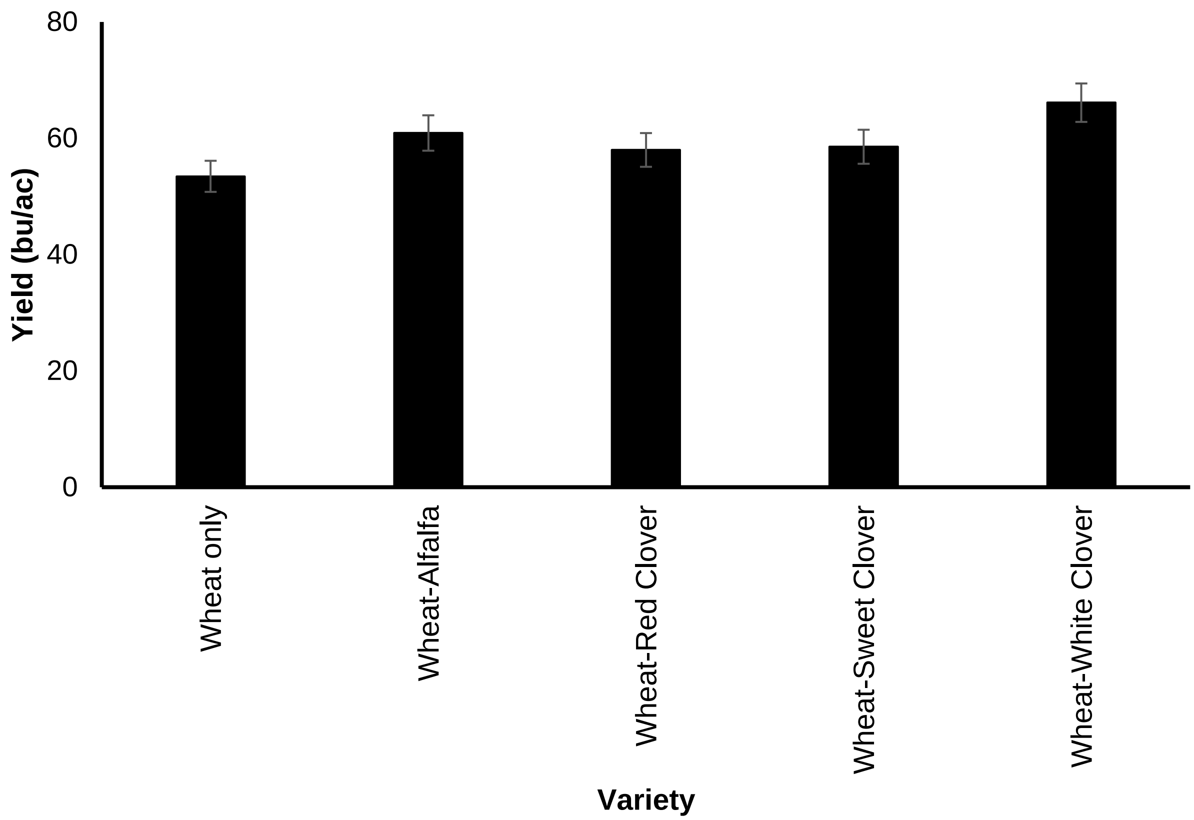

Figure 1: Wheat yield (bu/ac) by treatment.

Table 1: Summary of statistical information for wheat yield

Treatment	Yield (bu/ac)	Statistical significance
Wheat only	53.5	A
Wheat-Alfalfa	60.9	A
Wheat-Red Clover	58.0	A
Wheat-Sweet Clover	58.5	A
Wheat-White Clover	66.1	A
CV (%)	10.7	
LSD (0.05)	28.61	

* Treatments not marked with the same letter are statistically different from other treatments.

Observations

Cover crop biomass was not collected, but qualitative assessments of the cover crops after harvest suggest that the treatments all established well. The oats were cut about 18-20" above the ground, and the loose straw was removed from the field so that the undamaged cover crop could continue to grow for the remainder of the season. Additionally, the longer stubble will trap more snow during the winter, providing better protection for the crop. Year 2 of the study will look at the winter survival and spring growth of the cover crop.

No herbicides were applied to the crop. Limited herbicide options are available for oat-cover crop intercrops, and the close proximity of the plots (and danger of spray drift) made it more feasible to hand-weed the plots. On a field-scale, careful field selection and pre-emergence herbicide application would be crucial to the establishment of a successful intercrop. Consult a herbicide guide or dealer to determine the best herbicide option for each intercrop.

Materials and methods

Experimental Design: Random Complete Block Design
Entries: 5
Seeding: May 22
Harvest: Sep 11
Treatments: 5

Table 2: Treatments by seeding rate (lb/ac)

	Wheat	Red Clover	White Clover	Sweet Clover	Alfalfa
Treatment 1	90 lb/ac	-	-	-	-
Treatment 2	90 lb/ac	10lb/ac	-	-	-
Treatment 3	90 lb/ac	-	5lb/ac	-	-
Treatment 4	90 lb/ac	-	-	5lb/ac	-
Treatment 5	90 lb/ac	-	-	-	18lb/ac

Data collected: Date Collected
Emergence: Wheat: May 24-25, Cover crops: May 27-30
Wheat variety: AC Goodeve VB

Wheat Heading:	Jul 5-8
Stand rating:	Jul
Vigor Rating:	Jul
Yield:	Sep 11
Moisture:	Sep 11

Agronomic info

Previous year's crop:	Barley Silage
Soil Type:	Erickson Loam Clay
Landscape:	Rolling with trees to the east
Seedbed preparation:	Heavy harrowed

Table 3: Fertility Information

	Available	Added	Type
N	61 lb/ac	128 lb/ac	46-0-0
P	47 ppm	10 lb/ac	11-52-0-0
K	393ppm		

Cover crops inoculated; no herbicide applied (hand weeded)

Intercropping: Wheat-Chicory (Pilot Year)

Project duration: May 2020 – September 2020
Objectives: To evaluate intercropping potential for wheat and chicory
Collaborators: PCDF

Background
Chicory is a short-lived, broadleaf perennial that has gained the attention of livestock producers for its high production potential, excellent nutritional qualities, and deep taproot. The crop may be seeded alone or as part of a chicory-grass or chicory-legume mixture. For a good summary of chicory cultivation see this agronomy factsheet, prepared by Penn State University. Figure 1 shows second-year chicory plants at PCDF. (Note that the taproot is broken off.)

The trial examines the potential for establishing chicory with a wheat crop. This would provide producers with the opportunity to benefit from a cash crop during the establishment year.

Figure 1: Year-2 chicory plants, showing 40” of top growth and strong taproot

Results
The data presented here are for the pilot year, which seeks to establish proof-of-concept. PCDF plans to continue the trial in 2021, with some modifications (detailed below). Treatment 5 differed from the check (wheat-only) (Table 1). However, the difference stems from variation in plot yield (bu/ac) for Treatment 5 (Rep 1 = 84.7, Rep 2 = 82.3, Rep 3 = 71.4). Stand establishment for Treatment 5, Rep 3 was poor, resulting in lower yield relative to the other plots for that treatment.

The results for the pilot year suggest that the lower seeding rates for chicory provide unsatisfactory results for establishing a chicory crop, based on the number of plants observed per plot. The trial will be redesigned for 2021 to use higher seeding rates (3 and 4 lb/ac) and additional intercrops (barley, oat and wheat), for 6 entries in total.

There are no registered herbicides for chicory, making intercropping more challenging. Good weed control prior to seeding is crucial. The trial was hand-weeded.

Table 1: Summary of statistical information for wheat yield

	Seeding rate				
Treatment	Wheat	Chicory	Wheat yield (bu/ac)	Statistical significance	
Treatment 1	90 lb/ac	-	83.4	A	-
Treatment 2	90 lb/ac	0.5 lb/ac	72.6	A	B
Treatment 3	90 lb/ac	1.0 lb/ac	75.2	A	B
Treatment 4	90 lb/ac	2.0 lb/ac	75.1	A	B
Treatment 5	90 lb/ac	3.0 lb/ac	79.5	-	B
CV (%)			7.5		
LSD (0.05)			9.05		

Yield for varieties not connected by the same letter are significantly different

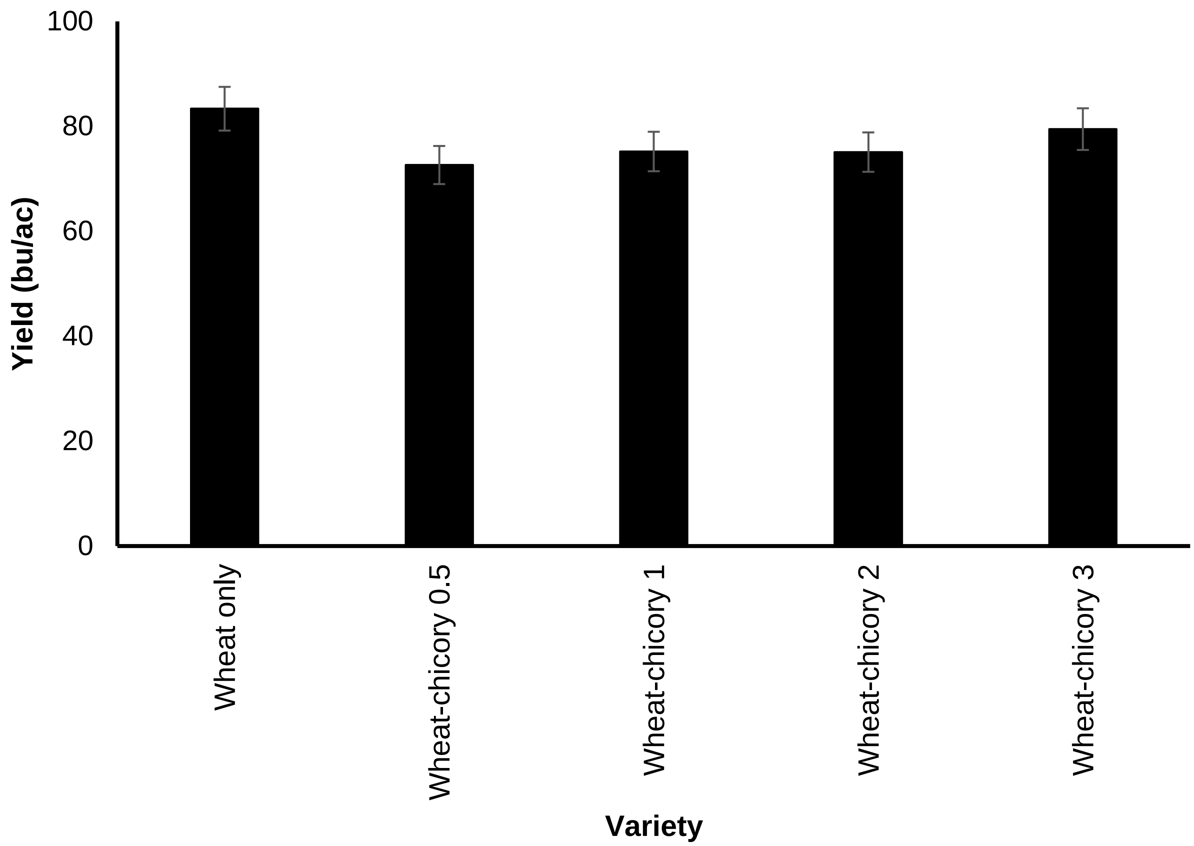

Figure 2: Wheat yield (bu/ac) by treatment.

Materials and methods

Experimental Design: Random Complete Block Design
Wheat variety: AC Goodeve VB
Entries: 5
Replications: 3
Seeding: May 22
Harvest: Sep 11

Data collected	Date Collected
Emergence:	Oat: May 24-25, Clover: May 27-30
Wheat Heading:	Jul 5-8
Stand rating:	Jul
Vigor Rating:	Jul
Yield:	Sep 11
Moisture:	Sep 11

Agronomic info

Previous year's crop:	Barley Silage
Soil Type:	Erickson Loam Clay
Landscape:	Rolling with trees to the east
Seedbed preparation:	Heavy harrowed

Table 3: Fertility Information

	Available	Added	Type
N	61 lb/ac	128 lb/ac	46-0-0
P	47 ppm	10 lb/ac	11-52-0-0
K	393ppm		

No herbicide applied (hand weeded)

Intercropping: Wheat-Lupin

Project duration: May 2020 – September 2020
Objectives: To evaluate intercropping potential for Wheat and Lupin
Collaborators: PCDF

Background
Lupin is a leguminous crop that produces high protein seeds similar in shape and size to peas. As a nitrogen-fixing crop, lupin makes a promising crop for a cereals intercrop. As with a pea-cereal intercrop, the large seed size for lupin makes separating with cereals crops feasible, although cracks and chips can be a difficulty. For an overview of lupin cultivation, see this Government of Western Australia e-guide.

Figure 1: Lupin, clockwise from top-left: (a) maturing pod; (b) plant with pods; (c) lupin intercrop with wheat (red dashed line shows the height difference between lupin and wheat; (d) dry lupin seeds.

Results
The wheat yield (bu/ac) for treatments is show in Figure 2. The lupin yield (lb/ac) is shown in Figure 3.

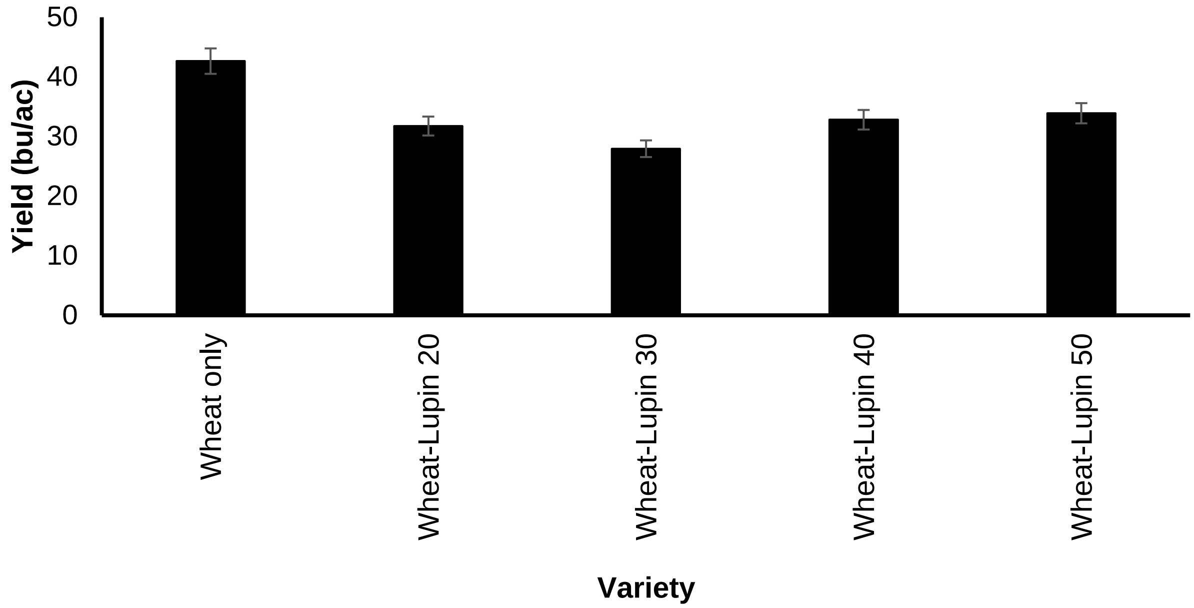

Figure 2: Wheat yield (bu/ac) by treatment.

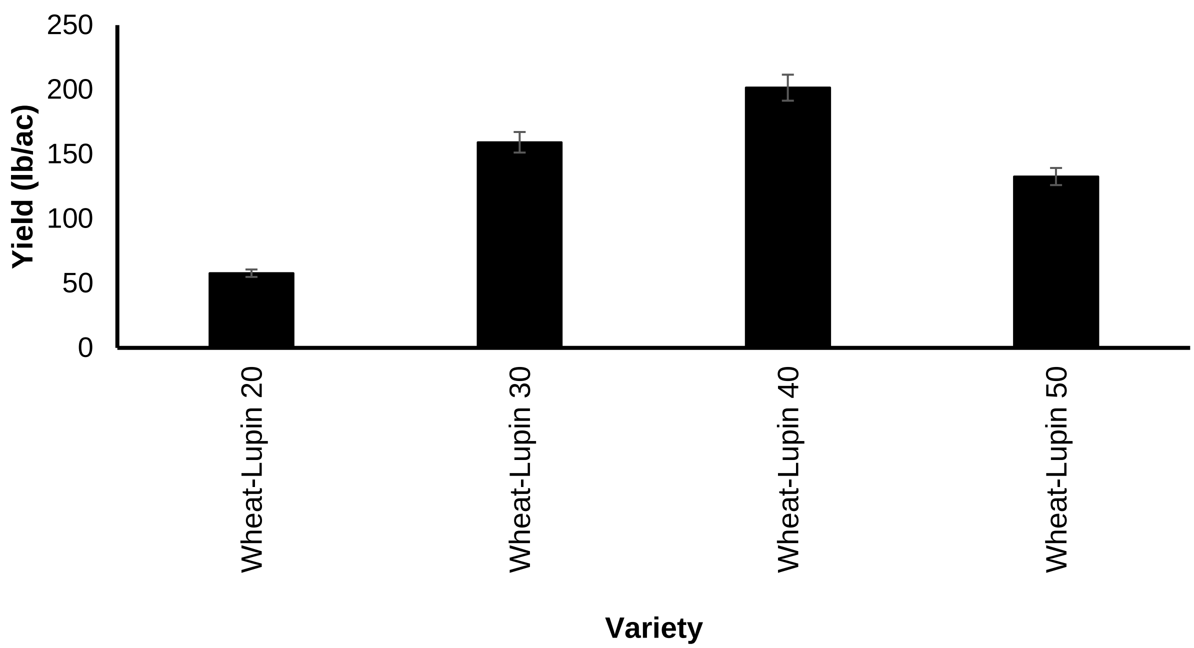

Figure 3: Lupin yield (lb/ac) by treatment.

The reliability of the results is low, due to the high percent CV for both wheat and lupin (Table 1). The overall yield is poor, relative to the five-year average for the Roblin area from 2014-2019 (59.6 bu/ac). This was seen even in the check (42.6 bu/ac), suggesting a fertility error. Lower yields for lupin intercrops is likely due to the lack of inoculant placed with the lupin. No lupin-specific inoculant was available, and PCDF hopes to secure some lupin-specific inoculant for 2021.

Table 1: Summary of statistical information for wheat and lupin yield

Entry	Wheat yield (bu/ac)	Lupin yield (lb/ac)	Statistical significance: Wheat	Statistical significance: Lupin*	
Wheat only	42.6	-	No statistical differences	-	B
Wheat-Lupin 20	31.8	57.8		A	B
Wheat-Lupin 30	28.0	159.2		A	B
Wheat-Lupin 40	32.8	201.5		A	-
Wheat-Lupin 50	33.9	132.7		A	B
CV (%)	25.2	53.2			
LSD (0.05)	14.8	1.8			

* Treatments not marked with the same letter are statistically different from other treatments.

Herbicides for lupin are limited, and no herbicides are registered for both lupin and wheat, making intercropping more challenging. Good weed control prior to seeding is crucial. The trial was hand-weeded.

Materials and methods

Experimental Design: Random Complete Block Design
Wheat variety: AC Goodeve VB
Entries: 5
Seeding: May 22
Harvest: Sep 11
Treatments: 5

Table 2: Treatments

	Wheat	Lupin
Treatment 1	90 lb/ac	-
Treatment 2	90 lb/ac	20 lb/ac
Treatment 3	90 lb/ac	30 lb/ac
Treatment 4	90 lb/ac	40 lb/ac
Treatment 5	90 lb/ac	50 lb/ac

Data collected	Date Collected
Emergence:	Wheat: May 25-26, Lupin: May 24-25
Wheat Heading:	Jul 7-9
Lupin Flowering:	Jul 6-9
Stand rating:	Jul
Vigor Rating:	Jul
Yield:	Oct 30
Moisture:	Oct 30

Agronomic info
Previous year's crop: Barley Silage
Soil Type: Erickson Loam Clay

Landscape: Rolling with trees to the east
Seedbed preparation: Heavy harrowed

Table 3: Fertility Information

	Available	Added	Type
N	61 lb/ac	128 lb/ac	46-0-0
P	47 ppm	10 lb/ac	11-52-0-0
K	393ppm		
Inoculant added; no herbicide applied (hand weeded)			

Intercropping: Wheat-Phacelia

Project duration: May 2020 – September 2020
Objectives: To evaluate intercropping potential for wheat and phacelia
Collaborators: PCDF

Background
Phacelia is a flowering broadleaf plant that may be included in cover crops mixtures as an outstanding pollinator species with moderate soil texture-building characteristics. Honey producers prize the crop for its long flowering period and light honey quality. Conversely, cereals crops such as wheat rely on wind for pollination, and do not provide good habitat for pollinators. Intercropping wheat and phacelia increases in-crop diversity, provides pollinator habitat in cereals crops (which are usually less attractive to pollinators), and can attract beneficial predators, such as wasps that predate wheat midge. This trial evaluates the potential for intercropping wheat and phacelia, and the effect of different rates of phacelia on wheat yield in particular. For a detailed summary of phacelia cultivation, see this USDA Plant Guide.


Figure 1: (top) wheat-phacelia intercrop; (bottom) phacelia blossoms with a pollinator.

Results

The wheat yield (bu/ac) for treatments is shown in Figure 2. The phacelia yield (lb/ac) for treatments is shown in Figure 3.

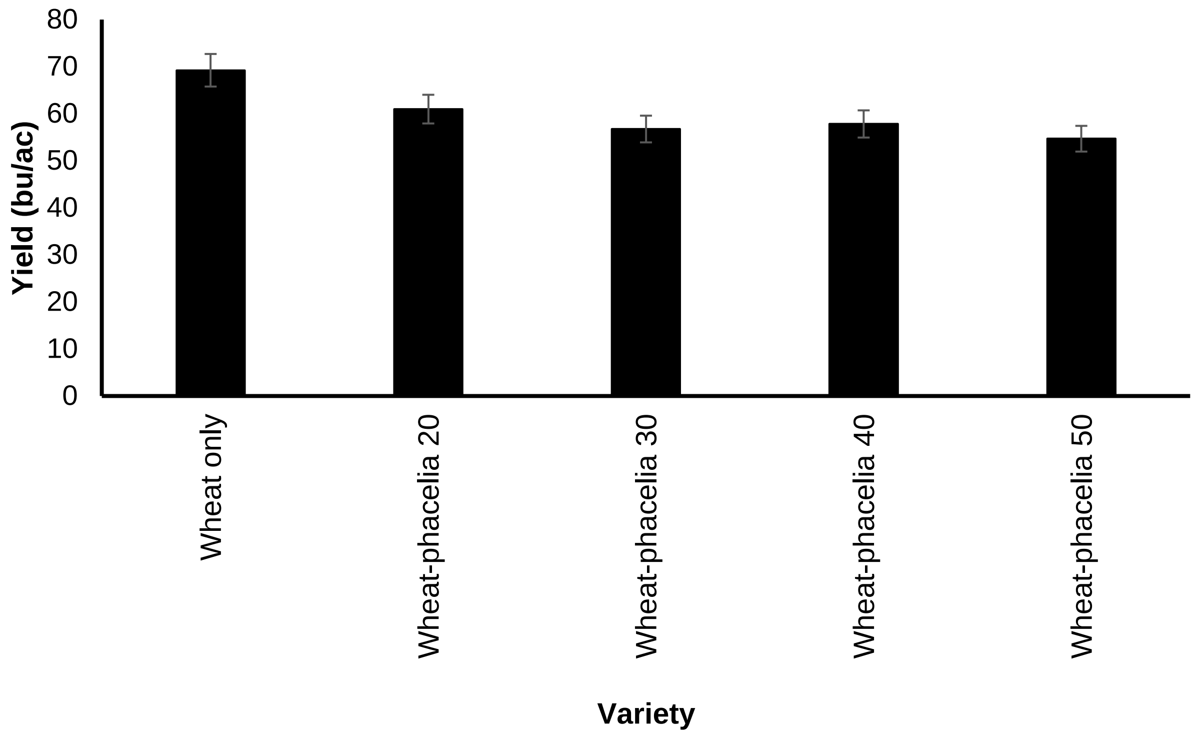

Figure 1: Wheat yield (bu/ac) by treatment.

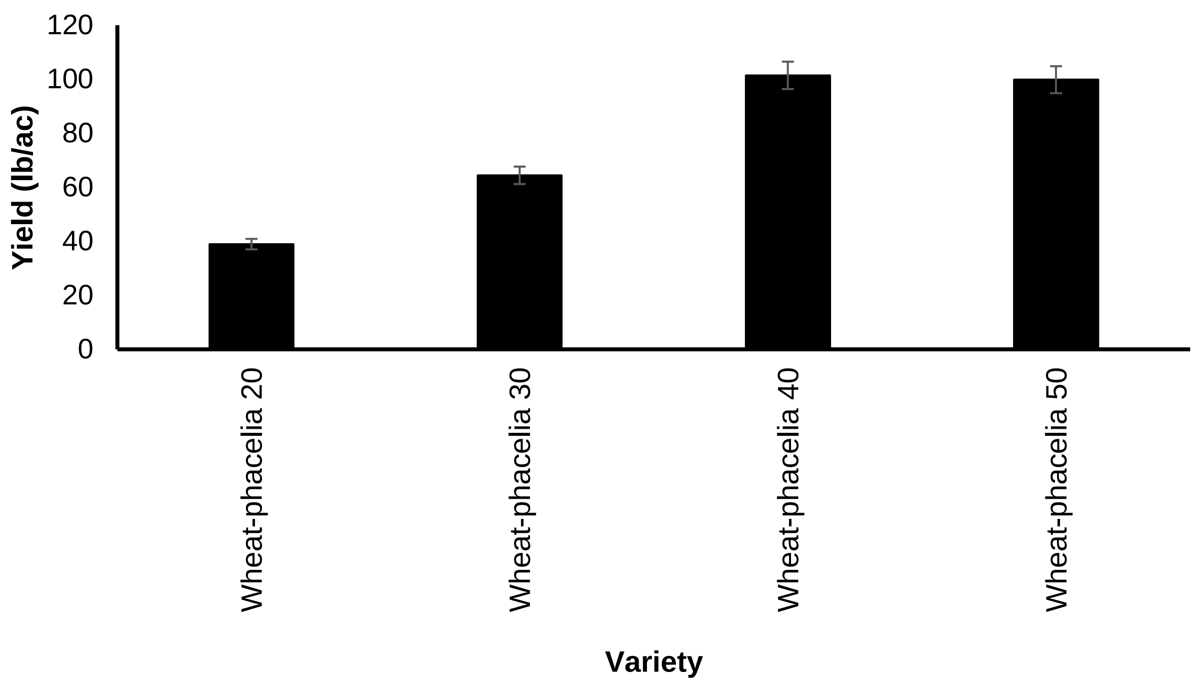

Figure 3: Phacelia yield (lb/ac) by treatment.

The results for wheat yield differ statistically by treatment (Table 1). Including phacelia treatment decreased the yield for wheat by up to 14.5 bu/ac (Treatment 5), likely due to increased water usage by the phacelia crop. Phacelia yield increased with seeding rate, but the reliability of those results is low due to a high percent CV for the phacelia yield.

Table 1: Summary of statistical information for wheat and lupin yield

Entry	Wheat yield (bu/ac)	Phacelia yield (lb/ac)	Statistical significance: Wheat*		Statistical significance: Phacelia*		
Wheat only	69.2	-	A				
Wheat-Lupin 20	61.0	38.9	A	B	A		
Wheat-Lupin 30	56.7	64.4		B		B	
Wheat-Lupin 40	57.8	101.4	A	B			C
Wheat-Lupin 50	54.7	99.8		B			C
CV (%)	12.6	36.4					
LSD (0.05)	37.0	11.3					

* Treatments not marked with the same letter are statistically different from other treatments.

There are no herbicides registered for phacelia, making intercropping with wheat a challenge. Good weed control prior to seeding is crucial. The trial was hand-weeded.

Materials and methods

Experimental Design: Random Complete Block Design
Wheat variety: AC Goodeve VB
Entries: 5
Seeding: May 22
Harvest: Sep 11
Treatments: 5

Table 2: Treatments

	Wheat	Phacelia
Treatment 1	90 lb/ac	-
Treatment 2	90 lb/ac	2 lb/ac
Treatment 3	90 lb/ac	3 lb/ac
Treatment 4	90 lb/ac	4 lb/ac
Treatment 5	90 lb/ac	5 lb/ac

Data collected: Date Collected
Emergence: Wheat: May 23-26, Phacelia: May 26-30
Wheat Heading: Jul 5-7
Phacelia Flowering: Jul 11-18
Stand rating: Jul
Vigor Rating: Jul
Yield: Oct 30
Moisture: Oct 30

Agronomic info

Previous year's crop:	Barley Silage
Soil Type:	Erickson Loam Clay
Landscape:	Rolling with trees to the east
Seedbed preparation:	Heavy harrowed

Table 3: Fertility Information

	Available	Added	Type
N	61 lb/ac	128 lb/ac	46-0-0
P	47 ppm	10 lb/ac	11-52-0-0
K	393ppm		

No herbicide applied (hand weeded)

Intercropping: Hemp-Cereal Silage

Project duration: May 2020 – August 2020
Objectives: To evaluate intercrop mixes with hemp for silage production
Collaborators: PCDF, Manitoba Horticulture Productivity Enhancement Centre (MHPEC)

Background
Silage plays an important part in the Manitoba livestock industry. Corn silage provides high yields, relative to barley silage (14 t/ac, over 7.5 t/ac, 2020 Silage Cost of Production, MARD). In the Parkland area, the yield for corn silage is variable and many producers opt to produce a cereal silage, such as barley or oat. PCDF and MHPEC have worked together to explore intercropping options for cereals silage.

Hemp provides an interesting opportunity for silage production, due to its high production potential and good nutritional qualities. However, Canadian regulations currently prohibit the use of hemp products as a livestock feed ingredients in Canada. As such, this research is purely exploratory, and is not intended to provide recommendations to producers. PCDF may use the data to provide information to regulatory agencies around the use of hemp in livestock feed.

Results

Figure 1: Clockwise from top-left: (1) hemp-only; (2) barley-hemp; (3) oat-hemp; (4) oat-only; (5) hemp-oat silage, chopped; (6) long fibres from over-ripe hemp plants.

The silage yields (t/ac) for treatments is shown in Figure 2. The results are for one year of data only.

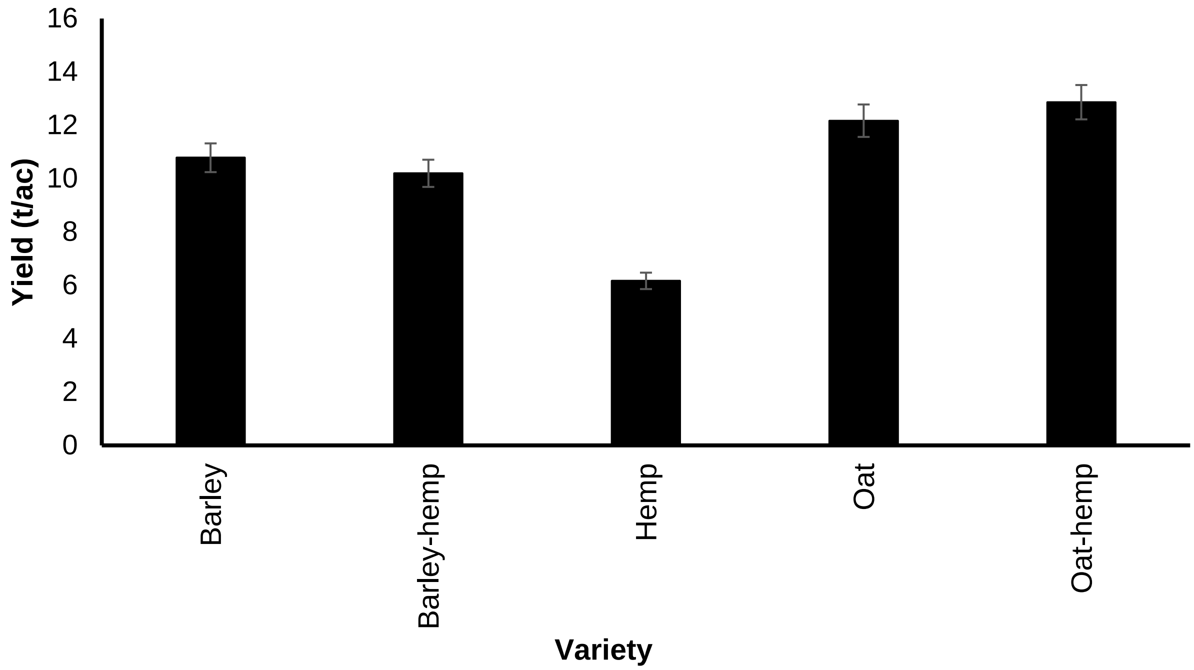

Figure 2: PCDF wet silage yield (t/ac) by treatment; all yields adjusted to 65% moisture.

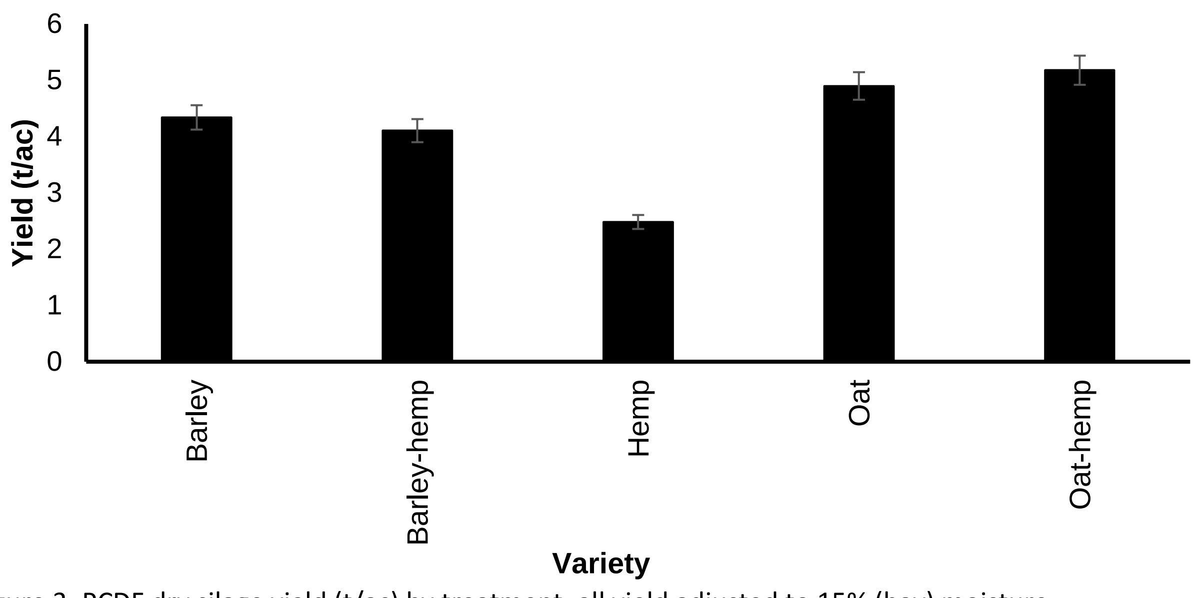

Figure 3: PCDF dry silage yield (t/ac) by treatment; all yield adjusted to 15% (hay) moisture.

The results for silage yield differ statistically by treatment (Table 1). The hemp-only treatment provided significantly lower silage yields than treatments including barley and oat. Further, the inclusion of hemp in the silage mixture did not significantly increase yield over barley-only or oat-only. Note that the reliability of these results is low due to a high percent CV for silage yield. The feed values and mineral content for each treatment are shown in Tables 2 and 3.

Table 1: Summary of statistical information for silage yield

Entry	Silage yield (t/ac) wet yield	Silage yield (t/ac) dry yield	Statistical significance: wet and dry*	
Barley	10.8	8.7	A	
Barley-hemp	10.2	8.2	A	
Oat	12.2	9.8	A	
Oat-hemp	12.9	10.4	A	
Hemp	6.2	5.0		B
CV (%)	27.8			
LSD (0.05)	3.4	2.8		

* Treatments not marked with the same letter are statistically different from other treatments.

Table 2: Feed values for silage by treatment compared to animal feed requirements*

Entry	% Crude Protein	% TDN
Barley	10.14	58.27
Oat	10.80	59.79
Hemp	12.58	43.70
Barley-hemp	12.18	58.69
Oat-hemp	12.22	58.94
Animal feed requirements		
Mature cows		
Mid gestation	7	50-53
Late gestation	9	58
Lactating	11-12	60-65
Replacement heifers	8-10	60-65
Breeding bulls	7-8	48-50
Yearling bulls	7-8	55-60

* Animal feed requirements developed by Elisabeth Nernberg (ARD).

Table 3: Mineral content for silage by treatment

Mineral	Barley	Oat	Hemp	Barley-hemp	Oat-hemp
Ca	0.35	0.28	1.55	0.64	0.38
P	0.19	0.20	0.27	0.24	0.21
Mg	0.12	0.13	0.36	0.18	0.15
Na	0.39	0.49	0.12	0.30	0.47
K	1.25	1.42	1.46	1.29	1.56
Mo	1.29	2.54	1.33	1.13	2.07
Cu	4.23	3.54	7.51	5.35	3.68
Zn	17.30	17.88	23.54	21.34	19.39
Mn	30.24	52.04	64.06	36.88	54.02
Fe	112.85	153.07	151.36	145.81	184.17

There are some herbicides registered for use with hemp, and there are no herbicides registered for both hemp and barley or oats, making silage intercropping for hemp and cereals a challenge. Good weed control prior to seeding is crucial. The trial was hand-weeded.

Table 4: Treatments, seeding rates and costs

Treatments	Percent of each monocrop seeding rate	Seeding Rate (lb/ac)	Cost per acre
Barley (Maverick)	100	90	$14.91
Oat (Haymaker)	100	90	$19.72
Hemp (Katani)	100	25	$50.00
Barley-hemp (Maverick-Katani)	75-33	68-8	$27.26
Oat-hemp (Haymaker-Katani)	75-33	68-8	$30.90

Observations

The silage was prepared by running the harvested material from each plot through a plant shredder (see Figure 1.5). Hemp is a plant with long fibres that become tougher towards maturity. If the crop becomes too mature, these fibres have the potential to tangle in the chopping equipment. Further, the higher fiber content makes for lower digestibility by livestock. This is reflected in the lower percent-TDN figure for the hemp-only treatment (Table 2). Nevertheless, even a reduced rate of hemp appeared to positively increase percent-protein content for the oat-hemp and barley-hemp treatments.

Materials and methods

Experimental Design: Random Complete Block Design
Entries: 5 (3 replications)
Seeding: May 25
Harvest: Aug 12

Data collected Date Collected
Hemp Emergence: May 28 – Jun 7
Cereal Emergence: May 25 – Jun 6
% Overall Emergence: Jul 11-18
Plot Wet Weight: Aug 12
Plot Dry Weight: Sep 12

Agronomic info
Previous year’s crop: Barley Silage
Soil Type: Erickson Loam Clay
Landscape: Rolling with trees to the east
Seedbed preparation: Heavy harrowed

Table 5: Fertility Information

	Available	Added	Type
N	79 lb/ac	47 lb/ac	46-0-0
P	22 ppm	10 lb/ac	11-52-0-0
K	257 ppm		

Intercropping: Pea-Cereal Silage

Project duration: May 2020 – August 2020
Objectives: To evaluate pea-cereal intercrop mixes for silage production
Collaborators: PCDF

Background
Silage plays an important part in the Manitoba livestock industry. Corn silage provides high yields, relative to barley silage (14 t/ac, over 7.5 t/ac, 2020 Silage Cost of Production, MARD). In the Parkland area, the yield for corn silage is variable and many producers opt to produce a cereal silage, such as barley or oat. Some producers have explored pea-cereals mixtures as a means to increase silage protein content. PCDF is eager to explore options for cereals silage production.

Results
The silage was harvested at soft-dough stage (65% moisture). The wet silage yields (t/ac) for treatments are shown in Figure 1, and dry yields (lb/ac at 15% moisture) are shown in Figure 2. The results are for 2019 and 2020.

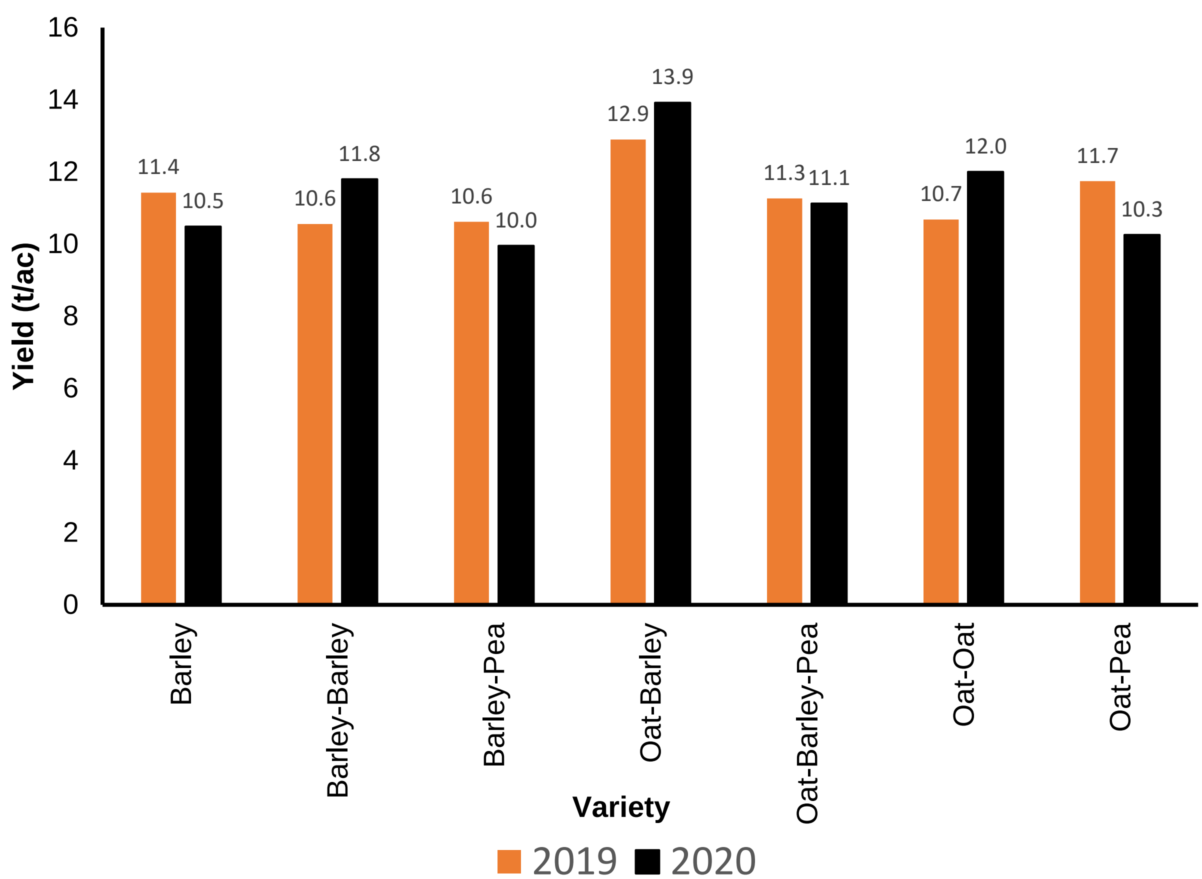

Figure 1: Wet silage yield (t/ac) by treatment, adjusted to 65% moisture.

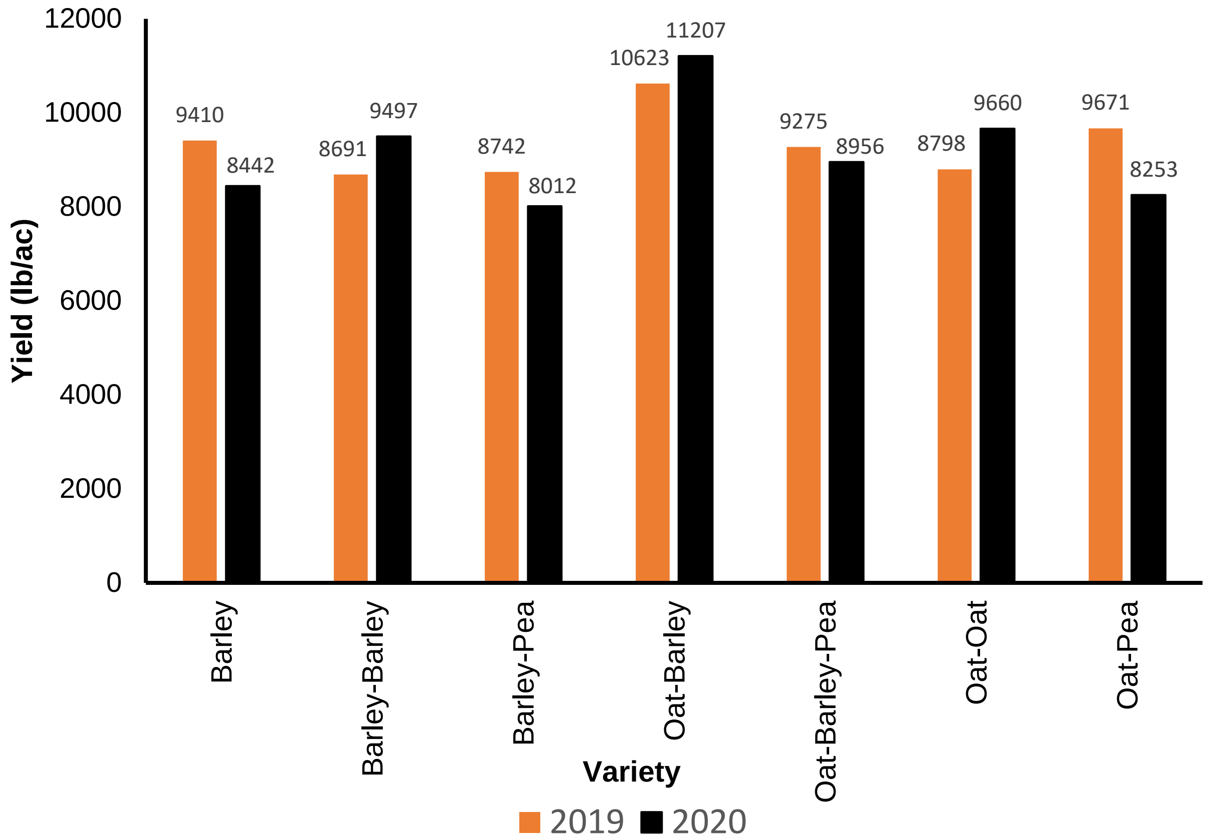

Figure 2: Yield (lb/ac) by treatment, adjusted to 15% (hay) moisture.

The results for silage yield differ statistically by treatment (Table 1). Oat-barley yields were significantly higher than other treatments (A). Yields for treatments including pea were not statistically different from the barley-only treatment (C).

Table 1: Summary of statistical information for 2020 silage yield

Entry	Statistical significance: wet and dry*		
Barley-only		B	C
Barley-Barley		B	
Barley-Pea			C
Oat-Barley	A		
Oat-Barley-Pea		B	C
Oat-Oat		B	
Oat-Pea		B	C
CV (%)	13.8		
LSD (0.05)	1.8		

* Wet = 65% moisture; dry = 15% moisture. Treatments not marked with the same letter are statistically different from other treatments.

The feed values for each treatment, as well as recommendations, are shown in Table 2.

Table 2: Feed values for silage by treatment compared to animal feed requirements*

Entry	% Crude Protein	% TDN
Barley	8.21	58.86
Oat-oat	7.78	61.46
Barley-barley	8.24	60.51
Oat-barley	7.14	63.19
Barley-pea	10.91	60.65
Oat-pea	9.12	59.26
Oat-barley-pea	8.84	60.43
Animal feed requirements		
Mature cows		
Mid gestation	7	50-53
Late gestation	9	58
Lactating	11-12	60-65
Replacement heifers	8-10	60-65
Breeding bulls	7-8	48-50
Yearling bulls	7-8	55-60

* Animal feed requirements developed by Elisabeth Nernberg (ARD).

Observations

The silage was prepared by running the harvested material from each plot through a plant shredder. The oat-barley treatment appears to be a promising option, both for higher yields relative to other treatments (Table 1) and higher TDN values (Table 2). However, this treatment will not provide enough protein to meet all animal feed requirements.

Materials and methods

Experimental Design: Random Complete Block Design
Entries: 7
Replications: 3
Seeding: May 25
Harvest: Aug 12

Barley-oat silage allows for good weed control, but there are no herbicides registered for barley-oat-pea silage intercrops. Good weed control prior to seeding is crucial. The trial was hand-weeded.

Table 3: Treatments, seeding rates and seeding costs

Treatments	Percent of Monocrop Seeding Rate	Seeding Rate (lb/ac)	Cost per acre
Barley (Maverick)	100	90	$14.91
Barley-barley (Maverick-Austenson)	75-75	68-68	$22.53
Barley-pea (Maverick-Lacombe)	25-100	22-150	$34.89
Oats-oats (Haymaker-Summit)	75-75	68-68	$28.40
Oats-barley (Haymaker-Maverick)	75-75	22-150	$26.16
Oat-pea (Haymaker-Lacombe)	25-100	22-150	$36.07
Oats-barley-pea (Haymaker-Maverick-Lacombe)	12.5-12.5-100	11-11-150	$35.48

Data collected	Date Collected
Pea Emergence:	Jun 2-4
Cereal Emergence:	Jul 5-7
% Emergence:	Jul 11-18
Plot Wet Weight:	Aug 12
Plot Dry Weight:	Sep

Agronomic info	
Previous year's crop:	Barley Silage
Soil Type:	Erickson Loam Clay
Landscape:	Rolling with trees to the east
Seedbed preparation:	Heavy harrowed

Table 3: Fertility Information

	Available	Added	Type
N	72 lb/ac	none	N/A
P	22 ppm	10 lb/ac	11-52-0-0
K	257 ppm		
Inoculant added			

Multi-Crop Intercrop trial (Pea-Oat-Canola-Wheat-Flax-Mustard)

(Adapted from a report written by Justice Zhanda, WADO)

Project duration: 2019-2021

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

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

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 turned to various intercropping systems to address 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 help address climate change in ways such as biological control of insect pests, weeds and diseases. Biological control allows for less use of synthetic chemicals hence addressing the chemical resistance issues. Another benefit of intercropping is improving soil health at low cost considering residual nitrogen if a legume is included. In other studies, pea-wheat intercropping systems have been shown to be efficient in the use of nitrogen due to their spatial self-regulating dynamics, which allows pea to improve its interspecific competitive ability in fields with lower soil nitrogen and vice versa for wheat (Andersen et al., 2004 and Ghaley et al., 2005). This enables future options to reduce synthetic nitrogen inputs and negative environmental impacts of crop production. Compared to pea sole crop, pea-oats intercrop results in reduced pea lodging because of the support provided by oats to the pea crop, this also helps reduce harvesting difficulties and increase economic returns (Kontturi et al., 2010). This study evaluated various intercrop combinations that can be utilized by producers in different areas of production.

Materials and Methods

The trials were established at Reston, Melita and Roblin in 2020. Soil tests were conducted to determine nutrient status before seeding at all sites (Table 1). A randomized complete block design with 11 treatments and 4 replicates was used at each site. Reston site was seeded on May 15th then reseeded on the 29th due to severe damage by flea beetles while Melita site was seeded on May 8th at a depth of 0.75". Fertilizer was applied together with the inoculant during seeding at 10-35-20-8-2 (N-P-K-S-Zn) lb ac^{-1} at Reston and 9-35-20-8-2 (N-P-K-S-Zn) lb ac^{-1} at Melita. Differences in N application rates was due to differences in soil test results at both sites. Reston and Melita received 0.5 L ac^{-1} Roundup + 0.015 L ac^{-1} Aim, 0.08 L ac^{-1} Authority + 0.65 L ac^{-1} Rival in flax, pea and mustard, and 0.65 L ac^{-1} Rival in canola plots soon after seeding to burnoff weeds. Additional herbicide application was done as post emergence control with 17.3 g ac^{-1} Odyssey in pea-canola and peas, 0.1 L ac^{-1} Arrow in pea-flax-mustard, 0.91 L ac^{-1} Basagran in wheat and flax-pea, and 0.1 L ac^{-1} Select in all treatments except cereals at Melita. At Reston, post emergence herbicides applied were 0.91 L ac^{-1} Basagran tank mixed with 0.1 L ac^{-1} Arrow in flax or flax-pea, 17.3g Odyssey + 0.1L ac^{-1} Arrow in pea or pea-canola, 0.5 L ac^{-1} Axial + 0.283 L ac^{-1} in wheat or wheat-pea and 8 g ac^{-1} Muster + 0.2 L ac^{-1} Assure II + 0.5% Prosurf in canola. Flea beetles were controlled initially at V1 stage using 0.063 L ac^{-1} Pounce followed up by a second application at Melita while Reston required three applications of the same product to effectively control the insect pests. Desiccant products applied at Reston before harvest were 0.65 L ac^{-1} Reglone + 0.5 L ac^{-1} + 0.5% v/v LI700 surfactant + 0.5 L ac^{-1} Roundup ensuring spray volume of 20 gal ac^{-1} while 0.5 L ac^{-1} Roundup + 0.042 L ac^{-1} Heat LQ was applied at Melita. Summary of site description and agronomy are presented in Table 2. Various data were collected and these included plant counts at emergence and flowering, weed counts at flowering, flowering date, grain yield, percentage of pea splits, percentage of pod shatter, test weight and protein content. Disease severity data collected was for mycospharella, powdery mildew, rust, sclerotinia and fusarium wilt. Data were analyzed using Minitab 18 and means were separated using Fisher's LSD at the 5% significance level.

Table 1: Soil test results and nutrients applied by site in 2020

Soil Test

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

Applied

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

Table 2: Site characterization and agronomic description in 2020

Location	Reston, MB	Melita, MB	Roblin, MB
Legal Land Location	SE 11-7-27 W1	SE 26-3-27 W1	NE 20-25-28 W1
Soil Series	Ryerson Loam	Newstead Loam	Erickson Clay Loam
Previous Crop	RR Canola	Spring wheat	Silage Barley
Field Preparation	Harrowed, No-till	Harrowed, No-till	Harrowed, No-till
Pre-Emergent Herbicides	Glyphosate all, Authority + Rival on Flax Pea Mustard; Rival in Canola plots after seeding	Glyphosate all, Authority + Rival on Flax Pea Mustard; Rival in Canola plots after seeding	Glyphosate
Soil Moisture at Seeding	Good	Excellent	Excellent
Seed Date	May/29	May/08	May/19
Seed Depth (inch)	0.75	0.75	0.75
Herbicides	Basagran, Arrow, Odyssey, Axial, Muster + Assure ll	Odyssey, Arrow, Basagran	None used
Insecticides	Pounce x 3 - flea beetles	Pounce x 2 -flea beetles	None
Desiccation	Reglone-August 25	Roundup- August 10	Reglone
Harvest Date	Aug/31	Aug/19	Sep/24
Combine Settings			
Rotor	800	800	800

cleaning fan	930	930	930
rotor-concave space	10 mm (3 mm flax)	10 mm (3 mm flax)	10 mm
Growing Season Report (May 1 - Aug 31, 2020)			
Precipitation (mm)	211	166	239
Normal (mm)	259	262	265
Growing Degree Days	1270	1303	1349
Normal GDDs	1248	1249	1302

Results and Discussion

Peas intercropped with canola yielded significantly (P<0.001) more grain resulting also in significantly higher partial pea LER (P<0.001) at 1.19 and higher TLER (P<0.0001) at 2.01 compared to other intercrop options at Reston. Similar trends were observed in 2019. Peas intercropped with flax resulted in significantly low grain yield of 101 kg ha^{-1} and low partial and TLER at the same site (Table 3). In 2020, Reston yields were markedly low owing to low seasonal rainfall compared to normal, presence of diseases as discussed in the Pea-Mustard-Canola study (Section 25.0) and reseeding on May 29 due to severe crop damage by flea beetles. Contrasting results were obtained from Melita, with the highest partial pea yield of 3072 kg ha^{-1} obtained from a flax intercrop but this was not significantly different from pea yield obtained from mustard (3027 kg ha^{-1}) or canola (2745 kg ha^{-1}) intercrops. Pea yield from oat intercrop was the lowest at 1501 kg ha^{-1}, more than 100% lower than pea-mustard intercrop option (Table 4). Partial pea land equivalence ratio followed the same pattern as yield with pea-flax, pea-canola and pea-mustard having 0.62, 0.55 and 0.61, respectively. Just like in 2019, TLER for pea-mustard (1.30) intercrop was not significantly different from other treatments except pea-flax and pea-wheat intercrops which had 1.07 (P=0.001) (Table 4). Results from Roblin in Table 5, show significant (P=0.001) differences in partial pea intercrop yield. There appeared to be significant pea yield benefits for intercrops involving canola or mustard compared to oats, which recorded pea yield reduction of 1567 kg ha^{-1} compared to pea yield in the canola option. This was a significant shift from 2019, where no significant differences where observed among different intercrop combinations. Partial pea LER was significantly higher (P=0.001) in pea-canola (0.79), pea-flax (0.54) and pea-mustard (0.58) compared to pea-flax intercrop which had 0.31. Overall, TLER for intercrops at Roblin was lower than Melita and Reston in 2020 (Tables 3-5). In 2020, there were no significant differences observed in final crop emergence or weed biomass at all locations (Tables 6-8).

There were no significant differences in split peas obtained from different intercrop options at all locations based on a 500g pea sample. Throughout all intercropping options, split peas were estimated at 1 to 2.5% for each sample selected in 2020. Protein content of peas was not significantly different at either Melita or Reston and ranged from 23.6 to 24.5% at both locations. However, there were significant (P=0.035) differences in pea protein content in pea sole crop (23.8%) compared to pea-oat intercrop (22.7%) at Roblin during the 2020 season (Table 9). All other intercrop options were not significantly different from pea sole crop.

Significant differences were observed in net revenue realized from different pea intercrop options at all locations. Notable at Reston was the negative net revenue of -$282 for pea sole crop while significantly (P<0.001) higher revenues were obtained from pea-mustard ($713) and pea-oat ($633). This suggests same benefits in revenue when a producer decides to include either mustard or oats in their intercropping system compared to pea alone, which generates a net loss. Inclusion of flax, wheat or canola generates significantly less net revenue compared to mustard or oat but would be a better option than pea alone due to positive revenues of $142, $334 and $391, respectively at Reston in 2020 (Table 10). At Melita, there was no significant benefit of including oat or mustard in a pea intercropping system compared to pea sole crop because of similar net revenues of $213, $199 and $231 for pea sole, pea-oat and pea-mustard, respectively. On the other hand, pea-wheat and pea-flax had significantly (P<0.001) low net revenue of $72 and $122, respectively. Therefore, based on Melita results for 2020 alone, inclusion of flax or wheat may not be a best option for the producer considering other alternatives like oat or mustard (Table 12). At Roblin, pea-oat intercrop had a net revenue of $214, which was the highest but was not significantly different from revenue obtained from pea-wheat, pea-canola and pea-mustard (Table 13). However, pea-flax and pea sole had significantly (P=0.001) low net revenue of -$80 and $39, respectively, compared to other intercrop options. This implies that, selection of pea-flax intercrop results in significant losses by the producer under Roblin conditions in 2020.

Table 3: Analysis of variance for yield, partial LER and TLER at Reston MultiCrop in 2020

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

Table 4: Analysis of variance for yield, partial LER and TLER for Melita MultiCrop in 2020

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

Table 5: Analysis of variance for yield, partial LER and TLER for Roblin MultiCrop in 2020

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

Table 6: Analysis of variance for final crop emergence counts and weed biomass at Reston in 2020

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

Table 7: Analysis of variance for final crop emergence counts and weed biomass at Melita in 2020

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

Table 8: Analysis of variance for final crop emergence counts and weed biomass at Roblin in 2020

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

Table 9: Analysis of variance for pea splits and protein content at Melita, Reston and Roblin in 2020

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

Table 10: Economic analysis for Reston MultiCrop in 2020

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

Table 11: Economic analysis for Melita MultiCrop in 2020

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

Table 12: Economic analysis for Roblin MultiCrop in 2020

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

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Faba-Flax, Faba-Buckwheat, Faba-Oat and Oat-Pea Intercropping dynamics

(Adapted from a report written by Justice Zhanda, WADO)

Project duration: May-September 2020
Objectives: (1) To determine the influence of row orientation on intercrops compared to monocrops; (2) To determine grain, forage and quality output obtained from intercrops involving oats
Collaborators: WADO, PCDF

Background

Intercroppings systems are growing in popularity in Canada because their use has contributed to enhanced livestock production due to improved grain yield and forage quality. The importance of including legumes in intercropping systems is fall grazing for integrated crop and livestock systems, which can also compliment grazing of crop residues (Andersen et al., 2020). This helps save stored forage resources for winter feeding, thus reducing feed costs. Fababean is one of the most important potential crops that can be used for this purpose. The crop has key environmental benefits in its ability to fix atmospheric nitrogen symbiotically under a wide range of environmental conditions making nitrogen available under diversified crop rotations (Kopke and Nemecek, 2010; Andersen et al., 2020). Fababean enhances sustainable agricultural systems through diversified intercrops which provide an environment for soil microbes to improve soil conditions such as aeration and organic matter content. In other studies, inclusion of fababean in intercropping systems has been shown to increase phosphorus mobilization making it more available to plants. When determining fababean intercropping options, it is crucial to select one that provides more benefits in terms of soil health improvement, dry matter yield and disease reduction. Previous studies have examined various fababean: non-legume seeding ratios such as 75%:25%, 50%:50% and 25%:75%. They found out that the most productive intercrop was that of fababean-oats at 25%:75% seeding ratio (Dhima et al., 2013). As a result of potentially higher dry matter and protein content for intercrops involving fababean, this can be an alternative to sole fababean in forage production. The purpose of this study was to evaluate the influence of row orientation on fababean and oat intercrops compared to sole crops and to determine grain, forage and quality output from these intercrops.

Figure 1: Intercrops at Roblin, (a) faba-oat; (b) faba-flax; (c) faba-buckwheat.

Materials and Methods

The trials were conducted at Melita on Newstead loam soils and Erickson clay loam soils at Roblin in 2020. Plots were established under no till practices with only harrowing necessary to evenly spread crop residues from the previous season. Treatments were arranged as randomized complete block design with four treatments replicated three times for each cropping system (Table 1).

Table 1: Treatment description (target seed rate in plants per meter square) for Flax-Oat, Flax-Buckwheat, Flax-Pea and Flax-Fababean at Melita in 2020

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

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

Characterization and agronomic information for Melita and Roblin is presented in Table 2.

Table 2: Site characterization and agronomy information for Melita and Roblin in 2020

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

Harvest Date	Faba-Oat, Pea-Oat Aug 17, Faba-Flax Aug 26 , Faba-Buck Sept 10	02-Oct
Forage Harvest Date	11-Jul	14-Aug
Growing Season	(May 11 - Sept 10)	27-May to 2-Oct
GGDs actual Base5*C	1526	1287
GGDs normal	1485	1271
Precipitation actual	167	236
Precipitation normal	299	263

GDD = growing degree days; B = broadcast; SB = side-banded; NA = not applied; growing season length = seeding date to harvest date

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

Results and Discussion

Grain Yield

There were significant differences in both fababean and oat grain yield in the faba-oat intercrop at Melita and Roblin. At Melita, fababean yield was 38% and 61% higher in sole crop compared to mixed and alternate cropping systems, respectively (P<0.001). Oat yield in the sole crop was not significantly different from alternate cropping system. Mixed and alternate cropping systems did not significantly differ in oat grain yield obtained. However, yield from sole crop oat was significantly higher than mixed cropping system (P=0.01). At Roblin, fababean grain yield was significantly higher (P<0.001) in sole crop compared to mixed and alternate cropping systems and the difference amounted to 67% and 70%, respectively. As expected also, sole crop oat had significantly higher (P=0.001) grain yield compared to mixed and alternate cropping systems that had 40% and 50% lower oat grain yield, respectively. A combined site analysis found significant differences in fababean grain yield between sole crop (P=0.047) and alternate cropping system but not with mixed cropping system. There were no significant differences in oat grain yield when the two sites were combined (Table 3).

Pea grain yield from cropping systems in pea-oat intercrop was significantly different at Melita and Roblin. At Melita, pea yield in the sole crop was 2440 kg ha^{-1} and 3812 kg ha^{-1} more (P<0.001) than mixed and alternate cropping systems, respectively. Mixed cropping system yielded significantly higher than the alternate cropping system also. As expected again, oat yield was significantly (P<0.001) higher in the sole crop (6212 kg ha^{-1}) compared to mixed (2528 kg ha^{-1}) and alternate (4301 kg ha^{-1}) cropping systems (Table 4). At Roblin, pea yield (479 kg ha^{-1}) in the sole crop was significantly (P=0.036) different from that of the alternate (409 kg ha^{-1}) cropping system but did not differ significantly with mixed (279 kg ha^{-1}) cropping system. Oat yield in sole crop was 42% and 37% significantly (P=0.005) higher than in mixed and alternate cropping systems, respectively. Generally, grain yields were very low at Roblin compared to Melita probably as a result of differences in agroecological regions. Fababean grain yield from cropping systems in faba-buckwheat intercrop was significantly (P=0.009) different at Melita. Fababean grain yield obtained from alternate cropping system was the lowest (2237 kg ha^{-1}) while mixed and sole crop yielded 36% and 42% more, respectively. Buckwheat yield in sole crop was significantly (P<0.001) higher than mixed and alternate cropping systems that had 7- and 4-times lower grain yield, respectively. At Roblin, fababean grain yield in sole crop was significantly (P=0.001) more than in mixed and alternate cropping systems by 44% and 59%, respectively. Buckwheat yield was significantly (P=0.005) more by about 50% compared with mixed and alternate cropping systems. There were no significant differences in grain yield between mixed and alternate cropping systems at both sites. A combined analysis of the sites did not find significant differences in grain yield, at least in the current season but there is a possibility that with additional site years of data, differences in yield can be observed (Table 5).

There were significant differences in grain yield from faba-flax intercrop at Melita and Roblin (Table 6). At Melita, fababean grain yield was significantly (P=0.002) lower than sole and mixed cropping systems by more than 1300 kg ha^{-1}. Flax grain yield was statistically the same between mixed and alternate cropping systems but was significantly (P<0.001) higher by 10 and 4 times, respectively, in flax sole crop. At Roblin, fababean grain yield was significantly (P=0.039) lower in the alternate cropping system compared to the sole crop by about 1500 kg ha^{-1} while there were no significant differences between sole crop and mixed cropping system. Flax yield was significantly (P<0.001) higher in sole crop than mixed and alternate cropping systems. There were no significant differences in grain yield between mixed and alternate cropping systems. Flax grain yield averaged over Roblin and Melita was significantly (P=0.014) higher in sole crop (2710 kg ha^{-1}) compared to mixed (744 kg ha^{-1}) and alternate (827kg ha^{-1}) cropping systems (Table 6).

Dry forage yield

Faba-Oat intercrop did not significantly influence dry forage yield at Melita but the yield ranged from 6699 kg ha^{-1} to 10149 kg ha^{-1} in 2020. However, at Roblin, dry forage yield was significantly (P=0.002) different between sole crop oat and sole fababean only. Yield from sole crop oat (12680 kg ha^{-1}) was not significantly different from mixed (10793 kg ha^{-1}) and alternate (8720 kg ha^{-1}) cropping systems. There were no significant differences in dry forage yield when the 2 sites were combined (Table 3).

Similar to faba-oat intercrop, there were no significant differences in dry forage yield observed in all cropping systems under pea-oat intercrop at Melita. Dry forage yields ranged from 9014 kg ha^{-1} to 10510 kg ha^{-1}. At Roblin, there were also no significant differences in dry forage yield and the ranges were 9260 kg ha^{-1} to 10553 kg ha^{-1} (Table 4).

Land equivalence ratio

At Melita, faba-oat intercrop LER for fababean and oat were significantly (P<0.001 and P=0.003) lower in mixed and alternate cropping systems compared to sole crops that had LER of 1. However, total LER was significantly (P=0.005) higher in mixed (LER=1.09) and alternate (LER=1.11) intercrops signaling a significant benefit of intercropping versus sole cropping (Table 3). At Roblin, LER was significantly lower (P<0.001) when faba and oat were analyzed separately. Total LER for both crops was also below 1, meaning there was no advantage of intercropping over sole cropping at Reston in 2020. When both sites were considered, sole crop prevailed compared to intercrop as the LER for the later were less than 1 for intercrops.

Pea and oat LER were significantly (P<0.001) low when crops were analyzed separately at Melita. Pea performed better in mixed compared to alternate intercropping system while the performance was vice versa for oat. Total LER suggested that there was a significant (P=0.004) benefit of pea-oat intercrop when an alternate cropping system (LER=1.13) is adopted compared to mixed (LER=1.05) or sole cropping system (LER=1) (Table 4). At Roblin, while partial LERs were significantly lower than 1 for oat or pea, total LER suggested a significant (P=0.039) benefit of intercropping pea with oats using either mixed (LER=1.40) or alternate (LER=1.19) cropping systems. A combined site analysis showed significant differences in partial LERs but there was no benefit in adopting any of the intercropping systems over sole crops and both mixed and alternate cropping systems did not have an advantage over the other.

Land equivalent ratio for sole (LER=1) fababean and mixed (LER=0.9) cropping systems was significantly (P=0.01) higher than alternate cropping system (LER=0.59) at Melita. Mixed cropping option had an advantage over alternate cropping system. Buckwheat LER was significantly (P<0.001) lower for mixed (LER=0.14) and alternate (LER=0.25) cropping systems compared to the sole crop (LER=1) (Table 5). The TLER was not significantly different, hence, similar benefits could be obtained from adopting either cropping systems. At Roblin, LER for fababean sole crop was significantly (P=0.001) higher than mixed and alternate cropping systems that had values less than 1. Buckwheat LER for the sole crop was also significantly (P=0.03) higher than the other two cropping systems (Table 5). Similar to results from Melita, there were no benefits of adopting either intercropping systems over sole crops at Roblin in 2020. However, a combined analysis of the two sites showed mixed (TLER=1.06) cropping system to be a significantly (P=0.005) better option than alternate (TLER=0.87) cropping system.

Land equivalent ratio for sole (LER=1) fababean and mixed (LER=1.04) cropping systems was significantly (P=0.002) higher than alternate (LER=0.73) cropping system for faba-flax intercrop at Melita (Table 6). Flax LER was significantly (P<0.001) lower for mixed and alternate cropping systems compared to sole crop. The TLER for mixed (TLER=1.13) cropping system was significantly (P=0.024) higher than alternate (TLER=0.98) cropping system. In this case, mixed cropping system would be a better option than alternating rows of flax and fababean. At Roblin, alternate cropping system had significantly (P=0.025) lower LER (0.73) compared to fababean sole crop. Flax LER in mixed and alternate cropping systems was also significantly (P<0.001) lower than flax sole crop. Neither cropping systems proved to be better options over sole crops at Roblin in 2020.

Protein content and seed weight

Oat protein ranged from 9.93% to 11.2% for faba-oat intercrop at Melita but there were no significant differences between cropping systems. However, at Roblin, alternate (11.08%) cropping system had significantly (P=0.034) higher protein content than sole (10.03%) crop oat. There were no significant differences between mixed and alternate cropping systems, and between mixed and sole crop (Table 7). Oat seed weight based on a 500 seed count was significantly (P=0.042) different at Melita. Oat seed in sole crop weighed 38.23 g per 500 seed count, while seed in mixed and alternate cropping systems weighed 33.84 g and 35.62 g per 500 seed count, respectively. Fababean seed weight was also measured for 500 seed count and there were significant (P=0.031) differences in seed weight at

Melita. Alternate cropping system produced fababean seed with 216.3 g per 500 seed count while mixed and sole crop had 6.79 g and 26.87 g lower seed weight, respectively. There were no significant differences in seed weight for faba-oat intercrop systems at Roblin in 2020.

Oat protein for pea-oat intercrop was significantly (P=0.006) higher in mixed (10.93%) and alternate (10.47%) cropping systems compared to sole crop (9.87%) at Melita. Similar trends were observed at Roblin with significantly (P<0.001) higher oat protein in mixed (10.98%) and alternate (10.81%) cropping systems compared to sole crop (9.93%) (Table 7). Pea seed weight at Melita was significantly (P=0.032) higher in alternate (129.25 g) cropping system while mixed cropping system seed weighed 121.64 g per 500 seed count. There were no significant differences in pea seed weight at Roblin. At all sites, there were also no significant differences in oat seed weight in 2020.

Table 3: Mixed Model Analysis of variance for Faba-Oat dry forage yield, grain yield and LER at Melita and Roblin in 2020

Location	Crop System	Dry Forage kg/ha	Grain Yield (kg/ha)		Land Equivalent Ratio		
			Faba	Oat	Faba	Oat	Total
Melita	MonoOat	10030	*	5597a	*	1a	1b
	MonoFaba	6699	4944a	*	1a	*	1b
	Mixed	8433	3070b	2571b	0.62b	0.47c	1.09a
	Alternate	10149	1941c	3972ab	0.39c	0.72b	1.11a
	P value	0.07	<0.001	0.01	<0.001	0.003	0.005
	CV	16	8	15	8	10	3
Roblin	MonoOat	12680a	*	4879a	*	1a	1a
	MonoFaba	6527b	2892a	*	1a	*	1a
	Mixed	10793ab	962b	2926b	0.33b	0.60b	0.93ab
	Alternate	8720ab	869b	2457b	0.30b	0.51b	0.81b
	P value	0.012	<0.001	0.001	<0.001	<0.001	0.007
	CV	16	12	8	6	6	5
REML (both sites)	MonoOat	11355	*	5238	*	1a	1
	MonoFaba	6613	3918a	*	1	*	1
	Mixed	9613	2016ab	2748	0.48	0.54b	1.01
	Alternate	9435	1405b	3215	0.35	0.61ab	0.96
	P value	0.1	0.047	0.112	†NH	0.043	†NH
	CV	9	7	8		6	

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

Table 4: Mixed Model Analysis of variance for Pea-Oat dry forage yield, grain yield and LER at Melita and Roblin in 2020

Location	Crop System	Dry Forage kg/ha	Grain Yield (kg/ha)		Land Equivalent Ratio		
			Pea	Oat	Pea	Oat	Total
Melita	MonoOat	10510	*	6212a	*	1a	1b
	MonoPea	10030	6735a	*	1a	*	1b
	Mixed	9744	4295b	2528c	0.64b	0.41c	1.05b

	Alternate	9014	2923c	4301b	0.44c	0.69b	1.13a
	P value	0.256	0.001	<0.001	<0.001	<0.001	0.004
	CV	8	8	4	6	4	3
Roblin	MonoOat	10300	*	3771a	*	1a	1a
	MonoPea	10553	497a	*	1a	*	1a
	Mixed	10373	409ab	2181b	0.82ab	0.58b	1.40a
	Alternate	9260	279b	2373b	0.56b	0.63b	1.19a
	P value	0.621	0.036	0.005	0.029	0.003	0.039
	CV	16	17	10	15	9	13
REML	MonoOat	10405	*	4991	*	1a	1
(both sites)	MonoPea	10291	3616	*	1a	*	1
	Mixed	10058	2352	2355	0.73ab	0.49b	1.23
	Alternate	9137	1601	3337	0.50b	0.66b	1.16
	P value	0.181	†NH	†NH	0.034	0.016	†NH
	CV	6			7	5	

Table 5: Mixed Model Analysis of variance for Faba-Buckwheat grain yield and LER at Melita and Roblin in 2020

Location	Crop System	Grain Yield (kg/ha)		Land Equivalent Ratio		
		Faba	Buckwheat	Faba	Buckwheat	Total
Melita	MonoBuckwheat	*	1497a	*	1a	1
	MonoFaba	3878a	*	1a	*	1
	Mixed	3475a	212b	0.90a	0.14c	1.04
	Alternate	2237b	366b	0.59b	0.25b	0.82
	P value	0.009	<0.001	0.01	<0.001	0.118
	CV	11	13	11	6	10
Roblin	MonoBuckwheat	*	949a	*	1a	1
	MonoFaba	3461a	*	1a	*	1
	Mixed	1951b	494b	0.56b	0.53b	1.09
	Alternate	1427b	474b	0.41b	0.50b	0.92
	P value	0.001	0.005	0.001	0.003	0.087
	CV	11	14	10	12	6
	GM	2279.4854	639	1	1	1
	MSE	64205	8181	0	0	0
REML	MonoBuckwheat	*	1223	*	1	1ab
(both sites)	MonoFaba	3669	*	1	*	1ab
	Mixed	2713	353	0.73	0.33	1.06a
	Alternate	1832	420	0.50	0.38	0.87b
	P value	0.085	†NH	0.101	†NH	0.005
	CV	7		7		5

Table 6: Mixed Model Analysis of variance for Faba-Flax grain yield and LER at Melita and Roblin in 2020

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

Table 7: Analysis of variance for Faba-Oat and Pea-Oat protein content and seed weight at Melita and Roblin in 2020

Location	Faba-Oat				Pea-Oat			
	Cropping System	Oat Protein %	Seed weight (g/500seeds)		Cropping System	Oat Protein %	Seed weight (g/500seeds)	
			Oats	Faba			Pea	Oats
Melita	MonoOat	9.93	38.23a	*	MonoOat	9.87b	*	42.19
	MonoFaba	*	*	189.43b	MonoPea	*	125.05ab	*
	Mixed	11.2	33.84b	209.51ab	Mixed	10.93a	121.64b	39.453
	Alternate	10.73	35.62ab	216.3a	Alternate	10.47a	129.25a	42.247
	P value	0.081	0.042	0.031	P value	0.006	0.032	0.261
	MSE	0.24444	1.883	62.65	MSE	0.03611	4.728	3.991
Roblin	MonoOat	10.03b	26.33	*	MonoOat	9.93b	*	26.333
	MonoFaba	*	*	205	MonoPea	*	124.67	*
	Mixed	10.71ab	25.33	218.33	Mixed	10.98a	129.33	29
	Alternate	11.08a	24.67	227.67	Alternate	10.81a	125.67	28.33
	P value	0.034	0.365	0.223	P value	<0.001	0.703	0.806

Conclusions

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

References

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Kopke, U., and Nemecek, T. 2010. Ecological services of fababean. *Field Crop Research* 115 (3): 217-233 https://doi.org/10.1016/j.fcr.2009.10.012

Andersen, B. J., Samarappuli, D. P., Wick, A., Berti, M. T. 2020. Fababean and Pea Can Provide Late Fall Forage Grazing without Affecting Maize Yield the Following Season. *Agronomy* 2020, *10*(1), 80; https://doi.org/10.3390/agronomy10010080

Organic Trials

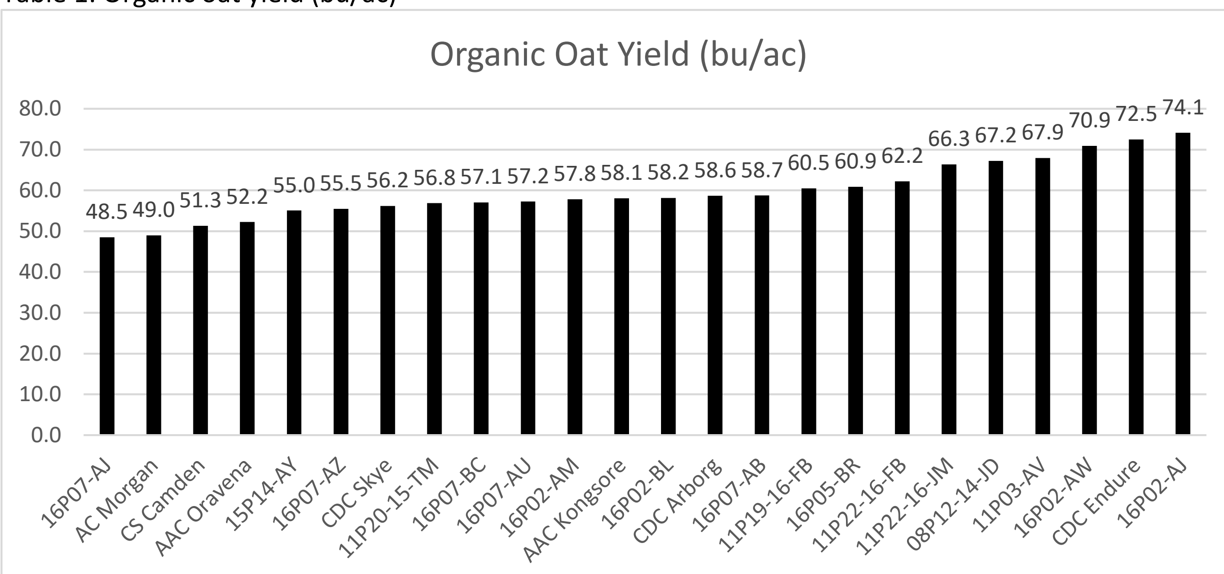
Organic Oats Variety Evaluation

Project duration: May 2020 – October 2020
Objective: To evaluate oat varieties for organic production.
Collaborators: Jennifer Mitchell-Fetch, AAFC Brandon

Background
Research suggests that selection of cereal crops specific to organic agriculture should be conducted on organically managed land [1,2]. Conventional management systems may mask or confound certain plant characteristics, resulting in selection of sub-optimal cultivars for organic production systems. The trial was grown on certified organic land belonging to a local organic producer.

Results
The majority of the entries in this test are unregistered varieties. The yield results are shown in Table 1 for reference and to allow interested producers to track the entries in the future.

Table 1: Organic oat yield (bu/ac)



Materials and methods

Experimental Design: Random Complete Block Design
Entries: 25 varieties
Seeding: May 14
Harvest: Sep 2

Table 2: Varieties included at Roblin 2020

AC Morgan	Summit	AAC Oravena	AAC Kongsore	CS Camden
CDC Arborg	CDC Skye	CDC Endure	11P03-AV	11P20-15-TM
11P22-16-FB	11P19-16-FB	11P22-16-JM	08P12-14-JD	16P02-AW
16P07-AU	16P07-AJ	16P02-AJ	16P07-BC	16P05-BR
16P02-AM	16P02-BL	16P07-AB	16P07-AZ	15P14-AY

Data collected	Date collected
Maturity:	Aug 15-17
Height:	Aug 14
Lodging:	Sep 2
Yield:	Sep 2
Moisture:	Sep 2

Agronomic info	
Previous year's crop:	Organic wheat
Soil Type:	Erickson Clay Loam
Landscape:	Rolling with trees to the south
Seedbed preparation:	Cultivated and harrowed

Table 3: Spring 2020 Soil Test

	Available
N	73 lb/ac
P	5 ppm
K	168 ppm

References

[1] Reid, T., Yang, R.-C., Salmon, D. and Spaner, D. (2009). Should spring wheat breeding for organically managed systems be conducted on organically managed land? Euphytica 169:239-252.

[2] Dalhousie University, Organic Agriculture Centre of Canada. The crafting of organic oats. https://www.dal.ca/faculty/agriculture/oacc/en-home/about/about-oacc/documents/newpaper-articles/newsarticles-2012/newsarticles-2012-fetch.html

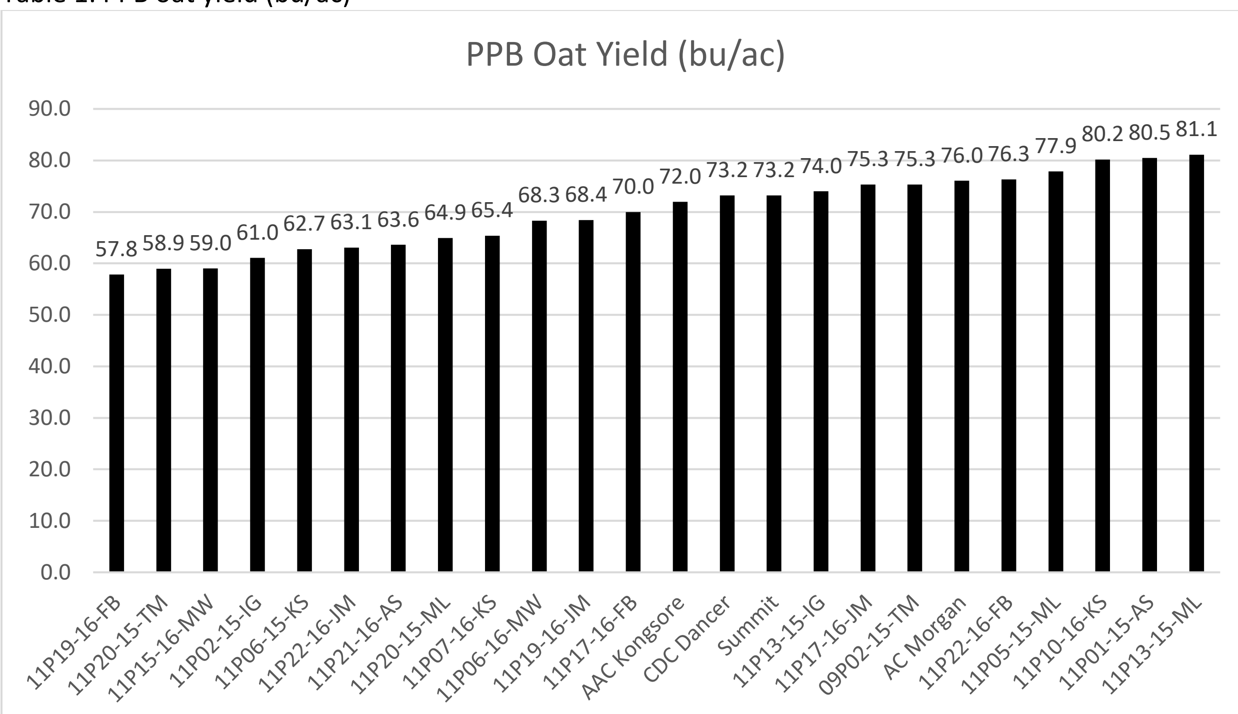
Organic Oats Participatory Plant Breeding

Project duration: May 2020 – October 2020
Objective: To evaluate oat varieties for organic production.
Collaborators: Jennifer Mitchell-Fetch, AAFC Brandon

Background
Research suggests that selection of cereal crops specific to organic agriculture should be conducted on organically managed land [1,2]. Conventional management systems may mask or confound certain plant characteristics, resulting in selection of sub-optimal cultivars for organic production systems. The trial was grown on certified organic land belonging to a local organic producer.

Results
The majority of the entries in this test are unregistered varieties. The yield results are shown in Table 1 for reference and to allow interested producers to track the entries in the future.

Table 1: PPB oat yield (bu/ac)



Materials and methods
Experimental Design: Random Complete Block Design
Entries: 25 varieties
Seeding: May 14
Harvest: Sep 2

Table 2: Varieties included at Roblin 2020

11P01-15-AS	11P13-15-IG	11P15-16-MW	11P19-16-FB	AC Morgan
11P21-16-AS	11P02-15-IG	11P06-15-KS	11P17-16-FB	CDC Dancer
11P05-15-ML	11P20-15-TM	11P10-16-KS	11P22-16-JM	Summit
11P13-15-ML	09P02-15-TM	11P07-16-KS	11P19-16-JM	AAC Kongsore
11P20-15-ML	11P06-16-MW	11P22-16-FB	11P17-16-JM	

Data collected	Date collected
Weekly Maturity:	Aug 5-29
Height:	Aug 14
Lodging:	Sep 2
Yield:	Sep 2
Moisture:	Sep 2

Agronomic info

Previous year's crop:	Organic wheat
Soil Type:	Erickson Clay Loam
Landscape:	Rolling with trees to the south
Seedbed preparation:	Cultivated and harrowed

Table 3: Spring 2020 Soil Test

	Available
N	73 lb/ac
P	5 ppm
K	168 ppm

(Organic trial: no fertilizer or herbicide applied)

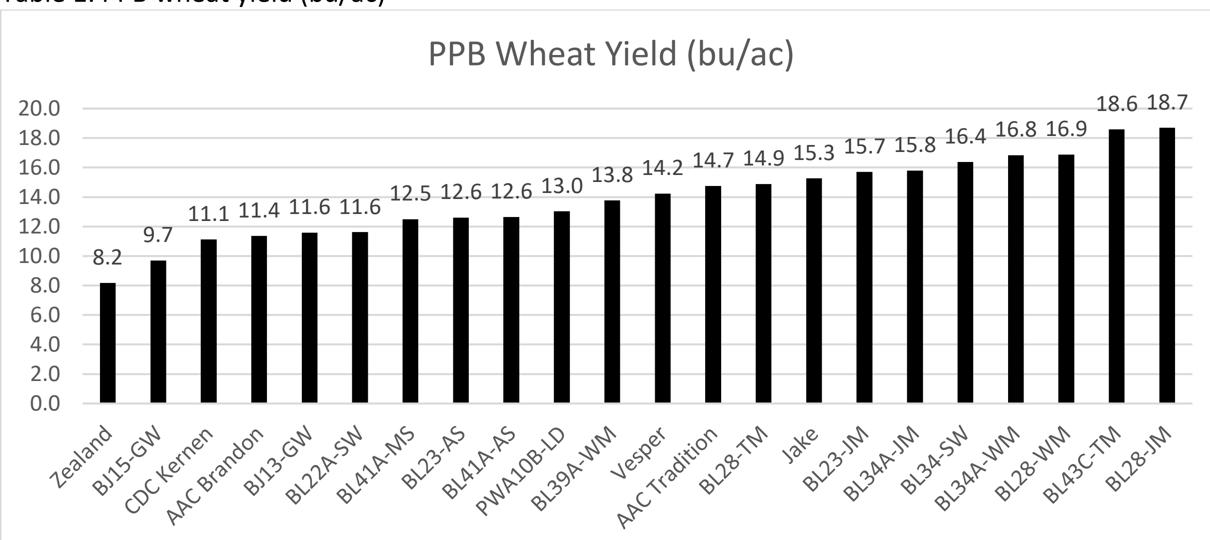
Organic Wheat Participatory Plant Breeding

Project duration: May 2020 – October 2020
Objective: To evaluate oat varieties for organic production.
Collaborators: Martin Entz, Michelle Carkner, University of Manitoba

Background
Research suggests that selection of cereal crops specific to organic agriculture should be conducted on organically managed land [1,2]. Conventional management systems may mask or confound certain plant characteristics, resulting in selection of sub-optimal cultivars for organic production systems.

Results
The majority of the entries in this test are unregistered varieties. The yield results are shown in Table 1 for reference and to allow interested producers to track the entries in the future.

Table 1: PPB wheat yield (bu/ac)



The low wheat yields are due to low precipitation and fertility levels, as well as high weed competition. Yields were likely also reduced by disease pressure from preceding wheat crops.

Materials and methods
Experimental Design: Random Complete Block Design
Entries: 22 varieties
Seeding: May 14
Harvest: Sep 2

Table 2: Varieties included at Roblin 2020

BJ13-GW	BL28-JM	BL34-SW	PWA10B-LD	Jake
BJ15-GW	BL28-TM	BL39A-WM	AAC Brandon	CDC Kernen
BL22A-SW	BL28-WM	BL41A-AS	Vesper	
BL23-AS	BL34A-JM	BL41A-MS	AAC Tradition	
BL23-JM	BL34A-WM	BL43C-TM	Zealand	

Data collected	Date collected
Weekly Maturity:	Aug 5-29
Height:	Aug 14
Lodging:	Sep 2
Yield:	Sep 2
Moisture:	Sep 2

Additional plant sample collection, including leaf, root and soil core from the same plant, from a total of 50 plants, was completed at wheat heading and sent to a Toronto PhD Student for analysis. These samples measured both leaf functional traits (leaf area, specific leaf area, and leaf nitrogen), and root traits (root diameter, root mass, and root nitrogen) for three of the wheat varieties.

Agronomic info	
Previous year's crop:	Organic wheat
Soil Type:	Erickson Clay Loam
Landscape:	Rolling with trees to the south
Seedbed preparation:	Cultivated and harrowed

Table 3: Spring 2020 Soil Test

	Available
N	73 lb/ac
P	5 ppm
K	168 ppm

(Organic trial: no fertilizer or herbicide applied)

Pulse Trials

Soybean – (Year 3 of a 6-Year Crop Rotation)

Project duration: Spring 2018 – Fall 2023
Objectives: To assess the economic and agronomic impact of a 6-year rotation, using integrated management practices.
Collaborators: Parkland Crop Diversification Foundation

Background
The use of green manures for fertility has the potential to reduce fertilizer inputs during the following cropping year. In 2018, a green manure was planted and terminated in late July, with some regrowth. The green manure yielded 6100 lb/ac (dry), resulting in an estimated 152 lb/ac of available N. However, some of this N was only slowly available as the plant material decomposed. Further, a relatively low legume-to-cereal ratio (35-65) may have tied up some available N during the decomposition phase. A spring 2019 soil test showed 115 lb/ac available. AC Goodeve wheat was planted on the site on May 14, with N fertilizer added according to the treatments and costs shown in Table 1. Figure 1 shows the full six-year rotation for the trial. Soybean was seeded in 2020.

Table 1: 2019 added N (lb/ac) and costs by treatment

Treatment	Added N (lb/ac)	Total N (lb/ac)	Cost N/ac ($0.50/lb)
No added Nitrogen	0.0	115.0	$0.00
10% added Nitrogen	9.7	124.7	$4.84
20% added Nitrogen	19.4	134.4	$9.68
40% added Nitrogen	38.7	153.7	$19.35
60% added Nitrogen	58.1	173.1	$29.03
80% added Nitrogen	77.4	192.4	$38.71
100% added Nitrogen	96.8	211.8	$48.38

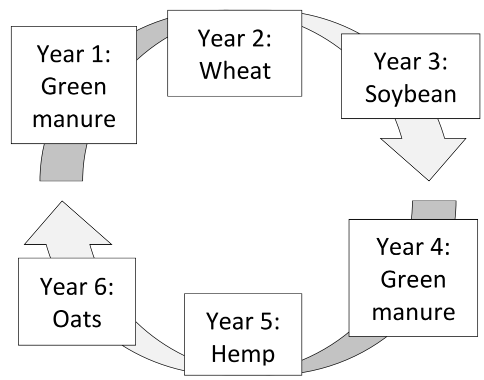
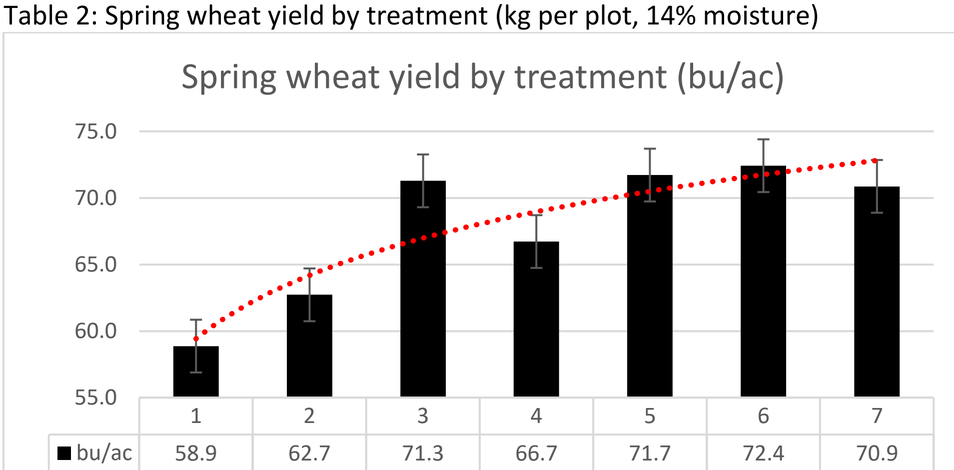


Figure 1: Six-Year Rotation Schematic

Results
<u>2019</u>
Average yields for spring wheat by treatment are show in Table 2. The red line shows the trend for yield.

Table 2: Spring wheat yield by treatment (kg per plot, 14% moisture)



2020

The site was seeded to soybean in 2020. Start-up P and inoculant was applied with the seed, but no N was applied. Average yield for soybean by treatment is shown in Table 3. Average test weight for soybean by treatment is shown in Table 4.

Table 3: Soybean yield by treatment (kg per plot, 13% moisture)

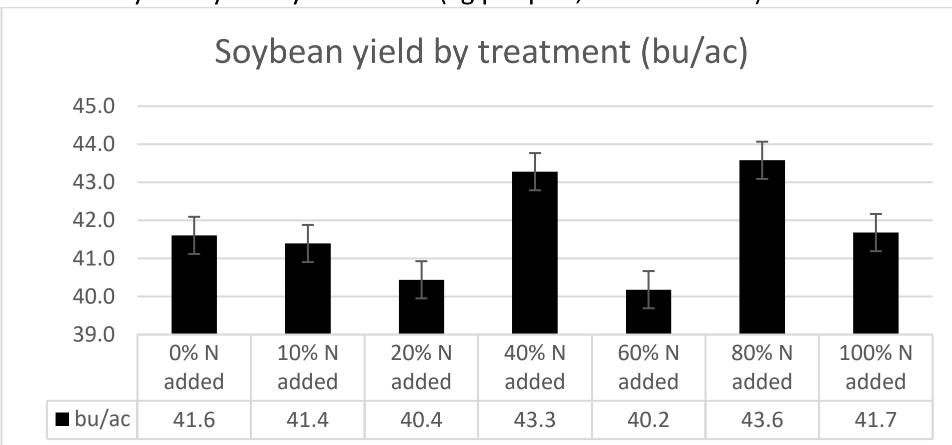
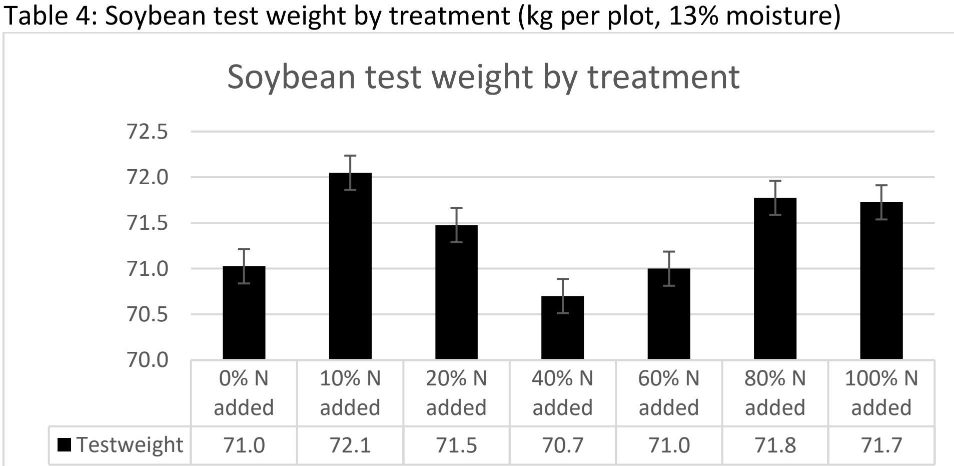


Table 4: Soybean test weight by treatment (kg per plot, 13% moisture)



Observations

The average spring wheat yield for each treatment (Table 2) indicates a responsiveness to added nitrogen over the amount provided by the green manure in 2018. Table 2 appears to indicate a decrease in yield for treatment 4; however, the reduced yield for that treatment can be attributed to poorer plant establishment in some plots.

Table 5 shows a summary of statistical information for spring wheat and soybean. Average yield and test weight do not differ significantly between treatments for either spring wheat or soybean.

In 2021, a green manure will be planted on the site.

Table 5: Summary of statistical information yield and test weight for spring wheat and soybean

Treatment	Yield (bu/ac)		Statistical significance (yield)*		Test weight		Statistical significance (test weight)*	
	Wheat	Soybean	Wheat	Soybean	Wheat	Soybean	Wheat	Soybean
No added Nitrogen	59.9	41.6	A	A	56.1	71.0	A	A
10% added Nitrogen	62.7	41.4	A	A	56.2	72.0	A	A
20% added Nitrogen	71.3	40.4	A	A	56.5	71.5	A	A
40% added Nitrogen	66.7	43.3	A	A	55.7	70.7	A	A
60% added Nitrogen	71.7	40.2	A	A	56.1	71.0	A	A
80% added Nitrogen	72.4	43.6	A	A	56.2	71.8	A	A
100% added Nitrogen	70.9	41.7	A	A	55.6	71.7	A	A
CV (%)	10.3	5.4			3.4	1.2		

* Treatments not marked with the same letter are statistically different from other treatments.

Materials & Methods

Experimental Design: Random Complete Block Design
Entries: 7 treatments
Seeding: May 14
Harvest: Sept 11

Agronomic info (2020)

Previous year's crop: Spring wheat
Soil Type: Erickson Loam Clay
Landscape: Rolling with trees to the east
Seedbed preparation: Zero-till

Yellow Pea Response to Preceding Crop, Residue Management, and P Fertilizer Placement (Establishment Year)

Project duration: 2020 – 2023
Objectives: Determine the effect of preceding crop, residue management and P fertility strategy, and their interactions, on pea establishment, weed community, disease incidence, yield and seed quality
Collaborators: Kristen MacMillan – Soybean and Pulse Agronomy and Cropping Systems Research Lab, University of Manitoba

Background (provided by Kristen MacMillan)
In Manitoba, 38% of pea acres are grown on wheat stubble and 20% on canola stubble [Manitoba Agricultural Services Corporation (MASC) 2010-2015]. The yield impact of preceding crop on pea yield is not currently known despite some obvious agronomic concerns. Crop rotation data from MASC (2010-2015) points to some of these risks by showing that the relative yield of pea grown on wheat stubble is 103% compared to 96% for peas grown on canola stubble. Canola is a non-mycorrhizal crop and a host to Sclerotinia white mould. Peas are also susceptible to white mould and are a mycorrhizal crop, therefore, may be negatively affected by reduced AMF populations and increased sclerotinia risk following canola stubble. Starter P is commonly recommended in fields with low soil test levels. We aim to investigate if there is an interaction between field pea response to P fertilizer and preceding stubble type arising from the mycorrhizal and non-mycorrhizal crops. Little research has been conducted on P fertilizer strategy in field pea and strategies vary widely among farmers. In an informal Twitter poll in August 2019, the majority of farmers apply P fertilizer as starter in the seed row (44%) followed by side band or mid placement (26%), seed row plus side band or mid row (14%) and none (16%). According to the 2015 fertilizer use survey, only 45% of western Canadian farmers are applying P, primarily in the seed row (44%) and at an average rate of 19 lbs P205/ac. Yield response to 25 kg ha-1 of starter P has been documented, but no work is currently available on P fertilizer placement. Overall, there are fewer agronomic risks associated with seeding peas into wheat stubble. Peas are also tolerant to early seeding into cool soil and present an opportunity for reduced or rotational no-till systems in regions of Manitoba where tillage is common practice.

Results
In 2020, spring wheat and canola crops were established to provide the residue treatments for the 2021 pea test. Target spring wheat and canola seeding rates are shown in Table 1. Treatments for 2021 are provided in Table 2.

Table 1: Targets

	Seeding Rate seeds/ft2	Live Plant Stand plants/ft2	Seed Survival %
Wheat	32	27	85
Canola	10	6	60

Table 2: Treatment Structure

Treatment No	Preceding crop	Residue Management	P Fertility Strategy
1	Wheat	Tilled	None
2	Wheat	Tilled	Seed row
3	Wheat	Tilled	Side band
4	Wheat	Direct Seed	None
5	Wheat	Direct Seed	Seed row
6	Wheat	Direct Seed	Side band
7	Canola	Tilled	None
8	Canola	Tilled	Seed row
9	Canola	Tilled	Side band
10	Canola	Direct Seed	None
11	Canola	Direct Seed	Seed row
12	Canola	Direct Seed	Side band

Materials and methods

Experimental Design: Rectangular Lattice
Treatments: 12
Varieties: Wheat – AAC Brandon; Canola – L233P
Seeding: May 19
Harvest: Sep 22

Agronomic information
Previous year's crop: Barley Silage
Soil Type: Erickson Loam Clay
Landscape: Rolling with trees to the east
Seedbed preparation: Heavy harrowed

Data collected	Date collected
Plant Density:	Jun 16 (4 weeks after seeding)
Disease risk at wheat flag leaf:	Jun 24
Disease risk at canola anthesis:	Jul 8-15 (20-50% bloom)
Height:	Aug 15
Lodging:	Aug 15
Yield:	Oct 27
Moisture:	Oct 27

Table 3: 2020 Fertility Information

	Available	Wheat Added	Canola Added	Type
N	58 lb/ac	131 lb/ac	96 lb/ac	46-0-0
P	71 ppm	15 lb/ac	10 lb/ac	11-56-0-0
K	513 ppm	-	-	-

Table 4: Pesticide Application

Crop stage	Date	Product	Rate
Pre-emerge	May 19	Heat	28.0 g/ac
		Round-up	0.64 L/ac
In-crop	Jul 9	Proline (canola)	140 ml/ac
		Prosaro (wheat)	325 ml/ac
	Jun 22	Prestige XC-A	0.17 L/ac
Desiccation	Aug 25	RoundUp	0.64 L/ac
		Heat	20.0 g/ac
		Merge	0.3 L/ac

Agriculture and Agri-Food Canada Conventional Soy Protein Variety Evaluation

Project duration: May 2020 – October 2020

Objectives: Examine 20 varieties of conventional soybean to determine protein differences between eastern and western Canada sites

Collaborators: Elroy Cober – Research Scientist, soybean breeding and genetics, AAFC
Simon Lackey – Soybean breeding AAFC

Background

This project is part of a long-term 5-year multi-site study across Canada, led by Elroy Cober.

Results

The soybean entries from Roblin were submitted to Elroy Cober's team for protein analysis. The protein results are shown in Figure 1. Average soybean yield by variety is shown in Table 1.

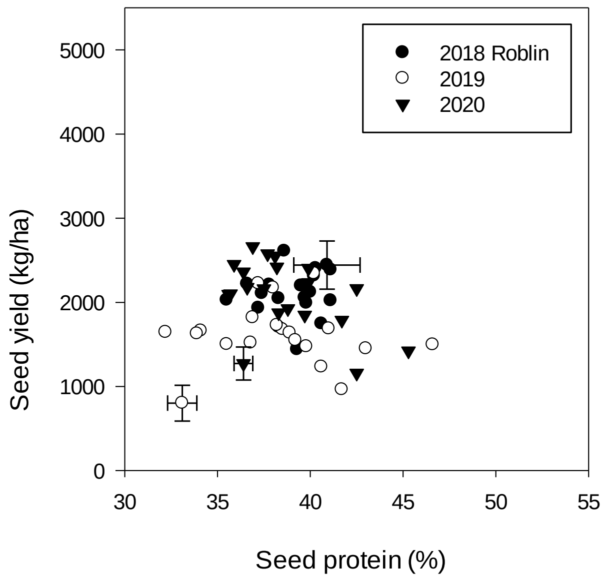


Figure 1: Roblin soybean protein results (2018-2020) (provided by E. Cober)

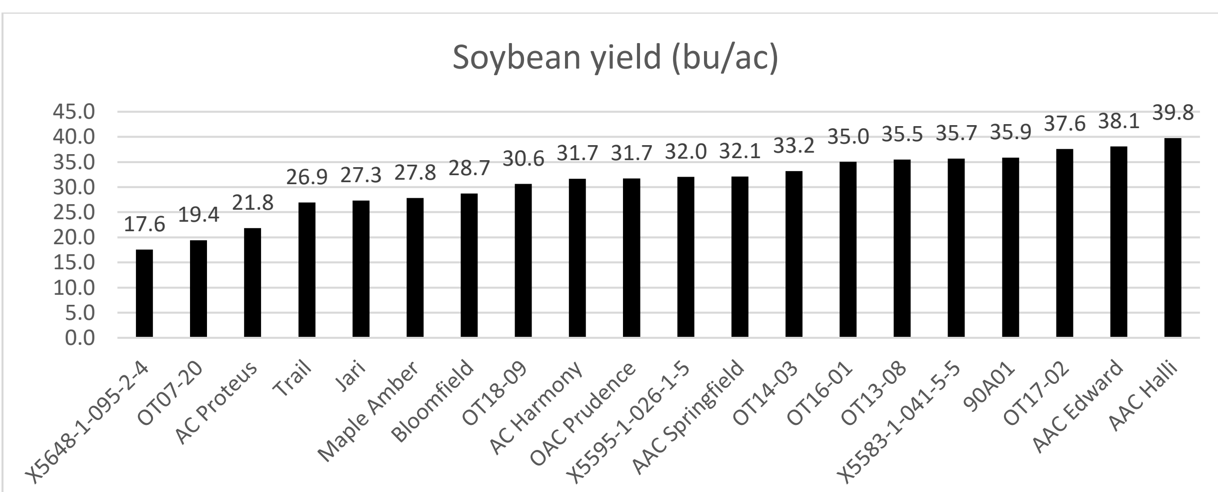


Table 1: Average soybean yield by entry (bu/ac)

Materials and methods

Experimental Design:	Rectangular lattice
Entries:	20 entries; 4 replications
Seeding:	May 21
Harvest:	Oct 6

Table 2: Varieties included in trial

90A01	OT14-03	AAC Edward	X5595-1-026-1-5
Trail	X5583-1-041-5-5	OT16-01	Bloomfield
OAC Prudence	OT13-08	Maple Amber	AAC Springfield
OT17-02	AAC Halli	AC Harmony	AC Proteus
Jari	OT07-20	OT18-09	X5648-1-095-2-4

Data collected	Date collected
Population Score:	Jun 16
Flowering:	Jul 22-24
Heights:	Aug 14
Maturity:	Sep 7
Lodging:	Oct 6
Yield:	Oct 25
Moisture:	Oct 25
Seed Weight g/100:	Oct 26

Agronomic info	
Previous year's crop:	Barley Silage
Soil Type:	Erickson Loam Clay
Landscape:	Rolling with trees to the east
Seedbed preparation:	Heavy harrowed twice

Table 3: Spring 2020 Soil Test

	Available	Added	Type
N	61 lb/ac	-	-
P	47 ppm	10 lb/ac	
K	393 ppm	-	-

Inoculant added with seed; P banded with seed

Table 4: Pesticide Application

Crop stage	Date	Product	Rate
Pre-emerge	May 19	RoundUp	0.64 L/ac
		Heat	28.0 g/ac
In-crop	Jul 22	UAN 28%	0.8 L/ac
		Viper	0.4 L/ac

Saskatchewan Pulse Growers Soy Variety Trial

Project duration: May 2020 – October 2020
Objectives: To evaluate early soybean entries for the Saskatchewan Pulse Growers (SPG)
Collaborators: Laurie Friesen, SPG

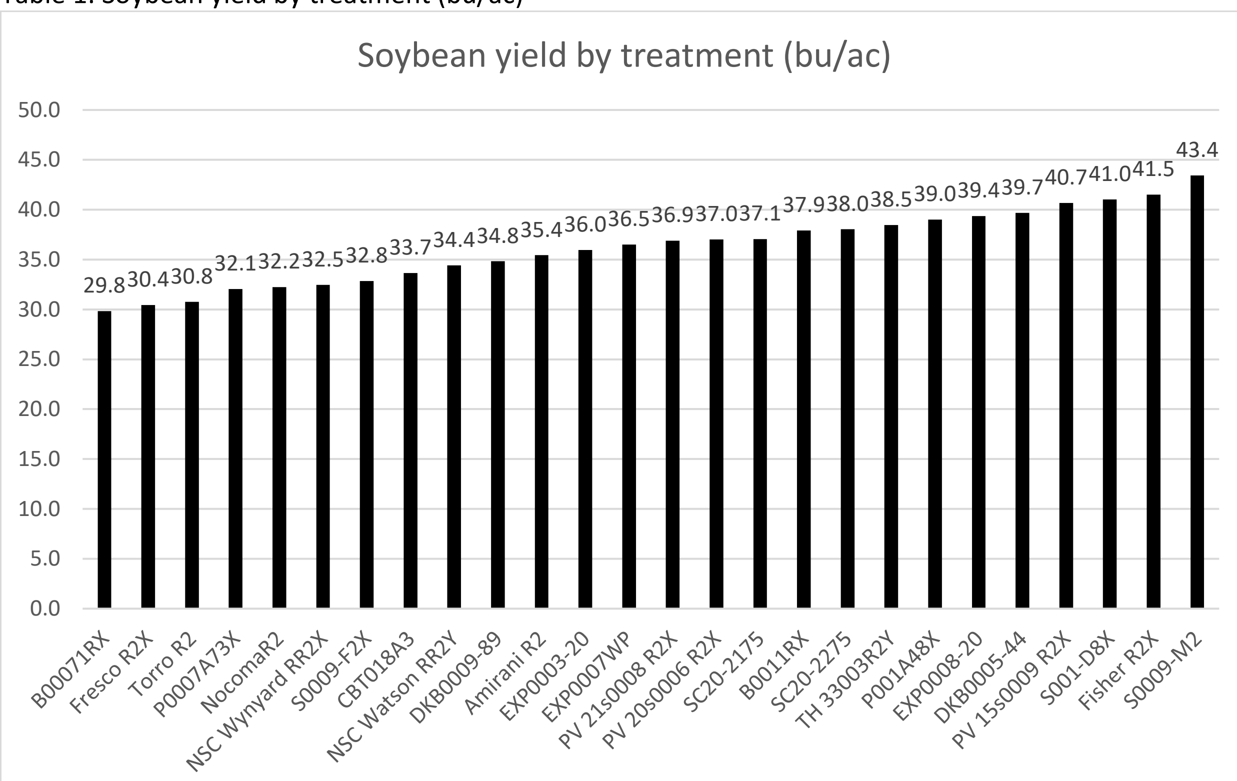
Background

(Adapted from the SPG website): Soybeans are photosensitive and latitude greatly affects day length. For this reason, varieties are bred for specific north-south ranges of adaptation, typically in a range of 150 to 250 kilometres. Growing a variety north of its maturity band may delay maturity and it will be at a great risk of not reaching full maturity prior to frost. The test examines some of the earliest (i.e., most northern-adapted) glyphosate-tolerant soybean lines.

Results

Average soybean yield for entries are shown in Table 1. Numbered entries are included for tracking purposes.

Table 1: Soybean yield by treatment (bu/ac)



Materials and methods

Experimental Design:	Rectangular lattice
Entries:	28 entries; 3 replications
Seeding:	May 21
Harvest:	Oct 7

Table 2: Varieties included in trial

NSC Watson RR2Y	PV 15s0009 R2X	NocomaR2	S001-D8X	SC20-2175
DKB0009-89	EXP0007WP	PV 20s0006 R2X	Fresco R2X	PV 21s0008 R2X
B00071RX	NSC Wynyard RR2X	TH 33003R2Y	EXP0003-20	-
EXP0008-20	SC20-2275	Fisher R2X	DKB0005-44	-
S0009-F2X	CBT018A3	S0009-M2	P0007A73X	-
B0011RX	P001A48X	Amirani R2	Torro R2	-

Data collected	Date collected
% Plant Stand:	Jun 16
Maturity:	Sep 7
Yield:	Oct 25-26
Moisture:	Oct 25-26

Agronomic info	
Previous year's crop:	Barley Silage
Soil Type:	Erickson Loam Clay
Landscape:	Rolling with trees to the east
Seedbed preparation:	Heavy harrowed twice

Table 3: Spring 2020 Soil Test

	Available	Added	Type
N	61 lb/ac	-	-
P	47 ppm	10 lb/ac	11-52-0-0
K	393 ppm	-	-

Inoculant added with seed; P banded with seed

Table 3: Pesticide Application

Crop stage	Date	Product	Rate
Pre-emerge	May 19	RoundUp	0.64 L/ac
		Heat	28.0 g/ac
In-crop	Jul 22	UAN 28%	0.8 L/ac
		Viper	0.4 L/ac

Wheat Trials

Parkland Coop Wheat Variety Evaluation

Project duration: May 2020 – August 2020
Objectives: To evaluate spring wheat varieties for the Parkland Coop
Collaborators: Dean Spanner – Coordinator, University of Alberta Research Station
Klaus Strenzke – Research Technician, University of Alberta Research Station

Background
The Parkland Cooperative wheat trial is conducted across the Prairies as a resource for wheat breeders to generate data in support of registration of new Canada Western Red Spring varieties. Additional samples taken to test for wheat midge were sent away at the end of July.

Results
These data were generated for the Parkland Coop; however, due to intellectual property issues pertaining to Plant Breeders' Rights, results for individual lines are not provided in this report. Table 1 provides the entries in this test. For more information on the Coop trial, contact Klaus Strenzke, University of Alberta.

Materials and methods
Experimental Design: Rectangular Lattice
Entries: 30 varieties
Seeding: May 11
Harvest: Sep 1

Table 1: Varieties included in trial at Roblin, 2020

AAC Brandon	PT5003	PT660	PT4001	PT799
AC Carberry	PT5005	PT661	PT4002	PT7000
Glenn	PT793	PT795	PT5009	PT7001
Parata	PT496	PT258	PT5010	PT7002
PT789	PT5007	PT499	PT5011	PT7003
PT495	PT5008	PT4000	PT5012	PT7004

Agronomic information
Previous year's crop: Barley Silage
Soil Type: Erickson Loam Clay
Landscape: Rolling with trees to the east
Seedbed preparation: Heavy harrowed

Data collected — Date collected
Maturity: Aug 25
Height: Aug 5
Lodging: Sep 1
Yield: Sep 1
Moisture: Sep 1

Table 2: 2020 Fertility Information

	Available	Added	Type
N	70 lb/ac	119 lb/ac	46-0-0
P	41 ppm	15 lb/ac	11-56-0-0
K	545 ppm	-	-

Table 3: Pesticide Application

Crop stage	Date	Product	Rate
Pre-emerge	May 19	Heat	28.0 g/ac
		Round-up	0.64 L/ac
In-crop	Jun 22	PrestigeXC-A	0.17 L/ac
Desiccation	Aug 25	RoundUp	0.64 L/ac
		Heat	20.0 g/ac
		Merge	0.3 L/ac

SVPG Wheat Variety Evaluation 1 (CWRS) and Evaluation 2 (HY)

Project duration: May 2020 – August 2020
Objectives: Two tests to evaluate spring wheat varieties for the Saskatchewan Variety Performance Group
Collaborators: Mitchell Japp, Saskatchewan Agriculture

Background
(From the Saskatchewan Wheat Development Commission website): The Saskatchewan Variety Performance Group (SVPG) is an informal group made up of stakeholders who are interested in variety performance testing in Saskatchewan. SVPG has coordinated the post-registration regional performance testing of spring wheat, durum, barley, oats, and flax varieties since 2006. The data collected from these trials is entered into annual publications "Varieties of Grain Crops and SaskSeed Guide". In this project, SVPG is collecting additional wheat data in the variety performance trials on priority traits including maturity, height, lodging, test weight, thousand kernel weight, protein, ergot and wheat midge, to enhance the available data set, and to provide farmers with more productive information on farming decisions.

Results
The average yield for spring wheat entries in Evaluation 1 (Canadian Western Red Spring) is shown in Table 1. The average yield for entries in Evaluation 2 (High Yielding) is shown in Table 2.

Table 1: Average yield for spring wheat entries (Canadian Western Red Spring, Evaluation 1)

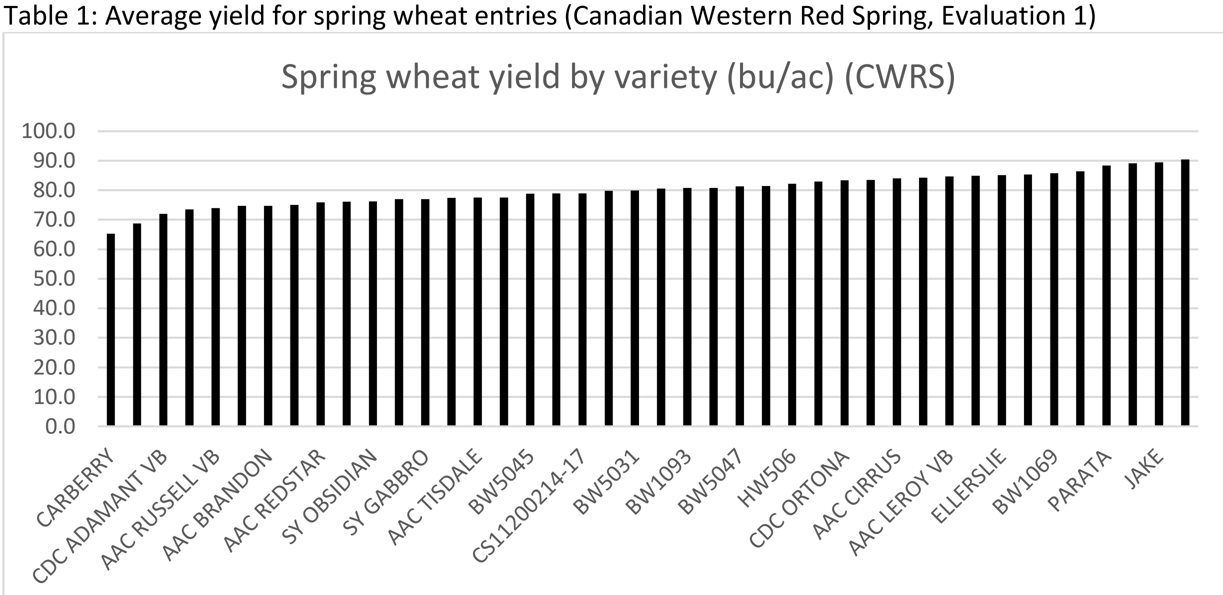
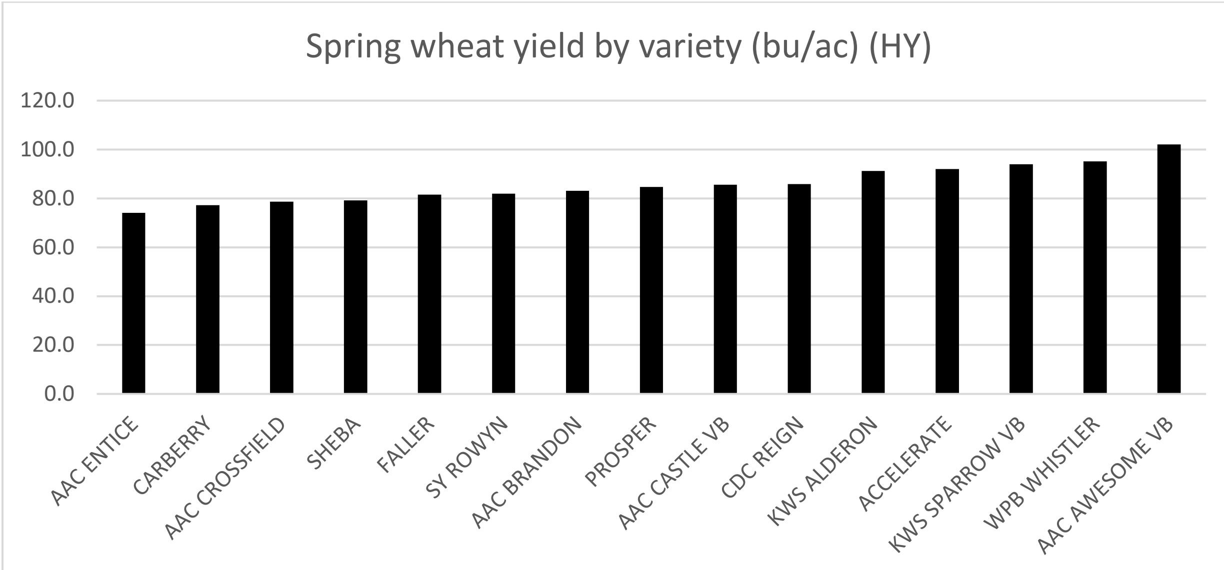


Table 2: Average yield for spring wheat entries (High Yielding)



Materials and methods

Experimental Design: Random Complete Block Design
Entries: 33
Seeding: May 11
Harvest: Sep 1

Table 3: Varieties included in SVPG Wheat Variety Evaluation 1

AAC REDSTAR	AAC BRANDON	LNR15-1405	AAC GOODWIN	DAYBREAK
SY OBSIDIAN	BW1069	REDNET	CDC ADAMANT VB	AAC TISDALE
CARBERRY	AAC STARBUCK VB	AAC MAGNET	PT599	CDC ORTONA
SY GABBRO	BW5055	BW5031	HW506	AAC CIRRUS
BOLLES	AAC WHEATLAND VB	LNR15-1741	TRACKER	BW5047
PT598	BW5044	AAC ALIDA VB	AAC RUSSELL VB	JAKE
AAC WARMAN VB	PT652	BW1064	SY TORACH	CS11200214-17
PARATA	AAC LEROY VB	HW402	BW1093	CS11200104-11
BW5045				

Table 4: Varieties included in SVPG Wheat Variety Evaluation 2

AAC AWESOME VB	ACCELERATE	KWS SPARROW VB
AAC BRANDON	CARBERRY	PROSPER
AAC CASTLE VB	CDC REIGN	SHEBA
AAC CROSSFIELD	FALLER	SY ROWYN
AAC ENTICE	KWS ALDERON	WPB WHISTLER

Agronomic information

Previous year's crop: Barley Silage
Soil Type: Erickson Loam Clay
Landscape: Rolling with trees to the east
Seedbed preparation: Heavy harrowed

Data collected	Date collected
Maturity:	Aug 25
Height:	Aug 5
Lodging:	Sep 1
Yield:	Sep 1
Moisture:	Sep 1

Table 5: 2020 Fertility Information

	Available	Added	Type
N	70 lb/ac	119 lb/ac	46-0-0
P	41 ppm	15 lb/ac	11-56-0-0
K	545 ppm	-	-

Table 6: Pesticide Application

Crop stage	Date	Product	Rate
Pre-emerge	May 19	Heat	28.0 g/ac
		Round-up	0.64 L/ac
In-crop	Jun 22	PrestigeXC-A	0.17 L/ac
Desiccation	Aug 25	RoundUp	0.64 L/ac
		Heat	20.0 g/ac
		Merge	0.3 L/ac

Ducks Unlimited Canada: Winter wheat fertility program to maximize yield potential of new winter wheat varieties

(Adapted from a report by Justice Zhanda, WADO)

Project duration: 2019-2020

Objectives: To compare historical/standard "Producer Practice [100% spring]" fertility program to a balanced "High Yield Practice [Balanced]" as determined by Western Ag Soil analysis and recommendations.

Collaborators: Elmer Kaskiw, Ducks Unlimited Canada, Western Ag Lab and Professional Agronomy

Background

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

Materials and Methods

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

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

A summary of fall soil tests conducted at Melita, Roblin, Carberry and Arborg, and fertilizer treatments for 2019/2020 are presented in Table 1.

Table 1: Fall Soil test results by site and fertilizer treatments for winter wheat in 2019/2020 season

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

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

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

Results

Winter wheat yield was not significantly influenced by variety, fertilizer management practice or interaction of the two factors at Melita but there was a significant (P=0.004) variety influence on protein content. Gateway had 13.5% protein compared to Elevate and Wildfire that had 12.2% and this could only due to genetic differences between the varieties. Although there were relatively low grain yields at Roblin compared to other sites, there was a significant influence of variety (P<0.001), variety x fertilizer management practice (P=0.012) and no significant effect of fertilizer management practice on winter wheat yield. Wildfire yielded significantly more grain (4145 kg ha^{-1}) compared to Elevate (3234 kg ha^{-1})

and Gateway (2875 kg ha^{-1}). An interaction of Wildfire variety x balanced fertilizer management practice significantly contributed to more grain yield (4692 kg ha^{-1}) compared to other interactions while Wildfire variety x 100% spring applied fertilizer management practice yielded significantly more grain (3598kg ha^{-1}) than balanced fertilizer application on Gateway variety (2732 kg ha^{-1}). As observed at Melita, protein content was significantly (P=0.001) high for Gateway variety (15.6%) compared to Elevate (14.6) and Wildfire (14.2%). Fertilizer management practice also significantly (P=0.022) influenced protein content at Roblin with balanced fertilizer having 15.1% compared to 100% spring applied on 14.5%. At Carberry, there was a significant influence of variety (P<0.001) and fertility management practice (P=0.001) on winter wheat grain yield. Wildfire, Elevate and Gateway yielded 6864 kg ha^{-1}, 6336 kg ha^{-1} and 5822 kg ha^{-1}, respectively. Balanced fertilizer management practice resulted in approximately 8.33% more grain yield compared to 100% spring applied practice. There was no significant influence by any of the treatments on protein content. At Arborg, variety significantly influenced winter wheat grain yield (P=0.024) and protein content (P=0.007) while fertility management practice had a significant influence on yield (P=0.014) alone. On variety influence, Wildfire had the highest yield (6082 kg ha^{-1}) while Gateway and Elevate had 5233 kg ha^{-1} and 5110 kg ha^{-1}, respectively. Gateway variety continued to show similar trends as other sites with significantly higher protein content (13.3%) compared to Elevate (12.2%) and Wildfire (12.3%). Combining data from all sites resulted in significant influence by variety (P<0.001) on yield and protein content while fertility management practice significantly (P<0.001) influenced yield only. Four-site year analysis showed Wildfire leading in yield at 5473 kg ha^{-1} followed by Elevate with 4891 kg ha^{-1} and Gateway at 4588 kg ha^{-1}. On the other hand, Gateway had the highest combined protein content of 14.3% compared to 13.3% for Elevate and Wildfire. Balanced fertility management significantly influenced winter wheat grain yield resulting in attainment of 5199 kg ha^{-1} compared to 100% spring applied fertility management practiced that attained 4769 kg ha^{-1} (Table 3). Results from this study indicate that balanced fertilizer management approach could be a better option than the farmer practice of applying all nitrogen in spring. This is largely due to the fact that winter wheat requires adequate starter nitrogen during early days of establishment in fall and when it resumes development in spring. Continued field study would be necessary to effectively develop fertilizer management recommendations that winter wheat producers can use for their areas of production.

Table 3: Analysis of variance for winter wheat yield (kg ha^{-1}) and protein content (%) at Melita, Roblin, Carberry, Arborg and combined for all sites in 2019/2020 season

			Location									
			Melita		Roblin		Carberry		Arborg		All Sites	
	Treatment		Yield	Protein	Yield	Protein	Yield	Protein	Yield	Protein	Yield	Protein
Variety	Elevate	1	4884	12.2b	3234b	14.6b	6336b	14.4	5110b	12.2b	4891b	13.3b
	Gateway	2	4420	13.5a	2875b	15.6a	5822c	14.8	5233b	13.3a	4588c	14.3a
	Wildfire	3	4803	12.2b	4145a	14.2b	6864a	14.6	6082a	12.3b	5473a	13.3b
Fertility	100%Spring	1	4628	12.6	3292	14.5b	6065b	14.8	5089b	12.6	4769b	13.6
	Balanced	2	4776	12.7	3545	15.1a	6616a	14.4	5861a	12.5	5199a	13.7
Var x Fert	1,1		4706	12.4	3258bc	14.5	6157	14.6	4538	12.3	4665	13.4
	1,2		5062	12	3210bc	14.6	6515	14.2	5681	12.1	5117	13.2
	2,1		4312	13.2	3019bc	15	5489	14.9	4692	13.6	4378	14.2
	2,2		4528	13.8	2732c	16	6154	14.6	5774	12.9	4797	14.4
	3,1		4866	12.1	3598b	14	6549	14.8	6038	12.1	5263	13.2
	3,2		4739	12.3	4692a	14.5	7180	14.4	6126	12.4	5684	13.4
	P values	Variety	0.21	0.004	<0.001	0.001	<0.001	0.371	0.024	0.007	<0.001	<0.001
		Fertilizer	0.5	0.675	0.143	0.022	0.001	0.055	0.014	0.548	<0.001	0.738
		Var x Fert	0.644	0.361	0.012	0.226	0.49	0.968	0.225	0.282	0.988	0.351
		CV%	10	5	10	3	4	3	10	4	8	4

References

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Horticulture Trials

Fruit Demonstration

Established: May 2009
Objectives: To demonstrate varieties of fruits being developed by the University of Saskatchewan
Collaborator: PCDF

Background
Dwarf sour cherries are not a native crop to the Canadian Prairies. They are the product of a number of crosses were initially begun by Dr. Les Kerr of the University of Saskatchewan by crossing a cold hardy cherry from Siberia, *Prunus fruiticosa,* with a sour cherry originating in Europe (brought over by settlers) by the name of *Prunus cerasus.* Since then the development has continued by incorporations of other cherries and by the use of dwarfing root stalks. The advantage of the dwarfing root stalk is that it forces earlier fruiting from the plant and it also creates a more workable tree when harvesting, for both manual and mechanical pickers. Dwarf sour cherries constitute a very typical “cherry pie filling” cherry.


Figure 1: a) dwarf sour cherries (photo credit); b) haskap berries (photo credit).

The haskap berry was introduced to Canada around 1967 and now grows across the country, thanks to new varieties developed by the University of Saskatchewan Fruit Program. The berries are similar in tast and texture blueberry, with a tartness closer to raspberry. The tartness makes them excellent for baking. Haskap plants attract fewer pests than many other prairie fruit crops and require little maintenance. Further, the crop thrives in cold climates, making it a natural fit for the Canadian prairies. Haskap is one of the first berries to ripen, and pickers can enjoy the berry beginning in the mid-June.

Birds are a problem for both fruits and appropriate measures must be taken to prevent the loss of berries.

Results
A bird net was erected over the sour cherry and haskap plants in late 2019, resulting in much higher yield results for haskaps in 2020. Sour cherries tend to yield more biennially (that is, yield are higher every other year), so 2020 was a lower year than 2019. A comparative chart below shows successive yields since 2016.

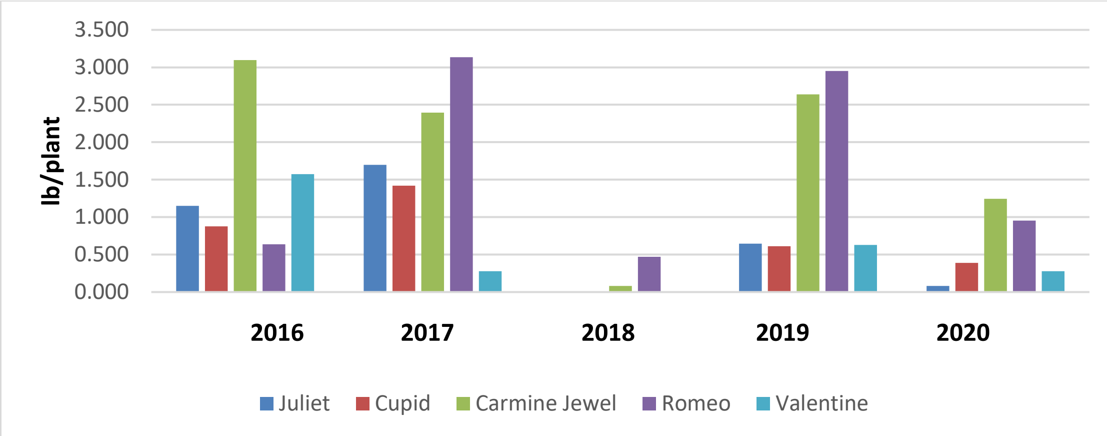

Figure 1: Roblin Sour Cherry Performance 2016-2020 (lb/plant)

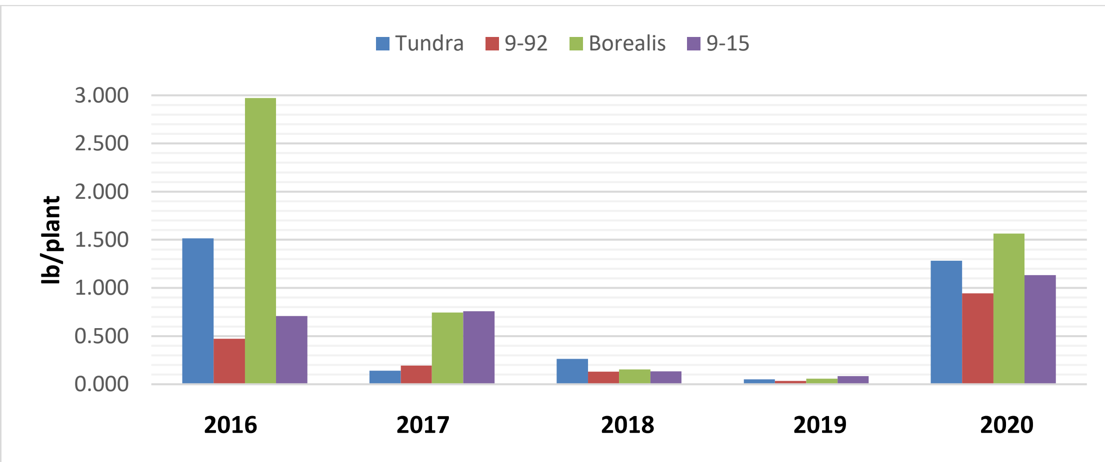

Figure 2: Roblin Haskap Performance 2016-2020 (lb/plant)

Materials and methods

Entries:	4 Haskap varieties; 5 Dwarf Sour Cherry varieties
Agronomic info	
Soil Type:	Erickson Loam Clay
Landscape:	Rolling with trees to the east
Planted:	Jun 2009
Fertilized:	Spring 2020
Pruned:	Spring 2019

Table 1: Dwarf Sour Cherry and Haskap Varieties

Haskap	Cherry
Borealis	Valentine
Tundra	Romeo
9-92	Juliet
9-15	Carmine Jewel
	Cupid

Hopyard Variety Evaluation

Established: May 2018
Objectives: To evaluate varieties of hops for production on the Prairies
Collaborators: PCDF

Background
Production of hops is of interest in Manitoba. This is especially true as interest in Winnipeg and other cities surrounding locally sourced grains and hops for their craft brews continues to grow. Hops provide alternatives for smaller acreage owners. Different varieties possess different fragrances and qualities that affect the beers and other beverages produced from them. Equipment for planting and harvesting are available. An August 2018 article in the *Manitoba Cooperator* describes how hops growers received funding through the Canadian Agricultural Partnership (CAP) for harvesting equipment.

A mature hops plant will quickly grow up to 20 feet in length, and an important working to get them properly strung up can provide for very busy work in the first part of the growing season. Once harvested, they are pressed into pellets, which are the preferred form for brewers. Some growers are looking at providing this service for other growers and others have devised their own means of producing pellets. The size of the operation will determine the best method for individual growers.

Infrastructure came into place toward the end of the season for the hops to grow upward in their characteristic manner. The summer of 2020 represented the first year that PCDF has harvested hops from these now well-established vines. The hops were not tested for flavour compounds at a lab, but plans have been made to test the material in 2021.

Results
The average yield for hops varieties are shown in Figure 1. Wet weights are for freshly harvested material, and dry weights are after the harvest material was left on air. The large differences in yield are due to differences in plant performance and wind damage. PDCF will continue the evaluation in 2021.

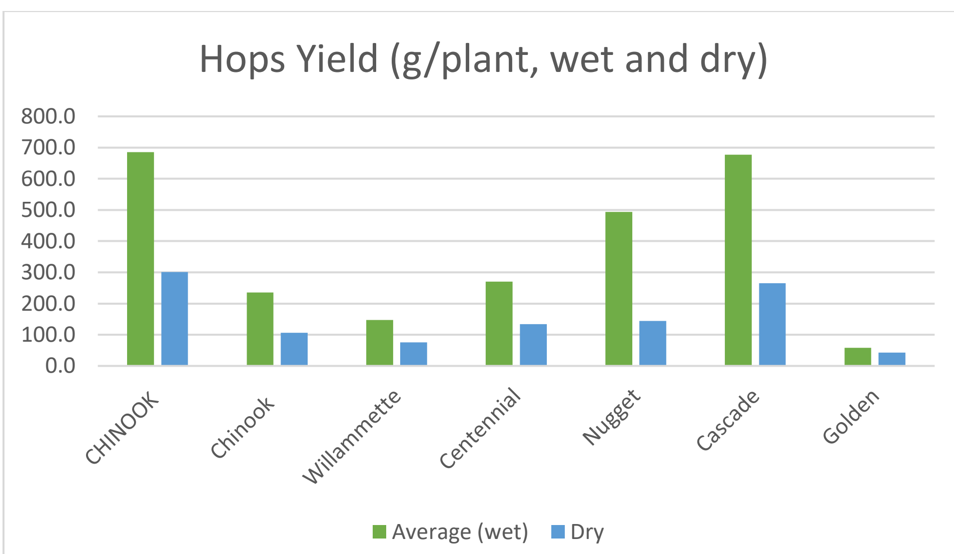

Figure 1: Yield for hops (g/plant, wet and dry) by variety

Materials and methods

Entries: 6 varieties in 3 repetitions
Varieties: See Table 1

Table 1: Hops Varieties at Roblin

Chinook	Willammette
Centennial	Nugget
Golden	Cascade

Agronomic info
Soil Type: Erickson Loam Clay
Landscape: Rolling with trees to the east
Planted: Jun 2018
Added Fertility: Composted sheep manure (2018, at planting)
100-20-10-15 lb/ac N-P-K-S added May 5, 2020

PCDF

Parkland Crop Diversification Foundation

Manitoba's diversification centres are funded in part by the Canadian Agricultural Partnership.

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