Westman Agricultural Diversification Organization

2017 ANNUAL REPORT

WADO

Contents

2017 Industry Partners

AgQuest
Agriculture and Agri-Food Canada
BASF
Canada MB Crop Diversification Centre
Canola Council of Canada
Composites Innovation Centre
Ducks Unlimited Canada
Flax Council of Canada
Gowan Agro Canada
Hemp Genetics International
La Coop fédérée
Manitoba Canola Growers Association
Manitoba Corn Growers Association
MB Agriculture
Parkland Industrial Hemp Growers
Pepsico /Quaker
Manitoba Crop Variety Evaluation Team
Manitoba Pulse & Soybean Growers Assoc.
Mustard 21
National Sunflower Association of Canada
Parkland Crop Diversification Foundation
Paterson Grain
Prairie Agricultural Machinery Institute
Seed Manitoba
Prairies East Sustainable Ag Initiative
University of Alberta
University of Manitoba
University of Saskatchewan (CDC)
University of Manitoba
Western Feed Grains Development Cooperative
Seed Manitoba

Farmer Co-operators 2017 Trial Locations

Darryl Breemersch - Melita
Mary Snyder -Melita
Wayne White - Melita
Alan Brown - Melita
Kirkup Farms - Melita
Barker Farms - Melita

WADO Directors

WADO functions with a board of directors that assists in communications, activities and project development. The directors are from all across southwest Manitoba and they have a direct connection to farming and agriculture. The directors listed below are those that participated with WADO operations for 2017.

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

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

WADO Board Advisor: Elmer Kaskiw – Shoal Lake

Introduction

The Westman Agricultural Diversification Organization Inc. (WADO) manages a wide range of value-added and diversification agriculture research and demonstration projects that are summarized in this report. WADO operates in the southwest region of Manitoba and works in conjunction whenever possible with the other Diversification Centres in Roblin (PCDF), Arborg (PESAI) and the Fed/Prov. Canada/Manitoba Diversification Centres (CMCDC) based in Carberry and Portage la Prairie. WADO owes its success to the excellent cooperation and participation we receive from the WADO Board of Directors, cooperating land owners, local producers, industry partners and cooperating research institutes. WADO acts as a facilitator and sponsor for many of the Ag Extension events held across the province in conjunction with other Manitoba Agriculture staff and industry personnel. This is all part of WADO's goal of helping farmers and our rural communities do better.

WADO receives the majority of its operating funds from the Agricultural Sustainability Initiative (ASI) and other Growing Forward (GF) programs. Smaller amounts of additional funding come from the MCVET committee and other Industry Partners for the contract work that WADO is able to provide to these organizations.

WADO Staff

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

Brett Teetaert joined Manitoba Agriculture in 2016 as a Technician assigned to WADO. He was responsible for field operations, plot management and data collection. Brett resigned in July 2017.

Chantal Elliot from Pipestone and Jessie Mayes from Pierson were returning summer students. Chantal remained with us through the winter to assist with sample analysis and shop work due to the absence of a crop technician. Jessie returned to McGill University in Montreal. Nick Fletcher joined our summer staff in May. He is enrolled in the Agriculture Diploma program at ACC. Leanne Mayes is our full time research associate.

WADO Staff 2017 (left to right): Scott, Brett, Jessie, Leanne, Chantal, Nick

Got An Idea?

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

Westman Agricultural Diversification Organization (WADO)
c/o Scott Chalmers Manitoba Agriculture
Box 519
Melita, MB R0M 1L0
204-522-3256 (office)
204-522-5415 (cell)
204-522-8054 (fax)
scott.chalmers@gov.mb.ca

2017 Weather Report and Data – Melita Area

Table 1: Melita 2017 Season Report by Month (normals based on 30-year average)

Month	Precipitation mm		Temperature °C		Corn Heat Units		Growing Degree Days	
	Actual	Normal	Average	Normal	Actual	Normal	Actual	Normal
April	12	29	5.5	4.6	118	78	52	24
May	6	53	12.2	11.59	379	365	216	205
June	63	101	16.8	16.8	573	583	354	351
July	45	69	21.6	19.49	805	712	514	453
August	39	78	18.7	18.52	676	659	424	415
September	51	35	13.8	12.69	401	369	256	211
October	3	31	6.1	5.58	186	116	74	40

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

Table 2: Season summary April 1 – October 31, 2017

	Actual	Normal	% of Normal
Number of Days	214		
Growing Degree Days	1890	1702	111
Corn Heat Units	3138	2884	108
Total Precipitation	219	399	87

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

To calculate growing degree days (GDD), first determine the mean temperature for the day. This is usually done by taking the maximum and minimum temperatures for the day, adding them together and dividing by 2. The base temperature (0°C for cereals, 5°C for both alfalfa and canola) is then subtracted from the mean temperature to give a daily GDD. If the daily GDD calculates to a negative number, it is made equal to zero. Each daily GDD is then added up (accumulated) over the growing season.

Corn heat units (CHU) are based on a similar principle to growing degree days. CHUs are calculated on a daily basis, using the maximum and minimum temperatures; however, the equation that is used is quite different. The CHU model uses separate calculations for maximum and minimum temperatures. The maximum or daytime relationship uses 10°C as the base temperature and 30°C as the ceiling, because warm-season crops do not develop at all when daytime temperatures fall below

10°C, and develop fastest at about 30°C. The minimum or nighttime relationship uses 4.4°C as the base temperature and does not specify an optimum temperature, because nighttime minimum temperatures very seldom exceed 25°C in Canada. The nighttime relationship is considered a linear relationship, while the daytime relationship is considered non-linear because crop development peaks at 30°C and begins to decline at higher temperatures. CHU's is a more accurate crop prediction tool for crops like corn and beans that require heat for proper growth.

A good visual of our growing season is illustrated on the 2017 Precipitation Map and the 2017 Corn Heat Unit Map. These can be found at http://www.gov.mb.ca/agriculture/weather/manitoba-ag-weather.html.

WADO continues to operate and draw data from several weather stations in the southwest. These stations include Melita, Hamiota and Reston. Continuous real time data recorded every 15 minutes and this can be viewed publicly at the following locations:

http://tgs.gov.mb.ca/climate/DisplayImage.aspx?StationID=bede253
http://tgs.gov.mb.ca/climate/DisplayImage.aspx?StationID=hamiotaWADO
http://www.gov.mb.ca/agriculture/weather/reston-cc.html

WADO Tours and Special Events

WADO attended Ag Days in Brandon, MB on January 16 – 18. Manitoba's Diversification Centres managed a booth showcasing new farming opportunities and possibilities. Over 45,000 people were in attendance.

On July 25approximately 100 people joined us for lunch and tour of our main plot site SW of Melita. Our annual Field Day is the main way that WADO communicates our activities and we were encouraged to see the participation from producers, fellow researchers and industry partners.

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

Scott participated as a speaker at the following events:

- Mandak - Minot North Dakota, January 11, 2017 (300 attendees). Participated in a panel discussion on intercrops.
- Patterson Field Day - Melita, July 26, 2017 (30 attendees). Spoke about a trial that WADO was executing in partnership with the University of Manitoba regarding high yielding wheat fertility requirements.
- Organic Hemp Production meeting - Carmen November 8, 2017 (25 attendees). Presented information regarding our Hemp Relay trial.
- Intercrop Innovators Meeting - Regina November 29, 2017 (180 attendees). Spoke on intercrops.
- Manitoba Agronomists Conference on December 14, 2017 (300 attendees and 400 online participants). Member of a panel on intercropping.

Understanding Plot Statistics

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

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

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

Grand mean is the average of the entire data set. Quite often, it helps gauge the overall yield of a site or trial location.

Sometimes ‘checks’ are used to reference a familiar variety to new varieties and may be highlighted in grey or simply referred to as ‘check’ in the results table or summary for the readers’ convenience.

Data in all replicated trials at WADO has been analyzed by statistical software from either Agrobase Gen II version 16.2.1 software, or Analyze-it version 2.03 software. Coefficient of variation and least significant difference at the 0.05 level of significance was used to determine trial variation and mean differences respectively. At this level of significance, there is less than 5% chance that this data is a fluke when considered significant. For differences among treatments to be significant, the p-value must be less than 0.05. A p-value of 0.001 would be considered highly significant.

MCVET Variety Evaluations

The Westman Agricultural Diversification Organization is one of many sites that are part of the Manitoba Crop Variety Evaluation Team (MCVET) which facilitates variety evaluations of many different crop types in this province.

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

The tables on the following two pages outlines our agronomy practices for MCVET we participated in. Yield data is published in the Seed Manitoba Guide.

Crop	Stubble	Burnoff	Soil Moisture	Seed Date	Seed Depth	Fertility Applied	Chemistry	Other Notes	Harvest Date
Winter Wheat	Flax	Glysophate 1L/ac	Good	15-Sep	0.5"	56-35-23-10 60 lbs Agrotain*	Achieve 0.2 L/ac + Mextrol 450 @ 0.5 L/ac + Turbocharge @ 0.5% v/v		28-Jul
Rye	BW	Glysophate 1L/ac	Good	15-Sep	0.5"	56-35-23-10 60 lbs Agrotain*	Achieve 0.2 L/ac + Mextrol 450 @ 0.5 L/ac + Turbocharge @ 0.5% v/v		28-Jul
Barley	Rye		Good	09-May	0.75"	80-35-25-10	Mextrol @ 0.5L/ac		14-Aug
Wheat 1	Rye	Roundup 1 L/ac + Aim 15 ml/ac	Good	09-May	0.75"	126-35-25-10	Mextrol @ 0.5L/ac		21-Aug
Wheat 2	Rye	Roundup 1 L/ac + Aim 15 ml/ac	Good	09-May	0.75"	126-35-25-10	Mextrol @ 0.5L/ac		31-Aug
Durum	Rye	Roundup 1 L/ac + Aim 15 ml/ac	Adequate	15-May	0.75"	126-35-25-10	Mextrol @ 0.5L/ac		28-Aug
Oat	Rye	Roundup 1 L/ac + Aim 15 ml/ac	Adequate	08-May	0.75"	116-35-25-10	Mextrol @ 0.5L/ac		23-Aug
Pea	Rye	Roundup 1L/ac + 75 ml/ac Arrow w/ 1%Xact + 30 ml/ac	Good	05-May	1.5"	16-35-25-10	Viper 400 mls/acre Matador for Aphids 34 ml/ac July 26	Rolled	14-Aug
Lentil	Rye	Roundup 1L/ac + 75 ml/ac Arrow w/ 1%Xact + 30 ml/ac Aim	Good	05-May	1.5"	16-35-25-10	Viper 400 mls/acre Matador for Aphids 34 ml/ac July 26	Rolled	21-Aug
Soybean	Rye	Roundup 1L/ac + 75 ml/ac Arrow w/ 1%Xact + 30 ml/ac Aim	Good	15-May	1"	16-35-25-10	1L glyphosate 1 REL glyphosate + .91L Basagran	Rolled	29-Sep
Con Soybean	Rye	Roundup 1L/ac + 75 ml/ac Arrow w/ 1%Xact + 30 ml/ac Aim	Good	15-May	1"	16-35-25-10	1 REL glyphosate + .91L of Basagran 1 REL glyphosate + .91L Basagran	Rolled	28-Sep
NR Beans	Rye	Arrow w/ 1%Xact + 30 ml/ac Aim Arrow w/ 1%Xact + 30 ml/ac Aim	Good	16-May	1"	67-35-25-10	1 REL glyphosate + .91L Basagran 1 REL glyphosate + .91L Basagran	Rolled	11-Sep
Canola SC VT	Rye	1L REL glyphosate, 75ml/ac Centurio Amigo	Adequate	12-May	0.5"	126-35-25-0	.5L/ac REL glyphosate, 1.35L/ac Liberty, .3L/ac rate Assure II		29-Aug
Canola Swath VT	Rye	1L REL glyphosate, 75ml/ac Centurio Amigo	Adequate	11-May	0.5"	116-35-25-10	.5Lac REL glyphosate, 1.35L/ac Liberty, .244ml/ac ares .3L/ac rate Assure II	Swathed 15-Aug	29-Aug

* Agrotain was broadcast on April 20th.

Crop	Stubble	Burnoff	Soil Moisture	Seed Date	Seed Depth	Fertility Applied	Chemistry	Other Notes	Harvest Date
Canola OP VT	Rye	1L REL glyphosate, 75ml/ac Centurio Amigo	Adequate	11-May	0.5"	116-35-25-10	8 g/ac Muster, .3L/ac Assurell	Swathed 15-Aug	01-Sep
Brassica Juncea	Rye		Adequate	11-May	0.5"	116-35-25-10	8 g/ac Muster, .3L/ac Assurell	Swathed 14-Aug	28-Aug
Yellow Mustard	Rye		Adequate	11-May	0.5"	116-35-25-10	8 g/ac Muster, .3L/ac Assurell	Swathed 14-Aug	28-Aug
Sunflower	Wheat	Authority + Aim @ 100ml+ 15ml/ac + Roundup at 0.75L/ac + Rival @ 0.65 L/ac	Adequate	17-May	2.2"	132-70-50-20	120ml Clethodim + Pounce 150ml rate, seperate pass Assert Full rate + pH adjuster Arrow 100 ml/ac, lower canopy for v. wheat Matador 34 ml/ac for lygus and bud moths		11-Oct
Corn	Barley	Roundup 1L/ac + Aim at 15ml/ac @ 10 gal/ac	Dry	15-May	2.2"	200-70-50-20 N banded and BC	1.5REL Glyphosate + .4L/ac Koril		20-Oct
Hemp VT	Rye	Glyphosate.5L/ac + Liberty at 0.75L/ac	Adequate	23-May	0.75"	120-35-25-10	Koril @ 0.4 L/ac + Arrow @ 100 ml/ac + X Act @ 0.5%v/v tank mixed		06-Sep
Quinoa	Rye	1 L/ac Roundup	Good	17-May	0.375"	126-35-25-10	75ml/ac Clethodim		28-Sep

Notes:

All cereals, oilseeds and pulses were seeded with Seedhawk 6 row seeder with 9.5" spacing.

Sunflowers and corn were planted with Wintersteiger 4 row planter on 30" spacing.

The main trial site was located on SW 22-3-27 W1. Soil type Waskada Loam. This site contained the majority of our trials. Exceptions are listed below:

Corn: NE 24-3-26 W1, soil type Waskada Loam

Sunflowers: NW 7-4-26 W1,soil type Waskada Loam

Winter Wheat and Rye: NE 27-3-27 W1, soil type Waskada Loam

Determining Optimum Target Plant Stands for Spring Cereal Crops in Manitoba

Project duration: 2017-2018
***Collaborators*:** Manitoba Agriculture; Anne Kirk, Earl Bargen and Rejean Picard

Objectives

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

Results

Plant Stand and Mortality

Plant stand increased as seeding rate increased at all barley sites and at all wheat and oat sites with the exception of Roblin. At the Roblin site there was no significant difference in plant stand between the seeding rate treatments for wheat or oat (data not shown). Results for the Roblin wheat and oat sites will not be shown as a range of plant populations was not established.

Figure 1. AAC Synergy barley planted at target plant stands of 15, 27, and 39 plants/ft^2 at Carberry.

Seedling mortality differed between locations with Arborg having very low seedling mortality, and an average mortality of 8, 32, and 39% at Carberry, Melita, and Roblin, respectively (Figure 2). There were no significant differences in seeding mortality between seeding rates for wheat and oat sites. In Roblin barley mortality significantly increased as seeding rate increased (Figure 2).

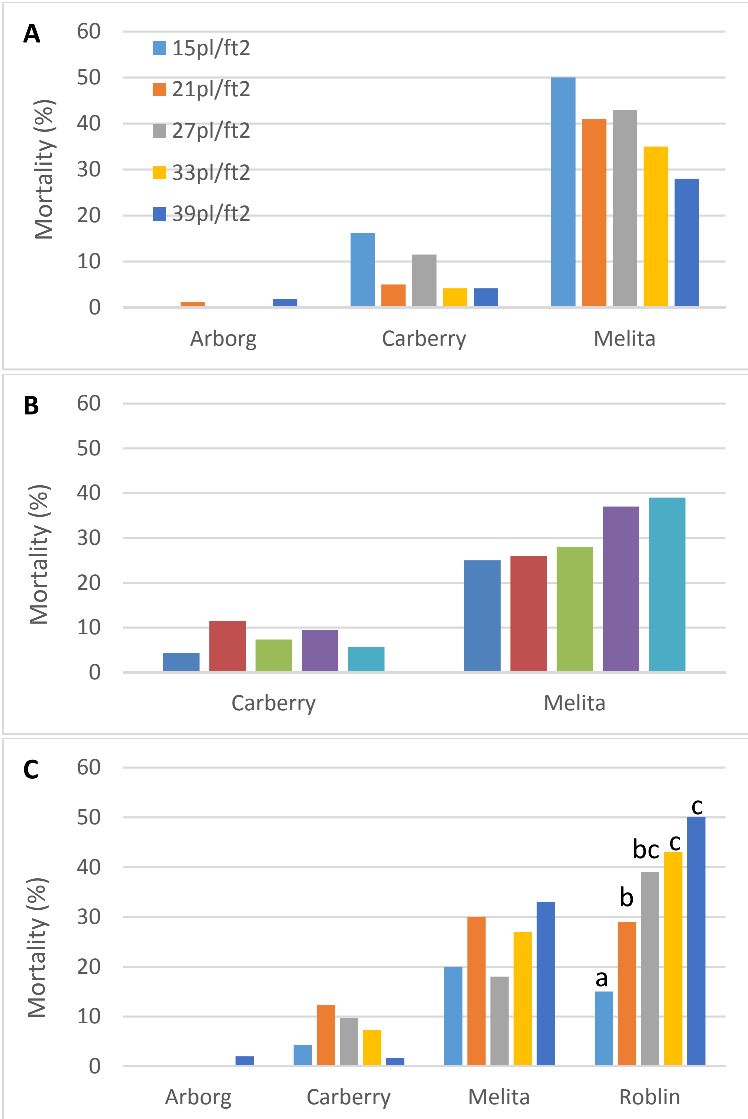


Figure 2. Mortality (%) for wheat (A), oat (B), and barley (C) at Arborg, Carberry, Melita, and Roblin.

Heading

Cereal cultivars have differing abilities to tiller, but in the first year of this study there were no significant differences in heads/ft^2 between the two wheat and oat cultivars at any location. In Melita the barley cultivar CDC Austenson had significantly more heads than AAC Synergy (Table 1).

Cereals typically compensate for lower plant populations by increasing tillering. Previous research in which spring wheat plants were given ample room found that stems/plant ranged from 19 to 44 depending on the variety (Wiersma 2014). In the first year of this study, heads/plant decreased as seeding rate increased for all crops and locations (data not shown). There was no significant difference in heads/ft^2 at one of the two wheat sites, all barley sites, and one of the two oats sites (Table 1), which demonstrates the ability of cereal crops to compensate for reduced plant populations by increasing tillering. At the wheat and oat site where there were significant differences in heads/ft^2, there were more heads/ft^2 at the highest plant populations compared to the lowest plant populations.

Table 1. Heads/ft² for wheat, barley, and oat at the Arborg, Melita, and Roblin locations. Significant P values (Pr<0.05) are indicated by an asterisk. Wheat varieties are AAC Brandon (A) and Prosper (B), barley varieties are AAC Synergy (A) and CDC Austenson (B), and oat varieties are Summit (A) and CS Camden (B).

	Wheat		Barley			Oat	
	Arborg	Melita	Arborg	Melita	Roblin	Arborg	Melita
	Heads/ft²						
Variety A	48	34	56	36	65	39	24
Variety B	51	31	54	44	68	42	22
Pr>F	*ns*	*ns*	*ns*	*	*ns*	*ns*	*ns*
LSD	*n/a*	*n/a*	*n/a*	*5*	*n/a*	*n/a*	*n/a*
Target Plant Population (pl/ft²)							
15	48	23	55	34	67	37	21
21	46	33	57	40	69	37	21
27	48	30	51	38	60	40	18
33	54	38	55	42	64	41	28
39	52	39	57	46	72	47	26
Pr>F	*ns*	*	*ns*	*ns*	*ns*	*	*ns*
LSD	*n/a*	*9.5*	*n/a*	*n/a*	*n/a*	*6.4*	*n/a*

Yield

For each crop type there was no interaction between seeding rate and cultivar, both cultivars of each crop responded similarly to increased seeding rates. There were yield differences between the wheat varieties, with AAC Brandon yielding significantly higher than Prosper at both Carberry and Melita. AAC Brandon yielded 6 bu/ac greater than Prosper at the Carberry location, and 8 bu/acre greater at the Melita location (data not shown). When averaged across cultivars, there were no differences in wheat yield across target plant densities at Carberry, but at Melita yield generally increased as seeding rate increased (Figure 2).

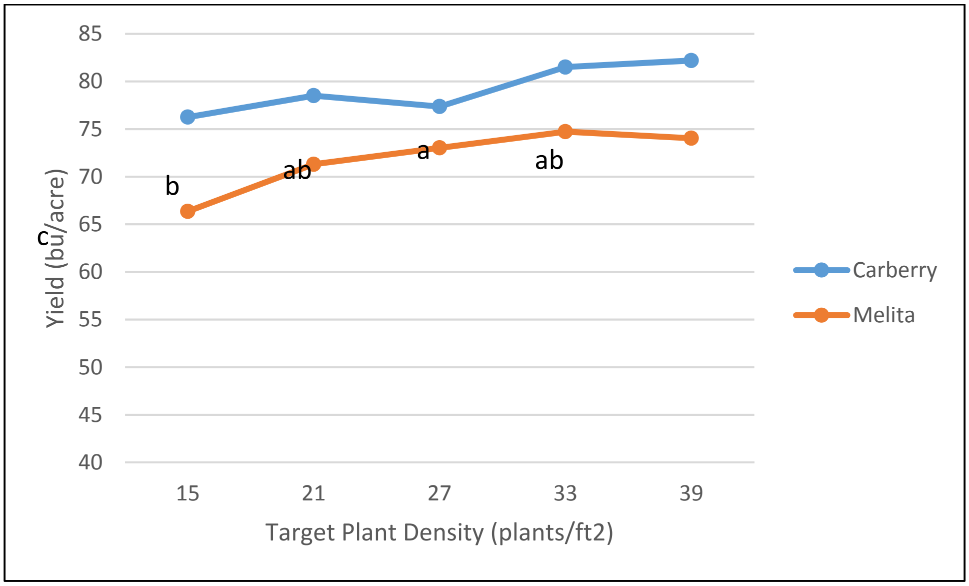


Figure 2. Wheat yield (bu/acre) at five target plant densities at Carberry and Melita. Statistically significant differences are shown by letters below the line. Treatments within the same site with the same letter are not significantly different (P<0.05).

For barley, there were significant yield differences between the two varieties at Arborg only. At the Arborg site CDC Austenson yielded 11 bu/acre higher than AAC Synergy (data not shown). At the Carberry and Melita sites there was no yield response to increasing plant densities (Figure 3). At the Roblin location there was no significant yield difference between the first four seeding rates, but yield was significantly reduced at the higher target plant density. There were significant yield differences between target plant densities at Arborg, but the range in yield was only 4 bu/acre and there was no yield trend (Figure 3).

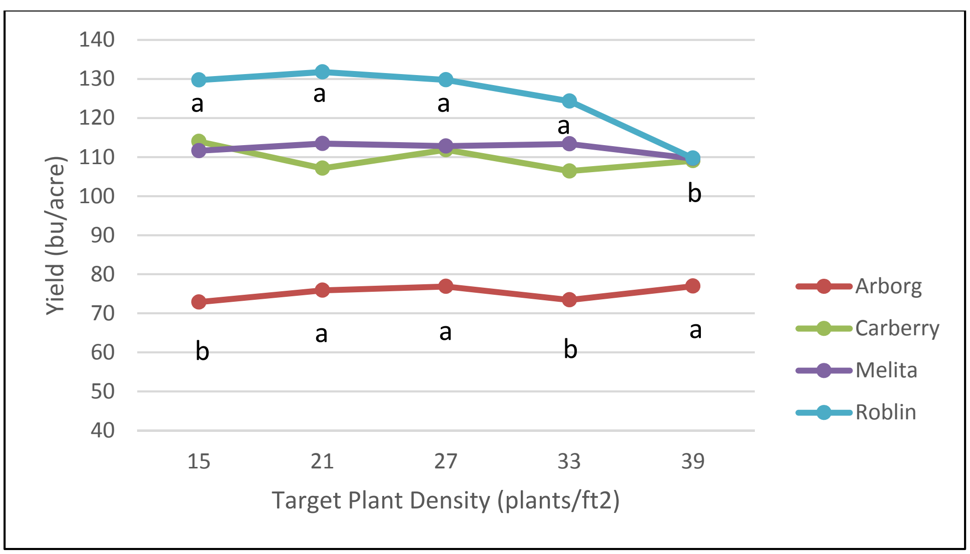


Figure 3. Barley yield (bu/acre) at five target plant densities at Arborg, Carberry, Melita, and Roblin. Statistically significant differences are shown by letters above the bars. Treatments within the same site with the same letter are not significantly different (P<0.05).

At the Carberry and Melita oat trials there was no significant yield difference between the two oat cultivars (data not shown). There was also no yield response to increasing target plant densities (Figure 4).

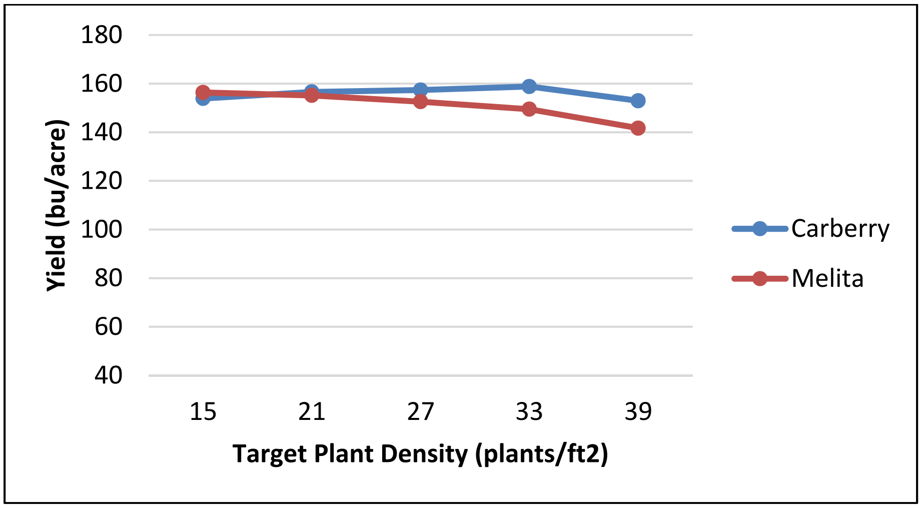


Figure 4. Oat yield (bu/acre) at five target plant densities at Carberry and Melita.

The results from the first year of the study suggest that the current recommended target plant populations for wheat, barley, and oat are sufficient, but more site years of data are needed to make a recommendation.

Background

Yield of spring cereals is impacted by many agronomic practices, but starts with variety selection, seeding date, target plant stand, and the seeding rate needed to achieve those plant stands. Optimum plant population is determined by factors including crop management practices and growing conditions. Manitoba Agriculture currently recommends target plant stands of 23-28 plants/ft^2 for spring wheat, 18-23 plants/ft^2 for oat, and 22-25 plants/ft^2 for barley (Manitoba Agriculture 2017). With the introduction of semi-dwarf and higher yielding cultivars, target plant stands may need to be adjusted to maximize profitability. Pervious research has shown that optimum plant populations can differ by both crop type and variety. In a North Dakota study, Mehring et al. (2016) found that optimum seeding rates for spring wheat ranged from 14 to 46 plants/ft^2 depending on the characteristics of the variety.

Materials and Methods

- Locations: Arborg, Carberry, Melita, and Roblin
- Experimental Design: Randomized complete block design with factorial treatments and replicated three times
- Treatments: Two cultivars of spring wheat, oat, and barley planted at five seeding rates. Target plant populations were 15, 21, 27, 33, and 39 plants/ft^2. See Table 2 for a complete treatment list.
    - Experiments were separated by crop type
    - Seeding rates were calculated based on thousand kernel weight and assumed 15% seedling mortality
- Data Collection: Plant stand, mortality, heads/plant, and yield.
    - Heads/plant was not collected at Carberry

- A late season hail storm damaged wheat and oat plots in Arborg. Yield data from Arborg wheat and oats is not included in this report

Table 2. Crop types, varieties, and target plant stands studied.

Crop Type	Variety	Target Plant Stand (pl/ft^2)
Spring Wheat	AAC Brandon	15
	AAC Brandon	21
	AAC Brandon	27
	AAC Brandon	33
	AAC Brandon	39
	Prosper	15
	Prosper	21
	Prosper	27
	Prosper	33
	Prosper	39
Oat	CS Camden	15
	CS Camden	21
	CS Camden	27
	CS Camden	33
	CS Camden	39
	Summit	15
	Summit	21
	Summit	27
	Summit	33
	Summit	39
Barley	AAC Synergy	15
	AAC Synergy	21
	AAC Synergy	27
	AAC Synergy	33
	AAC Synergy	39
	CDC AUSTENSON	15
	CDC AUSTENSON	21
	CDC AUSTENSON	27
	CDC AUSTENSON	33
	CDC AUSTENSON	39

Table 3. Agronomic information for wheat, oat, and barley trials.

Crop	Location	Seeding Date	Fertility (lb/acre) Available	Fertility (lb/acre) Applied	Herbicides	Spray Date	Harvest Date
Wheat	Arborg	19-May	107 N, 34 P	75 N, 25 P	Curtail @ 0.81 L/ac, Axial @ 0.48 L/ac	09-Jun	31-Aug
	Carberry	05-May	41 N	100 N, 17 P	Infinity @ 0.33 L/ac, Puma @ 0.412 L/ac	05-Jun	22-Aug
	Melita	10-May	10 N, 18 P	126 N, 35 P	Mextrol 450 @ 0.5 L/ac	06-Jun	28-Aug
	Roblin	17-May	86 N, 20 P	130 N, 10 P	RoundUp WeatherMAX @ 0.51L/acre	18-May	01-Sep
					Prestige XCA @ 0.26 L/ac + Axial BIA @ 0.96 L/ac	27-Jun	
					RoundUp @ 0.67 L/ac	24-Aug	
Oat	Arborg	19-May	107 N, 34 P	75 N, 25 P	Curtail @ 0.81 L/ac	08-Jun	07-Sep
	Carberry	12-May	41 N	30 N, 17 P	Bucktril M @ 0.4 L/ac	08-Jun	22-Aug
	Melita	10-May	13 N, 15 P	116 N, 35 P	Mextrol 450 @ 0.5 L/ac	06-Jun	23-Aug
					Roundup @ 0.5 L/ac	16-Aug	
	Roblin	18-May	86 N, 20 P	15 N, 10 P	RoundUp WeatherMax 0.51 L/ac	18-May	04-Sep
					Prestige XCA @ 0.17 L/ac	12-Jun	
					Roundup @ 0.67 L/ac	24-Aug	
Barley	Arborg	18-May	107 N, 34 P	75 N, 25 P	Curtail @ 0.81 L/ac + Axial @ 0.48 L/ac	09-Jun	29-Aug
	Carberry	12-May	54 N, 24 P	70 N, 17 P	Infinity @ 0.33 L/ac + Puma @ 0.412 L/ac	05-Jun	22-Aug
	Melita	09-May	13 N, 15 P	80 N, 35 P	Mextrol 450 @ 0.5 L/ac	06-Jun	14-Aug
	Roblin	18-May	86 N, 20 P	38 N, 10 P	RoundUp WeatherMax 0.51 L/ac	18-May	01-Sep
					Prestige XCA @ 0.26 L/ac + Axial BIA @ 0.96 L/ac	27-Jun	
					RoundUp @ 0.67 L/ac	24-Aug	

References

Crop Production. 2017. Manitoba Agriculture. Available online: https://www.gov.mb.ca/agriculture/crops/production/index.html

Mehring, G., Wiersma, J., and Ransom, J. 2016. What do the results from the recent seeding rate studies suggest for new spring wheat varieties? NSDU Crop and Pest Report. Available online: https://www.ag.ndsu.edu/cpr/plant-science/what-do-the-results-from-recent-seeding-rate-studies-suggest-for-new-spring-wheat-varieties-05-05-16

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

Effects and interactions of variety use, plant growth regulators, and fertility in high yielding winter wheat production in Manitoba

Cooperators: Ducks Unlimited Canada – Ken Gross
Manitoba Diversification Centres Field Trial Locations: Arborg, Carberry, Melita, Roblin

Trial Objectives:

- Assess BMPs for winter wheat production in terms of harvest management, yield, and protein quality.
- Integrate BMPs such as variety use, nitrogen application timing and rate, plant growth regulators (PGRs), and fungicides to achieve high yielding winter wheat.
- Understand the interaction between variety use, nitrogen application, and PGRs on yield, harvest management and protein quality parameters in high yielding winter wheat.

Introduction

Winter wheat can be a high yielding crop on the prairies. With producers aiming for higher yields and better protein values in winter wheat, come risks such as lodging. Lodging is the inability of a plant to sustain its own weight causing the plant to fall over. Factors that influence lodging include variety use (genetic) and environmental conditions such as heavy rain, wind, hail, disease issues, and often elevated soil fertility. Farmers often aim for high yield and high protein by utilizing high nitrogen fertilizer rates but this often results in a difficult to harvest crop that has lodged. Choice of variety, use of fungicides, and potentially plant growth regulators (PGRs) can reduce risk of lodging.

Palisade EC (Trinexapac-ethyl) is a plant growth regulator that has several highlights (syngenta.com) such as:

- Shortens internodes to reduce crop height and lower center of gravity, which improves crop standability and mitigates risk from adverse weather
- Increases stem thickness and diameter to help strengthen the stem and decrease lodging, which avoids harvest delays, yield loss and reduced grain quality
- Has very good crop tolerance when applied between Feekes Growth Stages 4 to 7 and under favorable environmental conditions

The Manitoba Diversification Centres, in collaboration with Duck Unlimited Canada aimed to determine the effects of nitrogen rate, variety and use of a plant growth regulator (Palisade EC) on winter wheat performance in terms of yield potential, crop height, and lodging. A small plot trial was designed to test these factors over one year in four locations across Manitoba.

Treatments and Design: Split-Split Plot Design, 3 replicates

Factor 1: Fertility (main plot)

1. 70% in Fall recommended Rate N (this is what the traditional farmer will do)
2. 100% Fall (Blend) all down at once.
3. 70% Fall (Blend) + 30% spring applied (use either UAN or granular Urea with Agrotain ASAP in spring @ breaking of dormancy)
4. 70% Fall (Blend) + 30% spring applied (use either UAN or granular Urea at Boot; Zadoks 32)

Factor 2: Variety (sub plot)

1. AAC Gateway, Gateway has "very good" lodging resistance. High Yielding, CWRW wheat class
2. AAC Wildfire. Wildfire has "good" lodging resistance. High Yielding, CWRW wheat class

Factor 3: PGR (sub-sub plot)

1. Control (without)
2. Palisade – applied at first node detectible (Feeks 4-7 or Zadoks 31-33)

<u>All sites had to abide by the following agronomic practices:</u>

Seeding Rate is 33 plants/ft^2. Seed Treated with Raxil Pro. A single seed source was used for all sites.

Weed control:

a. Pre-seed burn off
b. Winter annual in fall if required
c. Spring broadleaf if required

Fertilizer Program:

- Provide fertility for 250 lbs/ac N as 100% rate ([soil N x 1.4] plus applied N) to achieve 120 bu/ac wheat yield
- Fall treatments use 50/50 blend of ESN and straight urea (46-0-0 granular)
- P, K are applied for removal rates plus 10%. Phosphorous is 0.56 lbs/bu plus 10% (73 lbs/ac P), K is 0.37lbs/bu plus 10% (49 lbs/ac K)
- Sulfurs normal recommendation in soil tests say 10-20 lb/ac or 0.16 lb/bu
- Side band all base fertilizer in the fall (NPKS)
- Broadcast spring nitrogen (with Agrotain) at dormancy or boot stages

Trials were located in Arborg, Roblin, Carberry and Melita across the province of Manitoba. Carberry will be omitted from the report data set since this location used a different PGR and may have had an environmental influence during application of PGRs with a north wind, thus skewing treatment effects. Specific agronomic information is located in the table below for each location.

Specific Site Agronomy:

Location	Melita	Carberry	Roblin	Arborg
Soil Series	Waskada Loam	Wellwood Loam	Erickson Loamy Clay	Peguis Clay
Pre-Seed Soil Test (0-24")				
N - lbs/ac	71	63	42	66
P- ppm	3	10	26	38
K - ppm	218	327	302	400
S - lbs/ac	114	48	46	234
Burnoff Date	15-Sep-16	15-Sep-16	17-Sep-16	1-Sep-16
Product	Roundup	Roundup	Roundup	Roundup
Seed Date	15-Sep-16	20-sep-16	16-Sep-16	2-Sep-16
Seed Depth	0.5"	1"	0.5"	0.75"
Fall Base Fertilizer (Less ESN/Urea Blend per treatment)				
N – lbs/ac	33	9	33	11
P – lbs/ac	73	40	73	50
K – lbs/ac	48	0	48	50
S – lbs/ac	21	0	21	
Spring Top Up Fertilizer Dates	Apr 20 (dorm) 29-May (boot)	24-Apr May	24-Apr May	Apr 30-May
In-crop Herbicides Date	11-May-17	5-Jun-17	None	None
Herbicide Product	Achieve, Mextrol	Tundra	None	None
PGR Date	26-May-17	16-May-17	5-Jun-17	5-Jun-17
Fungicide Date	16-Jun-17	June 19, July 5	10-Jul-17	26-Jun-17
Fungicide product/rate	Prosaro	Prosaro	Prosaro	Prosaro
Harvest Date	28-Jul-17	11-Aug-17	30-Aug-17	15-Aug-17

Data collected includes; lodging ratings at maturity, crop height at maturity, grain yield, grain moisture, test weights, and protein content. Data was combined and analyzed with an analysis of variance for each site (with interaction) and a REML analysis for all sites combined data using Agrobase Gen II statistical software. Probabilities of each factor were determined in addition to coefficient of variation, and least significant difference (LSD).

Results

There were significant differences overall in crop height and yield in regards to variety used and whether or not a PGR was applied. Individual site response was variable with use of variety or PGRs but not fertility. There were no significant interactions at Arborg or Roblin. There were some interactions between factors in Melita and Roblin which suggests that a combination of type of variety, use of PGRs or changes in fertility can play a role in crop height or yield response. In Melita, this interaction with fertility, PGRs or variety may have been exacerbated by local salinity effects on crop height. Overall and by individual location there were no differences in yield, crop height, or lodging among the use of fertility treatments after combining site data. This may have to do with low precipitation values for each site over the growing season. Percent of normal summer rainfall (Apr

15 - Aug 31) amounts where: Melita 78%, Roblin 63%, Arborg – 87%. Reference: Manitoba Ag Weather Program.

Lodging was significant in Arborg with both varieties or the use of PGRs. Fertility treatments did not have an effect on lodging.

Table 1: Probability of response to factors (variety, PGR, fertility) on crop height, lodging, and yield at locations Arborg, Melita and Roblin and overall.

Factor	Crop Height (cm)				Yield (kg/ha)				Lodge (1-5)
	Arborg	Melita	Roblin	All Sites	Arborg	Melita	Roblin	All Sites	Arborg
Variety	**0.001**	0.941	**0.002**	**0.016**	**<0.001**	**<0.001**	**0.006**	**<0.001**	**<0.001**
PGR	0.163	**0.002**	**0.001**	**<0.001**	**0.002**	0.166	**0.017**	**<0.001**	**0.048**
Fertility	0.694	0.704	0.865	0.787	0.575	0.985	0.462	0.416	0.157
Variety x PGR	0.847	0.149	0.494	0.226	0.117	0.494	0.352	0.751	0.489
Variety x Fertility	0.991	**0.014**	0.094	0.543	0.420	0.425	**0.017**	0.356	0.108
PGR x Fertility	0.822	**0.021**	0.677	0.614	0.555	0.975	0.906	0.899	0.493
Variety x PGR x Fertility	0.763	**0.004**	0.458	0.252	0.541	0.586	0.152	0.604	0.493
Coefficient of Variation	19.1	7.6	9.1	-	7.1	7.8	5.6	-	7.1
LSD Variety	**1.8**	4.0	**3.5**	3.441	**211**	**267**	**372**	176.4	**0.17**
LSD PGR	9.9	**3.5**	**4.0**	3.441	**312**	297	**208**	176.4	**0.25**
LSD Fertility	4.9	13.3	9.3	NS	NS	NS	NS	NS	NS
LSD Variety x PGR	13.9	5.0	5.7	NS	NS	NS	NS	NS	NS
LSD PGR x Fertility	19.7	**7.1**	8.1	NS	NS	NS	NS	NS	NS
LSD Fertility x Variety	19.7	**7.1**	8.1	NS	NS	NS	**416**	NS	NS

NS – not significant

Both Roblin and Arborg observed greater crop height of Wildfire compared to Gateway. All sites observed greater yield with Wildfire as well and Roblin experiencing slightly greater lodging with Wildfire compared to Gateway. With all data combined, both height and crop yield were significantly greater for Wildfire compared to Gateway.

At all sites, use of PGRs resulted in a shorter crop on average by 8 cm. However, use of a PGR also resulted in a 5% yield decrease when site data was combined. The Melita location did not experience a yield loss despite having the same response in crop height.

Table 2: Mean crop height, lodging, and yield responses to variety use, PGR application and nitrogen fertility in locations Arborg, Melita, and Roblin, and all sites combined overall.

Treatment			Crop Hieght (cm)			Yield (kg/ha)			Lodge (1-5)	Combined Sites Means and LSD			
Variety	PGR	Fertility	Arborg	Melita	Roblin	Arborg	Melita	Roblin	Arborg	Hieght	REML LSD	Yield	REML LSD
Gateway			**83**	76	**69**	**6781**	**5746**	**5823**	**1.08**	**76**	3.4	**6121**	176
Wildfire			**87**	76	**77**	**7703**	**6785**	**6460**	**1.75**	**80**		**6979**	
	Control		88	**79**	**77**	**7520**	6368	**6272**	**1.54**	**82**	3.4	**6726**	176
	PGR		82	**72**	**69**	**6964**	6164	**6011**	**1.29**	**74**		**6374**	
		70-30_Boot	85	78	71	7356	6309	6344	1.33	78	NS	6674	NS
		70_Fall	86	77	75	7091	6200	6250	1.25	79		6513	
		100_Fall	84	77	74	7286	6298	6014	1.58	78		6532	
		70-30_Dorm	85	71	73	7233	6310	5959	1.50	77		6481	

NS – not significant

Tables 3: Mean interaction effects of variety use, PGRs and fertility on crop height and yield by specific location.

Height by Site Means Table

Site	Gateway		Wildfire	
	PGR Control	PGR Applied	PGR Control	PGR Applied
Melita	76		76	
	78	76	81	70
Arborg	83		87	
	86	80	91	83
Roblin	69		77	
	73	66	82	73

Yield by Site Means Table Variety x PGR

Site	Gateway		Wildfire	
	PGR Control	PGR Applied	PGR Control	PGR Applied
Melita	5746		6785	
	5799	5694	6936	6634
Arborg	6781		7703	
	7181	6380	7859	7547
Roblin	5823		6460	
	5907	5740	6638	6282

Height by Site Means Fertility x PGR

Site	PGR Control				PGR Applied			
	70-30_Boot	70_Fall	100_Fall	70-30_Dorm	70-30_Boot	70_Fall	100_Fall	70-30_Dorm
Melita	84	81	76	76	71	74	**79**	66
Arborg	86	90	90	87	85	81	77	83
Roblin	76	79	76	78	67	70	72	69

Yield Site Means Fertility x PGR

Site	PGR Control				PGR Applied			
	70-30_Boot	70_Fall	100_Fall	70-30_Dorm	70-30_Boot	70_Fall	100_Fall	70-30_Dorm
Melita	6403	6319	6439	6309	6216	6080	6158	6201
Arborg	7544	7334	7505	7698	7169	6848	7067	6770
Roblin	6487	6326	6192	6084	6201	6174	5836	5834

Height by Site Means Variety x Fertility

Site	Gateway				Wildfire			
	70-30_Boot	70_Fall	100_Fall	70-30_Dorm	70-30_Boot	70_Fall	100_Fall	70-30_Dorm
Melita	78	79	81	**68**	78	75	73	76
Arborg	83	83	81	84	88	89	86	86
Roblin	67	74	66	70	76	75	81	76

Yield Mean Variety x Fertility

Site	Gateway				Wildfire			
	70-30_Boot	70_Fall	100_Fall	70-30_Dorm	70-30_Boot	70_Fall	100_Fall	70-30_Dorm
Melita	5730	5567	5982	5706	6889	6832	6615	6804
Arborg	6971	6414	6934	6805	7742	7768	7638	7663
Roblin	5893	5944	5526	5930	6795	6556	6502	**5988**

Conclusions

- Application of Palisade reduced crop height by 8 cm on average over all sites
- Application of Palisade also reduced crop yield by 5% overall. Yield was reduced in two of our three sites by use of Palisade.
- In Arborg, the use of Palisade PGR reduced lodging effect by 16% for Gateway and Wildfire combined.
- Wildfire compared to Gateway is more at risk for lodging due to height and yield capability.

Nitrogen Management Strategies for High-Yielding Spring Wheat in Manitoba

Amy Mangin and Don Flaten, University of Manitoba

Introduction

The overall purpose of this project was to determine the optimum nitrogen (N) fertilization strategies for high-yielding spring wheat in Manitoba. Researchers at the University of Manitoba, in collaboration with other partners, completed 8 site-years of field trials during the 2016 and 2017 growing seasons, using AAC Brandon (Canadian Western Red Spring class, CWRS) and Prosper (Canadian Northern Hard Red class, CNHR) spring wheat. High intensity, gold level experiments were conducted at Carman and Brunkild during both years (4 site-years), and less intensive, silver level experiments were conducted at Melita in both years, Carberry in 2016 and Grosse Isle in 2017 (4 site-years).

The potential yields for current varieties of spring wheat being grown across Manitoba are much higher than what they have been in the past and as a result, large amounts of N are required to achieve these yields. Pre-plant Nitrate-N tests are often used to measure the amount of early season available N in soil and, paired with the target yield for a particular field and year, are used to determine the current N recommendations for applied N.

Discussion

Yield and protein results for this study showed no biophysical interactions between N rate and variety, indicating that Prosper consistently out-yielded AAC Brandon, while AAC Brandon had constantly higher grain protein content across all N rates. The average total supply of N (spring soil test Nitrate-N + fertilizer N) required to obtain economic optimum yields across site-years in this project was 1.99 lbs N/bu, which is less than our current recommendation of 2.5 lbs N/bu; however, optimum economic rates of total N supply per bushel varied substantially, especially at silver level sites.

One of the reasons for this variability in optimum rates of N was the variability in growing season mineralization of soil N, especially across silver level sites, which resulted in large deviations from expected N supply from the soil. Conventional recommendations for the total supply of N do not take into account the variation in organic reserves of soil N that are released through mineralization during the growing season. Our study revealed that it is extremely difficult to use a pre-plant soil test to predict the amount of N that will be mineralized during the growing season across locations, probably due to variability in environmental conditions and management histories across sites and years.

Due to this uncertainty in soil N supply during the growing season it could be beneficial to apply enough N at planting to meet a modest yield goal and re-visit the question of N sufficiency for yield and protein potential once the crop is established. In this study, rainfall often occurred shortly after midseason applications of N, enabling split N application at planting and at stem elongation or flag leaf stages to yield at least as much grain as equivalent rates applied entirely at planting. At gold level sites, grain protein content increased with stem elongation split applications, compared to when N was applied entirely at planting. Flag leaf split applications consistently increased grain protein content compared to equivalent rates of N applied at planting and stem elongation split applications (0.3 – 0.7%). Late season post-anthesis N applications consistently increased grain protein content (1.1 – 1.8%), regardless of N source, but did not increase grain yield, compared to treatments with N applied only at planting. However, post-anthesis applications of urea solution increased grain yield (4.5 bu/ac) and protein content (0.6%) above that for post-anthesis applications of UAN.

The effectiveness of in-season N applications at stem elongation and flag leaf timing indicates that there is potential for delaying a portion of N fertilizer in-season without decreasing yield. To help determine whether in-season applications would be warranted, several vegetative indices were evaluated for their ability to predict grain yield. GreenSeeker and SPAD Meter were relatively reliable for predicting grain yield when combined across site-years and varieties, regardless of when these measurements were taken. NDVI measured by the GreenSeeker had the best relationship with final grain yield, in particular when it was measured at flag leaf timing, which coincided well with the responses to midseason applications of N fertilizer at this timing. Grain protein content was much more difficult to predict across site-years and varieties, probably due to the uncertainty of late season N supply from soil N mineralization.

Post-harvest soil residual NO_3-N measurements indicated that residual N typically did not begin to climb until N fertilization rates exceeded the economic optimum. When comparing economic optimum N rates to the amount of post-harvest NO_3-N in the top 2 feet (60 cm) of soil, we determined that if residual levels were greater than 55 lbs N/ac, the N supply was likely more than adequate for reaching the optimum economic yield of spring wheat at that field site in that year.

A full report can be found on the Manitoba Wheat & Barley Growers Association website at: http://www.mbwheatandbarley.ca/wp-content/uploads/2018/05/Mangin-Flaten-N-mgmt-for-HY-wheat-project-revised-technical-report-2018-03-31.pdf

Advanced Forage Barley Variety Evaluation

Cooperators

- AAFC Brandon – Dr. Ana Badea – Barley Breeder
- AAFC Brandon – Rudy Von Hertzberg – Research Technician

Background

Forage barley varieties produce high total biomass but usually have insufficient grain yield to compete with regular varieties when only grain production is desired. Thus, the barley breeding effort at AAFC Brandon is aiming to develop new varieties of dual purpose six-row forage-feed barley well-suited to western Canada with improved disease resistance and agronomic performance combined with enhanced quality.

Objective

To test the top barley forage-feed breeding lines from the barley breeding program at AAFC-Brandon for grain yield.

Research Site: Melita, MB
Cooperator: Wayne White
Soil Texture: Waskada Loam
Location: SW 22-3-27 W1
Previous Crop: Fall Rye

Soil Test:

		N	P	K	S	Organic Matter
Depth	pH	ppm	ppm Olsen	ppm	lbs/ac	%
0-24"	7.2	4	10	245	16	3.3

Methods

The trial consisted of 14 entries in plots that were 1.44m wide by 9m long. The experimental design of the trial was a randomized complete block design replicated 3 times. Plots were seeded with a Seedhawk opener on 9.5" spacing and soil moisture was good at the time of seeding. Plots were harvested with a Wintersteiger plot combine.

Seeding Date	Seeding Depth	Fertility	Herbicide	Spray Date	Harvest Date
May 9 2017	0.75"	80-35-25-10	Mextrol 450 @ 0.5L/ac	June 6 2017	August 14 2017

Plant material

Three registered feed varieties, AC Ranger, CDC Austenson, and Vivar, were grown at Melita this year, as well as 11 numbered breeding lines under evaluation for possible advancement to the 2018 registration trial as forage, feed or forage-feed entries.

Results and Discussion

There were significant differences in yield, test weight maturity and crop height (Table). There were no differences in leaf disease and lodging did not occur in any plots. In the testing conditions at the Melita site, of note is one barley line, ABH4079-144. This line had similar grain yield to AC Ranger check cultivar and higher yield than the other two check cultivars, Vivar and CDC Austenson.

Table: Agronomic characteristics and performance of varieties of forage barley in Melita, 2017.

Variety	Yield kg/ha	Test Weight g/0.5L	Maturity Days	Leaf Disease 1-9 (9 severe)	Height cm
AC Ranger	5961	290	86	4	73
ABH4079-144	5950	291	86	4	74
EX833-16	5777	290	86	5	83
Vivar	5745	291	83	5	68
ABH4079-125	5661	290	88	4	78
EX836-49	5655	296	86	4	80
CDC Austenson	5612	311	89	4	68
ABH4079-103	5601	292	86	5	79
EX838-12	5582	286	86	4	87
ABH4079-101	5525	283	86	5	80
A515-05-071	5474	299	84	5	67
AT-4077-098	5271	288	86	4	77
ABH4079-142	5137	291	86	4	79
EX838-9	5092	270	91	4	78
Grand Mean	5574	291	86	4	76
CV%	5	1	1	15	5
P value	0.029	<0.001	<0.001	0.254	<0.001
LSD (p<0.05)	498	5	2	NS	7

Grain samples were sent to AAFC in Brandon, MB for further testing. For more information on sample quality please contact Ana Badea Ana.Badea@AGR.GC.CA .

Acknowledgements

This research is part of the Barley Cluster project led by Alberta Barley with funding from Western Grains Research Foundation and Agriculture and Agri-Food Canada (AAFC) under the Growing Forward 2 program. We gratefully thank R. Von Hertzberg and Bryan Graham from AAFC Brandon Research and Development Centre, for technical assistance and WADO for continued support in growing and caring for the trials.

Advanced Six-Row Malt Barley Variety Evaluation

Cooperators

AAFC Brandon – Dr. Ana Badea – Barley BreederAAFC Brandon – Rudy Von Hertzberg – Research Technician

Background

The barley breeding effort at AAFC Brandon is aiming to develop new varieties of six-row malting barley well-suited to western Canada with improved disease resistance and agronomic performance, combined with enhanced quality traits to expand market opportunities at home and abroad.

Objective

To evaluate different breeding lines of six-row barley for malting and feed.

Research Site: Melita, MB
Cooperator: Wayne White
Soil Texture: Waskada Loam
Location: SW 22-3-27 W1
Previous Crop: Fall Rye
Soil Test:

		N	P	K	S	Organic Matter
Depth	pH	ppm	ppm Olsen	ppm	lbs/ac	%
0-24"	7.2	4	10	245	16	3.3

Methods

The trial consisted of 36 entries in plots that were 1.44m wide by 9m long. The experimental design of the trial was a randomized complete block design replicated 3 times. Plots were seeded with a Seedhawk opener on 9.5" spacing and soil moisture was good at the time of seeding. Plots were harvested with a Wintersteiger plot combine.

Seeding Date	Seeding Depth	Fertility	Herbicide	Spray Date	Harvest Date
May 9 2017	0.75"	80-35-25-10	Mextrol 450 @ 0.5L/ac	June 6 2017	August 17 2017

Plant material

Three registered malting varieties, Tradition, Celebration and CDC Mayfair, and two registered feed varieties, AC Ranger and CDC Austenson, were grown at Melita this year, as well as 31 numbered breeding lines under evaluation for possible advancement to the 2018 registration trial as malting or feed entries.

Results and Discussion

There were significant differences in days to heading, crop height, maturity and test weight.

Table: Agronomic characteristics and performance of varieties of malt barley in Melita, 2017.

Variety	Heading Days	Height cm	Leaf Disease 1 to 9 (9 severe)	Maturity days	Test WT g/0.5L	Grain kg/ha
A515-05-109	56	74	2	86	293	6940
A536-8	53	89	2	86	290	6881
A518-44	54	78	2	84	298	6739
A518-43	54	82	3	85	294	6704
ABH4081-29	54	83	3	86	286	6695
CDC Austenson	62	72	1	90	316	6681
ABH4079-101	57	92	2	90	288	6641
ABH4079-95	55	81	3	86	285	6577
ABH4081-30	54	78	3	85	290	6571
A518-22	56	81	3	85	294	6532
A520-27	54	77	3	84	290	6528
ABH4081-82	54	86	2	85	290	6507
AC Ranger	56	76	2	86	289	6506
A519-15	56	82	2	85	294	6504
ABH4079-87	57	80	2	86	283	6502
A515-03-068	55	84	2	86	290	6463
A523-10	57	81	3	86	285	6442
A515-03-113	56	73	3	88	293	6373
ABH4079-109	57	81	2	89	284	6197
Celebration	56	81	3	85	297	6185
SM131640	55	71	2	86	291	6156
A524-8	56	76	3	86	279	6088
CDC Mayfair	55	80	3	85	290	6085
A518-17	53	80	3	84	302	6068
ABH4079-120	56	82	3	86	287	6049
ABH4082-31	53	81	3	85	290	6049
A518-23	55	80	3	84	291	6014
Tradition	55	82	3	85	299	5997
A518-13	54	81	2	84	299	5956
A515-03-111	54	77	3	83	289	5940
A515-02-124	57	76	3	85	294	5872
A520-7	53	75	3	83	289	5812
A515-04-007	55	74	3	85	300	5764
A515-05-037	54	75	3	84	293	5756
A518-24	57	77	3	86	291	5627
ABH4082-44	53	80	2	84	298	5553
Grand Mean	55.27	79.41	2.546	85.34	291.8	6270
CV%	2	5	25	2	2	9
P value	<0.001	<0.001	0.347	<0.001	<0.001	0.160
LSD	2	7	NS	2	9	NS

There were no differences in grain yield or leaf diseases. In the testing conditions at the Melita site, more than half of the six-row malting breeding lines tested had higher grain yield than the malting checks cultivar Celebration, CDC Mayfair and Tradition with five of the them, A515-05-109, A536-8, A518-44, A518-43 and ABH4081-29, having similar grain yield to the feed check, CDC Austenson. Grain samples were sent to AAFC in Brandon, MB for further testing. For more information on sample quality please contact Ana Badea Ana.Badea@AGR.GC.CA .

Acknowledgements

This research is part of the Barley Cluster project led by Alberta Barley with funding from Western Grains Research Foundation and Agriculture and Agri-Food Canada (AAFC) under the Growing Forward 2 program. We gratefully thank R. Von Hertzberg and Bryan Graham from AAFC Brandon Research and Development Centre, for technical assistance and WADO for continued support in growing and caring for the trials.

2017 Corn Nitrogen Rate Study

John Heard, CROPS Manitoba Agriculture

Background

Manitoba Agriculture nitrogen rate guidelines for corn[1] were developed before 1990 and are out-of-date for current yield levels. Recently NDSU has released N rate guidelines for corn[2] and a number of in-season crop scouting measures have been developed to assess sufficiency and need for more N. The following study was initiated to evaluate a number of N decision guides for suitability in fertilizing corn in Manitoba.

Methods

Three locations were located with cooperating farmers near Letellier, Winkler and Carman. Additional sites were research stations at Portage (AAFC) and Melita (managed by Manitoba Agriculture staff through WADO). Nitrogen rates of 0-200 lb N/ac were applied after planting but prior to emergence (PRE) as surface broadcast SuperU (46-0-0). An in-season, split N application to simulate the Y-drop method was as UAN solution (28-0-0) dribbled at either the V4 or V8 stage of corn on each side of the corn plant. For the split N plots, base rates were 40 or 80 lb N/ac and followed by 40 or 80 lb N/ac in season. Site description, weather, field activities and observations are listed in Tables 1-4.

Table 1: Site cropping history, soil characteristics and 2017 growing conditions.

Site	Letellier	Winkler	Carman	Melita	Portage
Cooperator	G Fontain	Southern Potato	Tyler Russell	WADO S Chalmers	CMCDC C Cavers
Soil type	Dencross clay	Reinland sand loam	Neuenberg loam	Waskada loam	Dugas clay
Prev crop	soybean	potatoes	Dry beans	barley	CRWS wheat
Soil analysis					
Nitrate-N lb/ac in 0-6" 6-24" 24-48"	 23 23 32	 21 39 51	 14 30 27	 14 14 40	 16 29 16
4 week min test – nitrate-N lb/ac	70	45	28	36	29
OM%	7.2	3.1	4.6	3.7	5.3
P ppm Olsen	12	25	17	36	6
K ppm	385	205	349	488	302
S lb/ac	70	159	161	102	58
Zn ppm	1.1	2.6	2.4	1.8	1.0
pH	7.9	7.5	6.1	6.5	8

Table 2: Weather and soil moisture

Site	Letellier		Winkler		Carman		Melita	Portage
Gravimetric Soil Moisture	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Spring
0-1’	39.6	29.1	23.3	18.8	24.8	18.9		34.2
1-2’	35.7	23.4	25.3	15.4	25.1	13.8		34.9
2-3’	34.3	20.8	22.2	14.3	25.1	16.5		31.4
3-4’	34.3	22.2	27.6	20.8	27.6	24.7		34.7
Total 0-4’	36.0	23.9	24.6	17.3	25.6	18.5	18.2	33.8
May-Oct weather								
Crop Heat Units	3019		2943		2702		2550	2807
% of normal	-		-		99%		106%	96%
Precipitation (in)	10.1		9.2		8.3		7.2	8.8
% of normal	-		-		62%		61%	66%

Table 3: Field Practices.

Site	Letellier	Winkler	Carman	Melita	Portage
Planting Date	May 7	May 3	May 4	May 15	May 15
Hybrid				DKC 26-28	DKC 26-28
Population ('000/ac)					34,000
Sidebanded fertilizer					
MAP lb P2O5/ac				8-40-0	40 lb P2O5/ac
Potash lb K2O/ac					
Pest management					
Herbicide1				May 23 sprayed+ Roundup 1L/ac + Aim at 15ml/ac @ 10 gal/ac	15-May Battalion/Elim @ 24 g/ac Dual II Magnum @ 300 mL/ac Banvel II @ 300 mL/ac
Herbicide 2				June 27 1.5REL Glyphosate + .4L/ac Koril	26-Jun 0.67 L/ac glyphosate
Machine Harvest	Oct 19	Oct 6	Oct 5	Oct 20	Oct 31

Table 4: Treatment applications and crop observations.

Site	Letellier	Winkler	Carman	Melita	Portage
Nitrogen Treatments					
Soil sampling (initial N and soil water)	April 21	May 1	April 26	May 3	May 5
PRE N	May 11	May 10	May 9	May 18	May 19
V4 N PSNT, SPAD, GreenSeeker, Height	June 12 V5	June 8 V4	Jun 7 V4	June 15 V3	June 20 V2-V4
V8 N SPAD, GreenSeeker	July 6 V8	Early July V8	July 8 V8	July 17 V7	July 18 V8
Observations					
Emergence populations (per ac)	Jun 12 37,400	Jun 9 36,800	Jun 9 38,800	Jun 15 67,000	Not reported
N Deficiency Leaf rating GL	Aug 23 R3	Aug 23 R3	Aug 24 R3	Sept 6 R4	Aug 31 R3
Stalk N sampling	Oct 11	Oct 5	Oct 4	nd	nd
Hand harvest dates	Oct 13	Oct 5-6	Oct 5	nd	nd
Residual N sampling (ending N and soil water)	Oct 16	Nov 13	Nov 9	nd	nd

- PRE N is surface application of SuperU fertilizer at the pre-emergent stage of corn.

- PSNT (pre side dress Nitrate-N test) soil sample taken between the rows to a depth of 12” at the V4 stage.
- SPAD chlorophyll readings measured of the mid-leaf of the earliest leaf with a developed collar. SPAD values are referenced as an index of those measured at full N rates.
- GreenSeeker readings of NDVI measured with the pocket GreenSeeker.
- Height (HT) is the height to the top of the whorl, determined in inches.
- N deficiency ratings are the number of corn leaves in 10 plants with green leaves (GL) with no N deficiency at the 3rd, 4th and 5th leaf below the ear. According to SDSU scouting procedures[5].
- nd = not determined at this site.

Results:

Results are reported by location. Insufficient resources were available for statistical analyses. Amy Mangin provided cursory statistical analyses of yields.

Table 5: Letellier corn response.

Stage	R6	V4				V8		R3			Post harvest Soil nitrate-N lb N/ac			Post harvest
Treatments lb N/ac	Grain yield	PSNT	GS1	SPAD1	HT1	GS2	SPAD2	GL 3rd	GL 4th	GL bot	0-24"	24-48"	Total 0-48"	Stalk-Nitrate ppm
1=0N	145.5 b	100	0.41	41.1	17.3	0.78	50.3	8.5	2.3	0.0	45	12	57	53
2=40N	159.3 ab	130	0.45	44.4	19.0	0.77	50.1	9.8	4.8	0.0	51	14	65	42
3=80N	174.9 ab	152	0.44	42.9	17.4	0.80	52.2	10.0	9.0	0.0	71	13	84	38
4=120N	181.6 a		0.45	42.4	18.2	0.77	50.5	10.0	9.8	0.0	102	13	115	199
5=160N	184.6 a		0.45	42.7	17.6	0.78	52.6	10.0	10.0	0.0	122	16	138	305
6=200N	181.2 a		0.42	42.5	18.5	0.80	52.2	10.0	10.0	0.0	162	15	177	1193
7=40N+V4 40N	173.8 ab		0.42	41.8	16.8	0.80	52.3	10.0	9.5	0.0				102
8= 40N+V4 80N	172.1 ab		0.43	40.9	16.9	0.75	51.6	10.0	9.3	0.0				131
9=80N+V4 40N	178.2 a		0.43	42.2	16.3	0.75	50.4	10.0	10.0	0.0				436
10= 40N+V8 40N	160.5 ab		0.43	43.3	19.1	0.77	49.0	10.0	4.3	0.0				38
11=40N+V4 80N	175.9 ab		0.45	41.6	17.0	0.79	50.4	9.8	7.3	0.0				27
12= 80N+V4 40N	177.1 a		0.43	42.9	16.0	0.78	51.1	10.0	9.5	0.0				26
Sign.	5% level	nd	Nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

Comments: good weed control, good stand

Table 6: Winkler corn response.

Stage	R6	V4				V8		R3			Post harvest Soil nitrate-N lb N/ac			Post harvest
Treatments lb N/ac	Grain yield	PSNT	GS1	SPAD1	HT1	GS2	SPAD2	GL 3rd	GL 4th	GL bot	0-24"	24-48"	Total 0-48"	Stalk-Nitrate ppm
1=0N	172.8	62	0.31		13.9	0.74	52.5	7.3	3.5	0	17	30	47	477
2=40N	178.2	108	0.30		15.3	0.71	52.7	9.3	6.8	0	26	50	76	936
3=80N	179.0	140	0.29		17.6	0.72	55.0	10.0	9.0	0	33	38	71	937
4=120N	185.5		0.29		14.2	0.73	50.7	10.0	10.0	0	41	43	84	1843
5=160N	185.0		0.29		14.5	0.73	53.8	10.0	10.0	0	41	29	70	1943
6=200N	179.5		0.28		16.0	0.72	54.3	10.0	10.0	0	57	54	111	2882
7=40N+V4 40N	178.3		0.28		14.6	0.71	53.7	10.0	10.0	0				2287
8= 40N+V4 80N	178.7		0.30		15.3	0.72	55.9	10.0	9.8	0				1842
9=80N+V4 40N	189.5		0.30		14.4	0.72	55.9	10.0	9.5	0				2143
10= 40N+V8 40N	178.1		0.28		13.6	0.70	53.3	9.8	8.8	0				901
11=40N+V4 80N	181.9		0.33		14.2	0.73	53.8	10.0	9.5	0				779
12= 80N+V4 40N	180.5		0.29		15.1	0.69	55.1	10.0	10.0	0				817
Sign.	ns	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Nd

Comments: excellent stand and weed control.

Table 7: Carman corn response.

Stage	R6	V4				V8		R3			Post harvest Soil nitrate-N lb N/ac			Post harvest
Treatments lb N/ac	Grain yield	PSNT	GS1	SPAD1	HT1	GS2	SPAD2	GL 3rd	GL 4th	GL bot	0-24"	24-48"	Total 0-48"	Stalk-Nitrate ppm
1=0N	143.4	59	0.27	45.6	10.3	0.75	51.5	2.5	0.8	0.0	43	16	59	937
2=40N	165.0	70	0.29	45.0	11.3	0.75	51.6	5.8	3.8	0.0	37	15	52	389
3=80N	161.6	72	0.26	44.1	9.7	0.77	55.2	8.8	5.0	0.0	41	13	54	950
4=120N	162.6		0.27	44.8	10.8	0.76	51.6	8.5	6.5	0.0	46	16	62	3169
5=160N	162.4		0.25	46.9	10.6	0.76	53.2	7.5	7.0	0.0	45	15	60	3130
6=200N	167.6		0.30	47.4	11.0	0.77	52.8	9.0	7.8	0.0	63	17	80	3932
7=40N+V4 40N	166.1		0.24	44.5	11.5	0.75	52.9	5.8	2.8	0.0				1300
8= 40N+V4 80N	164.6		0.26	46.8	10.0	0.75	52.9	7.3	5.0	0.0				2869
9=80N+V4 40N	159.2		0.28	45.4	9.2	0.78	52.9	8.3	6.3	0.0				2491
10= 40N+V8 40N	147.0		0.29	45.5	11.5	0.74	52.7	8.0	5.3	0.0				1376
11=40N+V4 80N	161.5		0.25	44.8	10.7	0.76	51.7	6.0	4.3	0.0				1668
12= 80N+V4 40N	159.0		0.24	42.3	10.4	0.73	54.3	5.8	4.0	0.0				1979
Mean														
Sign.	ns	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Nd

Comments: excellent stand and weed control. Some plot row trampling with field operations – spraying, Y-dropping.

Table 8: Melita corn response.

Stage	R6	V4				V8		R4		
Treatments lb N/ac	Grain yield	PSNT	GS1	SPAD1	HT1	GS2	SPAD2	GL 3rd	GL 4th	GL bot
1=0N	68.7 b	37	0.14	43.7	6.3	0.71	40.6	0.0	0.0	0.0
2=40N	91.6 ab	60	0.14	42.4	6.5	0.74	49.0	0.0	0.0	0.0
3=80N	98.4 ab	75	0.15	45.2	6.9	0.77	49.3	0.3	0.0	0.5
4=120N	111.1 a		0.15	40.4	6.8	0.80	52.3	0.0	0.0	0.0
5=160N	104.5 a		0.15	44.5	7.3	0.79	52.6	0.0	0.0	0.0
6=200N	103.9 a		0.15	39.9	6.4	0.77	51.4	1.0	0.0	2.0
7=40N+V4 40N	102.5 a		0.16	43.1	8.2	0.76	48.8	0.0	0.0	0.3
8= 40N+V4 80N	107.5 a		0.14	41.2	6.9	0.78	53.1	0.0	0.0	0.0
9=80N+V4 40N	104.6 a		0.15	43.4	6.8	0.74	52.0	0.0	0.0	0.3
10= 40N+V8 40N	101.1 a		0.15	43.6	7.2	0.75	46.6	0.8	0.0	1.8
11=40N+V4 80N	95.2 ab		0.14	44.6	7.4	0.78	46.3	0.0	0.0	0.0
12= 80N+V4 40N	106.3 a		0.15	46.9	6.9	0.75	50.3	0.0	0.0	0.5
Mean										
Sign.	5%	nd	nd	nd	nd	nd	nd	nd	nd	nd

Comments: very high population (final stand of 44,500 plants per acre) contributed to drought stress and limited yield potential.

Table 9: Portage corn response.

Stage	R6	V8		R3		
Treatments lb N/ac	Grain yield	GS2	SPAD2	GL 3rd	GL 4th	GL bot
1=0N	85.7	0.67	49.5	3.5	1.5	0
2=40N	98.7	0.69	49.8	5.8	3.3	0
3=80N	107.4	0.60	53.2	8.0	6.0	0
4=120N	112.6	0.67	52.0	9.8	8.3	0
5=160N	115.2	0.51	53.3	10.0	9.3	0
6=200N	115.1	0.67	53.4	10.0	10.0	0
7=40N+V4 40N	102.3	0.59	51.0	5.3	2.5	0
8= 40N+V4 80N	108.5	0.67	50.9	8.0	5.8	0
9=80N+V4 40N	114.4	0.57	54.1	9.0	5.8	0
10= 40N+V8 40N	101.3	0.62	50.9	6.5	3.3	0
11=40N+V4 80N	96.9	0.57	51.2	8.3	5.0	0
12= 80N+V4 40N	107.3	0.69	52.1	9.0	6.5	0
Mean						
Sign.	ns	nd	nd	nd	nd	nd

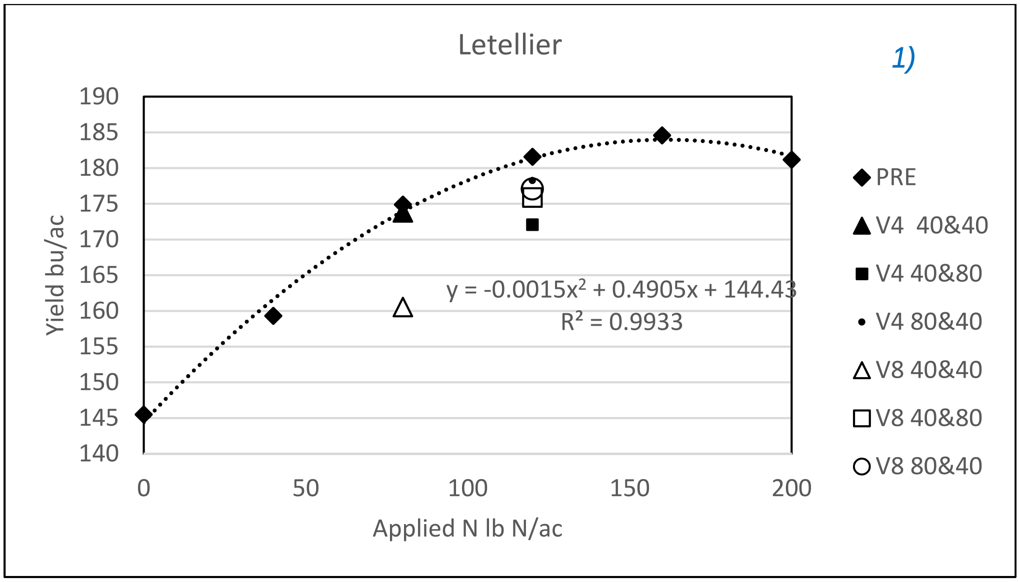
Comments: Seeded into cloddy seedbed resulting in spotty emergence and populations. Plant assessments on June 20 showed plants ranging from VE to V4 stage.

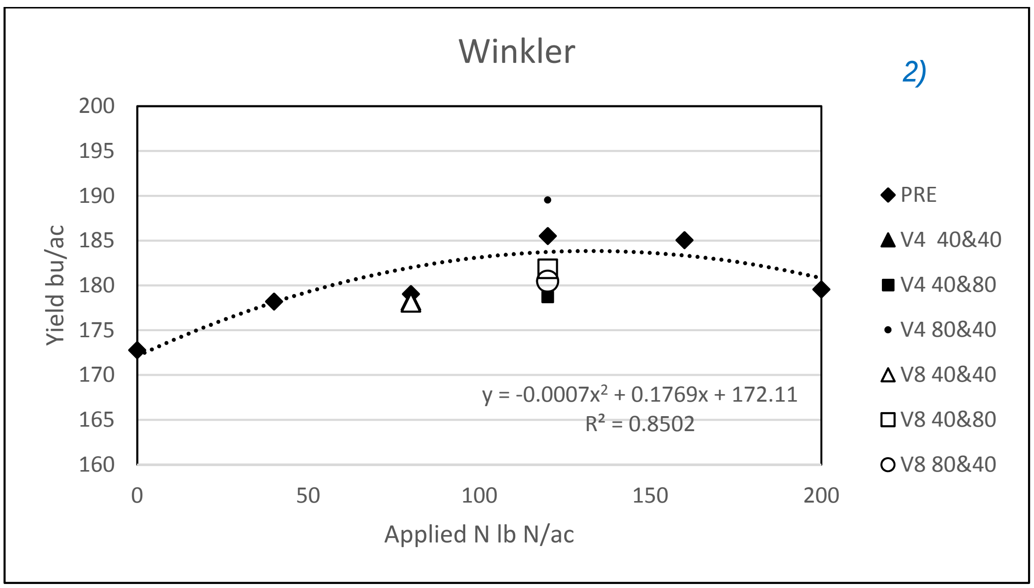
Discussion:

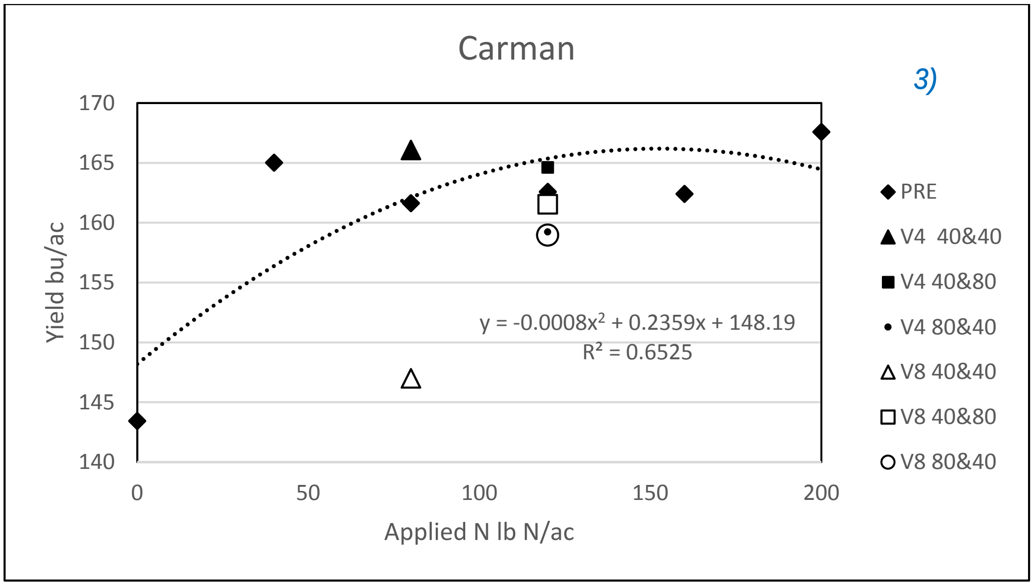
Corn yield response to increasing N was significant only at Melita and Letellier (Table 10). The quadratic response function was applied to N rate data, with good relationship at all but the Carman site where a linear-plateau or quadratic-plateau function may be more applicable (Figures 1-5). The most economic rate of N (MERN) for crop price of $4/bu and N cost of $0.40 /lb N is reported in Table 11.

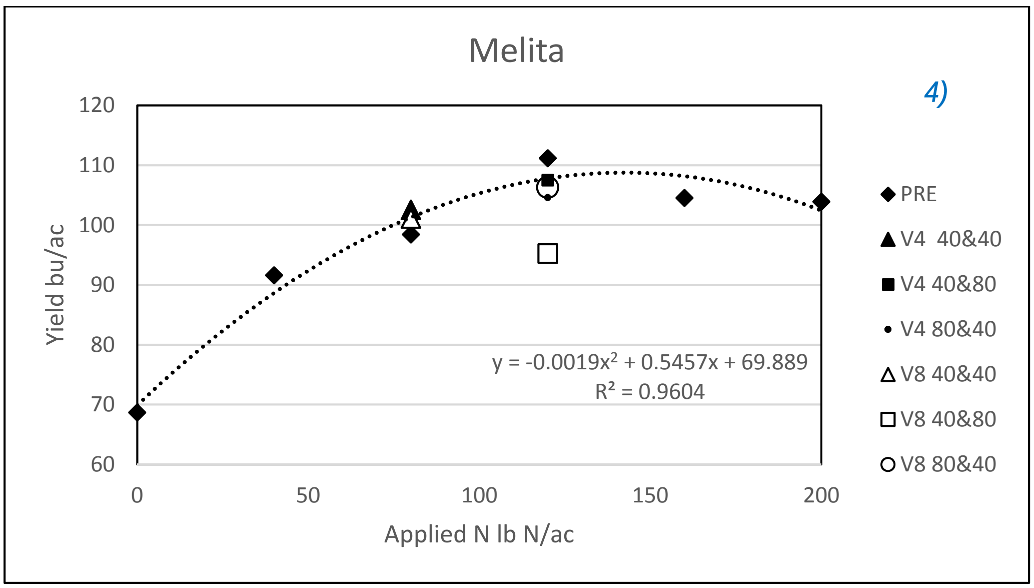
Table 10: Response of corn to applied N across 5 sites.

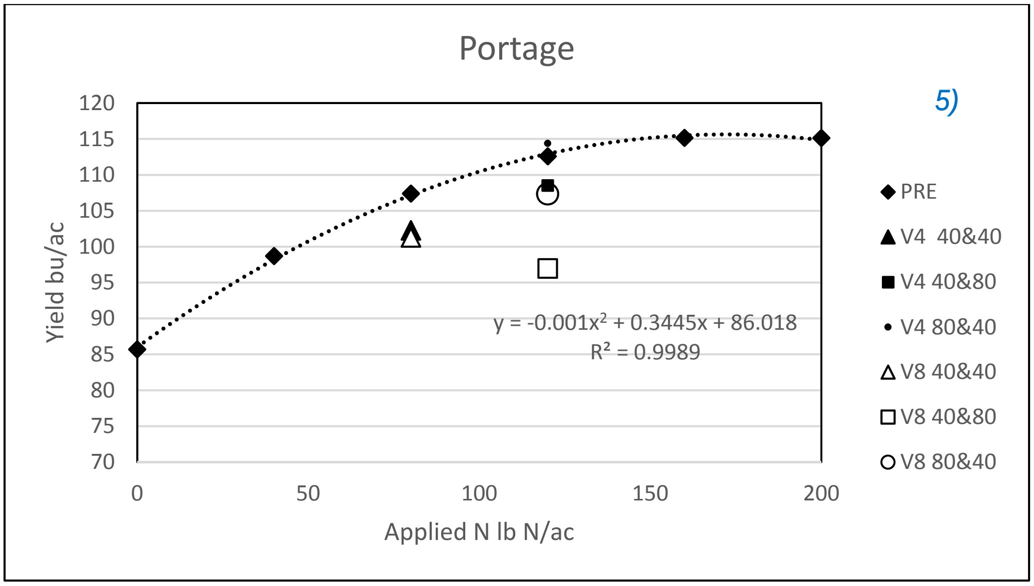
N rate	Letellier	Winkler	Carman	Melita	Portage	Mean
	Yield bu/ac					
0	146 b	173	143	69 b	86	123 c
40	159 ab	178	165	92 ab	99	139 ab
80	175 ab	179	162	98 ab	107	144 a
120	182 a	186	163	111 a	113	151 a
160	185 a	185	162	105 a	115	150 a
200	181 a	180	168	104 a	115	149 a
Sign	5% level	ns	ns	5% level	ns	5% level


Letellier
1)
190
185
180
175
170
165
160
155
150
145
140
Yield bu/ac
0
50
100
150
200
Applied N lb N/ac
y = -0.0015x² + 0.4905x + 144.43
R² = 0.9933
PRE
V4 40&40
V4 40&80
V4 80&40
V8 40&40
V8 40&80
V8 80&40


Winkler
2)
200
195
190
185
180
175
170
165
160
Yield bu/ac
0
50
100
150
200
Applied N lb N/ac
y = -0.0007x² + 0.1769x + 172.11
R² = 0.8502
PRE
V4 40&40
V4 40&80
V4 80&40
V8 40&40
V8 40&80
V8 80&40


Carman
3)
Yield bu/ac
170
165
160
155
150
145
140
0
50
100
150
200
Applied N lb N/ac
y = -0.0008x² + 0.2359x + 148.19
R² = 0.6525
PRE
V4 40&40
V4 40&80
V4 80&40
V8 40&40
V8 40&80
V8 80&40


Melita
4)
Yield bu/ac
120
110
100
90
80
70
60
0
50
100
150
200
Applied N lb N/ac
y = -0.0019x² + 0.5457x + 69.889
R² = 0.9604
PRE
V4 40&40
V4 40&80
V4 80&40
V8 40&40
V8 40&80
V8 80&40



Figures 1-5. Nitrogen response of corn at Letellier, Winkler, Carberry, Melita and Portage.

Table 11: Most economic rate of nitrogen (MERN) for $4/bu corn and $0.40lb N as calculated with response functions in Figures 1-5.

	Letellier	Winkler	Carman	Melita	Portage
MERN Lb N/ac	130	55	85	117	122

There were no significant yield differences among the base N and split N applications. In, general the V8 application stage of N yielded consistently less than the seeding time N application (Figures 1-5 and Table 12).

Table 12: Corn yield response to split N applications across 5 sites.

Total N applied	PRE	V4			V8		
Lb N/ac	At seeding	40 & 40	40 & 80	80 & 40	40 & 40	40 & 80	80 & 40
0	123 b						
40	139 a						
80	144 a	145 a			138 a		
120	151 a		146 a	149 a		142 a	146 a
160	150 a						
200	149 a						

Criteria for identifying profitable rates of N for corn and scouting criteria are listed in Table 13. These evaluations were not completed in time for this 2017 report.

Table 13: Decision criteria for N rate recommendations for corn.

Source	
MERN	Determined using $4/bu corn and $0.40 /lb N and by fitting a quadratic function to yield response.
Manitoba Agriculture	Using N recommendations from Soil Fertility Guide for 130 bu/ac corn and soil test N.[1]
NDSU	Using N calculator based on soil texture, historic yields less than 160 bu/ac, soil test N and OM, $4/bu corn and $0.40 /lb N.[2]
AgVise	Using yield goals and 1.2 lb N/bu
SPAD	Sufficiency is the N rate when SPAD index is >95%.
NDVI	Using NUE web-based N rate calculator for Minnesota corn.[3]
PSNT	Measured on plots with base rate of 40N and using criteria for supplementation from Iowa, Wisconsin and Ontario. See Table 1 for PSNT amounts.
Stalk nitrate	Low (<250 ppm) = N was deficient, Marginal (250-700 ppm) = possible that N shortage limited yield, Optimal (700-2,000 ppm) = yield not limited by N shortage, Excessive (>2,000 ppm) = N rates was high or some other factor reduced yield.
Green leaf (GL) assessment	If the third and fourth leaf below the primary ear leaf were green (without visual N deficiency) for corn following corn and soybean respectively, yield should not have been limited due to lack of N[5] .

Mineralization of soil organic matter (OM) obviously contributed greatly to the high check yields. A very crude calculation of N mineralization is shown in Table 14. The estimate is based on using a 1.12 lb whole plant N uptake/bu[4]. At sites where both starting and end of season soil nitrate was measured, the soil nitrate contribution is considered the difference.

Table 14: Crude estimate of nitrogen mineralization

Site	Letellier	Winkler	Carman	Melita	Portage
	Lb N/ac				
Check Yield bu/ac	146	173	143	69	86
Est .N uptake[4]	164	194	160	77	96
Start Soil nitrate 0-4’	78	111	71	74	61
Ending soil nitrate 0-4’	53	64	59	-	-
Mineralized N est.	139	130	148	3	35
Measured OM%	7.2	3.1	4.6	3.7	5.3

Additional soil Nitrate-N could also have been accessed through deep rooting in 2017.

Such high corn yields and large N mineralization rates challenge N recommendations developed with current preplant planning techniques. A next step would be to use combined models of soil N dynamics and crop growth adjusted with real-time weather information.

This project will continue under the guidance of Dr. Don Flaten and student Lanny Gardiner.

References:

- [1] Manitoba Soil Fertility Guide. 1996. Manitoba Agriculture http://www.gov.mb.ca/agriculture/crops/soil-fertility/soil-fertility-guide/
- [2] Franzen. 2014. Soil Fertility Recommendations for Corn. NDSU F722 https://www.ndsu.edu/pubweb/soils/corn/
- [3] http://www.nue.okstate.edu/SBNRC/mesonet.php
- [4]Bender et al. 2013. Better Crops. Vol.97 No. 1 p7-10.
- [5]Bly, A. 2013. Evaluating Late Season Corn Nitrogen Deficiency. http://igrow.org/agronomy/corn/evaluating-late-season-corn-nitrogen-deficiency/

Acknowledgements:

- Manitoba Corn Growers Association
- AgVise Laboratories
- KOCH Fertilizers
- DeKalb (Monsanto Canada)
- Soil Science Dept, University of Manitoba
- Manitoba Agriculture Crop Diversification Centres at Melita and AAFC Portage station
- Southern Potato Farms and Eric Unrau
- Tyler Russell, Russell farms, Carman, Manitoba
- Gaetan Fontain, Letellier

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

Cooperators: Lead Researcher: Chris Holzapfel - IHARF

Researchers: Jessica Pratchler – NARF
Jessica Weber – WARC
Scott Chalmers – WADO
Danny Petter - IHARF

Trial Objectives

The overall project objectives were to evaluate differences in stem and seed dry-down associated with various pre-harvest herbicide / desiccant options for the two dominant herbicide systems (Liberty Link® and Roundup®). It was assumed that options and results for Clearfield® canola would be similar to those for the Liberty Link® system. A total of 10 treatments were arranged in a RCBD with four replicates.

Methodology

Field trials were completed at four locations: Indian Head (SK), Melfort (SK), Scott (SK) and Melita (MB). The varieties 233P (Liberty Link® - LL - glufosinate ammonium tolerant) and 45M35 (Roundup

Ready® - RR - glyphosate tolerant) were seeded into cereal stubble in mid-May at a rate of 120 seeds/m^2. With the exception of Melfort where no herbicides were applied, weeds were controlled using registered pre-emergent and in-crop herbicides. At Indian Head and Melita, conventional canola products (i.e. Edge, Lontrel, Muster, Assure 2) were utilized while, at Scott, each variety was sprayed with its partner in-crop herbicide (i.e. glyphosate or glufosinate ammonium). The pre-harvest herbicide / desiccant treatments were targeted for 60-70% seed colour change (glyphosate and saflufenacil) or 80-90% seed colour change (glufosinate ammonium and diquat); however, the RR hybrid tended to mature slightly later than the LL hybrid, therefore compromises were sometimes made with regard to application timing for logistic reasons.

Table 1: Treatment list for Canola Pre-harvest Herbicide / Desiccation Study (CARP 2017.9).

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

Various data was collected during the growing season, at the time of harvest and during the winter months. For explanatory purposes and to help assess overall data quality/trial uniformity, emergence was assessed approximately 3-4 weeks after seeding by counting plants in 2 x 1 m sections of crop row in each plot. Once the treatments were applied, visual assessments of stem / overall plant dry-down (rating scale of 0-100) were completed on weekly intervals starting on the day of application with a final set of ratings on all plots immediately prior to harvest. These ratings were subjective and, as such, differed somewhat across locations and therefore should be interpreted with some caution.

The visual assessments of crop dry-down were not completed at Melfort. The intended harvest timing was before the crop dried down to the extent that treatment effects would no longer be evident but late enough that the canola could still be properly threshed and put through the combines; however, it was required that all plots of a given hybrid be harvested on the same date. At Indian Head, Melfort and Melita both hybrids were combined on the same date while, at Scott, the RR variety was harvested a few days later than the LL variety. Immediately after harvest, seed moisture content was assessed by weighing sub-samples both wet and again after being dried for a minimum of 24 hours at 70 °C or higher. This methodology appeared to work well at Indian Head and Melita; however, the values at Melfort and, to a lesser extent, Scott appeared too low (0.5-6.8% at Melfort and 2.7-5.5% at Scott) therefore methods at these locations may require refinement going forward.

Whole plant (including seed) moisture was determined either immediately before or after harvest (depending on plot size / harvest area) by harvesting representative plants from each plot at ground level, weighing them wet, drying (with heat and air), weighing them again and calculating percent gravimetric moisture content.

Seed weight, an important yield parameter with potential quality implications, was determined by counting a minimum of 300 seeds for each plot using an automated seed counting machine, weighing the counted seeds to the nearest 0.00 g and calculating g/1000 seeds.

Percent green seed was determined for each plot by counting the number of distinctly green seeds in a minimum of one 500 seed crush. Selected agronomic information is provided in Table 2.

Table 2: Selected agronomic information for canola desiccation trials at four Western Canadian locations in 2017.

Factor / Operation	Location (2017)			
	Indian Head, SK	**Melfort, SK**	**Scott, SK**	**Melita, MB**
Previous Crop	Wheat	Wheat	Wheat	Rye
Variety	L233P (LL) / 45M35 (RR)	L233P (LL) / 45M35 (RR)	L233P (LL) / 45M35 (RR)	L233P (LL) / 45M35 (RR)
Pre-emergent Herbicide	890 g glyphosate/ha (May-10) 24 kg Edge/ha (May-14)	none	980 g glyphosate/ha + 280 g bromoxynil/ha (May-6)	890 g glyphosate/ha + 185 ml Centurion/ha (Apr-20)
Seeding Date	May-17	May-19	May-15	May-12
Seeding Rate	120 seeds/m^2	120 seeds/m^2	120 seeds/m^2	120 seeds/m^2
Row spacing	30 cm	30 cm	25 cm	24 cm
Fertility (kg N-P_2O_5-K_2O-S/ha)	140-35-18-18	134-56-0-28	81-22-0-25	126-35-25-10
Emergence Counts	Jun-12	Jun-9	Jun-12	mid-June
In-crop Herbicide	561 ml Lontrel 360/ha (Jun-10) 30 g Muster/ha + 741 ml Assure 2/ha (Jun-18)	none	2 l Liberty 150 SN/ha (Jun-7) + 1.5 l Liberty/ha + 185 ml Centrurion/ha (Jun-20) 300 g glyphosate/ha (Jun-7) + 445 g glyphosate/ha (Jun-21)	20 g Muster/ha + 741 ml Assure 2/ha (Jun-7)
Fungicide	350 g Lance WDG/ha + 395 ml Headline E.C. (Jul-12)	865 ml Acapela/ha (Jul-18)	445 ml Priaxor/ha (Jul-8)	none
Insecticide	none	None	none	none
Pre-harvest Applications	Trt 2, 3, 4, 8, 9 (Aug-23) Trt 5, 7, 10 (Aug-28)	Trt 2, 3, 4, 8, 9 (Aug-29) Trt 5, 7, 10 (Sep-5)	Trt 2, 3, 4 (Aug-22) Trt 5, 7, 8, 9 (Aug-25) Trt 10 (Aug-28)	Trt 2, 3, 4, 8, 9 (Aug-16) Trt 5, 7, 10 (Aug-22)
Harvest date	Sep-8 (all treatments)	Sep-12 (all treatments	Sep-8 (LL) Sep-11 (RR)	Sep-1 (all treatments)

Response data was analyzed and summarized on an individual site basis in order to assess data quality prior to any final combined analyses and facilitate preliminary extension activities going into the 2nd year of the project. A mixed model analyses with treatment effects considered fixed and replicate effects considered random was used along with contrasts to compare pre-determined groups of treatments. Individual treatment means were separated using Fisher's protected LSD test (which requires a significant F-test before any treatment differences are considered real); however, the $LSD^{0.05}$ values were also provided which can be utilized to compare specific individual treatments. The specific contrast comparisons were: 1) untreated (1,6) vs treated (2,3,4,5,7,8,9,10); 2) untreated (1,6) vs saflufenacil (3,8); 3) untreated (1,6) vs glyphosate + saflufenacil (4,9); 4) untreated (1,6) vs diquat (5,10); 5) saflufenacil (3,8) vs glyphosate + saflufenacil (4,9); 6) saflufenacil (3,8) vs diquat (5,10); and saflufenacil + glyphosate (4,9) vs diquat (5,10). Glyphosate alone and glufosinate ammonium were excluded from the contrast comparisons since these products were not utilized in both herbicide systems.

Results

Growing season weather information for the four locations is presented along with the long-term (1981-2010) averages in provided in Tables 3-4. Overall, the weather tended to be both warmer and drier than average; however, with good initial moisture and timely precipitation in June at most locations, yield potential was reasonably high at all locations. In general, harvest aids for canola tend to be less important under warm and dry conditions during the late summer / early fall.

Table 3: Mean monthly temperatures for the 2017 growing season relative to the long-term averages (1981-2010) at 4 locations in western Canada.

Location	Year	Mean Monthly Temperature				
		May	June	July	August	Average
		ºC				
Indian Head	2017	11.6	15.5	18.4	16.7	15.6
	LT	10.8	15.8	18.2	17.4	15.6
Melfort	2017	10.8	15.2	18.7	17.2	15.5
	LT	10.7	15.9	17.5	16.8	15.2
Scott	2017	11.5	15.1	18.3	16.6	15.4
	LT	10.8	15.3	17.1	16.5	14.9
Melita	2017	12.2	16.7	20.1	17.4	16.6
	LT	10.7	16.1	19.3	18.4	16.1

Table 4: Mean monthly precipitation amounts for the 2017 growing season relative to the long-term averages (1981-2010) at 4 locations in western Canada.

Location	Year	Total Monthly Precipitation				
		May	June	July	August	Average
		mm				
Indian Head	2017	10.4	65.6	15.4	25.2	117
	LT	51.8	77.4	63.8	51.2	244
Melfort	2017	46.4	44.1	33.3	3.1	127
	LT	42.9	54.3	76.7	52.4	226
Scott	2017	69.0	34.3	22.4	53.0	179
	LT	36.3	61.8	72.1	45.7	216
Melita	2017	6.1	64.2	44.8	39.5	155
	LT	61.9	76.4	56.9	43.2	238

Indian Head 2017

Results from the Indian Head (2017) site are presented in Tables 5-6. Seedling mortality was high overall; however, many ungerminated seeds eventually came with rains after the counts were completed. While the F-test was significant (P = 0.035) the only differences amongst individual treatments were between that with the highest counts and several other treatments where plant densities were more typical. Other than the two varieties, there were no treatments imposed at this time that could affect emergence.

Only the final visual stem dry-down ratings (completed just prior to harvest) were statistically analyzed; however, the ratings over time are presented graphically for the LL and RR canola at Indian Head in Figs. 1 and 2, respectively. At the time of harvest, visual dry-down values for untreated canola were statistically similar for both varieties (37-41%) and consistently higher in the treated plots. For LL canola, visual stem dry-down was statistically similar for glyphosate, glyphosate + saflufenacil and diquat (62-67%) but lower for saflufenacil applied alone (46%). With RR canola, values were statistically similar for glufosinate ammonium and both treatments containing saflufenacil (44-48%) but higher for diquat (58%). The contrast comparisons detected an overall benefit to harvest aids both combined (P < 0.001) across hybrids and products and for individual products (P < 0.001-0.004). They also showed an advantage to the saflufenacil + glyphosate tank-mix over saflufenacil alone (P = 0.008) and to diquat over saflufenacil, with and without added glyphosate ($P \leq 0.001$) for this variable (Table 6).

Due to slight differences in maturity, seed moisture content at harvest was generally lower for the LL compared the RR hybrid. Looking at individual treatments in LL canola, seed moisture contents were mostly statistically similar across most treatments. Numerically, however, values were similar for the control and glyphosate alone (7.1-7.2%), intermediate for both saflufenacil treatments (6.5-6.7%) and lowest with diquat (5.8%). For the RR canola, seed moisture did not significantly differ between the control (11.9%) and the saflufenacil treatments (11.1-11.4%) but was lower with glufosinate ammonium (8.5%) and lowest with diquat (5.3%). The contrasts showed an overall benefit to harvest aids (P < 0.001) and to diquat (P < 0.001) but no difference between the control versus saflufenacil alone (P = 0.371) or with glyphosate (P = 0.160). When individual products were compared, there was no difference between saflufenacil and saflufenacil + glyphosate (P = 0.186) but the observed seed moisture was lower with diquat than both of those options (P < 0.001-0.002).

Total above-ground plant moisture at harvest was 31% and 39% in the LL and RR control treatments, respectively. No significant differences were detected amongst pre-harvest treatments were observed in the LL hybrid while in the RR hybrid the only product that significantly reduced whole plant moisture was diquat. Averaged across varieties and products, the contrasts did not show a significant benefit to the pre-harvest treatments for this variable (P = 0.252) or between the control and either of the treatments containing saflufenacil (P = 0.261-0.835) but did show a plant dry-down benefit to diquat (P < 0.001).

Provided that product applications and harvest were timed appropriately we did not expect to see any effect of pre-harvest applications on yield and this was the case at Indian Head in 2017 with no significant overall F-test (P = 0.691) or contrast comparisons (P = 0.153-0.977). While comparing hybrid performance was not an objective of this study, yields for both appeared to be similar at this site-year.

Table 5: Treatment means and tests of fixed effects for selected response variables at Indian Head, Saskatchewan in 2017. The treatments are various pre-harvest / desiccation options for glufosinate ammonium (LL) and glyphosate (RR) tolerant canola hybrids. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test; *P* ≤ 0.05).

Treatment	Plant Density	Visual Dry-down	Seed Moisture [Z]	Plant Moisture [Y]	Seed Yield	Seed Weight	Green Seed
	- plants/m² -	------ % ------	------ % ------	------ % ------	--- kg/ha ---	g/1000 seeds	------ % ------
1) LL – Control	33.2 ab	41.3 cd	7.1 cd	30.8 c	3226 a	3.28 bcd	0.1 b
2) LL – Glyphosate	30.4 b	65.0 a	7.2 bc	26.8 c	3222 a	3.19 d	0.1 b
3) LL – Saflufenacil	41.8 a	45.6 c	6.7 cde	30.3 c	3275 a	3.26 bcd	0.0 b
4) LL – Safl + Glyph	32.0 b	61.9 ab	6.5 cde	30.0 c	3217 a	3.24 bcd	0.1 b
5) LL – Diquat	33.2 ab	66.9 a	5.8 de	28.2 c	3204 a	3.22 cd	0.5 b
6) RR – Control	25.0 b	36.9 d	11.9 a	38.6 ab	3098 a	3.36 ab	1.7 b
7) RR – Gluf. Amm.	31.6 b	43.8 cd	8.5 b	39.5 ab	3306 a	3.33 abc	0.7 b
8) RR – Saflufenacil	26.3 b	48.1 c	11.4 a	38.5 b	3196 a	3.35 ab	1.8 b
9) RR – Safl + Glyph	29.1 b	44.4 c	11.1 a	42.8 a	3225 a	3.42 a	2.1 b
10) RR – Diquat	27.9 b	57.5 b	5.3 e	30.7 c	3263 a	3.32 a-d	13.2
SE	3.49	3.01	0.47	1.47	72.0	0.048	0.97
LSD [X]	8.76	7.20	1.35	4.24	191.3	0.134	2.78
Pr > *F* (p-value)	**0.035**	**< 0.001**	**< 0.001**	**< 0.001**	0.691	**0.038**	**< 0.001**
AICC [W]	215.7	204.8	-179.3	-108.4	399.6	-38.1	143.3

[Z] Gravimetric water content of seed at harvest
[Y] Gravimetric water content of above-ground plant material at harvest
[X] Least Significant Difference values presented can be used to compare individual treatments but do not control experiment-wise error
[W] Akaike Information Criterion (corrected) - A measure of overall model-fit (smaller is better)

While the overall F-test was not significant (*P* = 0.035), seed weight was not affected by pre-harvest treatments. There was an overall tendency for larger seeds with the RR variety; however, significant differences amongst individual treatments were rare. No contrast comparisons for seed weight were significant (*P* = 0.199-0.836).

Table 6. Contrast results for selected response variables in canola desiccation study at Indian Head, Saskatchewan in 2017.

Group Comparison	Plant Density	Visual Dry-down	Seed Moisture [Z]	Plant Moisture [Y]	Seed Yield	Seed Weight	Green Seed
	-----	-----	-----	p-value	-----	-----	-----
Untreated vs treated	0.322	**< 0.001**	**< 0.001**	0.252	0.153	0.444	0.068
Untreated vs Saflufenacil	0.115	**0.004**	0.371	0.835	0.274	0.799	0.979
Untreated vs Saflufenacil + Glyphosate	0.638	**< 0.001**	0.160	0.261	0.381	0.836	0.856
Untreated vs diquat	0.641	**< 0.001**	**< 0.001**	**0.001**	0.287	0.278	**< 0.001**
Saflufenacil vs Saflufenacil + Glyphosate	0.258	**0.018**	0.597	0.186	0.824	0.645	0.877
Saflufenacil vs Diquat	0.257	**< 0.001**	**< 0.001**	**0.002**	0.977	0.403	**< 0.001**
Saflufenacil + Glyphosate vs Diquat	0.997	**0.001**	**< 0.001**	**< 0.001**	0.846	0.199	**< 0.001**

[Z] Gravimetric water content of seed at harvest

[Y] Gravimetric water content of above-ground plant material at harvest

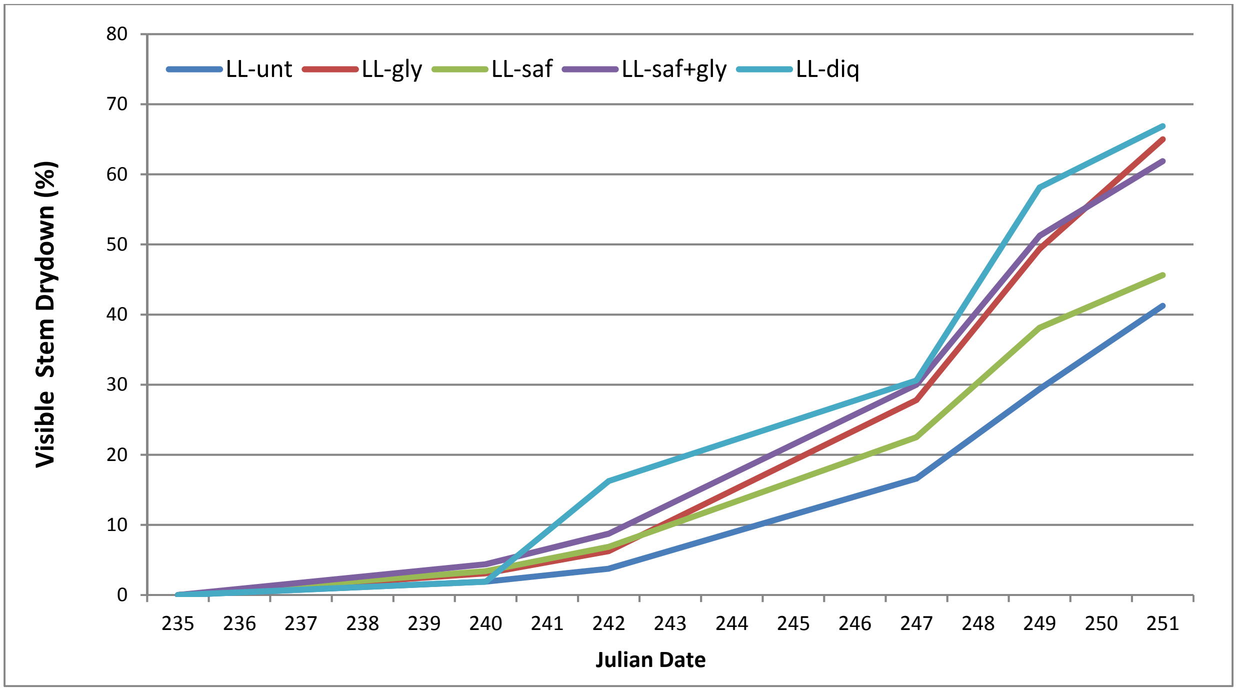


Figure 1: Rate of visible stem down for various pre-harvest treatments in glufosinate ammonium tolerant canola (Indian Head 2017).

The overall F-test for percent green seed was highly significant at Indian Head in 2017 ($P < 0.001$). Due to later maturity and the fact that all treatments were harvested on the same date, there tended to be higher green counts with the RR hybrid; however, in most cases, individual treatment differences were not significant. Treatments containing glyphosate, saflufenacil or glufosinate ammonium had no effect on percent green seed; however, results with diquat varied. With the LL variety, which was more advanced at the time of the treatment applications, percent green seed was 0.5% compared to 0.0-0.1%. On the other hand, in the RR variety percent green seed was 13.2% with diquat compared to 0.7-2.1% for the other treatments. With post-application precipitation and rehydrating of the affected seed it is possible that some of this would have cured out with time; however, these results illustrate the dangers of applying a fast-acting (albeit effective) product like diquat too early. The contrasts comparing the control to all treated plots was not significant at the desired probability level ($P = 0.068$); however, for the saflufenacil (with and without glyphosate) there was no impact ($P = 0.856$-0.979) while the effect of diquat was highly significant ($P < 0.001$).

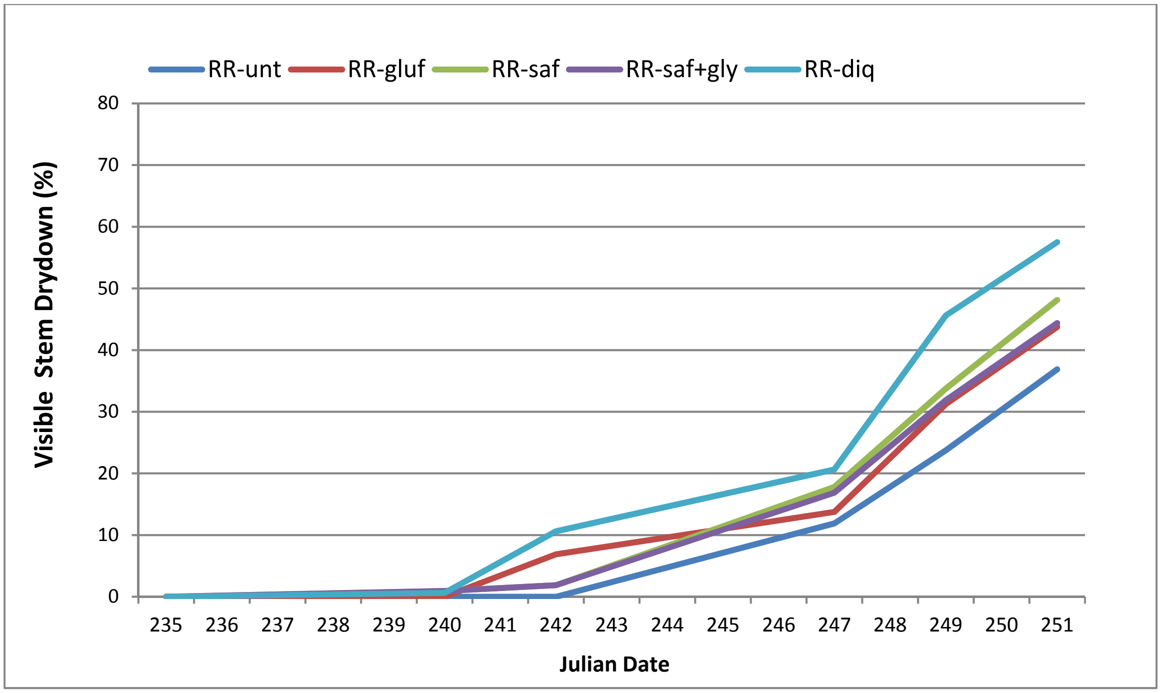


Figure 2: Rate of visible stem down for various pre-harvest treatments in glyphosate tolerant canola (Indian Head 2017).

Melfort 2017

Results from the Melfort site in 2017 are presented in Tables 7-8. Emergence at this site was variable but good overall with mean populations ranging from 58-89 plants/m^2. While the overall F-test was not significant (P = 0.335) at this site-year, some of the contrast comparisons were; however, this was solely attributed to random variability.

Visual dry-down ratings were not completed at Melfort in 2017.

The observed seed moisture values at this location were extremely low and are therefore somewhat suspect; however, the overall F-test for this variable was significant (P < 0.001) and there was evidence of benefits to the pre-harvest treatments. For the LL hybrid, the calculated seed moisture content in the control was 3.5% and the values ranged from 0.5-1.3% with no significant differences amongst the individual pre-harvest treatments. For the RR canola, the calculated seed-moisture content in the control was higher at 6.8% and ranged from 2.8-5.5% for the remaining treatments with the lowest values observed with saflufenacil + glyphosate and diquat. The contrast comparisons showed a benefit to using harvest aids over the controls when averaged across products (P = 0.002) and for individual products (P = 0.002-0.027) but no significant differences amongst individual treatments (P = 0309-0.898).

With a significant F-test (P = 0.003), whole plant moisture content at Melfort ranged from 24-31% and 26-28% for the LL and RR hybrids, respectively. For the LL canola, whole plant moisture was highest for the control (31%) and ranged from 24-27% in the treated plots but with no significant differences between products. For the RR variety, observed whole plant moisture was similar for across treatments. The contrast comparisons showed an overall reduction in plant moisture content when averaged across (*P* = 0.003) products and also with both treatments containing saflufenacil (*P* = 0.003-0.017). While the contrast comparing diquat to the untreated controls was not significant at the desired probability level (*P* = 0.063), whole moisture still tended to be lower with diquat and did not significantly differ from that observed with saflufenacil (with and without added glyphosate; *P* = 0.2030.552).

Yields were highly variable ranging from 3596-4233 kg/ha amongst individual treatments but with no significant F-test (*P* = 0.207) and a relatively high $LSD^{0.05}$ value of 618 kg/ha (11 bu/ac). According to the orthogonal contrasts, yields were higher for canola treated with diquat than for the untreated control plots (*P* = 0.008); however, it is probable that this result was due to random variability as opposed to a genuine treatment effect. The high yield variability at this site was primarily attributed to plugged runs and late trips when metering canola through the cone during seeding.

Table 7: Treatment means and tests of fixed effects for selected response variables at Melfort, Saskatchewan in 2017. The treatments are various pre-harvest / desiccation options for glufosinate ammonium (LL) and glyphosate (RR) tolerant canola hybrids. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test; *P* ≤ 0.05).

Treatment	Plant Density	Visual Dry-down	Seed Moisture [Z]	Plant Moisture [Y]	Seed Yield	Seed Weight	Green Seed
	-- plants/m² --	------- % -------	------- % -------	------- % -------	----- kg/ha -----	g/1000 seeds	------- % -------
1) LL – Control	88.6 a	–	3.5 bc	30.7 a	3596 a	3.55 a	0.4 cd
2) LL – Glyphosate	73.9 a	–	0.5 d	25.9 b	3715 a	3.55 a	0.4 d
3) LL – Saflufenacil	84.1 a	–	1.3 cd	24.7 b	3849 a	3.50 a	0.3 d
4) LL – Safl + Glyph	62.3 a	–	1.0 cd	23.7 b	3805 a	3.61 a	0.4 cd
5) LL – Diquat	79.6 a	–	1.3 cd	26.8 ab	4059 a	3.56 a	0.4 cd
6) RR – Control	71.0 a	–	6.8 a	27.9 ab	3517 a	3.66 a	1.1 a-c
7) RR – Gluf. Amm.	–	–	–	–	–	–	–
8) RR – Saflufenacil	78.3 a	–	4.5 ab	26.5 bc	3673 a	3.66 a	0.7 bcd
9) RR – Safl + Glyph	58.3 a	–	2.8 bcd	25.5 b	3705 a	3.67 a	0.8 bcd
10) RR – Diquat	67.7 a	–	2.8 bcd	26.2 b	4233 a	3.69 a	1.5 a
SE	9.43	–	1.16	1.94	271.1	0.051	0.23
LSD [X]	25.5	–	2.80	4.22	617.6	0.145	0.66
Pr > *F* (p-value)	0.335	–	**< 0.001**	**0.003**	0.207	0.159	**0.003**
AICC [W]	278.2	–	-128.3	-102.3	440.1	-33.5	53.5

[Z] Gravimetric water content of seed at harvest

[Y] Gravimetric water content of above-ground plant material at harvest

[X] Least Significant Difference values presented can be used to compare individual treatments but do not control experiment-wise error

[W] Akaike Information Criterion (corrected) - A measure of overall model-fit (smaller is better)

Table 8: Contrast results for selected response variables in canola desiccation study at Melfort, Saskatchewan in 2017.

Group Comparison	Plant Density	Visual Dry-down	Seed Moisture [Z]	Plant Moisture [Y]	Seed Yield	Seed Weight	Green Seed
	------------------	------------------	------------------	p-value	------------------	------------------	------------------
Untreated vs treated	0.239	–	**0.002**	**0.024**	0.145	0.944	0.972
Untreated vs Saflufenacil	0.875	–	**0.027**	**0.017**	0.329	0.657	0.278
Untreated vs Saflufenacil + Glyphosate	0.035	–	**0.002**	**0.003**	0.362	0.490	0.585
Untreated vs diquat	0.488	–	**0.003**	0.063	**0.008**	0.693	0.328
Saflufenacil vs Saflufenacil + Glyphosate	**0.025**	–	0.309	0.488	0.980	0.261	0.585
Saflufenacil vs Diquat	0.397	–	0.372	0.552	0.072	0.403	**0.045**
Saflufenacil + Glyphosate vs Diquat	0.141	–	0.898	0.203	0.080	0.767	0.133

[Z] Gravimetric water content of seed at harvest

[Y] Gravimetric water content of above-ground plant material at harvest

Seed weight was not affected at Melfort in 2017 (*P* = 0.159) with similar values across pre-harvest treatments and hybrids (3.5-3.7 g/1000 seeds). None of the predetermined contrast comparisons were significant for seed size at this location (*P* = 0.261-0.944), thereby providing further evidence that the pre-harvest applications did not affect this response variable.

The overall F-test for percent green seed was significant (*P* = 0.003) with lower values in general and no differences amongst the pre-harvest treatments for the LL hybrid. For the RR hybrid, the values were highest with diquat, intermediate in the untreated control and lowest with saflufenacil and glyphosate plus saflufenacil. When averaged across the hybrids, the only significant comparison was between saflufenacil and diquat (*P* 0.045) with a higher percentage of green seed when diquat was applied.

Scott 2017

Treatment means and contrast results for the Scott location are presented in Tables 9 and 10, respectively. While there was considerable variability in individual measurements, emergence was good overall and mean plant densities were consistent across treatments (64-76 plants/m2; *P* = 0.927). As expected, none of the contrast comparisons were significant (*P* = 0.28-0.93).

In general, visual dry-down ratings were higher at Scott than the Indian Head site; however, this may have been due as much to the subjective nature of these measurements as to differences in environmental conditions and timing of operations. The F-test for this this variable was highly significant (*P* < 0.001) and, for both the LL and RR hybrids, there were clear benefits to all pre-harvest options with mean ratings of 70-71% in the controls and 86-96% in the treated plots. Focusing on LL canola, the most thorough dry-down occurred with glyphosate and saflufenacil + glyphosate with no difference between these two treatments (95-97%). Dry-down with diquat treatment was slightly but significantly lower (90%) and the lowest dry-down ratings were recorded with saflufenacil applied alone (86%). For visual dry-down ratings in the RR canola, the most effective treatment was diquat (96%) while glufosinate ammonium and saflufenacil (with and without glyphosate) were also quite effective and performed similarly (91-93%). Bear in mind that harvest was completed at separate dates for the LL and RR at Scott (3 days later for RR); therefore, these values do not reflect the differences in maturity between the two hybrids. Data illustrating the overall rate of dry-down at Scott is presented graphically for LL and RR canola in Figs. 3 and 4, respectively.

Table 9: Treatment means and tests of fixed effects for selected response variables at Scott, Saskatchewan in 2017. The treatments are various pre-harvest / desiccation options for glufosinate ammonium (LL) and glyphosate (RR) tolerant canola hybrids. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test; *P* ≤ 0.05).

Treatment	Plant Density	Visual Dry-down	Seed Moisture [Z]	Plant Moisture [Y]	Seed Yield	Seed Weight	Green Seed
	-- plants/m² --	------- % -------	------- % -------	------- % -------	----- kg/ha -----	g/1000 seeds	------- % -------
1) LL – Control	76.0 a	70.0 f	3.6 bc	28.5 ab	3450 a	3.40 c	0.3 a
2) LL – Glyphosate	71.5 a	96.5 a	2.7 c	11.9 f	3440 a	3.40 c	0.4 a
3) LL – Saflufenacil	76.5 a	86.3 e	3.5 bc	29.5 a	3482 a	3.37 c	0.3 a
4) LL – Safl + Glyph	70.5 a	94.5 abc	2.9 bc	13.7 f	3385 a	3.40 c	0.3 a
5) LL – Diquat	73.3 a	90.3 d	2.8 c	25.2 a-d	3563 a	3.39 c	0.5 a
6) RR – Control	67.3 a	71.3 f	5.5 a	27.6 abc	3712 a	3.77 ab	0.2 a
7) RR – Gluf. Amm.	71.3 a	92.3 bcd	3.7 b	21.9 de	3743 a	3.65 b	0.2 a
8) RR – Saflufenacil	71.0 a	91.3 cd	5.2 a	22.9 cde	3992 a	3.77 ab	0.5 a
9) RR – Safl + Glyph	64.0 a	93.3 a-d	5.3 a	24.3 b-e	3908 a	3.83 a	0.3 a
10) RR – Diquat	71.8 a	96.0 ab	2.9 bc	20.0 e	3487 a	3.78 ab	1.9 a
SE	6.64	1.94	0.33	1.92	234.5	0.079	0.40
LSD [X]	17.10	3.95	0.92	4.88	530.8	0.166	1.10
Pr > *F* (p-value)	0.927	**< 0.001**	**< 0.001**	**< 0.001**	0.267	**< 0.001**	0.108
AICC [W]	255.4	170.8	-198.3	-95.9	463.6	-19.7	89.3

[Z] Gravimetric water content of seed at harvest

[Y] Gravimetric water content of above-ground plant material at harvest

[X] Least Significant Difference values presented can be used to compare individual treatments but do not control experiment-wise error

[W] Akaike Information Criterion (corrected) - A measure of overall model-fit (smaller is better)

While not to the same extent as Melfort, values for percent seed moisture were also unusually low at Scott; however, the overall F-test was highly significant ($P < 0.001$). For the LL canola, while no individual treatment differences were significant, seed moisture tended to be highest in the control and with saflufenacil applied alone (3.5-3.6%) but lower with glyphosate, saflufenacil + glyphosate, and diquat (2.7-2.9%). In the untreated RR canola control, percent seed moisture was 5.5% which did not significantly differ from that achieved with saflufenacil, regardless of whether it was tank-mixed with glyphosate (5.2-5.3%). At 3.7% and 2.9%, seed moisture of the RR canola was lower with both glufosinate ammonium and diquat, respectively. While diquat appeared to be more slightly effective, the difference in seed moisture between these latter two treatments was not significant. The contrast comparisons showed an overall benefit to pre-harvest applications for reducing seed moisture (*P* < 0.001; across products and hybrids) and, more specifically, an advantage to diquat over saflufenacil with or without glyphosate (*P* < 0.001-0.003). Again, glyphosate (alone) and glufosinate ammonium were not included in the contrast comparisons.

Table 10: Contrast results for selected response variables in canola desiccation study at Scott, Saskatchewan in 2017.

Group Comparison	Plant Density	Visual Dry-down	Seed Moisture [Z]	Plant Moisture [Y]	Seed Yield	Seed Weight	Green Seed
	----	----	----	p-value	----	----	----
Untreated vs treated	0.931	**< 0.001**	**0.001**	**< 0.001**	0.763	0.779	0.356
Untreated vs Saflufenacil	0.721	**< 0.001**	0.611	0.278	0.400	0.795	0.744
Untreated vs Saflufenacil + Glyphosate	0.464	**< 0.001**	0.203	**< 0.001**	0.724	0.635	0.948
Untreated vs diquat	0.883	**< 0.001**	**< 0.001**	**0.003**	0.762	0.983	**0.018**
Saflufenacil vs Saflufenacil + Glyphosate	0.280	**< 0.001**	0.436	**< 0.001**	0.622	0.465	0.794
Saflufenacil vs Diquat	0.834	**0.003**	**< 0.001**	**0.042**	0.256	0.812	**0.038**
Saflufenacil + Glyphosate vs Diquat	0.381	0.586	**< 0.001**	**0.041**	0.513	0.620	**0.021**

[Z] Gravimetric water content of seed at harvest
[Y] Gravimetric water content of above-ground plant material at harvest

Whole plant moisture content at harvest for this site-year was 29% for the untreated LL control and ranged from 12-25% in the treated plots. The only LL treatments that were a significant improvement over the control in this regard were those that contained glyphosate where the observed values were 12-13% compared to 25-30% for saflufenacil (alone) and diquat, neither of which significantly differed from the control. For RR canola, whole plant moisture in the control was 28% while that of the plots treated with glufosinate ammonium and diquat were significantly lower and did not differ from one another (20-22%). While the observed whole plant moisture values for saflufenacil and saflufenacil + glyphosate tended to be lower (23-24%) than the control, the difference was not significant according to the multiple comparisons test. The contrasts showed an overall benefit to pre-harvest applications across treatments (*P* < 0.001) and also for saflufenacil + glyphosate and diquat (*P* < 0.001-0.003) but not saflufenacil applied alone (*P* = 0.278). Furthermore, the contrasts also showed an advantage to the tank mix with glyphosate over saflufenacil alone (*P* < 0.001), to diquat over saflufenacil alone (*P* = 0.042) and to saflufenacil + glyphosate over diquat (*P* =

0.041). In the case of the latter comparison, the difference was primarily due to the strong performance of glyphosate in the LL canola as diquat performed better than the saflufenacil + glyphosate tank-mix in the RR canola.

While there was substantial variability with treatment means ranging from 3385-3992 kg/ha, the overall F-test for seed yield at Scott in 2017 was not significant (*P* = 0.267) and neither were any of the predetermined contrast comparisons (*P* = 0.256-0.763). Again, other than potential varietal differences (which were not a focus and therefore not specifically tested for), none of the pre-harvest treatments were expected to impact yield if applied at appropriate crop stages.

The overall F-test was highly significant for seed weight (*P* < 0.001) at Scott but appeared to be due entirely to larger seeds in the RR hybrid with no evidence to suggest pre-harvest application effects amongst either the individual treatment means or contrast comparisons (*P* = 0.465-0.812).

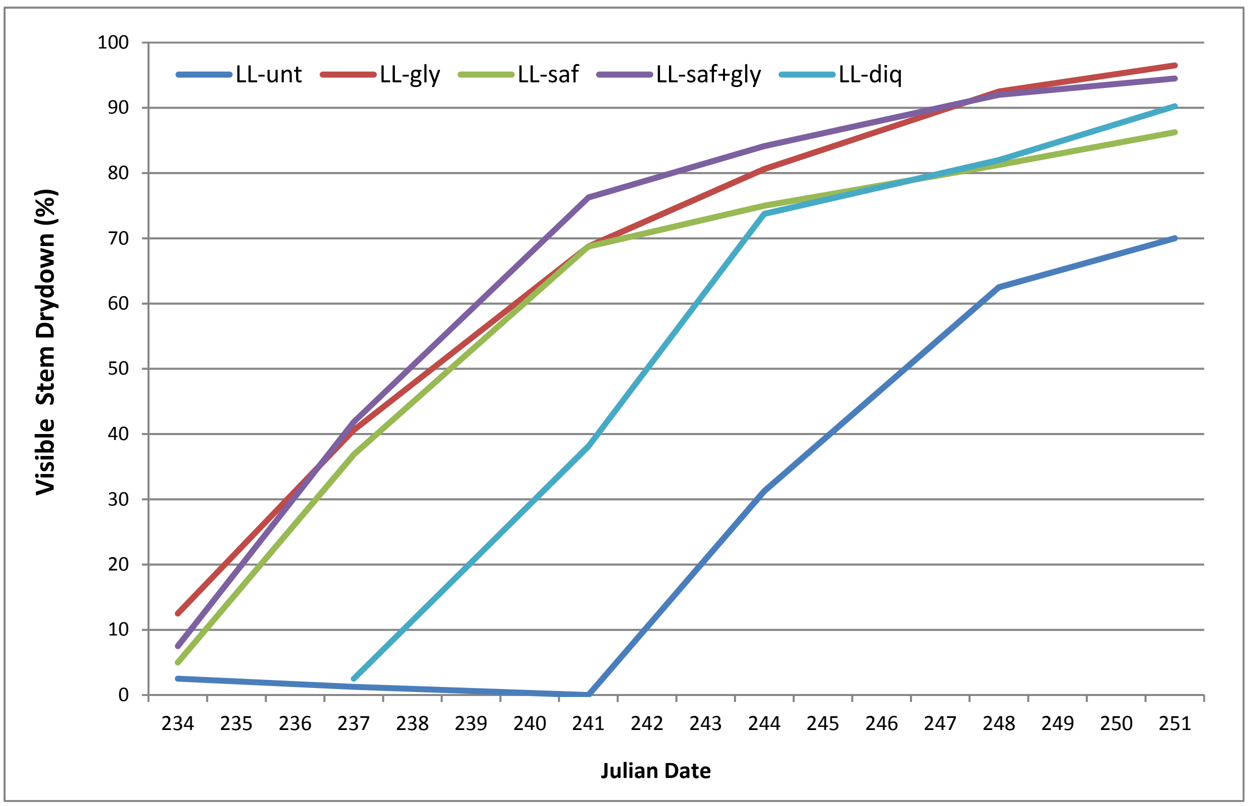


Figure 3: Rate of visible stem down for various pre-harvest treatments in glufosinate ammonium tolerant canola (Scott 2017).

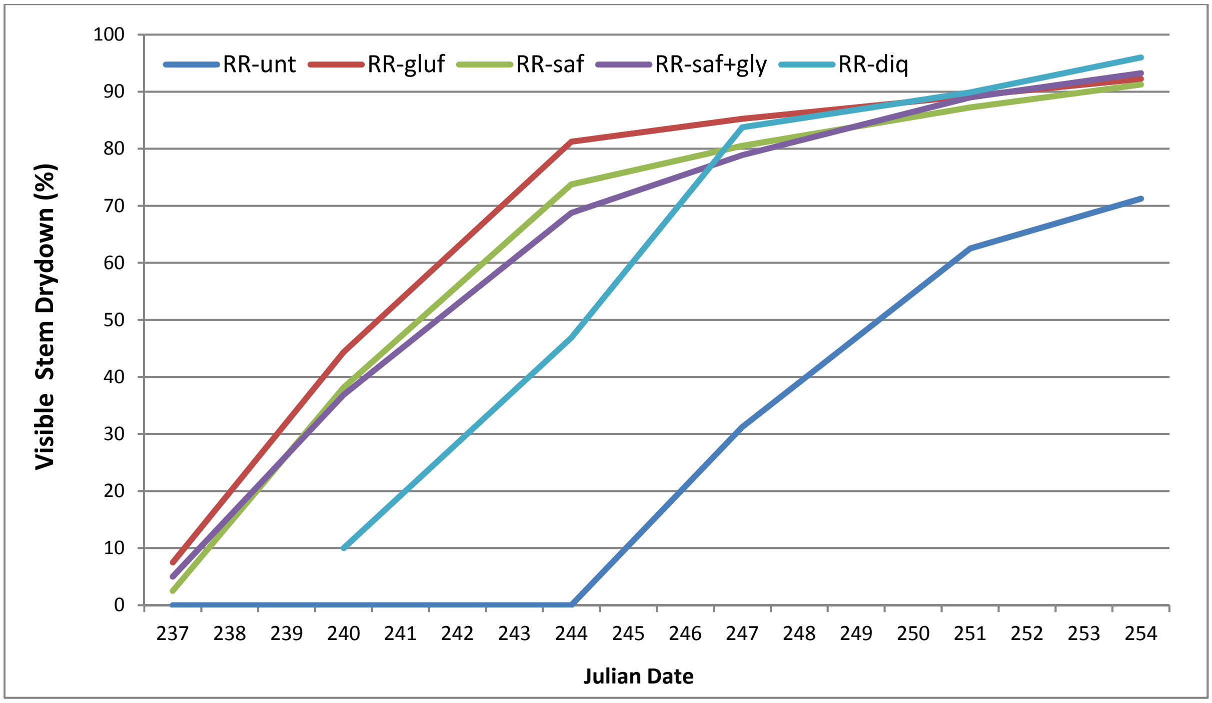


Figure 4: Rate of visible stem down for various pre-harvest treatments in glyphosate tolerant canola (Scott 2017).

Focusing on percent green seed, the overall F-test was not significant at the desired probability (P = 0.108); however, there was a tendency for more green seed in the plots treated with diquat, particularly for the RR hybrid (1.9% with diquat versus 0.2-0.5% for the remaining treatments). With LL canola, the effect was much less prominent and not significant with 0.5% green seed with diquat and 0.3-0.4% for the remaining treatments.

This difference in response was presumably due to the LL hybrid being more mature at the time of the treatment applications, despite their timing being specifically tailored to each hybrid at this site-year. The negative effect of diquat was also evident in the orthogonal contrasts where there was no overall effect of pre-harvest applications across hybrids and products (P = 0.356) but more green seed with diquat than either the untreated control or any other individual products to which it was directly compared (P = 0.018-0.038).

Melita 2017

Results for Melita in 2017 are presented in Tables 11-12 and Figs. 5-6. Emergence was variable with higher overall mortality for this site-year but establishment was noticeably better for the LL (35-56 plants/m^2) compared to the RR hybrid (13-21 plants/m^2). While some differences in emergence amongst the LL treatments were statistically significant, there were attributed to random variability and none of the contrast comparisons were significant (P = 0.297-0.922).

Visual stem dry-down ratings at harvest were affected by treatment with strong evidence of pre-harvest option effects and a highly significant overall F-test (P < 0.001). For the LL canola, percent visual dry-down was 71% in the control and significantly lower for glyphosate (both alone and tank-mixed with saflufenacil) and diquat (84-91%) but not for saflufenacil applied alone (71%). With the

RR canola, visual stem dry-down was rated at 68% in the control and was significantly higher with all pre-harvest options where the values ranged from 83-98%. With the exception of diquat being more effective than saflufenacil applied alone, no other individual differences amongst products were significant according to the multiple comparisons test. The contrasts showed an overall benefit to pre-harvest applications ($P < 0.001$) and to saflufenacil + glyphosate and diquat over the control ($P \leq 0.001$) along with a strong tendency for increased dry-down with saflufenacil alone over the control ($P = 0.067$). Information on the overall rate of dry-down at Melita (2017) is presented in Figs 5 and 6 for LL and RR canola, respectively.

Table 11: Treatment means and tests of fixed effects for selected response variables at Melita, Manitoba in 2017. The treatments are various pre-harvest / desiccation options for glufosinate ammonium (LL) and glyphosate (RR) tolerant canola hybrids. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test; *P* ≤ 0.05).

Treatment	Plant Density	Visual Dry-down	Seed Moisture [Z]	Plant Moisture [Y]	Seed Yield	Seed Weight	Green Seed
	-- plants/m² --	------- % -------	------- % -------	------- % -------	----- kg/ha -----	g/1000 seeds	------- % -------
1) LL – Control	37.8 bc	71.3 cd	8.7 abc	30.4 a-d	3584 a	3.28 a	0.3 bc
2) LL – Glyphosate	34.7 cd	88.8 ab	8.1 bcd	21.6 d	3496 a	3.21 a	0.1 c
3) LL – Saflufenacil	43.5 abc	71.3 cd	8.2 bcd	31.2 ab	3502 a	3.20 a	0.1 c
4) LL – Safl + Glyph	56.0 a	83.8 b	8.5 a-d	25.1 bcd	3689 a	3.18 a	0.4 bc
5) LL – Diquat	50.8 ab	91.3 ab	8.1 bcd	21.8 cd	3648 a	3.21 a	0.1 c
6) RR – Control	20.7 de	67.5 d	9.5 a	36.1 a	3613 a	3.24 a	0.9 b
7) RR – Gluf. Amm.	15.0 e	90.0 ab	7.8 cd	28.2 a-d	3524 a	3.21 a	0.7 bc
8) RR – Saflufenacil	19.2 e	82.5 bc	9.1 ab	33.9 ab	3436 a	3.27 a	0.5 bc
9) RR – Safl + Glyph	13.0 e	86.3 ab	8.7 abc	30.7 abc	3304 a	3.27 a	0.2 bc
10) RR – Diquat	19.2 e	97.5 a	7.5 d	26.5 bcd	3577 a	3.29 a	1.9 a
SE	5.76	5.23	0.43	3.06	122.4	0.073	0.24
LSD [X]	14.25	12.34	1.13	8.89	225.9	0.162	0.71
Pr > *F* (p-value)	**< 0.001**	**< 0.001**	**0.033**	**0.032**	0.070	0.864	**< 0.001**
AICC [W]	245.2	237.3	-184.2	-66.4	414.6	-21.9	58.2

[Z] Gravimetric water content of seed at harvest
[Y] Gravimetric water content of above-ground plant material at harvest
[X] Least Significant Difference values presented can be used to compare individual treatments but do not control experiment-wise error
[W] Akaike Information Criterion (corrected) - A measure of overall model-fit (smaller is better)

The overall F-test for percent seed moisture was significant ($P = 0.033$) but with greater pre-harvest treatment separation observed in the RR compared to the LL canola. In the LL canola, seed moisture at harvest was 8.7% in the control and ranged from 8.1-8.5% amongst the treated plots – none of which differed significantly from the control according to the multiple comparisons test. For RR canola specifically, seed moisture in the control was 9.5% which was significantly higher than that observed with glufosinate ammonium (7.8%) and diquat (7.5%) but not saflufenacil regardless of whether it was tank-mixed with glyphosate (8.7-9.1%). The contrast comparisons showed an overall benefit to pre-harvest treatments across hybrids and products ($P = 0.012$) and to diquat over the control ($P < 0.001$) but not saflufenacil or saflufenacil + glyphosate compared to the control (P = 0.245-0.284). Seed moisture content was also lower with diquat when compared directly to saflufenacil with or without the addition of glyphosate (P < 0.001-0.036).

The overall F-test for whole plant moisture content was also significant at Melita in 2017 ($P = 0.032$). The mean values for the untreated controls were 30% and 36% for the LL and RR varieties, respectively, with some evidence of reductions amongst the treated plots. For the LL canola, no treatment differences were significant according to the multiple comparisons test; however, the observed values tended to be lower for glyphosate (25%), saflufenacil plus glyphosate (25%) and diquat (22%). At 31% (compared to 30% in the control), there was no evidence of reduced plant moisture content for the LL canola when saflufenacil was applied alone. For the RR canola at this site, the only statistically significant difference was between the control and diquat (36% versus 27%); however, the values were also noticeably lower for glufosinate ammonium (28%). Saflufenacil alone (34%) and with glyphosate (31%) had less impact on total plant moisture in RR canola although the values were numerically lower. For the contrasts, the untreated versus treated and untreated versus diquat comparisons were both significant (P = 0.006-0.022) while the untreated versus saflufenacil + glyphosate comparison was not significant at the desired probability level but was worth noting ($P = 0.092$). The only significant product to product comparison was between diquat and saflufenacil applied alone ($P = 0.011$).

Yields at this site ranged from 3304-3689 kg/ha and neither the overall F-test ($P = 0.070$) nor any of the contrast comparisons (P = 0.070-0.858) were significant at the desired probability level of $P \leq 0.05$.

The overall F-test for seed weight was not significant ($P = 0.864$) and the individual treatment means ranged from 3.2-3.3 g/1000 seeds. As expected given the consistency of the individual treatment means, none of the predetermined contrast comparisons were significant (P = 0.438-0.842).

While the overall F-test for percent green seed was highly significant ($P < 0.001$), the values were noticeably lower and more consistent for the LL hybrid which ranged from 0.1-0.4% with no significant differences amongst the pre-harvest treatments. For the RR canola, percent green seed was statistically similar for the control and all pre-harvest treatments except for diquat where, at 1.9%, percent green seed was significantly higher than all other treatments. The only significant contrast comparisons were between diquat and saflufenacil, with or without the addition of glyphosate ($P = 0.008$); however, the untreated versus diquat comparison was worth noting ($P = 0.094$).

Table 12: Contrast results for selected response variables in canola desiccation study at Melita, Manitoba in 2017.

Group Comparison	Plant Density	Visual Dry-down	Seed Moisture Z	Plant Moisture Y	Seed Yield	Seed Weight	Green Seed
	---------- p-value ----------						
Untreated vs treated	0.582	**< 0.001**	**0.012**	**0.022**	0.225	0.438	0.701
Untreated vs Saflufenacil	0.674	0.089	0.284	0.827	0.108	0.595	0.271
Untreated vs Saflufenacil + Glyphosate	0.297	**0.001**	0.245	0.092	0.202	0.465	0.271
Untreated vs diquat	0.255	**< 0.001**	**0.002**	**0.006**	0.858	0.773	0.094
Saflufenacil vs Saflufenacil + Glyphosate	0.528	0.067	0.924	0.139	0.727	0.842	1.000
Saflufenacil vs Diquat	0.467	**< 0.001**	**0.033**	**0.011**	0.076	0.807	**0.008**
Saflufenacil + Glyphosate vs Diquat	0.922	**0.036**	**0.040**	0.235	0.148	0.657	**0.008**

Z Gravimetric water content of seed at harvest

Y Gravimetric water content of above-ground plant material at harvest

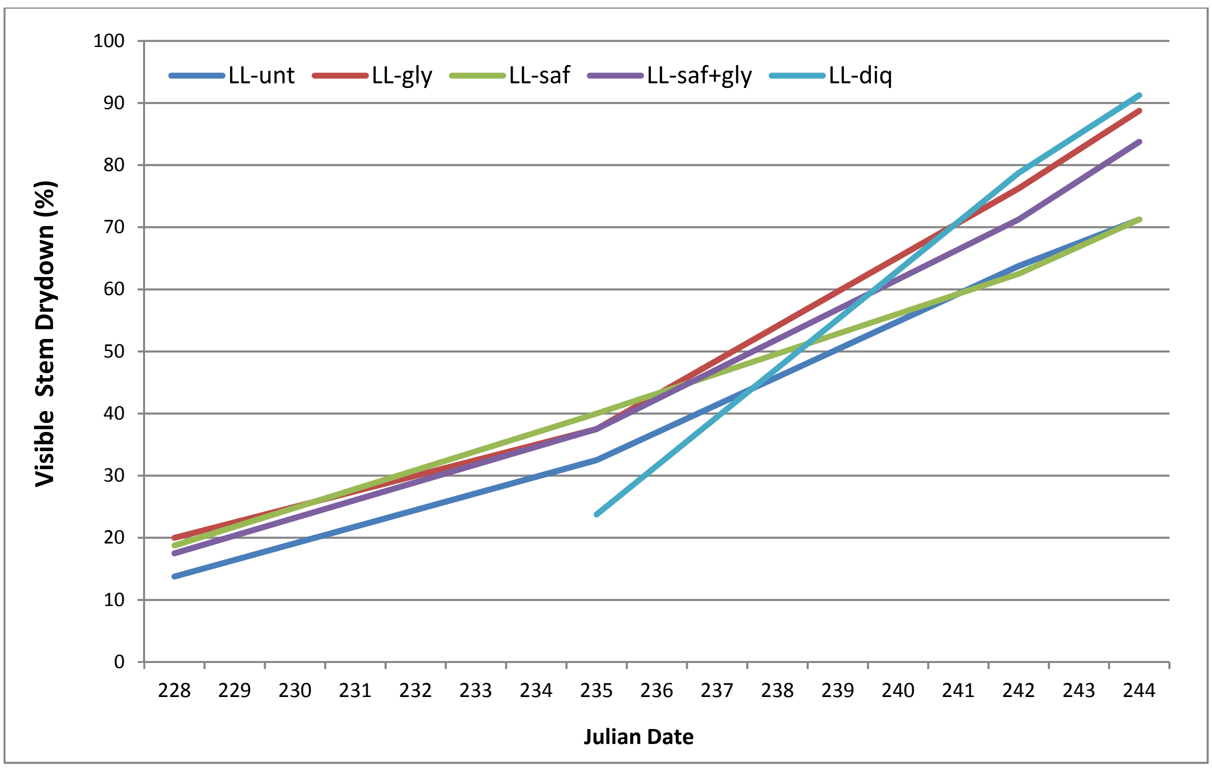


Figure 5: Rate of visible stem down for various pre-harvest treatments in glufosinate ammonium tolerant canola (Melita 2017).

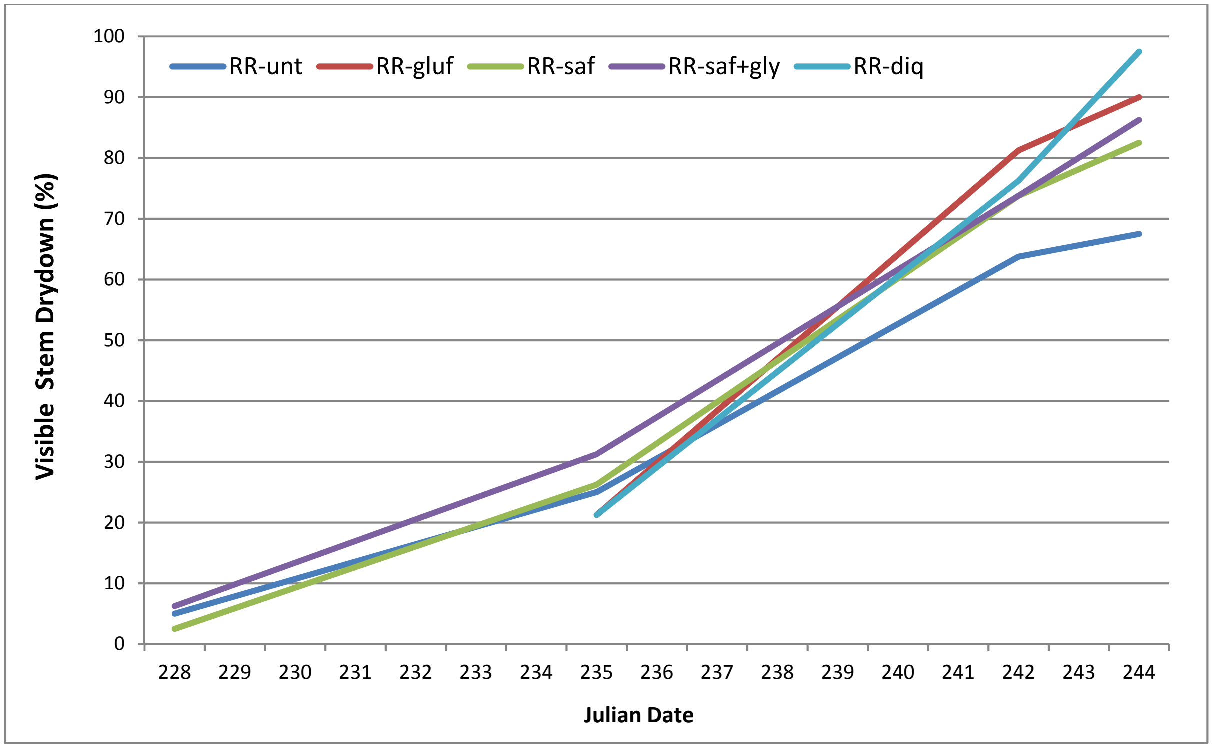


Figure 6: Rate of visible stem down for various pre-harvest treatments in glyphosate tolerant canola (Melita 2017).

Research and Action Plans – The Next Step

Preparations for the second year of field trials are underway. There are no fundamental changes to the protocols being considered; however, a few key refinements may be implemented.

First, while it was manageable, there were larger differences in maturity between the two test varieties (L233P-LL and 45H35-RR) than would be ideal; therefore, other options are being explored. The RR variety is still being confirmed but will ideally remain unchanged – 45H35 is currently sold out commercially but representatives with Dupont-Pioneer are working on securing new seed for the project. Other Pioneer-Protector® HarvestMax would also be suitable for the project. Representatives with Bayer CropScience (to become BASF) have been contacted and can provide either L233P or L255CP, the latter being a few days later and likely to be a closer match (with respect to maturity) to the RR hybrid. Hybrid selection will be finalized in the coming weeks with the ideal options being L255CP and 45M35 as the LL and RR test hybrids in 2018.

The principle reason for determining seed moisture off the combined using wet/dry weights was that it is quite accurate when done using appropriate methods/equipment and a representative sub-sample and also allows for assessment of seed which falls outside of the testable moisture range (i.e. ~5.5-14.5%). However, for this to be accurate the samples must be processed immediately after combining (before air-drying can occur) and collaborators must have access to a humidity controlled oven capable of temperatures exceeding approximately 70 °C. The methodology will be reinforced with emphasis on the time sensitivity of the measurements, need for high temperatures and, potentially, longer drying times. If appropriate drying equipment is not available for any reason, collaborators will be advised to use an electronic moisture meter, provided that the values do not fall outside of the testable range.

Co-operative Mustard Report 2017

Cooperator: Prairie Grain Development Committee

Trial Information, Sites and Co-operators

The 2017 Co-operative Mustard Test consists of 24 entries of yellow mustard (*Sinapis alba* L.) and ten entries of oriental and brown mustard (*Brassica juncea* L. Czern. and Coss.). There are five entries of oriental mustard and five entries of brown mustard. Thirteen trial sites were planted in 2017, representing the typical condiment mustard growing areas of western Canada. Analysis of variance is performed and data is reported only for sites with less than 16% Coefficient of Variation (C.V.) for yield. The trial sites, with the co-operators and seeding and harvest information are listed below († CV<16%). The entries, with their respective years in the Co-operative Mustard Test, are listed below. For yellow mustard, only the seven best lines are listed.

Site	Co-operator	Company or Institution	Species	Seeded	Harvest method
Saskatchewan					
Redvers (RED)	Lana Shaw	SERF	*B. juncea†* S. alba†	May 14	Desiccated and Straight Combined Desiccated and Straight Combined
May 14					
Saskatoon 1 (SA1)	Ryan Vetter	AAFC, Saskatoon Research Centre, Saskatoon	*B. juncea†*	May 20	Desiccated and Straight Combined
S. alba†		May 20		Desiccated and Straight Combined	
Saskatoon 2 (SA2)	Ryan Vetter	AAFC, Saskatoon Research Centre, Saskatoon	*B. juncea†* S. alba†	May 17 May 17	Desiccated and Straight Combined Desiccated and Straight Combined
Scott(SCT)	Greg Ford	AAFC, Scott Research Station, Scott	*B. juncea†*	May 29	Desiccated and Straight Combined
S. alba†		May 29		Desiccated and Straight Combined	
Swift Current (SWC)	Craig Gatzke	AAFC Swift Current	*B. juncea †*	May 12	Straight Combined
S. alba†		May 12		Straight Combined	
Vanguard (VNG)	Erin Burton	Westwind Ag Research	*B. juncea*	May23	Lost
S. alba		May23		Lost	
Vanscoy (VNS)	Ted Nodge	AgQuest	*B. juncea* S.alba	May 19	Lost Lost
May19					

Alberta					
Brooks (BRO)	Art Kruger	Crop Diversification Centre South	*B. juncea†* *S. alba†*	May 11 May 11	Straight Combined Straight Combined
Coaldale (COL)	Kimiko Epp	Hytech	*B. juncea* *S. alba*	May 16 May 16	Hailed Hailed
Lethbridge (LET)	Ryan Dyck	AAFC Lethbridge	*B. juncea †* *S. alba*	May 9 May 9	Combined August 14 Combined August 14
Medicine Hat (MED)	Michael Gretzinger	Farming Smarter	*B. juncea†* *S. alba*	May 18 May 18	Desiccated and Straight Combined Desiccated and Straight Combined
Taber (TAB)	Heather Ray	AgQuest	*B. juncea* S.alba	May 19	Lost Lost
Manitoba					
Melita (MEL)	Scott Chambers	MAFRI	*B. juncea†* *S. alba†*	May 11	Swathed and Combined

Methodology

The 2017 Co-operative Mustard Test was designed as a randomized complete block. The experiments consist of four replicates and include checks for each of the three types of condiment mustard. The checks are the registered cultivars 'Cutlass' oriental mustard, 'Centennial Brown' brown mustard and 'Andante' yellow mustard.

For the trial to be valid the Coefficient of Variation (C.V.) for yield must be below 16% and there must be three complete replicates. There were 7 sites for the yellow mustard and 9 sites for the brown and oriental mustard that met these requirements.

Statistical analysis of variance is performed using ARM version 8 and the SAS Institute Inc. SAS® System release 9.1, PROC MIXED model. Analysis of Variance using the randomized complete block design is performed, on a site basis, and yield and seed quality data are reported on sites with less than 16% C.V. for yield. For each site entries that are significantly better than the relevant check, at the 5% significance level are indicated by the letter 'a' or 'b' following the data point. Entries that are significantly worse than the relevant check are indicated by the letter 'z' or 'y' following the data point.

Grand means for 2016 are determined using the SAS PROC MIXED model where replicates (nested within sites) and site-by-entry interactions are classified as random variables. In tables comparing multiple sites or years means that are significant at the 5% level are marked by the symbol **†.** Means that are significant at the 1% level are marked with the symbol **‡**. When a test site has missing plots, the mean for the site, and the grand mean over all sites, is determined using ARM version 8 to estimate the missing values. Grand means over years (two years) are determined using the SAS PROC MIXED model, where years, locations, and their interactions with entries were classified as random variables.

All means are rounded to the first significant digit that occurs in one-quarter of their standard error, with the exception of height, flowering, and maturity.

Quality analysis in 2017 is done on a minimum of two replicates from sites with acceptable C.V. for yield. A sub-sample of approximately 60-grams from each plot of the selected replicates is further cleaned of chaff and dried at 37°C for 48 hours.

Seed fixed oil and protein content and seed colour were estimated using visible Near-Infrared (NIR) spectroscopy method. The NIR spectra were used with calibration sets developed by Dr. John Philip Raney, for *S. alba*, *B. juncea*, *B. carinata*, *B. napus* and *B. rapa*, which includes: determinations of fixed oil content by Nuclear Magnetic Resonance (NMR) spectroscopy; protein content by Dumas combustion analysis using the LECO; seed colour by reflectance (whiteness index Method E 313, American Society for Testing and Methods), using the HunterLab colorimeter.

The glucosinolate content were estimated by wet chemistry method (gas chromatography) which includes determinations of allyl isothiocyanate glucosinolate for *B. juncea and hydroxybenzyl isothiocyanate glucosinolate* for *S. alba*.

Results for protein and oil content are reported as percent whole seed on a dry weight basis. *Allyl isothiocyanate glucosinolate* and *hydroxybenzyl isothiocyanate glucosinolate* is expressed as µmole/g. Green seed is determined on the number of distinctly green seeds counted in 1000 crushed seeds, reported as a percent. Chlorophyll is analyzed by spectrophotometric method after solvent extraction, and reported as mg/kg on a whole seed basis (3.0 g per sample). Seed weight is determined on 1000 counted seeds and reported as g/1000 seeds.
The tables on the following three pages are selected summaries from the trial. To see the entire final report including all tables please contact……

Table 1: Performance of the oriental and brown mustard lines in the Co-op Mustard Test in 2017

	Yield		Seed Weight	Fixed Oil	Protein	GLS Allyl	Seed Colour	Distinct Green	Chloro-phyll	Height	Maturity
	kg/ha	% Check	g/1000seed	% whole seed		µmole/g seed	WI E313	%	mg/kg seed	cm	days
Cutlass*	**1892**	**100.0**	**2.57**	**41.1**	**27.6**	**115**	**-38.0**	**0.21**	**1.48**	**128**	**86**
O123DH25	2031†	107.3	2.73‡	40.5‡	27.5	120†	-38.9	0.26	1.55	132	88†
O123DH132	1786	94.4	2.58	40.1‡	28.2‡	116	-44.1‡	0.26	1.16	135‡	86
O2459DH31	1914	101.2	2.86‡	41.3	27.9†	113	-44.5‡	0.19	1.49	150‡	86
O2521	2010†	106.2	2.73‡	39.4‡	28.7‡	142‡	-34.3‡	0.08†	1.17	146‡	87
Centennial Brown*	**1692**	**100.0**	**3.08**	**35.4**	**29.4**	**109**	**-3.37**	**0.04**	**2.96**	**133**	**86**
AAC Brown 120	1961 ‡	115.9	3.56‡	36.6‡	29.1	121‡	-5.64‡	0.33‡	4.58‡	142‡	90‡
B2952	2022 ‡	119.5	2.89‡	37.6‡	28.1‡	102‡	-3.56	0.12	4.63‡	140‡	87
B3164	1949 ‡	115.2	3.13†	36.8‡	29.0†	117‡	-5.79‡	0.17†	5.09‡	142‡	86
B3318	2063 ‡	121.9	2.93‡	37.4‡	28.0‡	105†	-4.41	0.04	2.47	138†	87†
S.E.	55		0.03	0.19	0.17	2.21	0.58	0.06	0.34	2.00	0.56
F-Value	9.14		261	253	29.9	49.9	2120	5.93	42.3	21.7	8.76
L.S.D. (5%)	108		0.05	0.37	0.33	4.33	1.14	0.11	0.67	3.9	1.10
# station yrs	9		9	9	9	9	9	9	9	7	7

Estimate of differences between means: ns = not significant F-test at 5% level, ** = not significant at 1% level.
Estimate of difference relative to appropriate check: ‡ highly significant Pr>t = <0.01, † significant Pr>t= <0.05.
1 =NIR estimates used * = check

Table 6: Performance of yellow mustard lines in the Co-op Mustard Test in 2017

	Seed Yield		Seed Weight	Fixed Oil	Protein	GSL HoBe	Seed Colour[1]	Distinct Green	Chloro-phyll	Mucilage	Height	Maturity
	kg/ha	% Andante	g/1000seed	% whole seed		µmole/g seed	WI E313	%	mg/kg seed	cS*mlg⁻¹	cm	days
Andante*	**1674**	**100.0**	**5.73**	**29.5**	**33.1**	**149**	**-35.8**	**0.08**	**0.57**	**74.2**	**114**	**91**
Y1992	**1785†**	**106.6**	**5.53‡**	**30.7‡**	**32.1‡**	**149**	**-37.7‡**	**0.13**	**0.74**	**90.7‡**	**115**	**92†**
Y3428	**1743**	**104.1**	**5.37‡**	**30.1‡**	**32.7**	**154**	**-37.0†**	**0.19†**	**0.85**	**101.0‡**	**120‡**	**93‡**
Y3463	**1676**	**100.1**	**5.71**	**29.5**	**33.4**	**158†**	**-37.2†**	**0.27‡**	**1.03‡**	**91.0‡**	**125‡**	**92†**
Y3464	**1749**	**104.5**	**5.35‡**	**30.4‡**	**31.9‡**	**144**	**-36.6**	**0.17**	**0.74**	**81.4†**	**121‡**	**92‡**
Y3517	**1702**	**101.7**	**5.64**	**29.7**	**33.1**	**158‡**	**-37.6‡**	**0.23‡**	**1.00‡**	**68.0†**	**123‡**	**92‡**
Y3551	**1708**	**102.0**	**5.42‡**	**29.8**	**33.6**	**151**	**-42.7‡**	**0.12**	**0.63**	**75.9**	**125‡**	**92‡**
S.E.	51.7		0.06	0.21	0.28	3.08	0.52	0.05	0.13	2.87	2.01	0.41
F-Value	1.18		12.1	9.03	9.89	4.76	36.6	2.77**	2.93	31.6	9.34	3.81
L.S.D. (5%)	102		0.12	0.41	0.55	6.07	1.04	0.10	0.27	5.67	3.97	0.82
# station yrs	7		7	7	7	7	7	7	7	7	7	5

Estimate of differences between means: ns = not significant F-test at 5% level. ** = not significant at 1% level.
Estimate of difference relative to appropriate check: ‡ highly significant Pr>t = <0.01, † significant Pr>t= <0.05.
1 =NIR estimates used * = check

Determining the optimum seeding window for soybeans in Manitoba

Kristen P. MacMillan, University of Manitoba, kristen.macmillan@umanitoba.ca, Twitter @kristenpodolsky

Objective

The objective of this study is to determine the optimum seeding window for soybeans in various ag-eco regions of Manitoba. Traditional recommendations are to plant soybeans when soil temperature has warmed to at least 10°C, which is typically May 15-25 in Manitoba (Manitoba Agriculture). However, farmers are starting to plant soybeans earlier and recent work by Tkachuk (2017) supports this trend. Tkachuk investigated soybean seeding dates across a range of soil temperatures from 6 to 14°C at Carman, Morden and Melita in 2014 and 2015. At three site-years, soybean yield was optimized with the earliest planting date. To further validate these findings across a wider range of environments, this study was initiated at Carman, Arborg and Melita in 2017. Instead of soil temperature, which did not limit yield in previous work, seeding date treatments were defined as four seeding windows. Within each date, an early and long soybean variety was seeded.

Discussion

Preliminary analysis of 2017 yield data was done by site-year; at Melita17 (M17), soybean yield was optimized within the early and normal seeding window compared to late seeding. Soybeans seeded very early at Melita showed a statistically similar yield to the other dates despite experiencing frost on May 18 and 19 (emergence was recorded May 16). At Carman17 (C17), seeding at the normal or late date decreased yield compared to the early date, and while the very early date had a statistically similar yield, soybeans in this treatment were damaged by frost on May 18. There were no statistical differences in yield across seeding dates at Arborg (A17), despite a numerical trend for reduced yield as seeding was delayed. Frost occurred in Arborg on May 11, 12, 18 and 19 but no emergence was recorded in any treatments on May 24. This trial will be continued in 2018 at Carman, Melita, Arborg and Dauphin. Overall, seeding one week earlier than normal optimized yield while reducing risk of frost exposure in 2017; in comparison Tkachuk (2017) found that the very earliest dates tended to optimize yield regardless of soil temperature. The final year of study in 2018 is anticipated to provide further clarity on seeding date recommendations.

Table 1: Summary of analysis of variance for the effect of seeding date, variety and their interaction on soybean yield at Melita, Carman and Arborg in 2017

	Melita 17	Carman 17	Arborg 17
Date	*	*	ns
Variety	*	ns	ns
Date*Variety	ns	ns	ns

*Significant at $P \leq 0.05$, **Significant at $P \leq 0.01$, ***Significant at $P \leq 0.001$, ns = not significant

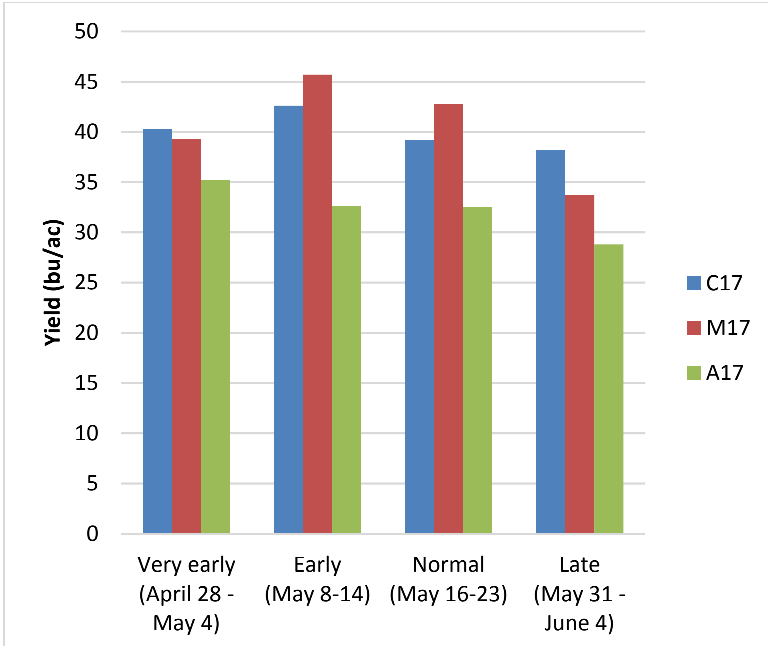


Figure 1. The effect of soybean seeding date on soybean yield Carman (C17), Melita (M17) and Arborg (A17) in Manitoba in 2017. Seeding date means at C17 and M17 with the same letter are not statistically different at $P \leq 0.05$.

The applied soybean and pulse research lab would like to thank Scott Chalmers of the Western Agricultural Diversification Organization (WADO) at Melita and Nirmal Hari of the Prairies East Sustainable Agriculture Initiative (PESAI) at Arborg for their contributions to this project.

Funding for this project is provided by Manitoba Pulse & Soybean Growers and Growing Forward 2.

Corn Intercropped with Hairy Vetch

Westman Agricultural Diversification Organization Inc. (2015)
Scott Chalmers P.Ag., Phone 1-(204)-522-3256. Scott.chalmers@gov.mb.ca
139 Main Street. Melita, MB Canada R0M 1L0

Hairy vetch (*Vicia villosa*) is considered a winter annual and is noted as a biennial or perennial. The plant is a fine stemmed, viney legume that is adapted to most soil types and is very competitive. Vines can grow over 100 cm long when able to trellis. Hairy vetch, when grown as a monocrop, lodges and tangles profusely with a height of 30 cm (similar to a good crop of Laird Lentils) and becomes difficult to swath. It apparently can contribute 60-120 lbs/ac nitrogen back to the soil from nitrogen fixation (source www.hort.purdue.edu). Hairy vetch has become popular in organic plow downs, and the cover crop cultures for this reason. WADO's observations with hairy vetch indicate the plant has good late season frost tolerance, but has highly variable (16-80%) winter survivability depending on environmental conditions and seed source. Root development is rather shallow and similar to field pea, which may make it a good candidate for intercropping with deep rooted crops such as corn or sunflower. Pod maturity is late seasoned (late August) when planted in the spring (May), and prone to shatter. Hairy vetch pasturage and seed can be toxic to livestock and should not be fed as forage in full bloom or containing seed, but is safe as a silage or hay. (Panciera R.J, Ritchey J.W & D.A 1992. Hairy Vetch Poisoning in Cattle: Update and Experimental Induction of Disease. J VET Diagn Invest. Vol. 4: 318-325). Prior to seed production, hairy vetch feed quality is exceptional and is similar to alfalfa (WADO feed analysis, 2008 & 2015). Hairy vetch can be pastured, hayed, or ensiled (Heson P.R., Schotch H.A., 1968 Vetch culture and uses. US Department of Agriculture Farmers' Bulletin 1740. US Government Printing Office, Washington DC.).

WADO has observed that if long season types of hairy vetch are seeded in late May in Manitoba, that seed production in vetch is rather limited in September, especially intercropped with corn and sprayed with powerful herbicides like glyphosate.

On the other hand, WADO has observed that hairy vetch is somewhat tolerant to modest rates of glyphosate (0.5 L/ac REL). For this reason, corn is ideal for intercropping with hairy vetch in addition timing of physiological development of both crops (Hairy vetch grows late into year while corn matures), potential fall-winter grazing in corn fields, and differing root zones accessing different water and nutrient profiles (corn grows deeper than vetch).

Objectives

1. Understand the interaction between corn yield and hairy vetch.
2. Understand the nitrogen economy and its economic value applied to monocrop and intercrop systems of corn and hairy vetch.

In the past, WADO conducted an experiment with corn and hairy vetch several times but have failed to attain any corn yield data since deer have menaced the trial.

Methods

Trials were planted into a Ryerson Waskada loam soil type southeast of Melita, MB. Plots were seeded into wheat stubble.

Trial area was pre-treated with a tank mix of Primextra II herbicide at 1.2 L/ac, Roundup, Aim herbicide at 1 L/ac and 15 ml/ac, respectively, prior to seeding on May 23. Plot treatments consisted of 30" row corn (8" spacing) using variety DK26-79 RR from DeKalb, Monsanto, with and without hairy vetch. Corn was direct seeded at a depth of 2.2" using an Wintersteiger corn planter. Hairy vetch seed was broadcast prior at a rate of 22 lbs/ac after corn emerged on May 31. Incorporation of the seed was possible with a hand rake. Hairy vetch was inoculated with pea/lentil granular inoculant (BASF). Plot treatments were arranged in a Randomized Complete Block Design that were 1.44 m wide by 9 meters long and were replicated 3 times. Fertilizer was broadcast and incorporated with tillage at a rate of 32-70-50-20 lbs/ac (N-P-K-S) with a granular fertilizer blend plus an additional application of agrotain treated urea applied at 132 lbs/ac applied May 18th, prior to seeding. Plots were kept weed free with an application of 1.5 L/ac REL glyphosate application tank mixed with 0.4 L/ac bromoxynil (Koril) applied on June 27. The high rate of glyphosate was intensional to determine the impact of high rates on hairy vetch.

Plots were harvested for grain corn October 21 with a Wintersteiger Classic plot combine and a Geringhoff corn header. Samples were recorded for data including gross weight, percent moisture. Yields were corrected to 15% moisture.

Individual plot soil tests were taken on October 24 prior to freeze up to assess any noticeable differences in soil nutrient content. Plots were soil sampled with 3 cores per plot at 0-6" and 6-24" depths. Soil samples were sent to AgVise Laboratories (Northwood, ND) for analysis of soil nitrogen parameters to assess any nitrogen mineralization and fixation accumulations.

Results

There were no differences in corn grain yield, soil organic matter (SOM) or soil nitrates following corn harvest.

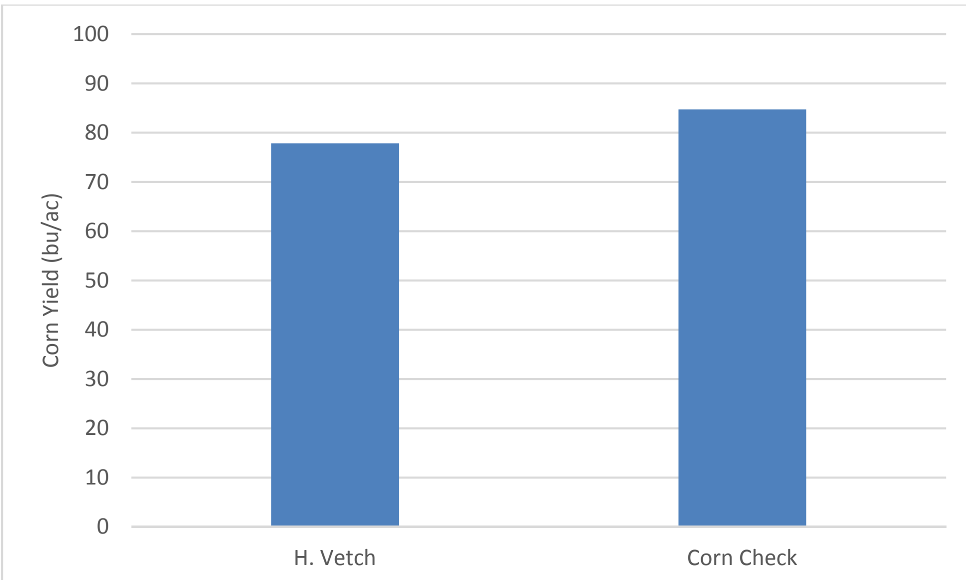


Chart: Corn yield in plots growth with hairy vetch and not with hairy vetch (corn check) near Melita in 2017.

Despite the high rate of glyphosate and rather aggressive tank mixed of bromoxynil, hairy vetch eventually recovered.

Photos. July 5, 2017

August 16, 2017 (below)

(Left) October 16, 2017 (Harvest Date)

Discussion

Intrinsic benefits that may be realized in future crop rotation are, greater soil N residue credits produced from the hairy vetch, as well as soil and ecosystem health and grazing day potential that could be utilized in real time after harvest. With approximately 0.5 ton per acre hairy vetch available forage in corn, a significant grazing period could be utilized. There were also no harvest issues with vetch grow in the understory of corn when using a corn header.

The potential for grazing corn stubbles intercropped with hairy vetch seems promising but poisoning from hairy vetch in livestock is still a risk. The economic value of the N credit (assuming 55 cents/lbs N) from hairy vetch residues is similar to the value of the forage itself (assuming 2 cents/lbs market value). Based on the economic values it would be a decision in the hands of the producer to choose to graze or leave residues for N credit for the next crop.

Direct seeding into hairy vetch mulches may prove difficult with current seeding equipment commonly used by farmers. A vertical tillage unit or a discer may be required to manage such heavy and tangled residues. The development of seeding openers designed to manage thick thatches of biomass may prove beneficial in this scenario.

Hairy vetch seed can lead to volunteer hairy vetch in following crops and may become a weed in following crops or as a contaminant in the corn sample or grain sample of the following crop. There are weed control options to control hairy vetch, but they are less likely to be found if a pulse crop would be in rotation after sunflowers such as peas, lentils, dry beans or faba beans. A cereal crop would likely pose the most options to control volunteer hairy vetch seedlings in the next growing season. If hairy vetch is planted later it reduces the time for the plant to produce seed before fall frosts.

An observation from a local farmer near Pierson, MB using hairy vetch in corn has noted that the success if overwintering in vetch is greatly reduced if the vetch is grazed in the fall, prior to overwintering.

WADO Flax Fibre Project 2017

Cooperators

- European Flax Fibre Company
- Eric Liu – MAFRD – Fibre and Composites Specialist (Winnipeg)
- Manitoba Diversification Centres (Portage, Melita)
- Prairie Agricultural Machinery Institute (Portage la Prairie)

Location and Soil Characteristics

Research Site: Melita, MB   Location: SW 22-3-27 W1   Soil Texture: Waskada Loam

Soil Test:

Depth	pH	N lbs/ac	P ppm Olsen	K ppm	S lbs/ac	Organic Matter %
0-6"	8.0	2	6	159	56	2.1
6-24"		3				

Previous Crop 2016: Fall Rye

Weeds burned off included:

Wild Mustard [*Sinapis arvensis* L., Brassica kaber (DC.) L.C. Wheeler var. pinnatifida (Stokes) L.C. Wheeler]

Volunteer rye

Objectives

1. To grow two fibre flax varieties across several regions in Manitoba and assess for flax fibre yield and quality (in a small field scale of 2 acres).
2. Pull the large plots of each variety and leave to rate over the fall of 2017.
3. Bale and ship back to Europe for quality and fibre yield assessment.

Methods

Pre-seed Herbicide application (burnoff): Roundup (glyphosate) @ 0.5 L/ac applied May 16, 2017

Seed Date: May 16, 2017 Rolled rocks after seeding with land roller.

Seed Rate: 75 lbs/ac **Seed Depth:** 3/4”

Varieties, Layout, Size:

Two flax fibre varieties named Eden and Melina were seeded in blocks about 0.5 acre in size per variety side by side. Long strips aided in fiber harvest in terms of the number of turns required at the headlands of each variety.

Fertilizer Applied:

Sideband 96 lbs/ac N, 35 lbs/ac P, 25 lbs/ac K, 10 lbs/ac S

Seeder: Seedhawk dual knife system with 6 rows with 9.5" spacing.

Soil Seeding Conditions: Poor moisture conditions at seeding, high residues.

Herbicide Application in Crop:

Application 1:

Products: Basagran @ 0.91 L/ac + Arrow at 0.1 L/ac + X-act adjuvant @ 0.5% v/v.

Water Volume Rates: 20 gals (imp.) per acre

Date: June 16, 2017

Results

Table: Results of yield after baling of fibre flax in Melita, MB in 2017.

Variety	Acres	Overall Bale Yield (lbs/ac)
Eden	0.40	2057
Melina	0.57	3851

Comments

Seeding was successful and plots were visually impressive. Seeding was accomplished using GPS guidance which kept rows straight and easy to pull at fibre harvest.

Photo: Melina on left and Eden on right on July 12, 2016 near the end of flowering.

Basagran herbicide was used for both volunteer canola control in addition to its relative crop safety.

There was no lodging this year regardless of variety tested.

The puller unit worked fantastic in general, pulling 5 rows at a time. Soil moisture conditions were moderately dry that day and with a loamy soil texture, plants pulled with ease.

When pulling occurred, plants were at physiological maturity where 95% of the bolls were brown, stems were generally green and leaves were only on the upper third of the plant whereas all other leaves had dropped naturally. The unit travelled about 4-5 mph and it took about 1.5 hours to pull 1 acre.

Order of Fibre Harvest Operations:

Pulling Date – Aug 17, 2017

Cam from PAMI operated the unit.

Turning Date: Sept 20, 2017

Cam from PAMI operated the unit.

Baling Date – Oct 5, 2017

Used a Verhaeghe 504 VE baler. Baling took 1/2 full day and was done by Cam Kliever of PAMI.

Bale Picking Date – Oct 6, 2017

Bales had to be baled in such a way that the stems where aligned in the same direction so that the bale was formed with roots on one side and seed bolls on the other. Sisal twine was used during baling and had to be strung between the layers of straw during the bale making process so that it will unwind in the factory as a single continuous later as it was in the field. Bales were wrapped with sisal during the final wrapping stage of the bale before being ejected from the baler.

Baling was cumbersome due to the complicated pickup system involved with this baler model. Steel fingers on the baler pickup would scratch the ground, sometimes hitting rocks. Sometimes flax straw would bunch and plug the pickup. This happened over a dozen times.

It took about two hours to pick all the bales and transport them to the shop at Melita with WADO's gooseneck trailer. Bales were stored in a steel pole shed on a trailer and covered with a tarp for fall storage. Bales were wrapped with sisal.

Photo (left): Illustration of the intake system of the baler. A conveyer of steel and rubber fingers feeds the flax into the baler with stems aligned the same direction for the entire makeup of the bale making process. The driver must be careful to keep the direction of the flax correct after every turn.

Photo (right): Bunches of straw in the baler intake were problematic during high winds. Bunches had to be untangled by hand dozens of times in the field.

Photo (left): Quality of fibre after retting and baling.

Photo (right): A bale was placed in a pickup truck, weighed and measured to determine bale density so that that density could be applied to all other bales for shipping purposes. WADO used a local producer owned elevator and measured to the nearest kilogram.

What's Next?

The plan is to ship the bales to Europe for quality analysis. Results from 2016 bales indicate that there were more than average short stem fibre and less long stem fibre with Manitoba grown linen than European grown linen. Further agro-climatic research is required to determine the source of this variation.

Efficacy of Avedex Herbicide Formulations in Field Pea on Yield and Weed Populations

Cooperator:

Mike Grenier – Gowan Canada

Location of experiment: SW 22-3-27W1 near Melita MB.

Year: 2017

Background

Herbicide tolerance in weeds is a great concern. Herbicide rotation is one management technique to prevent or manage resistance issues. Fortress and Edge herbicides offer possible solution to herbicide resistant kochia. Gowan Canada is testing various formulations and combinations of pre-seed applied herbicides for crop safety and weed efficacy.

Purpose

The purpose of the trial was to test different combinations and formulations of pre-seed applied on field pea and assess weed control on wild oats and broadleaf weeds as well as for crop safety.

Objectives

1. Apply pre-seed formulations and combination herbicides and assess early season weed control
2. Assess crop yield response to pre-seed formulations and combinations

Methods

A pre-seed burn-off was also applied April 20th using 1 L/ac Roundup transorb, 75 ml/ac clethodim (plus adjuvant). A total of 9 pre-emergent herbicides were applied April 28 using a 5 m wide plot Valmar applicator. Plots were arranged in a randomized complete block design and replicated 3 times with one untreated check, Plot dimensions were s 5 m x 8 m. Field peas (CDC Meadow) were seeded into applied herbicide treatments May 4th at a depth of 1.5". Plots were harvested for yield August 18, 2017.

Results

Weed pressure was not high in the trial location, the only weed present in sufficient uniform population to asses was wild buckwheat. Specific treatment identification has been omitted for proprietary reasons. Summary results for the control treatment of Fortress provided suppression of wild buckwheat with average control of 72% as compared to Edge granular providing good control at 83%. Performance of the various test formulations showed improvements in control levels over these two standard commercial treatments.

Average yield for the trial was 4050 kg/ha. Treated plots were generally numerically higher yielding as compared to the untreated check although there were no significant differences in yield among treatments ($p=0.916$). Coefficient of variation for overall grain yield among treatments was reasonable at 9%.

The trial results provided a good performance assessment of the test combination granules containing group 8 and 3 mode of action for resistant weed management in a herbicide layering program. More testing is planned for 2018. For more information, please contact Gowan Canada.

Photo: Plot Valmar application unit used to apply granular herbicides.

The Effect of Seeding Rate on Industrial Hemp Fibre Yield and Mortality in Manitoba

Project duration **-** May 2017 – October 2017
Objectives **-** To understand the effect of seeding rate on plant/seed mortality and final fibre yield of industrial hemp.
Collaborators **-** Parkland Industrial Hemp Growers

Results

- Seedling mortality was constant at both the Melita and Carberry locations (Figure 1).
- At the Roblin site mortality increased with seeding rate.
- Increasing seeding rate resulted in a decrease in height.
- There was no significant difference in total fibre yield at Carberry or Roblin, only at Melita.
- In general, fibre yield reached a maximum at a target rate of 250 plants/m2, however the recommended target rate of 150 plants was not significantly different from higher rates at all sites.

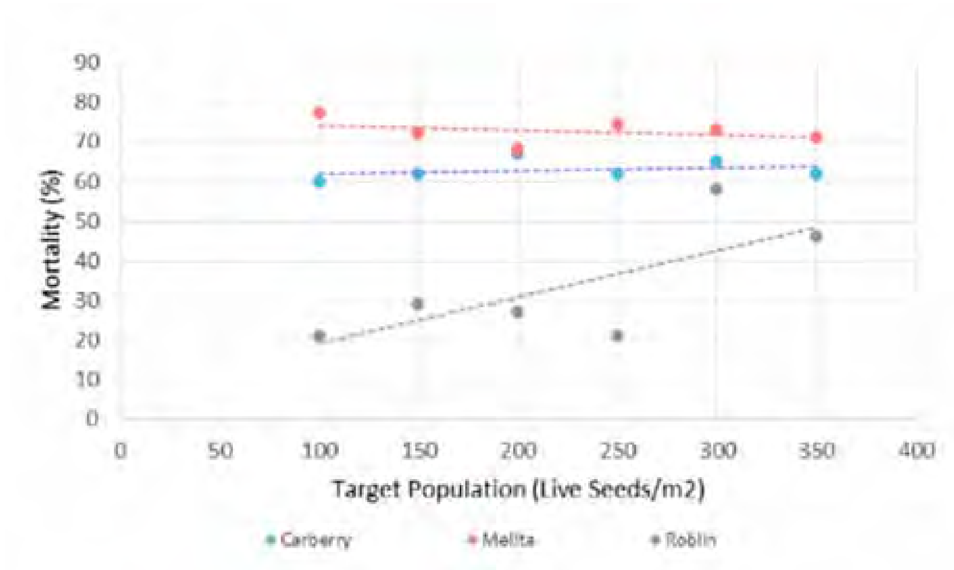


Figure 1: Seedling mortality rates relative to target planting populations at Melita, Carberry & Roblin, 2017.

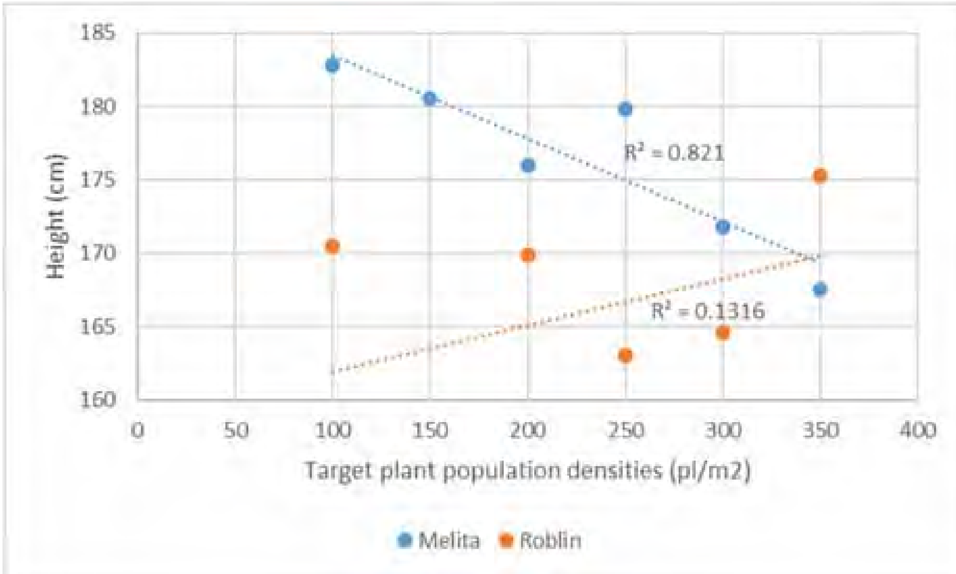


Figure 2: Effect of target population density on plant height in hemp at Melita and Roblin, Manitoba, 2017.

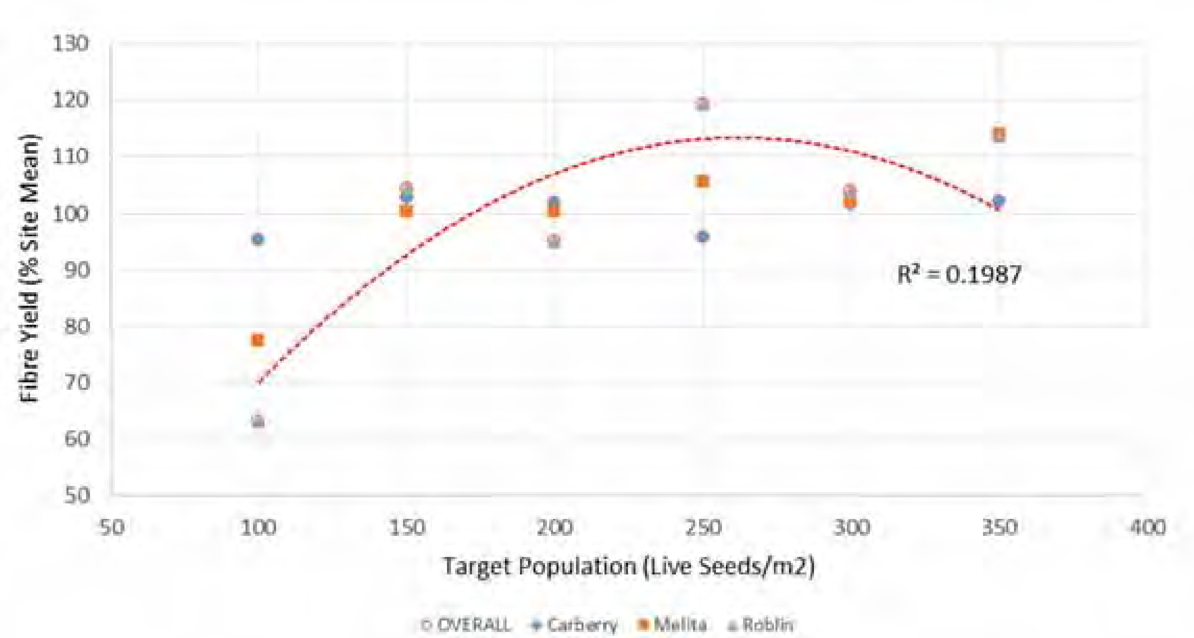


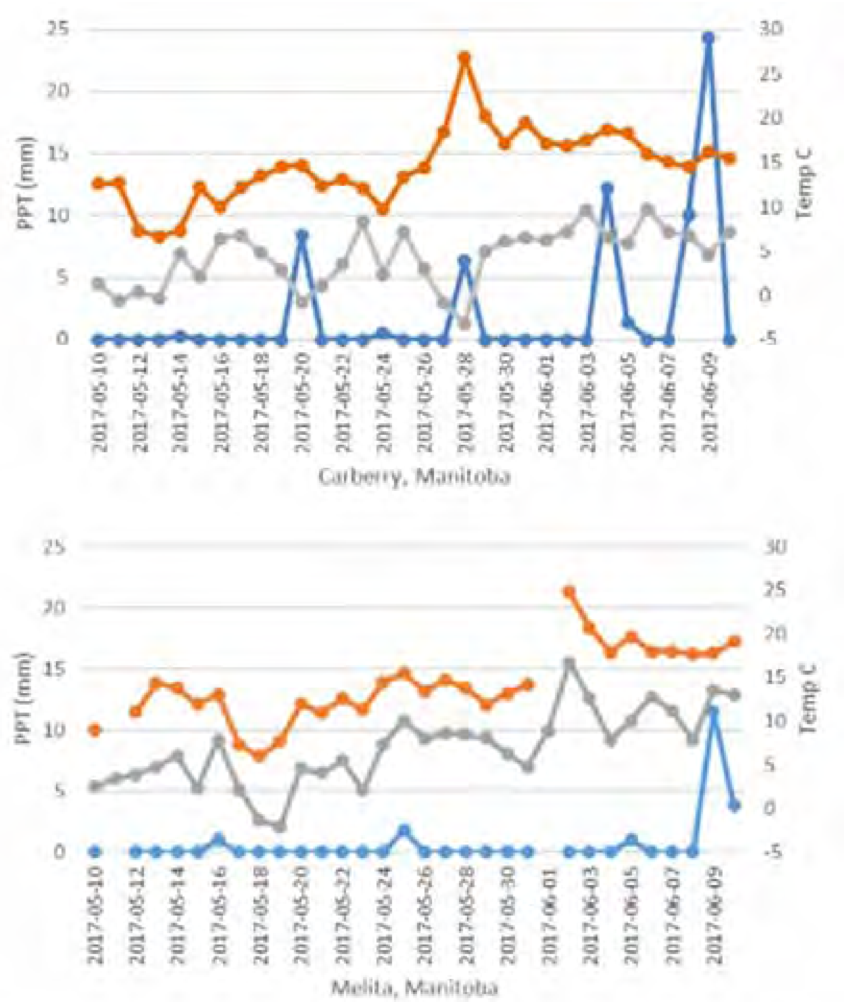
Figure 3: Effect of target population on hemp fibre yield at Carberry, Melita, and Robin Manitoba, 2017.

Project findings

This work supports previous work by the Diversification Centres focusing more specifically on grain varieties where mortality rates were constant and within a similar rage regardless of the target plant population.

Roblin in 2017 was a bit of an anomaly with regard to mortality rates changing with increased population targets. This needs to be investigated further to better understand the mechanisms behind the different mortality rates.

Unfortunately weather data is missing for the Roblin site between June 2 and June 16 however, comparisons between sites from May 10th to June 10 (Figure 4).



Overall, all sites had a moisture deficit relative to historical averages with Carberry, Melita and Roblin receiving 43%, 8% and 84% of 10yr average rainfall in May and the April prior was only at 63%, 80%, & 37% of normal, respectively. Moisture conditions at seeding for all sites was rated satisfactory. Both Melita and Carberry were similar with small rain events occurring around seeding but otherwise relatively fair to dry conditions with moderate temperatures. The Roblin site however, had a large rain event following seeding and cool temperatures. Given these differences however it would be expected that Roblin should have seen the largest levels of mortality and equal mortality across all plant populations which did not occur.

Future Work must focus more on environmental conditions during early stages of establishment, specifically soil conditions and the rate of emergence and seedling recruitment/death. The reasons why low stress weather conditions at both Carberry and Melita resulted in similar with mortality across all population levels verses the excess moisture and cooler temperatures at the Roblin site that resulted in different mortality rates across target populations needs to be explored in more detail.

Background

Mortality rates for industrial hemp can vary from 10-70% [1]. Nevertheless, the crop demonstrates the ability to adapt to different plant densities by altering its architecture (e.g. tall and thin vs. shorter and branched). Consequently, plant density has an impact on stem length and thickness. Higher seeding rates are used when targeting a hemp fibre crop. Varieties suited to fibre production typically have long, “pencil-thin” stems, sometimes exceeding two metres in height. Stem thickness affects the ratio of bast (long, outer fibres) and hurd (short, inner fibres), with thicker stems producing more hurd. This in turn affects the industrial application of the fibres.

http://www.hemptrade.ca/eguide/production/seeding
http://www.hemptrade.ca/eguide/fibre-production/selecting-hemp-varieties-for-fibre-only-applications

Materials & Methods

Experimental Design: Randomized complete block design
Entries: 5 (1 variety, 5 seeding rates)

Table 2: Treatments included in hemp fibre seeding rate trial, 2017

Variety	Seeding Rate (pl/m^2)
Canda	100
	200
	250
	300
	350

Table 3: Agronomic info for all sites

ITEM	Melita	Carberry	Roblin
Legal Location	NE 27-3-27W1		NE 20-25-28 W1
Soil Series	Waskada Loam	Wellwood Loam	Erikson Clay Loam
Soil Test (0-24")			
N - lbs/ac	7.2	33	86
P- ppm	11	32	10
K – ppm	260.8	673	183
S - lbs/ac	219.8	22	184
Burnoff Date	May 23	N/A	May 25
Product	Glyphosate/Liberty	N/A	RoundUp Transorb
Seed Date	May 24	May 18	May 24
Seed Depth	0.5”	1”	0.75”
Spring Fertilizer Application - lbs/ac			
N	120	100	49
P	35	0	10
K	25	0	0
S	10	0	0
Spring Fertilizer Date	SB at Seeding	SB at Seeding	Side-banded at seeding
In-crop Herbicides Date	June 16	N/A	N/A
Product	Koril/Arrow	N/A	N/A
Fibre Harvest Date	August 10		Aug 18
Grain Harvest Date	August 31	N/A	Sept 4

References

Canadian Hemp Trade Alliance: Production, Seeding Rate.
http://www.hemptrade.ca/eguide/production/seeding

The Effect of Split Nitrogen Application Rate on Three Varieties of Industrial Hemp in Manitoba

Collaborators - Hemp Genetics, Parkland Industrial Hemp Growers, Manitoba Harvest

Project duration - May 2017 – September 2017

Objectives - To understand the effect of split verses banding nitrogen fertilizer to optimize industrial hemp grain yields.

Results

- Overall, despite the split nitrogen application averaging 13% greater grain yield, overall there was no statistically significant difference in grain yield when applying nitrogen in one application at seeding verses 70% at seeding and 30% at stem elongation.
- At Melita there was a significant effect on grain yield when nitrogen was divided into split applications. At Carberry, although split application resulted in greater yield it was not statistically different do to overall higher variability in the trial.
- There was no significant difference in height between a split application or single application of nitrogen.
- Further study is required to better understand and confirm any positive effect of split verses banding all nitrogen at time of seeding on grain yield.

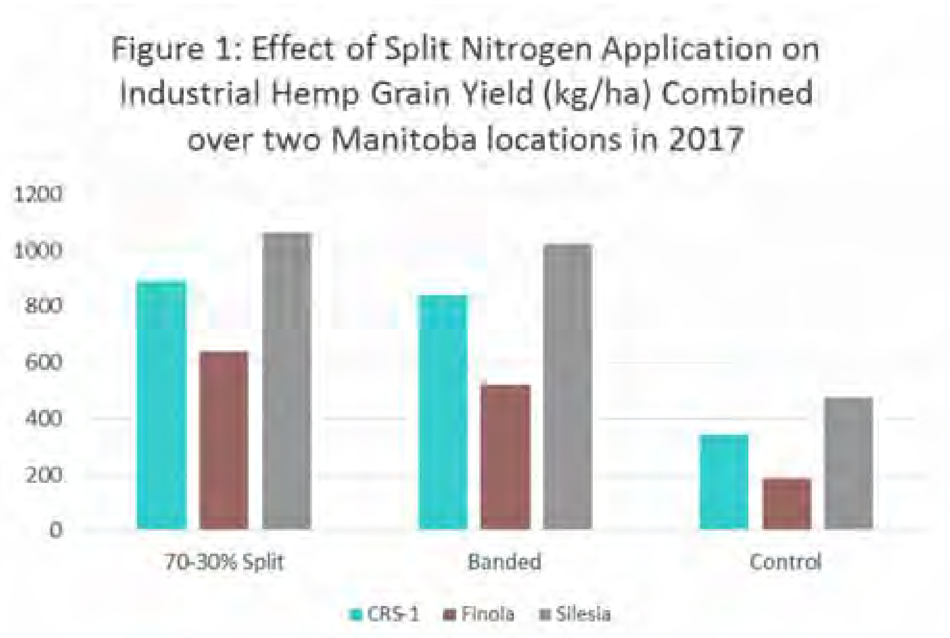


Figure 2: Effect of Split Nitrogen Application on Industrial Hemp Grain Yield (kg/ha) at Carberry, Manitoba 2017. LSD=169

Figure 3: Effect of Split Nitrogen Application on Industrial Hemp Grain Yield (kg/ha) at Melita, Manitoba 2017. LSD=132

Project findings

- Applying nitrogen at both sites resulted in a significant increase in grain yield.
- Applying nitrogen in a split format verses applying all at seeding increased grain yield at both sites; however, the increase was only significant at the Melita location.
- Lower yields at the Carberry site was most likely a result of below average rainfall, not allowing plants to fully utilize available nutrients.
- Further study is required to understand the potential benefit of split nitrogen application in industrial hemp.

Background

Current nitrogen recommendations for nitrogen are 80-120 lb/ac, with some suggesting higher rates, depending on variety and growing conditions. However, the economic risk of applying all nitrogen at planting can be high, especially if prolonged stress restricts the plants' utilization of the added nutrients. Additionally, in many cases it is not logistically possible to apply all the nutrient requirements at seeding. Split nitrogen applications have the potential to increase seeding efficiencies and allow growers to adjust rates of application according to growing conditions.

http://www.hemptrade.ca/eguide/production/nutrient-use

Materials & Methods

Locations:	Carberry, Melita (Roblin results not included due to high %CV)
Experimental Design:	Split plot design with four replications
Main plot:	Silesia (tall, fibre-type)
	CRS-1 (medium, dual purpose-type)
	Finola (short, grain-type)
Split plot:	Control – no nitrogen added
	Banded – nitrogen side-banded at seeding
	Split application – 70% nitrogen side-banded at seeding, 30% broadcast at canopy closure
Data collected:	Seeding date
	Emergence date
	Plants/m^2
	Mortality
	Vigor (1 low, 9 high)
	Height (cm)
	% Moisture
	Yield (kg/ha)

Table 2: Agronomic info for all sites

ITEM	Melita	Carberry	Roblin
Legal Location	NE 27-3-27W1		NE 20-25-28 W1
Soil Series	Waskada Loam	Wellwood Loam	Erikson Clay Loam
Soil Test (0-24")			
N - lbs/ac	7.2	33	86
P- ppm	11	64	10
K - ppm	260.8	673	183
S - lbs/ac	219.8	22	184
Burnoff Date	May 23	n/a	May 25
Product	Glyphosate/Liberty	n/a	RoundUp Transorb
Seed Date	May 24	May 19	May 24
Seed Depth	0.5”	1”	0.75”
Spring Fertilizer Application - lbs/ac	Variable N + Blend	46-0-0	
N	120/84+36	100/70+30	49
P	35	0	10
K	25	0	0
S	10	0	0
Spring Fertilizer Date	SB at Seeding + broadcast	SB at Seeding + broadcast	SB at Seeding + broadcast
In-crop Herbicides Date	June 16	N/A	N/A
Product	Koril/Arrow	N/A	N/A
Fibre Harvest Date	N/A	N/A	Aug 28
Grain Harvest Date	September 7		Sept 26

Performance of Relay Crop/Intercrop Legumes on Hemp Grain Production

Cooperators: Hemp Genetic International (seed)

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

Rational

On the Canadian prairies, hemp growers have been experimenting the merits of relay cropping legume cover crops under in hemp stands. This trial explores the merits of doing so, to investigate effect on hemp grain production, and assessment of regrowth of relay crops.

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

Methods

Legumes or rye were grown together and seeded on the same day as hemp. Broadcast relay crops were hand broadcast prior to seeding and then hemp was seeded through to help distribute and establish seed. Peas were seeded with the hemp down the same seed shank. Peas were inoculated with granular pea *Rhizobia* inoculant (Nodulator-G Pea/Lentil, BASF).

Location: Melita; legal land location SW 22-3-27 W1
Design: Randomized Complete Block Design; treatments replicated 3 times, plot size 12.96m2
Burn-off: Roundup transorb @ 0.5 L/ac + Liberty @ 0.75 L/ac applied May 23rd
Previous crop: Fall Rye
Seed Date: May 23, 2017
Hemp seed depth: 0.75”
Fertilizer: N-P-K-S: 126-35-25-10 (lbs/ac) Sideband UAN + granular blend
In Crop Herbicides: None
Hemp Grain Harvest Date: August 22, 2017
Relay Biomass Date: September 20th
Rainfall during trial: 222 mm (80% of normal)

Data Collected

- Emergence – 2 x 1 m counts per plot both hemp and relay
- Soil moisture after harvest (6” soil meter, HydraSense II hand held unit)
- Hemp Crop height
- Normalized Difference Vegetation Index (NDVI) at flower to assess chlorophyll content
- Hemp thousand kernel weight (500 seed count)

- Grain yield (hemp and field pea)
- Soil test Nitrogen after harvest (3 sample composite per plot)

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

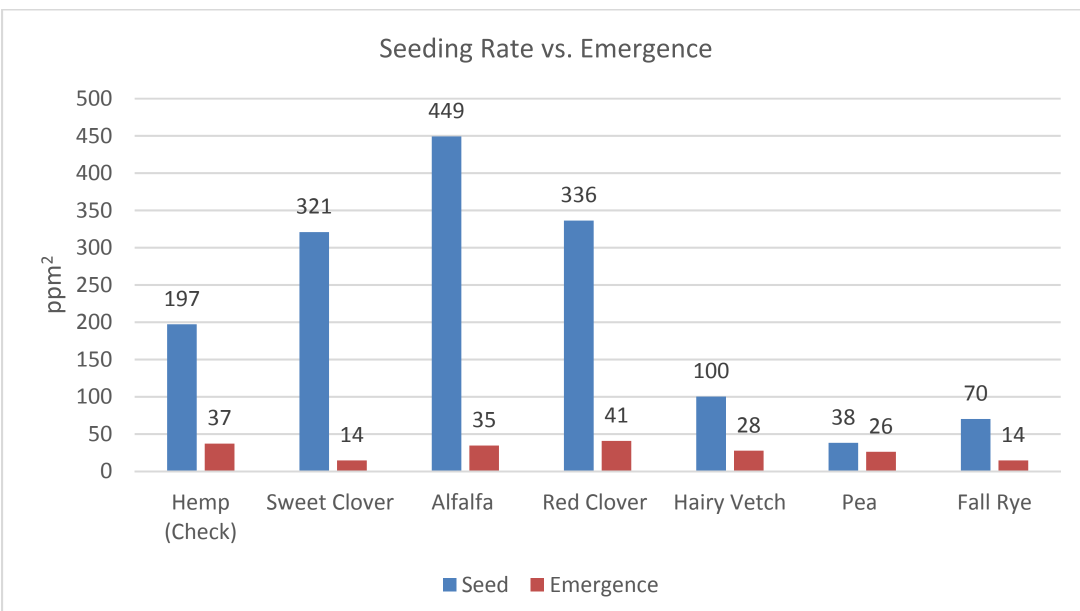
Treatment	Seed Method	Description	Variety	Seed Rate (lbs/ac)
1	Seeded	Hemp (Check)	Katani	25
2	Broadcast	Sweet Clover	Norgold	5
3	Broadcast	Alfalfa	Rangelander	8
4	Broadcast	Red Clover	Altaswede	5
5	Broadcast	Hairy Vetch	WADO	25
6	Seeded together	Field Pea	CDC Meadow	80
7	Broadcast	Fall Rye	Danko	20

* all but peas are broadcast prior to seeding hemp

Results

Due to the combination of broadcast seed and the lack of precipitation during the spring, there was poor emergence rates in sweet clover, alfalfa, red clover, hairy vetch and rye (Figure 1). Peas emerged fairly well since they were placed deeper in the soil with hemp seed. Establishment of relay was related to final success after hemp harvest of the relay crop. For example, due to poor emergence with red clover a poor biomass harvest was realized.

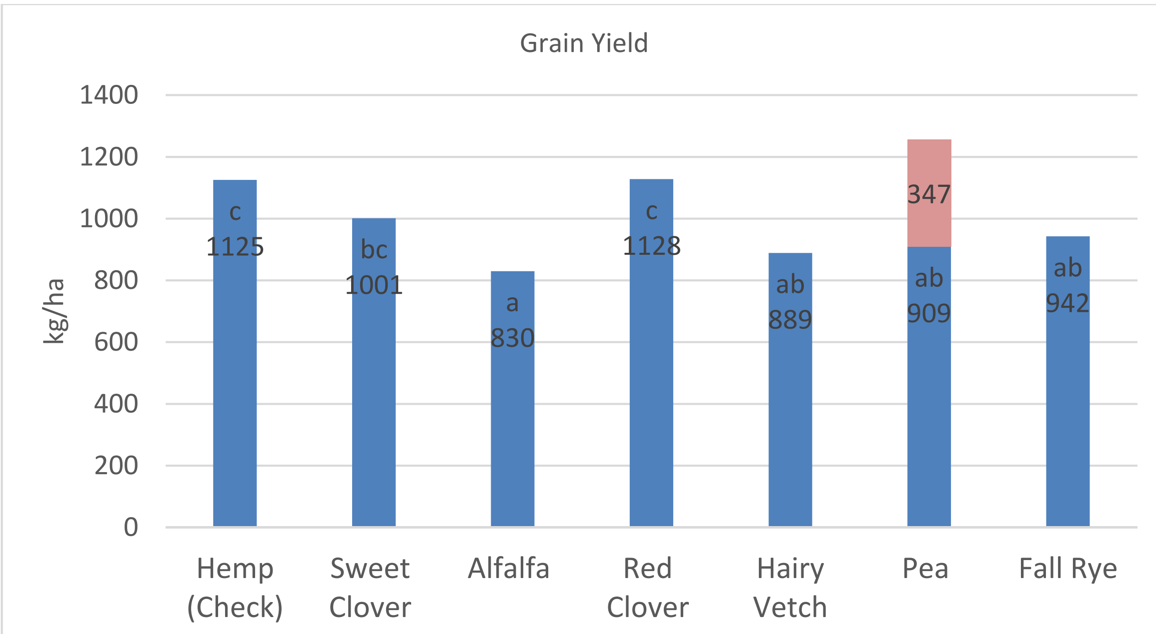
Figure 1: Emergence rates of the various relay crops with hemp in Melita for 2017.



There were no differences ($p<0.05$) in crop height (average of 136 cm), soil moisture after harvest, NDVI, thousand kernel weight of hemp compared to the check treatment. There were significant differences in grain yield ($p = 0.005$) and relay crop biomass one month after hemp grain harvest

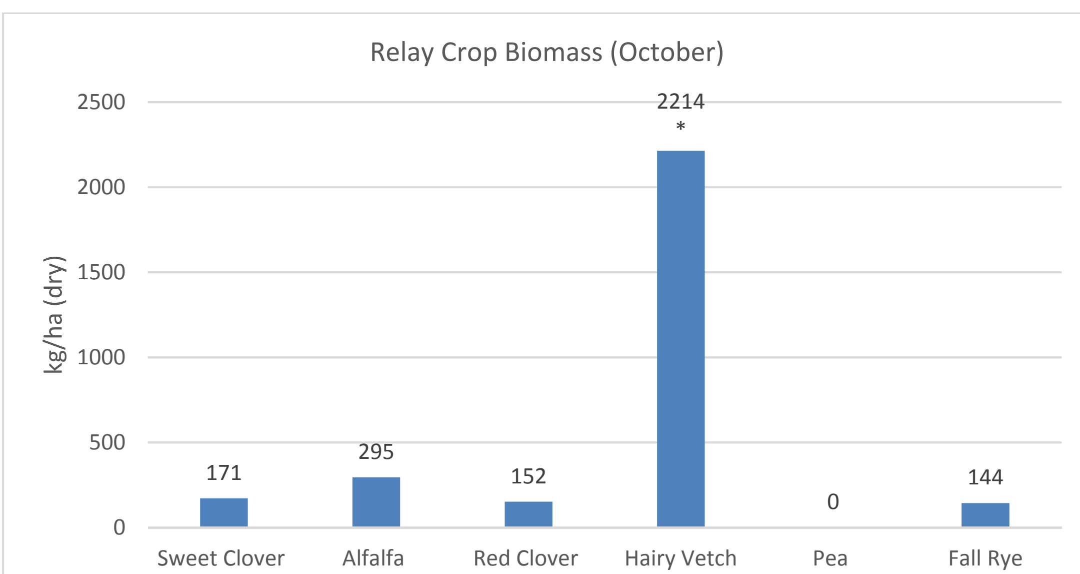
($p<0.001$). Hemp was significantly reduced with alfalfa, hairy vetch, field pea and rye. Sweet clover and red clover did not reduce hemp yield significantly. For field pea, additional pea harvest was achieved and did appear to over yield in total grain yield slightly compared to the hemp check yield.

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



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

Figure 3: Biomass of the relay crops following hemp harvest in Melita taken September 20th, 2017.



Discussion

Lack of overall rain fall during the year reduced the establishment and competitive ability of the relay crops to thrive. Alfalfa, peas and hairy vetch competed fairly well with limited water resources with the hemp. However, in competing with the hemp seem to reduce hemp yield through their success. This may be due to similar root zones competing for water when water was limited.

Rye appeared to reduce hemp yield likely due to lack of water resources early in development. Ideally, a herbicide would be used to take out the rye to reduce this effect. However, no herbicide was sprayed as it was apparent that rye was not competing well at the bolting stage of hemp and virtually disintegrated during flower in hemp. It was hypothesized that rye was "shaded out" by hemp after bolting.

Picture. Taken just prior to biomass sampling on September 20th. Note how hairy vetch, alfalfa did fairly well, while as red clover, rye and pea had poor development.

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

The practicality of intercropping field pea was minimal given the effort it would take to clean out a mere 350 lbs/ac. Economically and practically this would not be feasible. Perhaps on a normal to wet year this mixture would be economically beneficial, as would some of the other relay species that negatively affected hemp yield.

The trial is planned to be repeated in 2018 with hopes to have different weather conditions.

Yellow Peas

Hairy Vetch

Sweet Clover

Alfalfa

Red Clover

The Effect of Seeding Date on Three Varieties of Industrial Hemp in Manitoba

Project duration **-** May 2017 – September 2017
Objectives **-** To understand the effect of seeding date by variety on industrial hemp grain yields.
Collaborators **-**Hemp Genetics, Parkland Industrial Hemp Growers, Manitoba Harvest

Background

Earlier seeding dates (before May 15) for industrial hemp may result in high plant mortality rates, as well as taller, thicker stems [1]. Limited research is available on the effect of seeding date in Western Canada.

Materials & Methods

Locations:	Melita (Roblin results not included due to high %CV)
Experimental Design:	3 varieties with 5 seeding dates
Main plot:	CanMa (tall, dual purpose-type)
	CRS-1 (medium, dual purpose-type)
	Finola (short, grain-type)
Data collected:	Seeding date
	Emergence date
	Plants/m^2
	Mortality
	Vigor (1 low, 9 high)
	Height (cm)
	% Moisture
	Yield (kg/ha)

Table : Agronomic info for all sites

ITEM	Melita	Roblin
Legal Location	NE 27-3-27W1	NE 20-25-28 W1
Soil Series	Waskada Loam	Erikson Clay Loam
Soil Test (0-24")		
N - lbs/ac	7.2	86
P- ppm	11	10
K - ppm	260.8	183
S - lbs/ac	219.8	184
Burnoff Date	May 23	May 25
Product	Glyphosate/Liberty	RoundUp Transorb
Seed Date	Date 1-May 23 Date 2- May 31 Date 3- June 6 Date 4-June 16 Date 5- June 23	Date 1 – May 24 Date 2 – June 2 Date 3 – June 9 Date 4 – June 28 Date 5 – June 28
Seed Depth	0.75"	0.75"
Spring Fertilizer Application - lbs/ac		
N	120	49
P	35	10
K	25	0
S	10	0
Spring Fertilizer Dates	SB at Seeding	Side-banded at seeding
In-crop Herbicides Date	July 11 for Seed Date 2 - 5	N/A
Product	Koril/Arrow	N/A
Fibre Harvest Date	N/A	Aug 28
Grain Harvest Date	September 7	Sept 27

Results

- The greatest mortality was observed for Seeding Date 3 which followed a series of large rain events, affecting all varieties (Figure 1). Overall, variety was significant for seedling mortality with CRS-1 having the greatest mortality at 73%, followed by CanMa at 60% and Finola at 47%.
- Overall average grain yield for the trial was 871 kg/ha and ranged from 313-1427 kg/ha (Figure 2)
- The earliest seeding date in Melita resulted in the greatest grain yield.
- Seeding between May 31 and June 16 did not significantly increase grain yield.

- Seeding at June 23 significantly reduced grain yield.
- Overall height was negatively impacted by seeding date with the exception of Date 3.
- There was a significant interaction between test weight and variety with longer season varieties showing a negative relationship between seeding date and test weight (figure). Test weight Finola (early season) was not affected by seeding date while both CRS1 (mid-season) and CanMa (late season) were affected.

Figure 1: Mortality levels associated to seeding date and total precipitation events (within 5d period of seeding date)

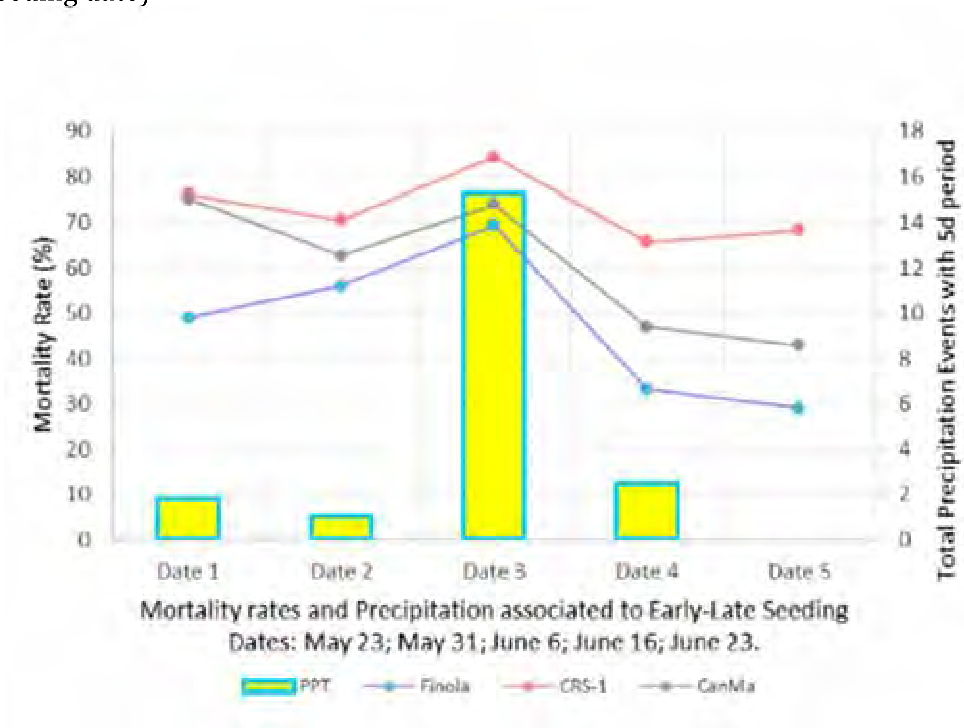


Figure 2: Effect of seeding date by variety on grain yield (kg/ha) for hemp planted at Melita Manitoba, 2017.

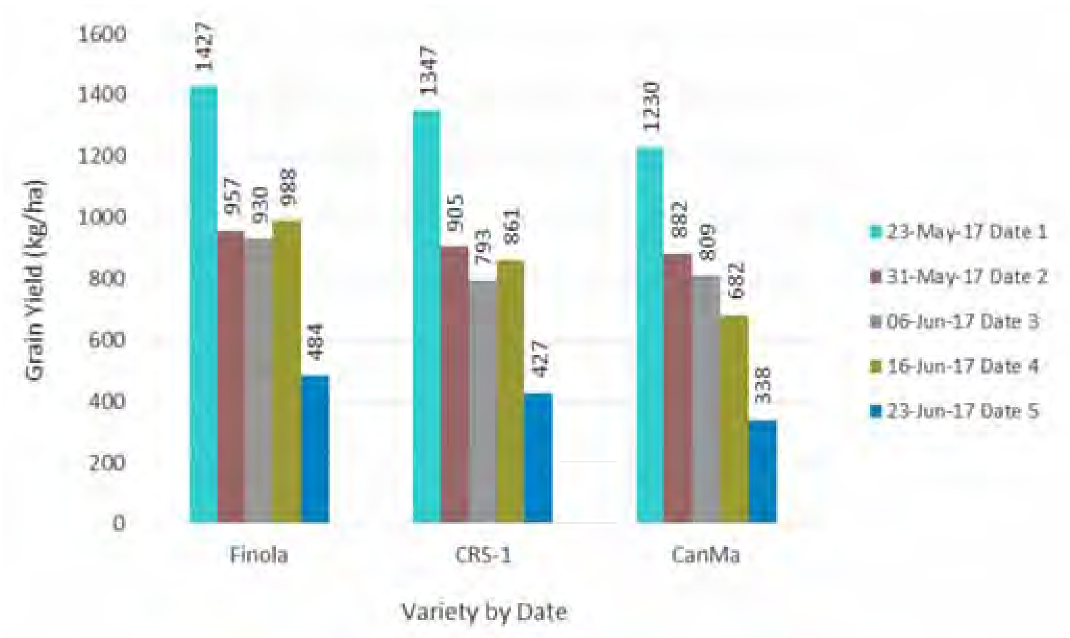


Figure 3: Effect of seeding date by variety on plant height (cm) for hemp planted at Melita Manitoba, 2017.

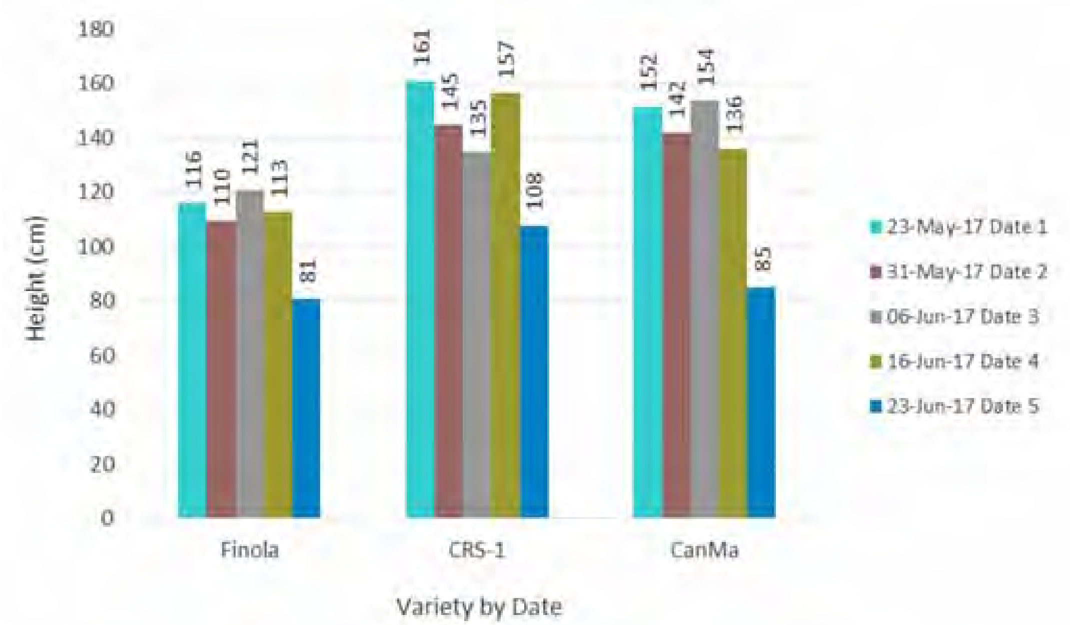
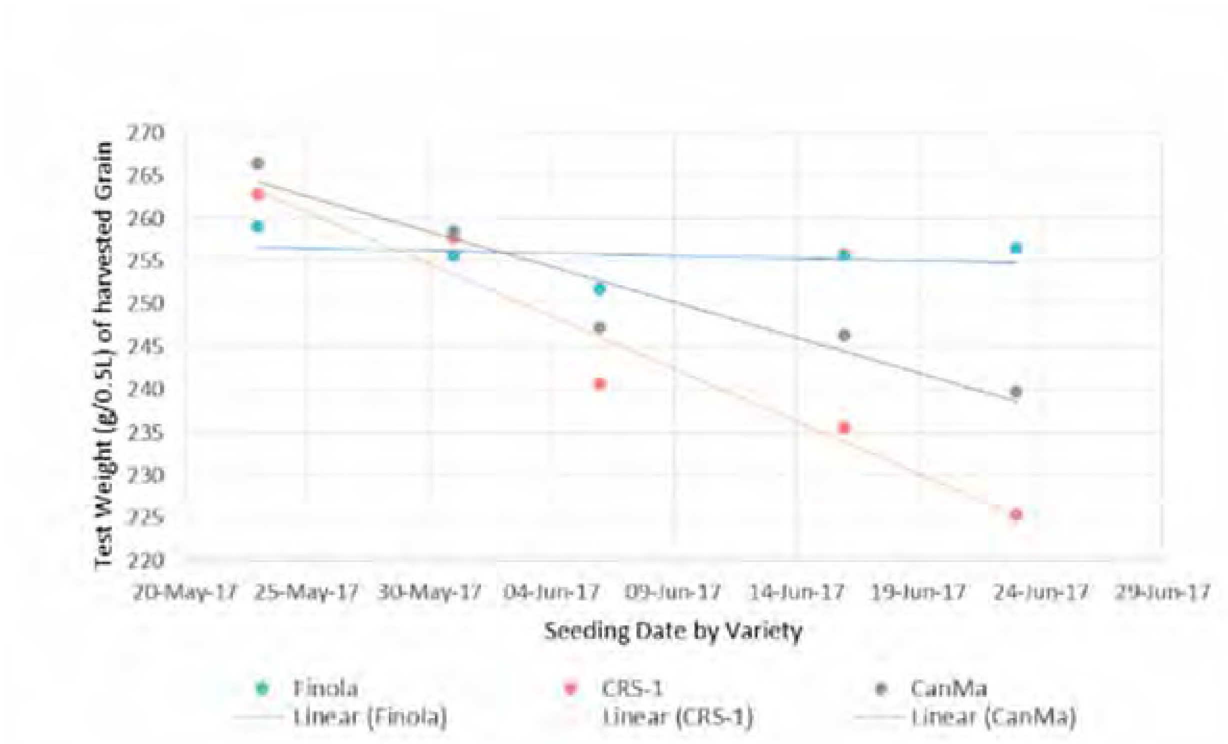


Figure 4: Effect of seeding date by variety on test weight (g/0.5L) for hemp planted at Melita Manitoba, 2017.



Project findings

- There was not a significant effect of seeding date on seedling mortality although there was a general trend of greater mortality for the earlier seeding dates. Despite the mortality levels seed densities were still sufficient, with Finola and CanMa averaging 79 and 59 plants/m2, respectively. The exception may have been CRS-1 which averaged 41 plants/m2. Previous work done by the Diversification Centres (2011-2012) demonstrated that grain yield is typically not affected until densities drop below 40 plants/m2. CRS-1 therefore would have had densities right around the threshold where yield may have been impacted.
- The effect of seeding date appears to be variety dependent. All varieties showed a general reduction in both height and grain yield with no interaction between variety and seeding date. However, there was no statistical advantage or penalty detected for seeding until mid-June. These results suggest that early seeding, if establishment risk factors (cold, wet soil conditions) are perceived low and the added height at harvest is not an issue can result in greater yield.
- Quality may also be of concern when choosing to seed late, especially for mid and long season varieties such as CRS-1 and CanMa. In this study both varieties expressed decreasing test weights as seeding date was delayed with CanMa being affected the most. Although there was a decrease in yield for Finola when seeded at the end of June, test weight was not effected by seeding date. CRS-1, and especially CanMa had both lower yield and decreasing test weights as seeding was delayed.

References

Canadian Hemp Trade Alliance: Production, Seeding Date.
http://www.hemptrade.ca/eguide/production/seeding

Industrial Hemp Variety Evaluation

Collaborators - Craig Linde – Diversification Specialist, Manitoba Agriculture
James Frey – Diversification Specialist, Manitoba Agriculture

Project duration - May 2017 – October 2017

Objectives - To estimate varietal differences in grain and fibre yield for industrial hemp in Manitoba.

Materials & Methods

Experimental Design: Randomized complete block design
Entries: 12 varieties

Table : Agronomic info for all sites

ITEM	Melita	Carberry	Roblin	Arborg
Legal Location	NE 27-3-27W1	SW 8-11-14W	NE 20-25-28 W1	RL 37-22-2 E
Soil Series	Waskada Loam	Wellwood Loam	Erikson Clay Loam	Heavy Clay
Soil Test (0-24")				
N - lbs/ac	7.2	33	60	138
P- ppm	11	12	11	15
K – ppm	260.8	250	194	300
S - lbs/ac	219.8	22	64	1634
Burnoff Date	May 23		June 3	
Product	Glyphosate/Liberty		RoundUp Transorb	
Seed Date	May 23	May 15	June 2	May 23
Seed Depth	0.75”	1”	0.75”	0.75”
Spring Fertilizer Application - lbs/ac				
N	120	110	75	25
P	35	0	10	25
K	25	0	0	0
S	10	0	0	0
Spring Fertilizer Date	SB at seeding	Side-banded at seeding	Side-banded at seeding	Side-banded at seeding
In-crop Herbicides Date	June 16	N/A	N/A	June 19
Product	Koril/Arrow	N/A	N/A	Brotex 240 @0.5L/ac
Fibre Harvest Date	August 11	Aug 17	Aug 18	Aug 10
Grain Harvest Date	September 6	Aug 25	Sept 11	Sep 14

Results

The average grain and fibre yields by variety are provided in Figures 1 and 2, respectively. Least significant differences for grain yield were 290lbs/ac and 190lbs/ac for Carberry and Melita, respectively. Least significant differences for fibre yield were 0.5, 0.6 & 0.3 tons/ac for Arborg, Carberry and Melita, respectively. Percent cannabidiol results are provided in Table 1. Due to high coefficients of variability, some results for Arborg are not included, and no results for Roblin are included.

Figure 1: Hemp grain yield (lbs/ac) 2017

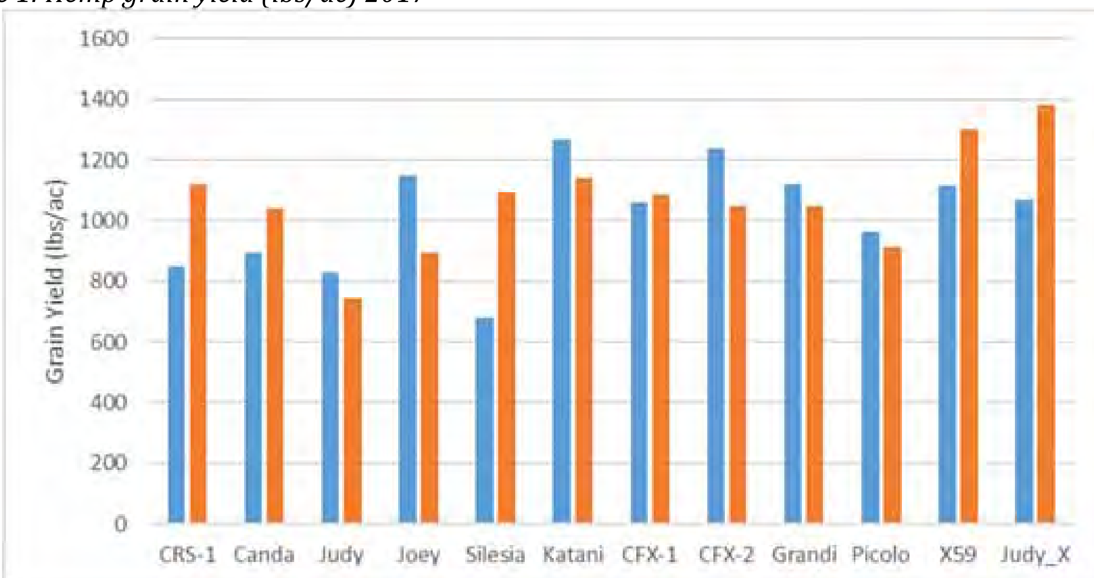


Figure 2: Hemp fibre yield (ton/ac) 2017

Table 1: Total cannabidiol (CBD) content (%) of upper stem leaf material removed at grain harvest (chaff)

Average of Total CBD	Location			
Variety Name	**Arborg**	**Carberry**	**Melita**	**Average**
Canda	0.39	0.48	0.70	0.52
CFX-1	1.89	0.94	1.81	1.55
CFX-2	1.07	0.72	1.70	1.16
CRS-1	0.98	0.85	1.78	1.20
Grandi	0.67	0.78	1.48	0.90
Joey	1.84	0.63	1.25	1.24
Judy	1.23	0.82	1.46	1.17
Judy X	1.14	0.34	1.35	1.04
Katani	0.96	0.89	1.53	1.13
Picolo	0.99	0.62	1.53	1.17
Silesia	0.25	0.30	0.66	0.40
X59	0.87	0.58	1.65	1.03
Average	**1.00**	**0.66**	**1.41**	**1.04**

Project findings

Grain yield results are available through the SEED Manitoba guide (2017).

Background

The Manitoba Diversification Centres participated in a hemp variety evaluation, in partnership with private industry and the Canadian Hemp Trade Alliance.

Pepsico (Quaker) Oats Variety Evaluation

Cooperators

- PepsiCo-Fritolay-Quaker-Gatorade Company

Background (taken from Wikipedia)

Oat bran is the outer casing of the oat. Its consumption is believed to lower LDL ("bad") cholesterol, and possibly to reduce the risk of heart disease. Oats contain more soluble fibre than any other grain. One type of soluble fibre, *beta-glucans*, has proven to help lower cholesterol.

After reports of research finding that dietary oats can help lower cholesterol, an "oat bran craze" swept the U.S. in the late 1980s, peaking in 1989, when potato chips with added oat bran were marketed. The food fad was short-lived and faded by the early 1990s. The popularity of oatmeal and other oat products again increased after a January 1998 decision by the Food and Drug Administration (FDA), when it issued a final rule that allows food companies to make health claims on food labels of foods that contain soluble fibre from whole oats (oat bran, oat flour and rolled oats), noting that 3.0 grams of soluble fibre daily from these foods may reduce the risk of heart disease. To qualify for the health claim, the whole oat-containing food must provide at least 0.75 grams of soluble fibre per serving. A class of polysaccharides known as Beta-D-glucans comprise the soluble fibre in whole oats.

Beta-D-glucans, usually referred to as beta-glucans, comprise a class of indigestible polysaccharides widely found in nature in sources such as grains, barley, yeast, bacteria, algae and mushrooms. In oats, barley and other cereal grains, they are located primarily in the endosperm cell wall.

Oat beta-glucan is a soluble fibre. In comparison, the indigestible polysaccharide cellulose is also a beta-glucan, but is not soluble. The percentages of beta-glucan in the various whole oat products are: oat bran, greater than 5.5% and up to 23.0%; rolled oats, about 4%; and whole oat flour about 4%.

The food and beverage company PepsiCo has partnered with Secan Seeds to evaluate varieties of oats keeping these beta-glucans in mind, while evaluating growth characteristics, yield and milling quality. The purpose being to find the best milling oat, with the best marketable beta-glucan content, that farmers will want to grow.

Trials were set up around the Prairies by Secan and Pepsico with cooperation of research groups like WADO, to evaluate some classic and some new varieties of oats available, and assess the geographical/environmental parameters that affect the quality and quantity of the oats being grown. One of these trial sites was grown in Melita by WADO. This was year seven of this partnership.

Methods

Twenty varieties were arranged in a randomized complete block design and replicated three times. The trial area was treated with 1 l/ac Roundup + Aim for pre-emergent weed control prior to seeding.

Plots were direct seeded into fall rye stubble at a depth of 3/4" on May 8th using a SeedHawk dual knife opener. Fertilizer was sideband at a rate of 116 lbs/ac actual nitrogen using 28-0-0 UAN including a granular blend of 12-17-15-10 applied at a rate of 205 lbs/ac. Plots were kept weed free by spraying in crop with Mextrol 450 applied at 0.5 L/ac, June 6th. Plots were not sprayed with fungicide.

Spring Soil Test:

Legal Land Location	Depth	pH	N ppm	P ppm Olsen	K ppm	S lbs/ac	Organic Matter %
SW 22-3-27 W1	0-6"	7.7	2	16	261	10	3.1
	6-24"		9			60	

Plots did not require desiccation prior to harvest on August 23rd. Plots were harvested with a Wintersteiger Classic plot combine. Data collected throughout the season included leaf disease, heading date, days to maturity, crop height, lodging, test weight, sample moisture, seed weight and grain yield. Plot samples were combined by variety and sent to PepsiCo for milling and beta-glucan content analysis (results confidential).

Data was analyzed with a two-way analysis of variance (ANOVA) using Minitab 18 statistical software. Coefficient of variation (CV), least significant difference (fishers unprotected) and grand mean were calculated.

Results

There were significant differences among days to heading, crop height, maturity, grain test weight and grain yield (Table 1). Treatments were sorted in the table by greatest grain yield.

There were no differences among varieties with leaf disease or lodging.

Table 1: Test weight, maturity, heading, lodging, height, disease, and grain yield of various oat varieties grown in Melita in 2017.

Treatment	Heading	Height	Maturity	Test Wt	Grain
	days	cm	days	lbs/bu	kg/ha
1	58	81	86	38	4969
2	59	98	90	36	5471
3	57	91	90	39	5499
4	58	91	94	37	5549
5	57	92	89	35	6311
6	59	90	89	35	5948
7	57	80	87	36	5527
8	56	86	88	37	5886
9	57	82	88	38	5862
10	57	98	88	37	6244
11	57	90	88	37	5749
12	58	85	89	37	5360
13	58	81	92	37	5700
14	61	94	93	35	5087
15	59	87	89	38	5921
16	55	79	87	37	5003
17	61	94	93	38	5634
18	58	84	93	38	5416
19	56	86	86	37	5879
20	56	95	87	37	5388
Grand Mean	58	88	89	37	5620
CV%	1	5	3	2	7
P value	<0.001	<0.001	0.004	<0.001	0.013
LSD (p<0.05)	1	7	4	1	693

Discussion

Testing varieties of oats over many locations over several years can be beneficial not only for the producer but for the processors. Processors could choose varieties that are outstanding in a certain region and also choose varieties with exceptional quality parameters such as high beta-glucan. PepsiCo-Quaker plans to use the composite samples to assess milling quality and beta-glucan content. The processor would then be in a position to advise producers what varieties would be valuable to grow and market in their region.

La Coop Fédérée Oat Variety Evaluation

Cooperator: La Coop fédérée, Christian Azar, Agr. M.Sc. Plant Breeder

Background

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

Methods

Twenty-eight varieties (identity confidential) were grown near Melita in a RCBD and replicated 3 times. The trial area was treated with 1 l/ac Roundup and 15 ml Aim for pre-emergent weed control prior to seeding. Plots were direct seeded into fall rye stubble with a target seeding rate of 240 plants/m^2.

Seeding Date	Seeding Depth	Fertility	Herbicide	Spray Date	Harvest Date
May 8 2017	0.75"	116-35-25-10	Mextrol 450 @ 0.5L/ac	06-Jun	August 23 2017

Plots were harvested with a Wintersteiger Classic plot combine. Data collected throughout the season included days to maturity, crop height, lodging, test weight, seed weight, sample moisture, and grain yield. Plot samples were combined by variety and sent to La Coop fédérée for milling and beta-glucan content analysis (results confidential).

Spring Soil Test:

Legal Land Location	Depth	pH	N ppm	P ppm Olsen	K ppm	S lbs/ac	Organic Matter %
SW 22-3-27 W1	0-6"	7.2	4	15	250	8	3.8
	6-24"		9			264	

Data was analyzed with a two-way analysis of variance (ANOVA) using Minitab 18 statistical software.

Results

There were significant differences in lodging, leaf disease, maturity, crop height, seed weight, test weight and yield (Table). Subsamples were sent to La Coop fédérée for quality testing.

Table: Performance of oat varieties grown in Melita, MB in 2017.

Variety	Grain	TKW	Lodging	Leaf Disease	Test WT	Height	Maturity
	kg/ha	g/500	(0-9, 9 severe)	(0-9, 9 severe)	g/0.5L	cm	days
1	6261	17.0	1.0	1.3	239	92	89
2	6162	19.5	1.0	1.0	244	100	90
3	6373	18.6	1.3	1.3	248	100	94
4	5672	17.6	1.0	2.7	240	101	91
5	5965	18.8	1.0	1.7	237	102	90
6	5824	18.6	1.0	1.0	240	96	92
7	6094	17.8	1.0	1.0	242	96	93
8	5939	16.0	1.0	1.3	232	100	93
9	6848	18.1	1.0	1.7	238	103	95
10	5812	16.9	1.0	1.7	246	89	89
11	6001	19.1	1.0	1.0	244	108	94
12	6177	17.9	1.0	2.7	244	98	93
13	6326	18.1	1.0	2.7	232	101	94
14	5872	19.8	1.0	1.0	256	107	94
15	5929	17.9	1.0	1.0	245	88	92
16	6081	18.8	1.0	2.3	240	91	92
17	5876	19.8	1.0	1.7	246	92	89
18	5548	18.0	2.0	4.3	244	93	87
19	5953	18.0	1.0	1.7	233	100	90
20	5918	17.3	1.0	1.3	243	94	91
21	6149	18.2	1.0	1.3	239	91	90
22	6329	17.8	1.0	1.7	260	94	95
23	5862	20.0	1.0	2.7	242	91	93
24	6465	16.6	1.0	1.7	249	94	90
25	6184	17.9	1.0	1.3	249	92	93
26	6391	17.3	1.0	2.0	235	95	89
27	6242	18.4	1.0	1.7	248	89	93
28	6115	19.1	1.0	3.0	228	85	92
Grand Mean	6085	18.2	1.0	1.8	242	96	92
CV%	5	6	21	43	2	4	2
P value	0.01	0.001	0.002	<0.001	<0.001	<0.001	<0.001
LSD (p<0.05)	526	1.7	0.4	1.2	8.4	6.3	2.7

Quinoa Adaptation Evaluation

Project duration **–** On Going

Objectives **-** Evaluate quinoa lines/varieties for adaptation and yield performance in the Central Plains region of Manitoba.

Collaborators **-** Phillex Inc.

Background

Quinoa is a broadleaf annual plant that producers small, round seeds with excellent nutritional qualities. The crop can be grown in all agricultural regions of Manitoba. Phillex Ltd, based in Portage la Prairie, participated with all four Manitoba Diversification Centres to conduct the quinoa variety trial.

Materials & Methods (Melita)

Experimental Design: Randomized complete block design with 3 replicates
Soil Type: Waskada Loam
Seeding Date: May 17, 2017
Harvest Date: Sept 28, 2017

Fertility: Added (available) lbs/acre of actual

Location	Nitrogen	Phosphorus	Potassium	Sulfur
SW 22-3-27W1	126 (9)	35 (14 ppm)	25 (339 ppm)	10 (422)

In Crop Weed Control: None Registered
Fungicide: None Registered

Results

Entries and yield results for Carberry, Melita and Roblin in Manitoba that participated are in Figure 1. Due to stand establishment problems at Carberry plot variability was high and no differences could be detected. Yield within Manitoba otherwise were very good in 2017 with many plots falling above 1500 kg/ha. More work is needed regarding pest control, optimal planting densities and seeding date; however, the yield potential of new lines being introduced to Manitoba are showing promise.

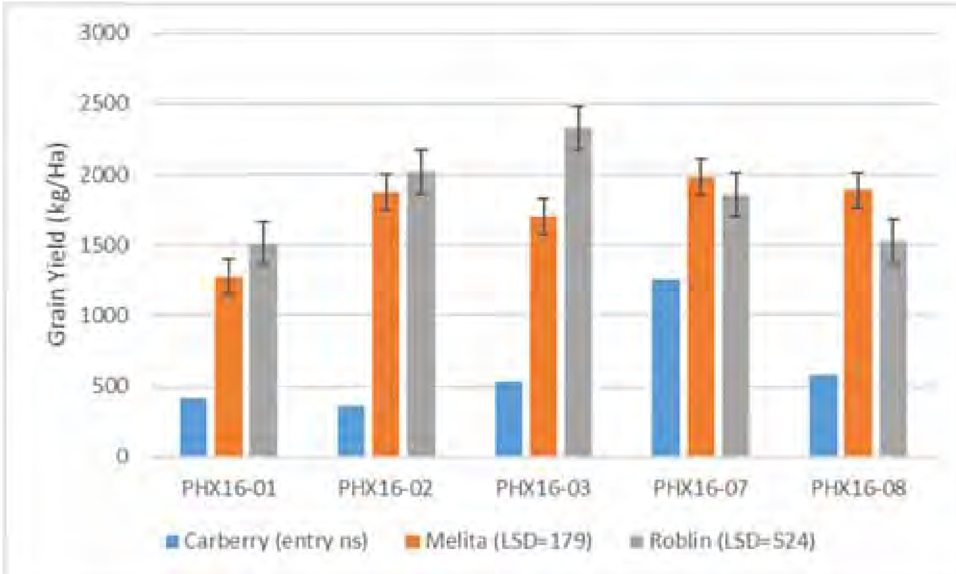


Figure 1: Quinoa lines and yield performance at Manitoba DC locations in 2017.

There were significant differences among plant vigor, final crop stand, crop height, lodging at harvest, thousand kernel weight, and final grain yield among varieties. A greater yield difference was found with PHX16-07, PHX16-08, PHX16-01, followed by PHX16-03 and then the lowest variety PHX16-01. Significant lodging occurred with PHX16-03, however this coefficient of variation was rather large. Variety PHX16-03 resulted in the least amount of lodging and was the shortest variety which may have contributed to lodging tolerance.

Table 1: Agronomic performance of quinoa varieties in Melita in 2017.

Variety	Vigor 1 to 5	Stand %	Crop Height cm	Lodging %	Test Wt g/0.5L	TKWT g/1000	Grain Yield kg/ha
PHX16-01	3.7	62	126	20	211	1.35	1277
PHX16-02	2.8	75	125	18	235	1.23	1877
PHX16-03	3.7	65	137	60	207	1.64	1700
PHX16-07	4.0	80	102	13	217	1.31	1980
PHX16-08	3.5	85	140	33	210	1.62	1889
Grand Mean	3.5	73	126	29	216	1.43	1745
CV%	9	10	7	37	5	11	5
P value	0.024	0.027	0.004	0.004	0.082	0.039	<0.001
LSD (p<0.05)	0.6	14	16	20	0	0.30	179

Photo: Aug 14, 2017. Note the color changes as maturity is close.

Soybean Inoculant Strategies: MPSG FINAL EXTENSION REPORT

Project start date: May 1, 2014

Project end date: December 31, 2016

Researchers

LEAD	Manitoba Pulse & Soybean Growers
COLLABORATORS	Dr. Yvonne Lawley, University of Manitoba Scott Chalmers, Western Agricultural Diversification Centre Craig Linde, Canada Manitoba Crop Diversification Centre James Frey, Parkland Crop Diversification Foundation Nirmal Hari, Prairies East Sustainable Agriculture Initiative

Executive summary

Selection of the appropriate *Bradyrhizobium japonicum* inoculant formulation, rate and combination of products is dependent on field history, equipment available, cost of inoculant and environmental conditions. The objective of this study was to compare fourteen inoculant products, formulations, rates and combinations across a range of locations and field histories in Manitoba. Field experiments

were conducted in 2014, 2015 and 2016 at Melita, Carberry, Carman, Roblin and Beausejour. Four of the site-years tested had a history of soybeans and five of the site-years had no history of soybeans. Site-years were combined and analyzed based on this cropping history.

Inoculation had important economic implications on fields with *no* history of soybean. Averaged across all site-years *without* a history of soybean, inoculant treatments increased number of nodules per plant by 20, yield by 15 bu ac^{-1} and protein by 4.8% compared to the uninoculated control. On fields *with* a history of soybean, there was no difference in yield, number of nodules or seed protein between inoculant treatments and the uninoculated control. Regardless of field history, under the optimal seeding and plant establishment conditions encountered in this study, inoculant product, rate or combination did not have an effect on nodule number per plant or seed yield. There are several possible explanations for the lack of response to double inoculation in this trial which cannot always be guaranteed under field conditions. Therefore, MPSG recommends using a double inoculation strategy on fields with a limited history of soybean and a single inoculation strategy after at least two successfully nodulated soybean crops have been established on a particular piece of land. See MPSG's Soybean Fertility Factsheet for more details regarding inoculation recommendations.

The minimum number of nodules required to reach 90% of maximum yield was approximately ten nodules per plant at the R4 stage. The R1 stage, however, permits assessment of nodulation failure prior to the ideal window to apply rescue nitrogen fertilizer (R2-R3).

Introduction

Soybeans are capable of creating 50-60% of their nitrogen (N) requirements through biological N fixation (Salvagiotti, et al. 2008.) The remainder of the required N is taken up from soil reserves. *Bradyrhizobium japonicum* is the soybean-specific bacteria which causes nodule development on roots and works symbiotically with the soybean to fix N within the nodules. These bacteria are not native to Canadian Prairie soils and thus must be introduced by using commercial inoculants. Once successfully inoculated soybean crops have been grown on a particular piece of land, populations of *B. japonicum* can build up and overwinter, providing sufficient inoculum for proceeding soybean crops.

There are many effective inoculant products available to soybean farmers in Manitoba. Selection of the appropriate formulation, rate and combination of products is dependent on the field history, equipment available, cost of inoculant and environmental conditions. Seed-applied liquid and peat-based products are generally cheap and can conveniently be applied to the seed prior to seeding. Granular inoculant applied in-furrow has been found to provide greater nodulation and higher yields compared to seed-applied inoculant on fields with no history of soybean (Muldoon, et al., 1980). Granular inoculants have also shown to be more resilient to environmental stress such as excess moisture (Hynes et al., 2001) and acidic soils (Rice et al., 2000) compared to seed-applied liquid formulations. However, granular inoculant is generally more expensive and must be applied in furrow, requiring an extra tank on the seed cart.

Some inoculant products are also formulated with additional molecules or living organisms which claim to improve early crop development, plant nutrition or the rate of nodulation. For example, both

JumpStart® and TagTeam® contain a phosphate-solubilizing rhizopheric fungus, *Penicillium bilaii*. *P. bilaii* lives in the rhizosphere (soil immediately surrounding the root) and may increase soil phosphorus (P) availability and hence, plant uptake. This occurs through one of two mechanisms: the bacteria secreting organic acids that acidify the soil, solubilizing P or chelating P molecules, protecting P from precipitation or adsorption to soil. Nodulator® N/T is formulated with *Bacillus subtilis* a plant growth promoting rhizobacteria which may increase soybean growth and nodule formation resulting from co-inoculation with *B. japonicum*. Optimize® is formulated with the lipo-chitooligosaccharide (LCO) molecule. The process of nodule development requires both the plant root and *B. japonicum* bacteria to send and receive signals for the process to initiate. The bacteria migrate towards roots, attracted by root exudate (root to bacteria signals); these exudates cause the bacteria to produce proteins called Nod factors (LCOs). The LCO molecules (bacteria to plant signals) in Optimize® may hasten the process of nodule development.

For first and second-time soybean fields a "double inoculation" strategy is recommended to insure adequate populations are introduced to the soil, facilitating proper nodulation. Double inoculation refers to the use of two inoculant formulations or placement techniques. A common strategy for double inoculation is to use a seed-applied liquid inoculant in addition to an in-furrow granular product. Increasing the rate of inoculant may also effectively increase rhizobia levels in the soil and improve nodulation (Muldoon, et al., 1980), but multiple formulations or placements provides the added benefit of potential better survivability of the rhizobia.

Once several successfully nodulated soybean crops have been established on a particular piece of land, farmers may choose to use a more economical, single inoculation strategy. MPSG's On-Farm Network found that double inoculation provided a significantly higher soybean yield compared to single inoculation at only two out of 25 trial sites in fields with at least two prior soybean crops. Similarly, in the upper Midwest United States a meta-analysis found that inoculation seldom increased yield or economic return compared to the untreated control on fields where soybeans had previously been produced (Bruin, et al., 2010).

The objective of this study was to compare inoculant products, formulations and rates across a range of locations and field histories in Manitoba. More specifically, the project aims to quantify the yield benefits of using 1) in-furrow granular 2) double inoculation, 3) 2X rate or 4) "enhanced" inoculant products compared to a standard seed-applied liquid inoculant (Cell-Tech® Liquid).

Methods

Field experiments were conducted in 2014, 2015 and 2016 at Melita, Carberry, Carman, Roblin and Beausejour, Manitoba. Field sites varied based on their cropping history: four sites had a history of soybean (Carman 2015, 2016, Carberry 2016 and Beausejour 2016) and five sites did not have a history of soybean (Melita 2014, 2015, 2016, Carberry 2015, and Roblin 2015). Fourteen inoculant strategies tested, i.e. different products, formulations, combinations and rates, and are listed in Table 1 and 2. A subset of 11 treatments were tested at Melita in 2014. Treatments were arranged as a randomized complete block design with four replicates at all sites except Beausejour in 2016, were there was only three replicates.

A complete list of site characteristics and field operations is listed in Table 5. NSC Reston soybeans were seeded at 210,000 seeds/ac on narrow row spacing into cereal stubble at all locations except for Melita in 2015, where the soybeans were seeded into flax stubble. The trial was seeded from late May to early June. Liquid inoculants were seed-applied and granular inoculants were applied in-furrow. No fungicide or insecticide seed treatments were used. Inoculant treatments were seeded in order of listing in Table 1 and 2. Seeding equipment was sanitized with bleach solution and an air hose after seeding the sixth, seventh, eighth, ninth and eleventh treatments. Weeds were controlled using pre-and post-emergence herbicides and supplementary phosphorus, potassium or sulphur fertilizer was applied as required. Soybeans were desiccated if necessary before direct harvesting using a plot combine.

Plant density was assessed at V1 and plants from four randomly selected, one meter rows were recorded and reported as plants per acre. The number of nodules per plant was assessed at both R1 and R4. Within each plot, ten randomly selected plants were dug up using a shovel and rinsed with water to wash off excess soil. Roots were generally then frozen and nodules counted at a later date. At R4, plant biomass was also measured by harvesting all above ground biomass from two, one meter rows. Biomass was dried at 60°C for two days and dry weight was reported in kilograms per hectare. Harvested grain was cleaned if necessary and grain moisture was recorded when clean samples were weighed. Reported grain weight was standardized to 14% moisture. Yield was analyzed as kilograms per hectare and converted to bushels per acre for reporting purposes. A subsample of grain from each plot was analyzed for seed oil and protein content and thousand kernel weight using a near-infrared reflectance grain analyzer (Foss NIR Systems, Inc., Laurel, MD, USA).

The Glimmix Procedure in SAS 9.4 was used to conduct the analysis of variance and orthogonal contrasts. Each measured variable was modelled with inoculant treatment and field history as a fixed effects and site-year and block as random effects. Because there was a significant interaction between treatment and field history, site-years were grouped based on field history and analyzed separately. Heterogeneous variance of the fixed effect was modelled only when it improved model fix as tested by chi test. The Univariate Procedure was used to test the normality of the data using the Shapiro-Wilk Statistic. Differences between treatment means using pre-planned contrasts were considered significant at $P<0.05$. The Regression and Non-Linear Procedures were used to analyze the relationship between number of nodules per plant and seed yield. Treatment means from individual site-years were used to develop these models. Linear, quadratic, exponential, linear broken-line and quadratic broken-line models were tested for model significance and best fit. A quadratic broken-line model was chosen based the best fit as determined by the lowest AIC value of all models tested.

Results

Fields with a History of Soybean

Yield was, on average, slightly higher (449 kg ha^{-1} or 6.7 bu ac^{-1}) on fields *with* a history of soybean compared to *no* history of soybean (Table 1, 2). There was no yield response to inoculant compared to the uninoculated check at the sites with a history of soybean (Table 3). In addition, there was no statistical difference in yield between individual inoculant strategies (Table 3). For example, there was no difference in seed yield between in-furrow granular inoculant compared to seed-applied liquid inoculant, nor was there a difference between single versus double inoculation treatments (Table 3). Similarly, there was no yield difference between 1X and 2X rates of liquid or granular inoculant (Table 3). In addition, 'enhanced' inoculant treatments did not result in higher yields compared to the standard *B. rhizobium* inoculant of equivalent formulation (Table 3).

The lack of yield response to inoculant on fields with a history of soybean is consistent with findings from the United States and Ontario. Bruin et al. (2010) reviewed studies from Indiana, Iowa, Minnesota, Nebraska and Wisconsin that tested 51 different inoculant products in 2000 to 2008 across 73 environments that all had a history of soybean. Of these 73 test sites, 63 showed no yield response to inoculant. Four sites showed a negative yield response (5-7% yield difference) and six sites showed a positive yield response (5-23% yield difference) to inoculant compared to the untreated control. This study also found that economic return was actually reduced by the small investment in inoculant and did not recommend the use of inoculants in fields with a history of soybean, regardless of price or ease of application. Similarly, in Ontario, failure to obtain a positive yield response to inoculant was documented in 1979 by Ernest and Hume at Ridgetown and Elora, where soybeans had been previously grown. A positive response to soybeans was only achieved at Woodstock, where soybeans had never been grown. MPSG's On-Farm Network is also currently investigating soybean response to single inoculation compared to no inoculant on fields with at least three previous years of soybeans. To date, none of the nineteen trial sites from 2016 and 2017 have shown a statistical yield response to single inoculation.

The lack of response to inoculant and amongst inoculant strategies at sites with a history of soybean was also reflected in the assessment of nodules conducted both at R1 and R4. The mean number of nodules per plant was 45 and 58 at R1 and R4 stages, (Table 1) respectively, and there were no statistical differences in nodule number across any treatments compared (Table 3). The average number of nodules per plant was notably higher at sites with a history of soybean than without a history (Table 1, 2).

There was also no response to inoculant or difference amongst inoculant treatments in protein or thousand kernel weight. There were statistical differences in plant density, biomass and oil content among some inoculant strategies; however, these differences are not understood and may be due to random variation.

Fields with No History of Soybean

As expected, there was a statistically and agronomically significant yield response to inoculant at field sites with *no* history of soybeans. On average, the uninoculated soybeans yielded 1725 kg ha^{-1} or 25.6 bu ac^{-1}. Using an inoculant increased yield by an average of 1019 kg ha^{-1} or 15.1 bu ac^{-1}. The difference in yield between the untreated control and inoculated soybeans can be explained by the increase nodules per plant recorded at the R4 stage with the use of inoculant. The mean number of nodules increased from less than two nodules on the uninoculated soybeans to 22.3 nodules per plant on inoculated soybeans.

Similar to the response seen on fields with a history of soybean, there were no differences in yield observed between any of the inoculant strategies (Table 4). There were some differences in nodule number per plant among inoculant treatments at R1, but the data reported is from a single site and these differences did not appear at R4 (Table 4), when the crop's nitrogen requirements are highest.

Although there was no yield or nodulation benefit to double inoculation in this trial, the recommendation to double inoculate soybeans when grown on fields with two or less soybean crops grown previously still stands. There are several possible explanations for the lack of response to double inoculation in this trial which cannot always be guaranteed under field conditions:

Soybeans were seeded into ideal soil conditions. These trials were all seeded in late May to early June, when soil conditions were relatively favourable for crop emergence and inoculum survival. Unfavourable soil conditions often encountered with earlier seeding dates may reduce the viability of inoculant. Therefore, using an in-furrow inoculant in addition to the seed applied inoculant may ensure adequate rhizobium populations are present in fields with low rhizobia populations.

Inoculants were properly stored, handled and applied. Inoculants should always be kept in a cool, dry environment, should not be frozen, used before the expiration date and opened only just before using. Ideally, seed treated with inoculant should be planted within the same day as inoculant application. Planting windows for seed-applied inoculants do vary and review of individual product labels is recommended.

No compatibility issue with seed treatment. Fungicide and/or insecticide seed treatments may affect the effectiveness of seed-applied inoculant; however, in this experiment seed treatment was not applied in an effort to standardized inoculant application and avoid potential differences in treatment compatibility. Be sure to review product labels for specific inoculant and seed treatment combination compatibility.

Seed quality was also markedly influenced by inoculation. Although mean protein and oil content was similar at sites without a history of soybean compared to sites with a history of soybean, inoculant increased protein by 4.8% and decreased oil by 1.9% compared to the uninoculated control at sites without a history of soybean. This large increase in seed N due to inoculation demonstrates the level of whole plant N sufficiency caused by proper nodulation. In addition, thousand kernel weight also increased by 12.5 g per 1000 seeds, which shows that the increase in yield due to inoculation can be attributed in part by an increase in individual seed weight.

Soybean Yield and Nodules per Plant

How many nodules should a soybean have to maximize yield? Regardless of the inoculant strategy and field history, success of the inoculant and nodulation should be assessed on every field, every year. Ideally, nodulation should be assessed at R1 to ensure the crop will have adequate N during critical growth stages (R4-R5) to maximize yield (Heard et al., 2014).

At R4 to R5, N fixation and N requirements for soybean have reached a maximum (Heard 2006). At this point, however, it is too late to conduct a rescue N application. In this study, most sites only recorded nodules numbers at R4 so the relationship between yield and nodules per plant was modelled using the data from the R4 stage. Results from this study found that an average of at least 10 nodules per plant was required to reach 90% of maximum yield potential (Figure 1).

Relevance to farmers

Inoculation has important economic implications on fields with no history of soybean. Averaged across all site-years without a history of soybean, inoculant treatments increased number of nodules per plant by 20, yield by 15 bu ac^{-1} and protein by 4.8% compared to the uninoculated control.

Regardless of field history, under the optimal seeding and plant establishment conditions encountered in this study, inoculant product, rate or combination did not have an effect on nodule number per plant or yield. MPSG recommends using a double inoculation strategy on fields with a limited history of soybean and a single inoculation strategy after at least two successfully nodulated soybean crops have been established on a particular piece of land. See MPSG's Soybean Fertility Factsheet for more details regarding inoculation recommendations.

The minimum number of nodules required to reach 90% of maximum yield was approximately ten nodules per plant at the R4 stage. Assessing nodulation at R1, however, permits assessment of nodulation failure prior to the ideal window to apply rescue nitrogen fertilizer (R2-R3).

Acknowledgements

Thank you to Scott Chalmers, Yvonne Lawley, Craig Linde, James Frey and Nirmal Hari for leading and executing the field studies and sharing your data.

Thank you to the many technicians and summer students at each collaborating institution for contributing to the success of this project.

References

Bruin, J.L., et al. 2010. Probability of Yield Response to Inoculants in Fields with a History of Soybean. Crop Sci. 50:265-272.

Ernest, S. and D.J. Hume. 1979. Effects of inoculation and fertilizer N levels on N2 fixation and yields of soybeans in Ontario. Can. J. Plant Sci. 59:1129-1137.

Heard, J. 2006. Nutrient uptake and partitioning by soybeans in Manitoba. Proc. Manitoba Agronomists Conference.

Heard, J., G. Bardella and K. Podolsky. 2014. Rescue nitrogen applications on poorly nodulated soybeans in Manitoba. 2014. Proc. Manitoba Agronomists Conference.

Hynes R.K., D.C. Jans, E. Bremer, N.Z. Lupwayi, W.A. Rice, G.W. Clayton, and M.M. Collins. 2001. Rhizobium population dynamics in the pea rhizosphere of rhizobial inoculant strain applied in different formulations. Can. J. Mircobiol. 47:595-600.

Muldoon, J.F., D.J. Hume and W.D. Beversdorf. 1980. Effects of seed- and soil-applied Rhizobium japonicum inoculants on soybean in Onatario. Can. J. Plant Sci. 60:399-409.

Rice, W. A., Clayton, G. W., Olsen, P. E. and Lupwayi, N. Z. 2000. Rhizobial inoculant formulations and soil pH influence

field pea nodulation and nitrogen fixation. Can. J. Soil Sci. 80: 395–400.

Salvagiotti, F. K.G. Cassman, J.E. Specht, D.T. Walters, A. Weiss, A. Dobermann. 2008. Nitrogen uptake, fixation and response to fertilizer N in soybeans: A Review. Field Crop Research. 108:1-13.

Appendix

Table 1. Field operations and site characteristics.

	Melita			Carman		Carberry		Roblin	Beausejour
	2014	2015	2016	2015	2016	2015	2016	2015	2016
Field Operations									
Seeding Date	Jun-11	Jun-05	Jun-07	May-27	Jun-07	Jun-04	Jun-07	May-25	Jun-07
Plant Density Assessment	-	Jun-15	Jun-23	Jun-17	Jun-29	-	Jul-15	Jun-18	N/A
Pre-Emergent Herbicide Application	Jun-12	Jun-03	Jun-06	Jun-04	N/A	-	Jun-06	May-25	N/A
In-Crop Herbicide Application	Jul-23	Jun-15 & Jul-6	Jun-22	Jul-6 & Jul-30	Jun-25	-	Jun-30	Jun-16	-
Biomass Collection	Aug-25	Aug-10	Aug-04	Jul-30	Aug-11 & Aug-12	-	Aug-10	Aug-25	Aug-11
R1 Nodule Assessment	N/A	N/A	Jul-22	Jul-10	N/A	-	N/A	N/A	N/A
R4 Nodule Assessment	N/A	Aug-10	Aug-02	Jul-30	Aug-12 to Aug-16	-	Aug-10	Aug-12	Aug-11
Desiccation Date	N/A	N/A	Sep-27	-	N/A	-	N/A	Sep-29	N/A
Harvest Date	Oct-14	Oct-01	Sep-26	-	Oct-15	Oct-19	Oct-18	Oct-14	Oct-14

Site Characteristics									
Previous Crop	Winter wheat	Flax	Winter wheat	Spring wheat	Sprin g whea t	-	Wheat	Wheat	Cereals
Row Spacing (in)	9.5	9.5	9.5	7.5	7.5	-	12.0	9.5	8
Soil pH (0-6”)	7.4	7.3	7.6	5.2	6.0	-	6.3	6.8	-
Soil Organic Matter % (0-6”)	3.1	3.8	2.9	2.7	4.2	-	5.4	3.7	-
NO3-N (0-24” lbs ac^{-1})	36	145	29	81	91	-	31	30	-
PO4-P (0-6” ppm)	4	7	3	7	20	-	13	9	-
K2O (0-6” ppm)	424	366	field	113	346	-	321	151	-
SO4 (0-24” lbs ac^{-1})	59	317	264	40	52	-	37	50	-
N fertilizer (lbs $N0_3^-$ ac^{-1})	16	N/A	N/A	N/A	N/A	-	N/A	16	N/A
P fertilizer (lbs P_2O_5 ac^{-1})	23	61	N/A	60	N/A	-	N/A	35	27
K fertilizer (lbs K_20 ac^{-1})	20	N/A	N/A	N/A	N/A	-	N/A	15	N/A
S fertilizer (lbs SO^{-4} ac^{-1})	14	N/A	N/A	N/A	N/A	-	N/A	10	N/A

"N/A" refers to not applicable information "-" refers to missing information

Table 2. Least squared means for plant density, nodules per plant, biomass, yield, protein, oil and thousand kernel weight for site-years **with a history of soybeans**

Treatment	Plants ac^{-1}	R1 Nodules $plant^{-1}$†	R4 Nodules $plant^{-1}$	Biomass (kg ha^{-1})	Yield (kg ha^{-1})	Protein %	Oil %	g 1000 $seeds^{-1}$
Untreated Control	201982	44.5	60.7	3746	3078	35.18	17.07	135.02
Cell-Tech® Liquid	181513	48.4	60.6	3550	3170	35.27	17.15	136.42
Cell-Tech® Liquid (2x rate)	209340	46.8	57.7	3866	3126	35.27	17.04	135.36
Cell-Tech® Liquid + Cell-Tech® Granular	184722	41.0	56.7	3779	3084	35.08	17.03	135.18
Cell-Tech® Granular	193462	49.8	62.6	3465	3040	35.16	17.09	134.2
Cell-Tech® Granular (2x rate)	194790	46.3	57.1	3383	2989	35.33	17.03	135.27
Cell-Tech® Liquid + JumpStart®	214991	46.0	60.6	3518	3087	35.26	17.14	136.71
Optimize® Liquid	205394	45.6	60.3	3404	3071	35.36	16.93	134.62
TagTeam® Granular	199714	44.8	58.9	3598	2972	35.12	17.07	134.36
Nodulator® Granular	185717	42.6	61.1	3823	3173	35.16	17.12	134.14
Nodulator® Granular (2x rate)	215267	46.6	59.2	3959	3301	35.29	17.22	133.18
Nodulator® N/T LQ	211276	42.9	57.2	4303	3082	35.12	17.09	132.55
Nodulator® N/T LQ (2x rate)	201097	49.3	61.8	3640	3091	34.78	17.26	135.17
Nodulator® N/T LQ + Nodulator® Granular	196063	42.6	56.8	3756	3147	34.98	17.14	135.03
Mean	200685	45.1	57.8	3683	3123	35.11	17.10	134.80
Coefficient of Variation (%)	33.2	31.0	33.3	33.8	16.7	4.6	2.2	8.5
Test of Fixed Effects (P>F)	0.1613	0.6253	0.9376	0.2604	0.1729	0.5533	0.3119	0.9512

†only two site-years of data (Carman 2015, Carberry 2016)

Table 3. Least squared means for plant density, nodules per plant, biomass, yield, protein, oil and thousand kernel weight (TKW) for site-years **with no history of soybeans**

Treatment	Plants ac^{-1}	R1 Nodules plant^{-1}†	R4 Nodules plant^{-1}	Biomass (kg ha^{-1})	Yield (kg ha^{-1})	Protein %	Oil %	g 1000 seeds^{-1}
Untreated Control	149777	0.4	1.9	3574	1725	29.89	19.46	135.89
Cell-Tech® Liquid	160096	22.1	27.6	4601	2858	34.74	17.49	148.09
Cell-Tech® Liquid (2x rate)	157887	20.5	31.3	4688	3087	35.03	17.34	148.03
Cell-Tech® Liquid + Cell-Tech® Granular	152339	22.4	33.2	4662	2654	35.64	17.11	149.23
Cell-Tech® Granular	144919	7.6	27.6	4365	2848	35.51	17.19	149.92
Cell-Tech® Granular (2x rate)	146203	10.4	31.5	4401	2794	35.46	17.19	148.60
Cell-Tech® Liquid + JumpStart®	135008	18.4	23.2	4005	2566	34.76	17.53	145.79
Optimize® Liquid	164143	14.1	27.2	4691	2874	35.04	17.38	151.99
TagTeam® Granular	162603	10.1	18.7	3883	2594	34.49	17.65	149.06
Nodulator® Granular	168676	2.8	7.2	3481	2671	33.68	17.99	146.62
Nodulator® Granular (2x rate)	141686	4.8	12.6	3933	2651	34.46	17.69	147.55
Nodulator® N/T LQ	162591	3.4	15.7	4042	2688	34.02	17.80	145.10
Nodulator® N/T LQ (2x rate)	162317	5.3	14.5	3484	2595	33.76	18.01	151.14
Nodulator® N/T LQ + Nodulator® Granular	172032	7.3	19.2	4361	2788	34.63	17.63	147.84
Mean	156048	10.7	22.3	4076	2674	34.36	17.68	143.98
Coefficient of Variation	29.1	75.1	76.1	44.3	25.4	5.2	6.7	14.4
Test of Fixed Effects	0.5427	<.0001	<.0001	0.3591	0.0001	<.0001	0.3119	<.0001

†Only one site-year of data (Melita 2016)

Table 4. Orthogonal contrasts comparing the difference in plant density, nodules per plant, biomass, yield, protein, oil and thousand kernel weight (TKW) between select inoculant strategies, averaged across site-years **with a history of soybeans**. Means reported in columns is the difference in treatment means between treatment 1 minus treatment two for each measured variable.

Treatment 1 (+)	Treatment 2 (-)	Plants ac^{-1}	R1 Nodules plant^{-1}	R4 Nodules plant^{-1}	Biomass (kg ha^{-1})	Yield (kg ha^{-1})	Protein %	Oil %	g 1000 seeds^{-1}
All Inoculant Treatments	Untreated Control	-2494	1.1	-1.5	-51	25	-0.01	0.03	-0.23
Cell-Tech® Liquid	Cell-Tech® Liquid (2x rate)	-27827*	1.6	2.9	-316	43	0.00	0.11	1.06
Cell-Tech® Liquid	Cell-Tech® Granular	-11950	-1.4	-2.0	85	129	0.11	0.06	2.22
Cell-Tech® Liquid	Cell-Tech® Liquid + Cell-Tech® Granular	-3209	7.3	4.0	-229	86	0.18	0.12	1.23
Cell-Tech® Granular	Cell-Tech® Granular (2x rate)	-1328	3.4	5.5	83	52	-0.17	0.07	-1.07
Cell-Tech® Granular (2x rate)	Cell-Tech® Liquid + Cell-Tech® Granular	10069	5.3	0.4	-396	-95	0.24	-0.01	0.08
Cell-Tech® Liquid	Optimize® Liquid	-23882	2.8	0.3	146	99	-0.10	0.22*	1.80
Cell-Tech® Liquid	Cell-Tech® Liquid + JumpStart®	-33478*	2.4	0.0	32	83	0.01	0.01	-0.29
Cell-Tech® Granular	TagTeam® Granular	-6251	5.0	3.8	-132	68	0.04	0.03	-0.16
Cell-Tech® Liquid	Nodulator® N/T LQ	-29763*	5.5	3.4	-753*	88	0.15	0.06	3.87
Nodulator® N/T LQ	Nodulator® N/T LQ (2x rate)	10179	-6.4	-4.6	663*	-9	0.33	-0.17	-2.62
Nodulator® N/T LQ	Nodulator® N/T LQ + Nodulator® Granular	15214	0.3	0.4	547	-65	0.13	-0.05	-2.48
Nodulator® Granular	Nodulator® Granular (2x rate)	-29550*	-4.0	1.8	-136	-128	-0.13	-0.10	0.96

* Difference between treatment means is statistically significant at $P<0.05$

†only two site-years of data (Carman 2015, Carberry 2016)

Table 5. Orthogonal contrasts comparing the difference in plant density, nodules per plant, biomass, yield, protein, oil and thousand kernel weight (TKW) between select inoculant strategies, averaged across site-years **with no history of soybeans**. Means reported in columns is the difference in treatment means between treatment 1 minus treatment two for each measured variable.

Treatment 1 (+)	Treatment 2 (-)	Plants ac^{-1}	R1 Nodules $plant^{-1}$†	R4 Nodules $plant^{-1}$	Biomass ($kg\ ha^{-1}$)	Yield ($kg\ ha^{-1}$)	Protein %	Oil %	g 1000 $seeds^{-1}$
All Inoculant Treatments	Untreated Control	6416	11.1*	20.4*	626	1019*	4.82*	-1.92*	12.50*
Cell-Tech® Liquid	Cell-Tech® Liquid (2x rate)	2209	1.6	-3.7	-87	-229	-0.29	0.14	0.06
Cell-Tech® Liquid	Cell-Tech® Granular	15177	14.5*	0.0	236	10	-0.78	0.30	-1.83
Cell-Tech® Liquid	Cell-Tech® Liquid + Cell-Tech® Granular	7757	-0.3	-5.6	-61	204	-0.91	0.38	-1.14
Cell-Tech® Granular	Cell-Tech® Granular (2x rate)	-1285	-2.8	-3.9	-36	54	0.05	-0.01	1.32
Cell-Tech® Granular (2x rate)	Cell-Tech® Liquid + Cell-Tech® Granular	-6136	-12.0*	-1.7	-261	140	-0.18	0.09	-0.63
Cell-Tech® Liquid	Optimize® Liquid	-4047	8.0*	0.4	-89	-16	-0.31	0.11	-3.90
Cell-Tech® Liquid	Cell-Tech® Liquid + JumpStart®	25088	3.7	4.4	596	292	-0.03	-0.04	2.30
Cell-Tech® Granular	TagTeam® Granular	-17685	-2.5	8.9	482	254	1.03	-0.46	0.86
Cell-Tech® Liquid	Nodulator® N/T LQ	-2495	18.7*	11.9*	559	170	0.72	-0.31	2.99
Nodulator® N/T LQ	Nodulator® N/T LQ (2x rate)	274	-2.0	1.2	559	93	0.26	-0.21	-6.03
Nodulator® N/T LQ	Nodulator® N/T LQ + Nodulator® Granular	-9441	-3.9	-3.6	-318	-100	-0.61	0.17	-2.74
Nodulator® Granular	Nodulator® Granular (2x rate)	26990	-2.0	-5.4	-452	20	-0.78	0.30	-0.94

* Difference between treatment means is statistically significant at P<0.05

†only one site-year of data (Melita 2016)

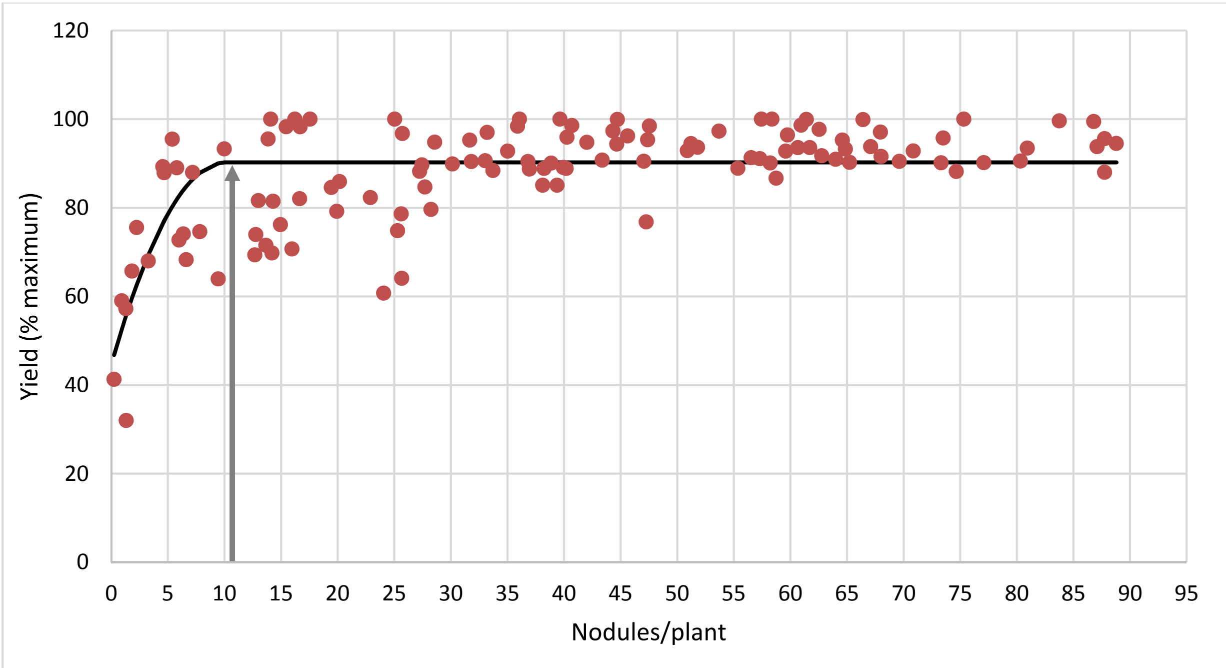


Figure 1. Relationship between number of nodules per soybean plant and relative yield.

Establishment methods for sweet clover or alfalfa in spring wheat

Year: 2017 (1 year trial)

Objective:

1. To determine the establishment success of alfalfa or sweet clover in spring wheat by comparing methods:
    a. Pre-broadcast legumes prior to seeding spring wheat
    b. Post broadcast legumes after seeding spring wheat
    c. Drilling legumes within the seed row of wheat at the same time of seeding.
2. Determine the effect of legume on wheat grain yield, and grain yield factors
3. Determine the biomass produced by the legume after wheat harvest
4. Determine if any soil residual effects could be observed such as soil nitrogen, soil organic matter

Rational

The Seedhawk drill is considered a no-till implement on the Canadian prairies however does provide some soil disturbance during seeding. This disturbance could be used to help cover broadcast seeded relay crops if broadcast prior to seeding. This may be an alternative method to drilling seed or more successful in terms of establishment to broadcasting after seeding.

A trial was set up to determine the differences of method of legume establishment and biomass production. In addition, to establishment, the effect of the legume on the cash crop yield and yield factors was explored.

Methods

Location: Melita; legal land location SW 22-3-27 W1
Design: Randomized Complete Block Design; treatments replicated 3 times, plot size 12.96m2
Burn-off: Roundup transorb @ 0.5 L/ac just prior to seeding
Previous crop: Fall Rye
Seed Date: May 23, 2017
Wheat seed depth: 0.5"
Crop Varieties and Seeding Rates:

Crop	Variety	Seed Rate (lbs/ac)
Wheat	Glenn	86
Sweet Clover	Norgold	6
Alfalfa	Rangelander	8

Fertilizer: N-P-K-S: 90-35-25-10 (lbs/ac) Sideband UAN + granular blend
In Crop Herbicides: Achieve @ 0.2L/ac (plus intake adjuvant) + Basagran at 0.91 L/ac
Grain Harvest Date: Sept 6, 2017
Legume Relay Biomass Date: September 20th
Rainfall during trial: 222 mm (80% of normal)

Data Collected

- Legume Emergence – 3 counts x 0.25 m2 in June and October
- Soil test after relay biomass including nitrates and soil organic matter per plot, 3 core Composite per plot (0-24").
- Dry Matter Biomass of Legumes on Sept 20, 2017
- Grain Yield of Wheat
- Grain protein
- Grain Thousand Kernel Weight (n=500)
- Grain Test Weight

Statistical Model: two-way ANOVA (GenStat)

Results

Due to the combination of broadcast seed and the lack of precipitation during the spring, there was poor emergence rates in sweet clover, alfalfa. Interestingly for alfalfa, during establishment, drilled alfalfa performed more poorly compared to broadcast alfalfa, whereas clover did not prefer one method over another. Seeding legumes at a depth of 0.5" may decrease emergence compared to broadcast treatments. However, in terms of biomass of legumes, no method differed better or worse than the other in wheat. Of course there was significantly more biomass in monocrop legumes than relay crops.

For wheat, there were significant differences among treatments in terms of grain yield but not seed weight, test weight or protein content. Generally, relay cropping legumes resulted in a lower grain yield than the wheat monocrop such as in post broadcast alfalfa, seeded sweet clover and post broadcast sweet clover. Seeded alfalfa, pre-broadcast alfalfa or sweet clover was not significantly different in wheat yield than monocrop wheat.

Table: effects of alfalfa or sweet clover stand establishments methods on wheat yield, soil nitrogen and soil organic matter in Melita in 2017.

Treatment	Final Stand	Legume Biomass		Wheat Test Weight	Wheat Seed Weight	Wheat Yield		Wheat Protein	Soil N	SOM
	ppm2	kg/ha		g/0.5L	g/500	kg/ha		%	lbs/ac 0-24"	%
Wheat Check	-	-		411	15.6	4174	ab	11.7	20.3	3.4
Alfalfa Seeded	23.6 a	381	c	411	15.9	4113	abc	12.0	16.3	3.3
Alfalfa PreBroadcast	46.7 b	354	c	413	15.7	4128	abc	11.8	21.3	3.3
Alfalfa PostBroadcast	58.2 b	327	c	411	15.9	3869	c	11.7	26.0	3.5
Clover Seeded	20 a	279	c	409	16.0	3870	c	11.9	21.3	3.6
Clover PreBroadcast	28 a	168	c	412	16.1	4374	a	11.9	21.3	3.5
Clover PostBroadcast	19.6 a	267	c	410	15.9	3980	bc	12.2	17.7	3.4
Clover (drilled)	13.3 a	2126	a	-	-	-		-	16.3	3.3
Alfalfa (drilled)	11.1 a	1313	b	-	-	-		-	18.3	3.7
CV%	36.4	62.2		1.3	2.3	4.1		2.7	20.7	5.6
P value	<.001	<.001		0.903	0.708	0.032		0.474	0.176	0.182
Significant	**Yes**	**Yes**		No	No	**Yes**		No	No	No
LSD (p<0.05)	17.6	710		NS	NS	300		NS	NS	NS

There were no differences in fall soil nitrate or soil organic matter (SOM).

Discussion

Lack of overall rain fall during the year reduced the establishment and competitive ability of the relay crops to thrive. However, with drilled legumes, these treatments were able to grow in soil moisture right after seeding, and in the case for sweet clover was able to grow above the wheat crop, whereas legumes broadcast never germinated until the first rain of June 9th and there rather set back compared to drill treatments (photo).

Lack of rainfall at critical growth times also created a "weed-like" situation between legumes and wheat, with wheat reducing yield compared to the monocrop check in some situations. It would be interesting to see if this would continue to happen during more normal to above normal rainfall situations.

Picture. Monocrop Alfalfa, seeded clover in wheat and alfalfa broadcast after seeding.

Monocrop alfalfa	***Seeded Sweet Clover***	***Broadcast alfalfa***

Reponses of Pea and Canola Intercrops to Nitrogen and Phosphorous Applications (year 2 of 2; final report)

Chalmers S., 2017. Westman Agricultural Diversification Organization Inc., 139 Main Street. Melita, MB Canada. R0M 1L0. Email: scott.chalmers@gov.mb.ca

Introduction

Intercropping is the agricultural practice of cultivating two different crops in the same place at the same time (Andrews & Kassam 1976). In nature, plant species are rarely found as sole members in a population but rather are usually found as a diverse mix of different species. The many benefits of intercropping can lead to greater than expected yields compared to monocropping. Reasons for additional yield may be the result of greater efficiency in the use of nutrients, light and water (Szumigalski & Van Acker 2008). Intercropping is not a new concept and has been used by farmers for generations. However, recent improvements in farm machinery, individual variety characteristics and herbicide tolerance have once again tweaked producers' interest in intercropping.

Little is known about intercropping peas and canola (peaola). Research by Chalmers (WADO, 2014) from a three-year field plot study suggested an approximate 28% yield increase was possible by intercropping peaola and that row orientation was the main influence for this yield increase as opposed to nitrogen applications which did not make a significant impact. Similar research was found by Bartley *et al.* (2016) where additions of nitrogen fertilizer made no impact on total yield of peaola, despite a response in canola yield. In addition, WADO has surveyed crop inputs from 30 producer fields of peaola over Manitoba and Saskatchewan and found that nitrogen applications, despite having a positive influence on canola, had a greater negative influence on the pea yield, thus reducing total combined yield to be in a negative trend in relation to greater nitrogen application. This is likely due to supplied nitrogen fertilizers inhibiting the nodulation process between rhizobia and pea. These observations are likely supported from formal research in peas where high rates of available nitrogen inhibit nitrogen fixation by rhizobia (Voisin *et al.* 2002) and also with Waterer *et al*. (1994) who also found that the addition of nitrogen had little contribution to yield and LER in pea mustard intercrops. It is suspected that fixed nitrogen is supplied in credit to the soil rhizosphere and that canola may be using this nitrogen, driving the fixation process even greater. Fustec *et al.* (2013) described the sharing of nitrogen between faba bean and rapeseed illustrating that rapeseed accumulated 20% more nitrogen than in monocrops. Intercropping systems with pulses summarized by Xue *et al*. (2016) suggest multiple mechanisms that nitrogen fixation drives soil chemistry processes in alkaline calcareous soils to mobilize inorganic and organic forms of phosphorus to more active forms.

WADO's survey says the addition of increasing phosphorous fertilizer rates corresponded with greater overall yield. However, in this survey, few fields applied phosphorus at anymore than a traditional rate. WADO hypothesises that since peaola is generally over yielding, demand and extraction of phosphorus from soils must be greater than in the monocrop of pea or canola. Despite phosphorus being complementary to canola and pea, the source, and mechanism of uptake is not understood in an intercropping system.

A simple nitrogen and phosphorus trial (Table 1) was set up near Melita, MB. This report focuses and describes the combined data of 2016 and 2017. This trial had several objectives including:

1. To determine if intercrops of pea and canola require additional fertilizer applications such a phosphorous (a nutrient in demand by both crops) by crop yield and land equivalent ratio responses
2. To determine response of pea and canola intercrops to nitrogen application and examine the effect of pea-nodulation on yield of crop components and total yield and land equivalent ratio.
3. To examine if any relationship (interaction) exists between combined nitrogen and phosphorous applications in pea canola intercrops in terms of yield, land equivalent ratio or nodulation in pea.

Methods

Trials were grown on a strongly calcareous soil near Melita MB. Plot treatments were seeded in a randomized complete block design and replicated three times.

Table 1: List of treatments and their respective cropping system, nitrogen and phosphorus applied fertility rates.

Treatment	Crop	Fertilizer Applied (lbs/ac actual)	
		Nitrogen	Phosphorous
1	Pea (Check)	0	30
2	Canola (Check)	90	30
3	Pea Canola	0	0
4	Pea Canola	45	0
5	Pea Canola	90	0
6	Pea Canola	0	30
7	Pea Canola	45	30
8	Pea Canola	90	30
9	Pea Canola	0	60
10	Pea Canola	45	60
11	Pea Canola	90	60

A spring soil test was taken as a composite of samples taken over the trial area prior to seeding (Table 2) to determine residual fertility levels.

Table 2: Pea canola intercropping trial spring soil test nutrient levels prior to seeding derived from a sum of 0-6” and 6-24” depths. N=Nitrogen, P=Phosphorous, K = Potassium, S= Sulfur, OM = organic matter

Year	Location	Legal Land Location	Soil Type	N lbs/ac	P ppm Olsen	K ppm	S lbs/ac	pH	OM %
2016	Melita	NE 27-3-27W1	Waskada Loam	33	6	245	480	7.5	~2.8
2017	Melita	SW 22-3-27 W1	Waskada Loam	8	9	333	12	7.6	4.1

In 2016 plot area was sprayed prior to seeding with Rival (0.5 L/ac), Roundup Transorb (1 L/ac) and Aim (15 ml/ac) herbicides tank mixed then sprayed with a water volume application rate of 10 gal/ac. In 2017, only a single burnoff was done April 20th, 2017 with 1 L/ac Roundup Transorb tank mixed with water. Plots were seeded with a SeedHawk dual knife single side band air seeder 9.5" spacing. Plots were 1.44 m wide by approximately 8.5 meters long. Plots were land rolled after seeding for stones.

Table 3: Agronomic/field operation dates and rates

Seeding Date	Seeding Depth	Fertility	Herbicide	Water Volume	Spray Date	Harvest Date
May 6 2016	0.625	Various Rates of N+P & 27K+18S	Odyssey 17g/ac + Equinox 67ml/ac +Merge	20gal/ac	June 2 2016	Aug 22 2016
May 17 2017	0.625	Various Rates of N+P, MAP used	Odyssey 17g/ac + Select 75 ml/ac + Merge	10gal/ac	June 2017	Sep 6 2017

Target plant stand for canola and pea in the monocrop treatments was 80 p/m^2. Seeding rates for mixed row intercrops was 40 p/m^2 for canola and 40 p/m^2 for pea. Varieties used in this trial were '2020CL' in 2016 and 5545CL in 2017 for canola, and 'CDC Striker' in 2016 and 'CDC Meadow' in 2017 (green type) for peas. Plots were managed according to Table 3. Plots were desiccated with Reglone herbicide at a rate of 0.61 L/ac at an application volume of 20 U.S. gal/ac at maturity (canola reached 80% seed color change). Plots were harvested with a Hege plot combine set to normal canola harvest settings. Data collected on plots included: emergence, pea nodule counts, pea seed bleaching, SPAD meter readings, aphid counts and soil moisture readings (near maturity). Pea nodules were counted from 5 random plants; percent seed bleaching and percent diseased seed was determined by looking at 50 seeds per plot. Canola plots were sampled (10 plants per plot) July 10th with a SPAD 502 Plus Chlorophyll Meter [Spectrum Technologies, Aurora, IL] at mid flower as a covariate to plant health. Aphid counts (10 plants per plot) were taken July 2017 due to an infestation. After aphid counts were taken, Matador insecticide was applied to control aphids and avoid damage which could skew the experiment. Soil moisture content was taken as an average of five readings per plot using a HydroSense II (Campbell Scientific). Sensor probes rods (CS658) are 20 cm long and measure soil volumetric water content (percent water) in a sandy soil (soil setting 1). Readings were taken during late flower development of both crops. This data was analyzed with a 2-way ANOVA.

Grain samples were separated into individual crops using a small bench seed cleaner (Eclipse Model 324, Seedburo Equipment Co.). Final grain yield was calibrated to a grain moisture content of 10% for both crops. Final grain yields were also converted to partial land equivalent ratios (PLER) for peas and or canola, which were combined into a total land equivalent ratio value using the following equation:

$$\text{Total LER} = la/Sa + lb/Sb = \text{partial LER peas} + \text{partial LER canola}$$

Where total LER is the total Land Equivalent Ratio, I is the intercrop yield (in the rep), S is the sole crop yield (of the rep), and "a" and "b" refer to the crop components. Pea sole crop was the inoculated check and the canola sole crop used was the 90 lbs/ac N rate check.

Grain yield, land equivalent ratio, pea nodule count data sets were analyzed with AgroBase Gen II statistical software using a Residual Maximum Likelihood (REML) variance components analysis also tested with interaction between nitrogen and phosphorous rate components. Least significant difference (LSD) was calculated at the 0.05 level of significance.

Results

There were no statistical differences in SPAD meter reading, percent volumetric soil moisture content, percent pea seed disease, or percent bleached seed (Table 4). There were significant differences found in 2017 when aphids invaded the plot. There were significantly more aphids in pea monocrop compared to all other intercrop treatments.

Table 4: Significant differences in SPAD, VWC, pea disease, bleach peas and pea aphids (2017 only) in 2016 and 2017 combined data.

N	P	TRT	Crop	NAME	SPAD	%VWC	%Pea Disease	% Bleach Pea	Aphids/plant
0	30	1	P	P-0-30	-	29.7	5.3	37.0	16.7
90	30	2	C	C-90-30	46.4	28.6	-	-	-
0	0	3	PC	PC-0-0	45.2	31.2	2.3	36.0	1.6
45	0	4	PC	PC-45-0	47.0	31.4	5.3	36.6	0.3
90	0	5	PC	PC-90-0	48.6	28.7	5.0	35.3	2.1
0	30	6	PC	PC-0-30	47.4	30.5	3.0	36.6	2.6
45	30	7	PC	PC-45-30	48.3	29.6	3.0	38.6	1.9
90	30	8	PC	PC-90-30	48.8	27.9	2.8	41.9	1.7
0	60	9	PC	PC-0-60	47.6	29.0	4.0	34.0	2.3
45	60	10	PC	PC-45-60	48.8	28.9	3.7	36.3	1.4
90	60	11	PC	PC-90-60	48.5	29.6	4.3	36.6	2.9
				CV	5.4	38.6	113.6	78.2	119.4
				LSD	3.0	13.2	5.2	33.8	6.9
				P value	0.273	1.000	0.948	1.000	0.004
				Significant	No	No	No	No	Yes

There were statistical differences among grain yield, land equivalent ratio and pea nodule counts (Table 5). Responses to only nitrogen or phosphorous were found and there was no apparent interaction among these factors between nitrogen and phosphorous.

Table 5: REML analysis of pea nodulation, pea and canola yield (inclusive of monocrop check means) and land equivalent ratios (LER) in response to combinations of nitrogen and phosphorous fertilizer rates in intercropped pea and canola in 2016 and 2017 for Melita, MB.

Fertilizer (lbs/ac)		Pea		Pea Nodules		Pea Yield		Canola Yield		Pea LER		Canola LER		Total LER	
N	P	TKW		per plant		kg/ha		kg/ha							
0	0	215		32		1657		495		0.57		0.20		0.80	
0	30	224		36		1932		651		0.67		0.27		0.96	
0	60	216		29		1888		763		0.66		0.32		1.03	
45	0	231		19		1895		682		0.65		0.28		0.94	
45	30	219		27		2009		768		0.71		0.32		1.03	
45	60	226		33		1998		858		0.70		0.36		1.05	
90	0	239		12		1614		662		0.57		0.27		0.94	
90	30	229		25		2103		824		0.75		0.34		1.08	
90	60	238		24		2225		952		0.79		0.40		1.11	
0		218.0	a	32.40	a	1826	a	636	a	0.63	a	0.263	a	0.93	a
45		225.4	ab	26.14	b	1967	a	769	b	0.69	a	0.322	b	1.01	a
90		234.9	b	20.17	c	1981	a	813	b	0.70	a	0.338	b	1.04	a
	0	228	a	20.9	a	1722	a	613	a	0.60	a	0.252	a	0.90	a
	30	224	a	29.2	b	2015	b	748	b	0.71	b	0.312	b	1.03	b
	60	227	a	28.6	b	2037	b	858	b	0.72	b	0.359	b	1.06	b
P value	N	**0.007**		**0.001**		0.165		**0.017**		0.066		**0.018**		0.157	
	P	0.909		**0.016**		**0.002**		**0.002**		**<0.001**		**0.002**		**0.013**	
	NxP	0.328		0.160		0.148		0.925		0.159		0.933		0.955	
Approx. LSD	N	9.97		6.02		174		119		0.06		0.053		NS	
(p<0.05)	P	9.98		6.02		174		119		0.06		0.053		0.12	
	NxP	17.2		10.4		301		206		0.10		0.091		NS	

Increases in nitrogen provided only a significant response in canola and not pea (Figure 1), whereas increases in phosphorous rates produced a response in both crops.

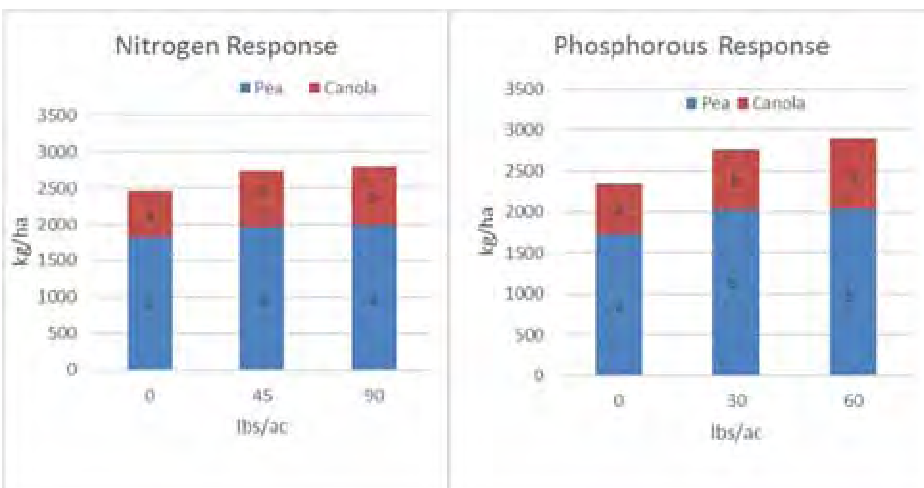


Figure 1: Yield response of pea and canola intercrops to nitrogen or phosphorus in 2016 & 2017 in Melita.

There were no interactions in either crop by using a combination of nitrogen and phosphorus fertilizer together, despite a steady increase trend in total yield as rates increased (Figure 2). It appeared that when nitrogen was fully supplied at 90 lbs/ac, total grain yield was held back by lack of phosphorus when none was applied (0 P + 90 N treatment).

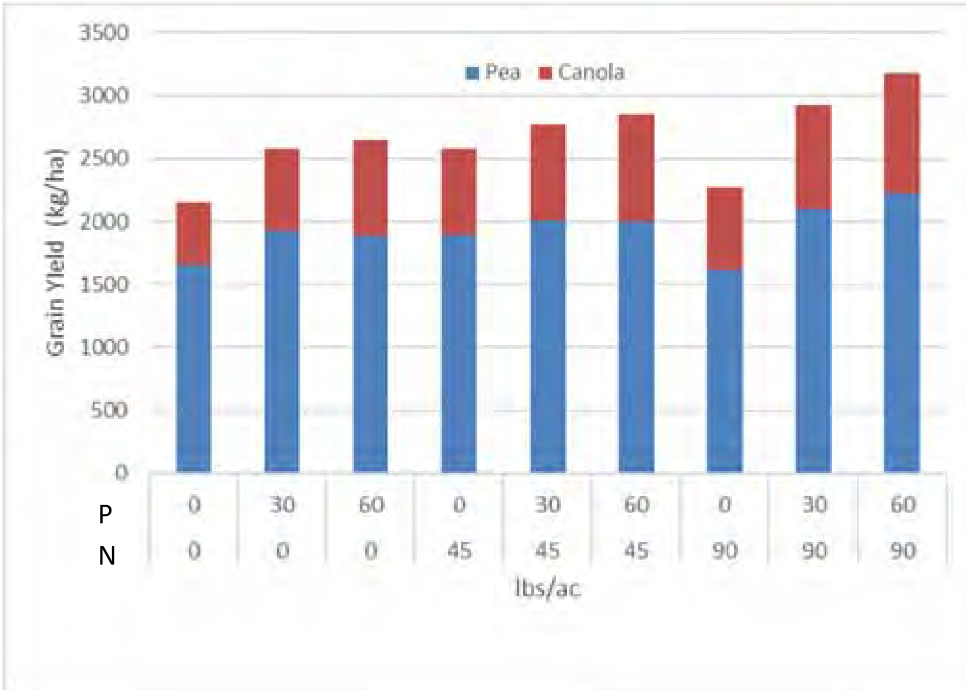


Figure 2: Combined REML mean yield responses of pea and canola to interactions of nitrogen and phosphorus application in 2016 & 2017 from Melita, MB.

Increases in phosphorus rates resulted in a significant increase in land equivalent ratio (LER) but increases in nitrogen did not (Figure 1).

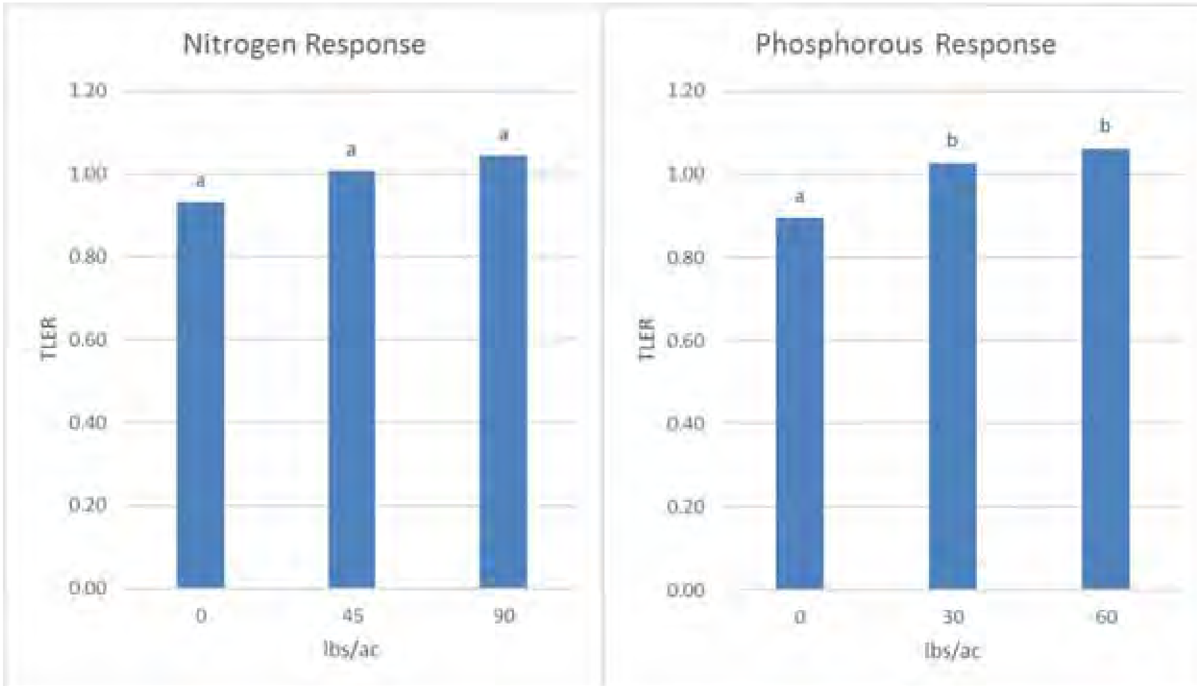


Figure 3: REML Total Land equivalent ratio means of pea canola intercrop response to either nitrogen or phosphorous applications in 2016 & 2017 from Melita, MB.

There was no interaction in either crop by using a combination of nitrogen and phosphorus fertilizer together, despite a steady increase trend in total LER as rates increased (Figure 4). Again, it appeared that when nitrogen was fully supplied at 90 lbs/ac, total land equivalent ratio was held back by lack of phosphorus when none was applied (0 P + 90 N treatment).

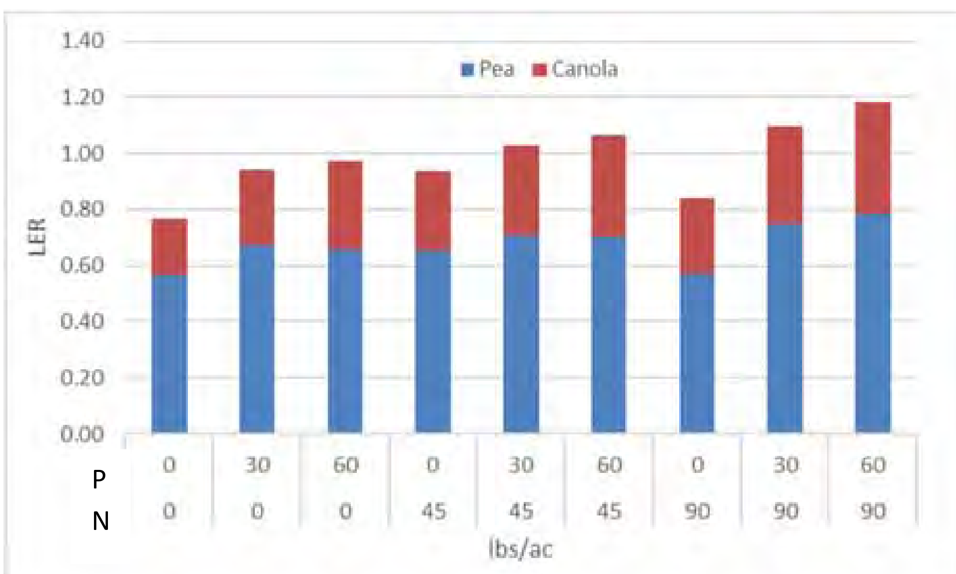


Figure 4: Combined REML mean land equivalent ratio (LER) responses of pea and canola to interactions between nitrogen and phosphorus application in 2016 & 2017 from Melita, MB.

A significant decline in pea nodulation was observed with increased rates of nitrogen fertilizer application (Figure 5). In contrast, a significant increase in pea nodulation was observed with increased rates of phosphorous. However, nodulation was statistically similar between rates of 30 and 60 lbs/ac applied phosphorus. There was no interaction between nitrogen and phosphorus fertilizer rates.

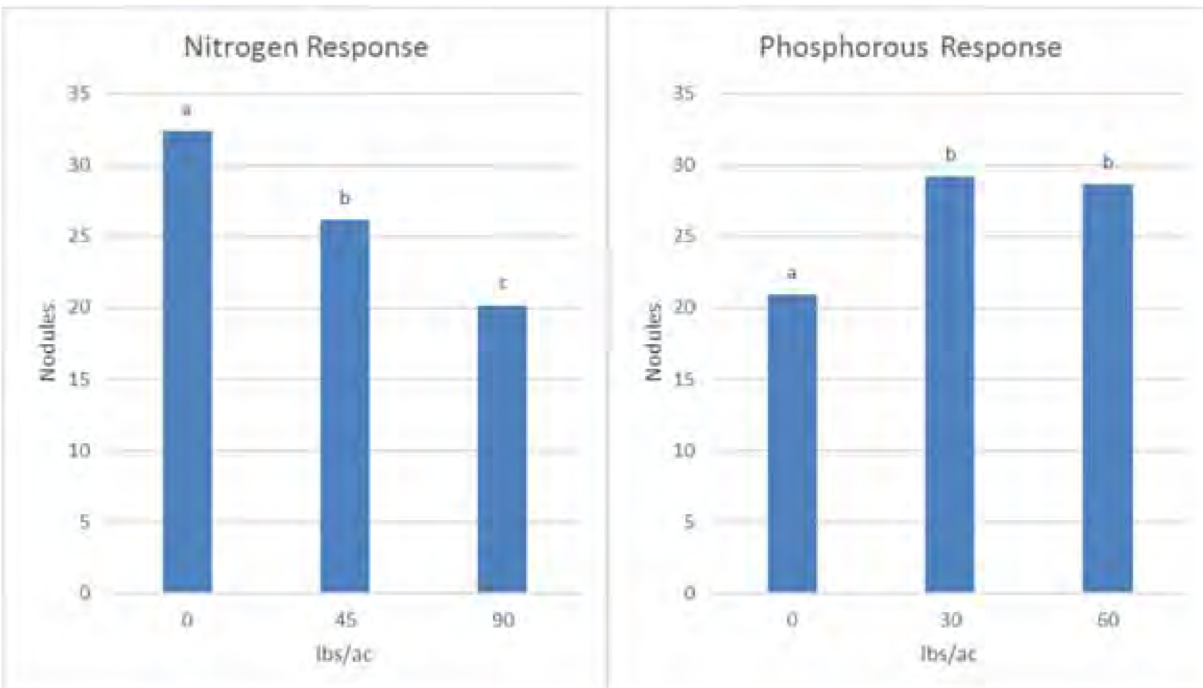


Figure 5: REML mean responses to nitrogen and phosphorous fertilizer applications in pea plant nodulation (nodules per plant) in 2016 & 2017 from Melita, MB.

Discussion

Phosphorous responses in field crop research can be difficult to achieve and this is further compounded in strongly calcareous soils such as in this soil association. However, this study was able to obtain a decent response. Phosphorous application appears to be directly related to increased yield in both crops and is a more important fertilizer in terms of total yield response in pea-canola intercrops than nitrogen.

Nodulation was inhibited by applied nitrogen fertilizer and promoted by the addition of phosphorus fertilizer.

Reasons for pea aphids avoiding pea-canola intercrops that are only a couple meters away from monocrop peas are unknown and could be many. Perhaps it is a physical barrier posed by the canola, chemical avoidance (from the canola) or some sort of behavior associated with the presence of canola. None the less, it is an interesting finding. In 2017, a producer in the region who had pea canola on their farm also indicated that they did not spray for bertha armyworm while neighbors had to do so.

In 2016, canola emergence in this trial was an issue with only 35% of a normal stand (14 plants/m^2). This emergence was similar in 2017 with about 50% emerging due to drought conditions (41 plants/m^2). It is possible that a different outcome may have resulted if canola stands were near more normal densities. Lack of stand may have been attributed to the use of three year old canola seed (2016), poor vigor and crusted post seeding soil conditions (2016 and 2017).

Photo: Peaola research trial. Monocrop pea on left in early flower and intercrop peaola on right, canola in early flower. Taken July 12, 2016 near Melita, MB.

References

1. Andrews, D.J., A.H. Kassam. 1976. The importance of multiple cropping in increasing world food supplies. pg. 1–10 in R.I. Papendick, A. Sanchez, G.B. Triplett (Eds.), Multiple Cropping. ASA Special Publication 27. American Society of Agronomy, Madison, WI.
2. Bartley G., VanKoughnet B. (2016). On Farm evaluation of Peaola – an intercrop of peas and canola. Manitoba Pulse and Soybean Growers Association. Available from: Pulse Beat Magazine 2016 Fall/ Winter Edition.
3. Szumigalski, A., Van Acker, R. C., 2008. Land equivalent ratios, light interception, and water use in annual intercrops in the presence or absence of in-crop herbicides. Agronomy Journal. Vol 100, Issue 4, pg. 1145-1154

4. Waterer, J.G., J.K. Vessey, E.H. Stobbe, and R.J. Soper. 1994. Yield and symbiotic nitrogen fixation in a pea-mustard intercrop as influenced by N fertilizer addition. Soil Biol. Biochem. 26:447-453.
5. Voisin AS., Salon C., Munier-Jolain N.G., Ney B., 2002. Quantitative effects of soil nitrate, growth potential and phenology on symbiotic nitrogen fixation of pea (*Pisum sativum* L.), Plant and Soil. Vol. 243, Issue 1, pg. 31-42.
6. Fustec J., Jamont M., Piva G., 2013. Sharing N resources in the early growth of rapeseed intercropped with faba bean: does N transfer matter? Plant Soil. Vol. 371, Issue 1-2, pg. 641-653.
7. Xue Y., Xia H., Christie P., Zhang Z., Li L, Tang C., 2016. Crop acquisition of phosphorous, iron, zinc from soil in cereal/legume intercropping systems: a critical review. Annals of Botany 117: 363-377
8. Chalmers S., 2014. WADO Annual Report 2014. Pg. 107. 139 Main Street, Melita MB, R0M 1L0. Scott.chalmers@gov.mb.ca
9. Holzapfel C., 2011. Exploring the merits of field pea-canola intercrops for improved yield and profit. ADOPT Project No. 20100292. Indian Head Agricultural Research Foundation, Box 156, Indian Head, SK, S0G 2K0

Appendix A - Background information

Equipment

John Deere 6140R

- Front end loader
- 3pt hitch
- Row crop capabilities
- Trimble RTK guidance
- Typically runs Wintersteiger planter, strip tiller, and sprayer

John Deere 5075M

- Front end loader with pallet forks
- 3pt hitch
- Greenstar guidance
- Typically runs plot seeder, sprayer, and mower

Wintersteiger Classic plot combine

- Straight header
- Gerringhoff 2 row corn/sunflower header
- Harvest Master/Mirus software
- Capable of individual bagging or bulk grain storage

Hege 140

- Straight header
- Sunflower Pans
- Capable of individual bagging or bulk grain storage

R-Tech plot Swather

Hege (Hemp combine)

Wintersteiger planter

- 4 Row 15-40" spacing.
- Capable of bulk seeding and individual plot
- Variable rate granular fertilizer capability
- Paired with JD6140R tractor with Trimble RTK guidance

SeedHawk seeder

- 9.5-inch spacing
- Dual knife opener single side band seed knife
    - Capable of placing fertilizer 1.5 inches to the side and 1.5 inches below the seed in one pass
- Set up for liquid nitrogen and dry granular blends
- Belt cone spinner
    - Alloys used to quickly and accurately seed plots with even seed disbursement
- Capable of bulk seeding

R-Tech 24ft Sprayer

- 3pt hitch
- Offset to spray full plot without tramping
- Two 15 gal mix tanks and One 70 gal fresh water tank

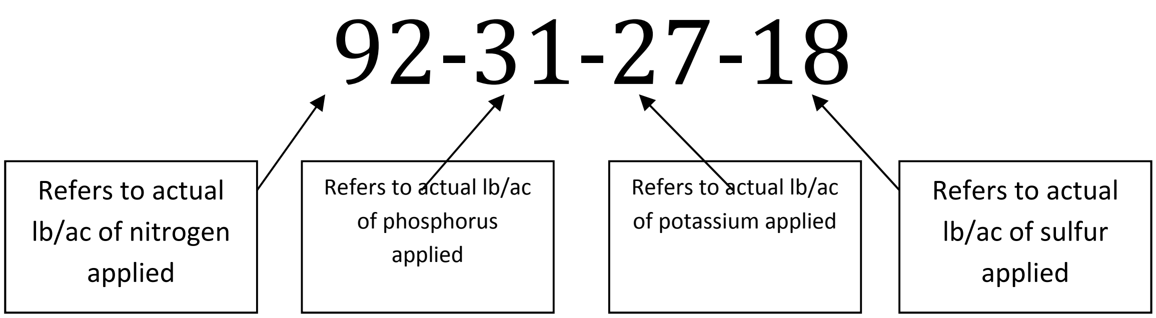
Elmers Strip tiller

- 4 rows – 30" spacing

Fertilizer

Fertilizer used

- Nitrogen is applied in the form of liquid 28-0-0 side banded
- Phosphorus is applied in a blend with potash and sulfur unless otherwise stated. Monoammonium Phosphate (11-52-0) is the product we use. This year we put down 31lbs actual on most plots which would also give us approximately 6.5lbs of nitrogen
- Potassium is applied in a blend with phosphate and sulfur. Potash (0-0-60) is the product we use. This year most plots received 27lbs actual.
- Sulfur is applied in a blend with phosphate and potash. Ammonium sulfate (21-0-0-24) is the product we use. This year most plots got 18lbs actual which would also give us approximately 15.75lbs of nitrogen.



Plot dimensions

Our plots are normally 9m in length by 1.44m wide. We seed pass these lengths and then trimmed them down using a 3-point hitch mower and a GPS enabled tractor.

Spraying

Our sprayer is offset which allows us to spray half of the plot from one side, then spray the other half from the other side without having to drive through the plot. Unless otherwise stated, our standard water volume we spray at is 10 gal/ac. We have a quad sprayer which we mainly use to spray ahead of the seeder. Most trials get an application of 1REL Glyphosate, .5l/ac trifluralin, and/or 15 ml/ac carfentrazone as a pre-seed burndown. These of course depend of re-cropping restrictions. We also have a $C0_2$ pressured backpack sprayer which allows us to be able to do individual plots inside a trial.

Data Processing

We have the ability to be able to take total weight, moisture content, bushel weight, thousand kernel weight, green count and protein. We have 2 small air screens for cleaning samples if need be.

WADO
Westman Agricultural
Diversification Organization Inc.

Manitoba's diversification centres are funded in part by
Growing Forward 2, a federal-provincial-territorial initiative.

Canada

Manitoba