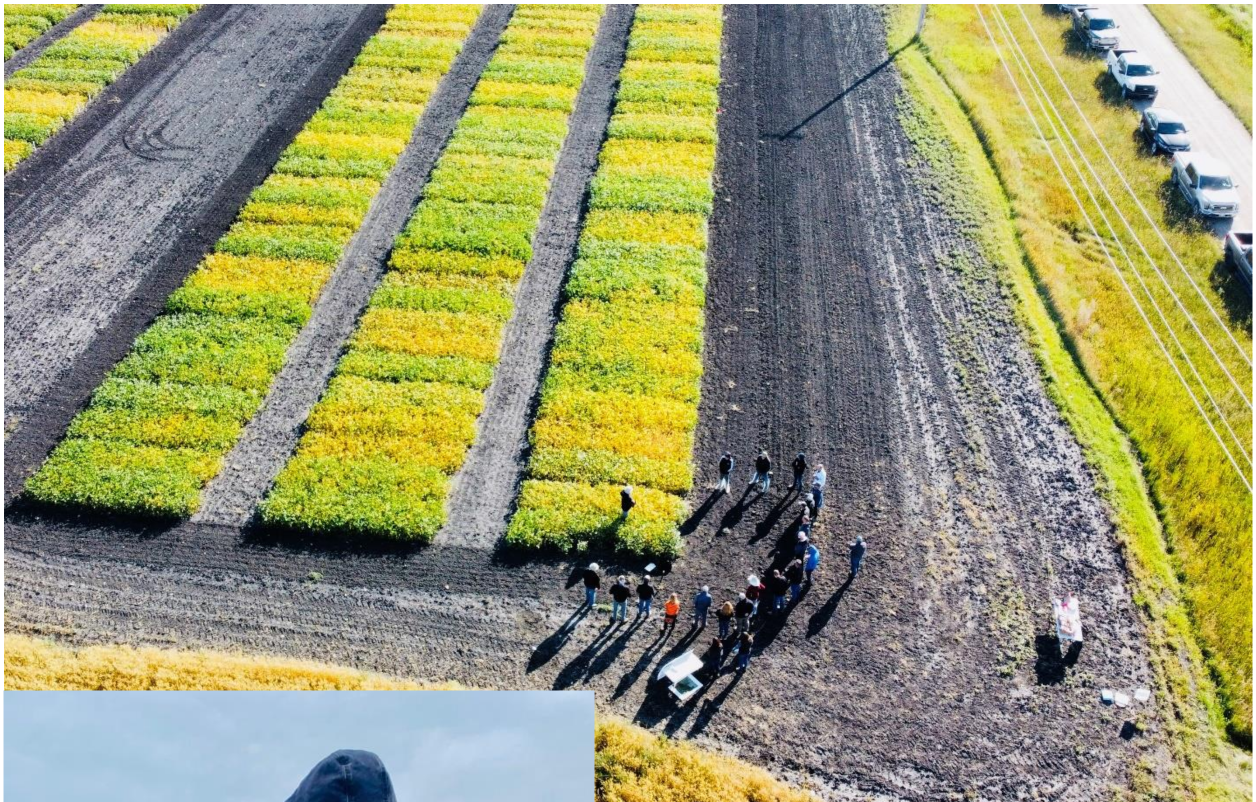

PESAI Annual Report 2022

PESAI

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- *Manitoba Pulse & Soybean Growers Association*
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- *Canadian Hemp Trade Alliance*
- *Canadian Agronomics Inc.*
- *Department of Plant Sciences, University of Manitoba*
- *FP Genetics*

PESAI

PESAI: Who we are?

Prairies East Sustainable Agriculture Initiative Inc. (PESAI) is a not-for-profit organization (incorporated in December 2005) serving the Interlake & Eastern Prairie region of Manitoba. It is one of the four Manitoba Diversification Centres, including Parkland Crop Diversification Foundation (PCDF) – Parkland Region, Westman Agriculture Diversification Organization (WADO) – Southwest Region and Manitoba Crop Diversification Centre (MCDC) – Central Region (Fig.1).

This initiative is a collaborative partnership between the agricultural communities of Interlake / Eastern Manitoba and Manitoba Agriculture. PESAI's objective is to support applied production research, crop diversification and value-added opportunities in the Eastern and Interlake areas. PESAI receives majority of its funds from the Agricultural Sustainability Initiative and Canadian Agricultural Partnership programs. Additional funding comes from the MCVET committee and other Industry partners for the contract plot work that PESAI is able to provide to these organizations.

Headquartered in Arborg, PESAI also does research work at Beausejour site. PESAI focuses on applied field research, innovation, diversification, value-added, advanced technology, market development and sustainability initiatives that directly benefit local area producers. The research results are communicated by various extension programs such as plot demonstrations; crop tours, seminars and workshops, annual reports & DC's website.

Fig 1. Diversification centres in Manitoba

2022-23 Board of Directors

An elected Board comprised of agricultural producers and entrepreneurs from the Eastern Prairie region directs PESAI activities (Table 1). Staff from Manitoba Agriculture / PESAI help to carry out PESAI activities (Table 2).

Table 1. PESAI Board of Directors during 2022 year.

Position	***Name***	***Area***
Chair	*Brian Kurbis*	*Beausejour*
Vice-Chair	*Wayne Foubert*	*St. Anne*
Secretary	*Linda Loewen*	*Riverton*
Treasurer	*Andy Buehlmann*	*Arborg*
Director	*Paul Grenier*	*Woodridge*
Director	*Gary Naurocki*	*Tyndal*
Director	*Garry Wasylowski*	*Fraserwood*
Director	*David King*	*Arborg*
Director	*Scott Duguid*	*Arnes*

Table 2. PESAI / Manitoba Ag Staff during 2022 crop season.

Position	*Name*	*Organization*
Diversification Specialist	*Dr Nirmal Hari*	*Manitoba Agriculture*
Diversification Technician	*James Lindal*	*Manitoba Agriculture*
Diversification Technician	*Brett Sigurdson*	*PESAI*
Summer Research Assistant	*Kate LeTexier*	*PESAI*
Summer Technician	*Eugene Delorme*	*PESAI*
Summer Technician	*Shaun Kendrick*	*PESAI*
Summer Research Assistant	*Emily Mazur*	*PESAI*

Fig 2. An aerial view of Arborg site buildings.

For more information about PESAI, Please visit www.mbdiversificationcentres.ca .

2022 Weather Summary

Arborg Site

Weather data was taken from the Manitoba Agriculture weather station located at the PESAI Research Site in Arborg.

Rainfall

During the 2022 growing season (May 1-Sept 30), Arborg site received 150% of the normal rainfall. Excessive amounts of snowfall over the winter led to spring overland flooding in the area. In addition to the excessive snowfall, Arborg site received above average rainfall for the months of May (204%), June (141%) and July (304%) This excessive rainfall led to flooding on some plots after seeding which caused problems in germination and seedling mortality (Picture

Picture 1. Flooding damage in plots (non-tiled land).

Picture 2. Heavy rainfall on July 19.

1). On July 19, Arborg received 99.6 mm of rainfall in two hours, which caused overland flooding. (Picture 2). The plots on tiled land survived but many plots on non-tiled land suffered losses and stress (Picture 3). In August and September, Arborg site received below average rainfall (49% and 51%, respectively). In summary, Arborg had a very wet spring and summer but a relatively dry weather towards fall months (Fig 1).

Picture 3. Plots on tiled land (right)

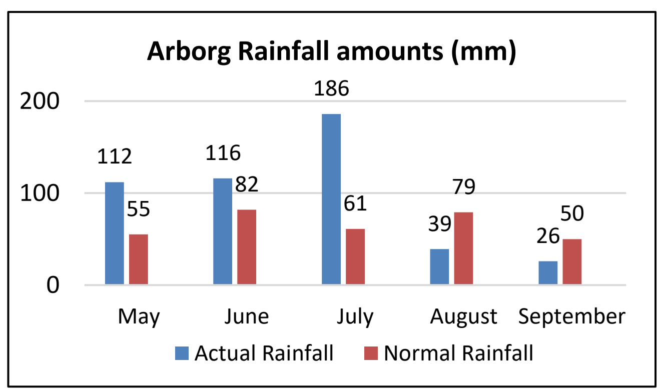
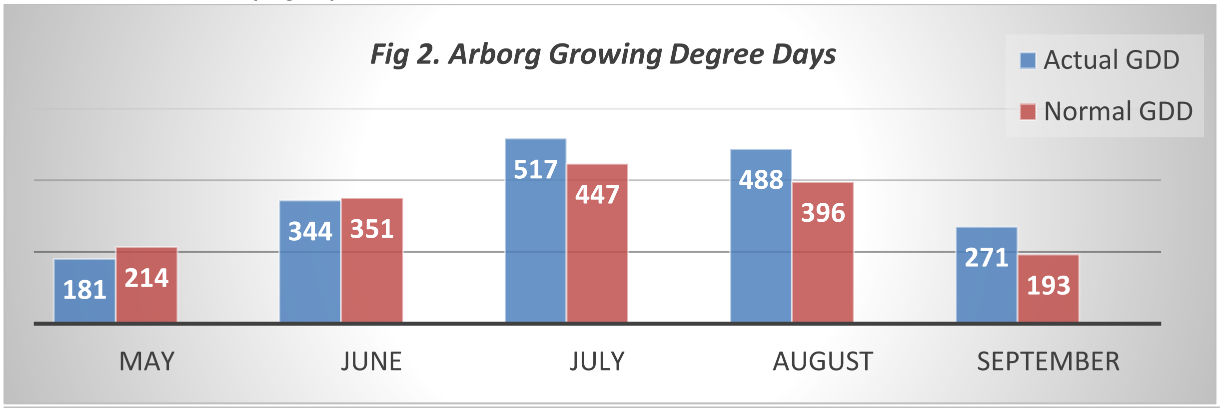
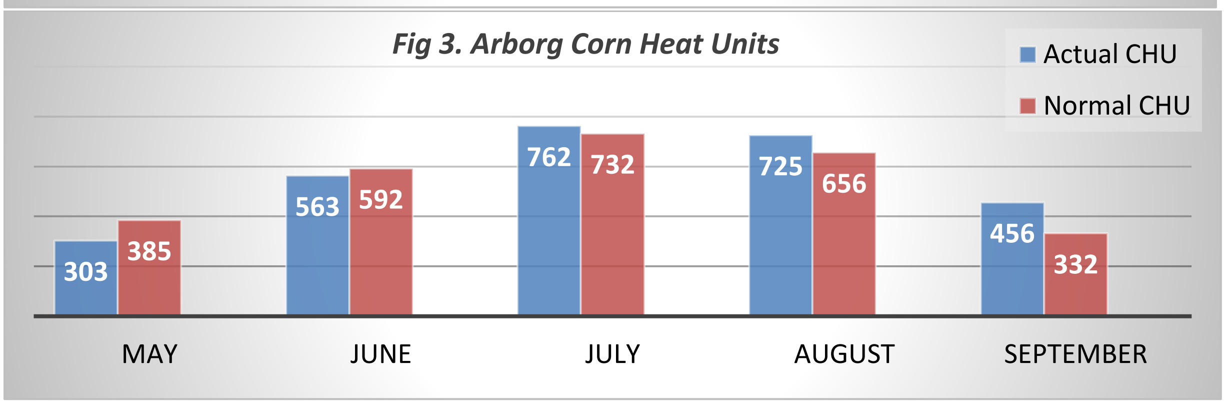


Figure 1. Monthly rainfall pattern at Arborg site.

Due to over land flooding, plots of MCVET canola, MCVET Flax, Cereal-legume intercrop and silage corn suffered significant losses. These trials were written off later on.

Growing Degree-Days and Corn Heat Units
During the 2022 growing season, Arborg site received 113% of normal growing degree-days (May 1-Sept 30). The months of May and June saw slightly below normal growing degree days (84% & 98%, respectively) while July, August and September months were above normal growing degree days (115%, 123% & 140%, respectively – Fig 2). Similar trend was observed for corn heat units (Fig 3.)

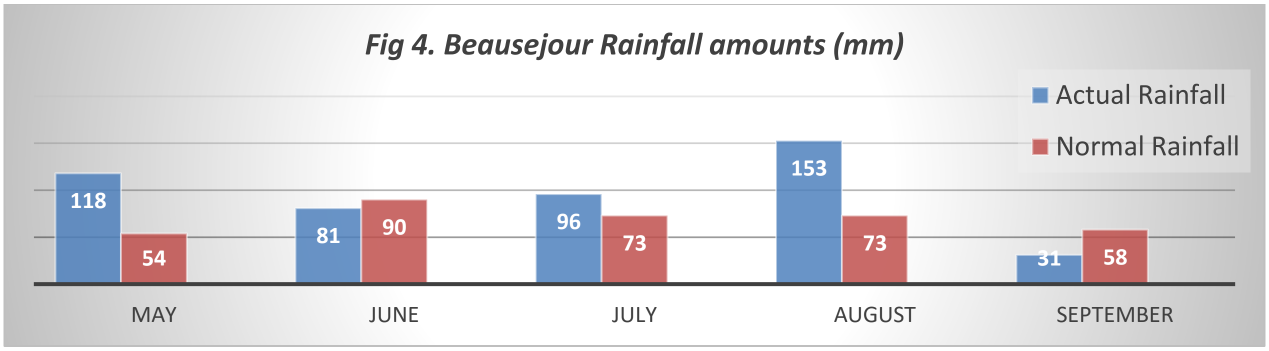




In spring, Arborg site had mild frost on May 3 (-2.2°C). First frost in the fall was on September 22 (-1.7°C) followed by frost events on September 26 (-1.2°C) and 27 (-3.5°C). This last frost caused damage on soybeans.

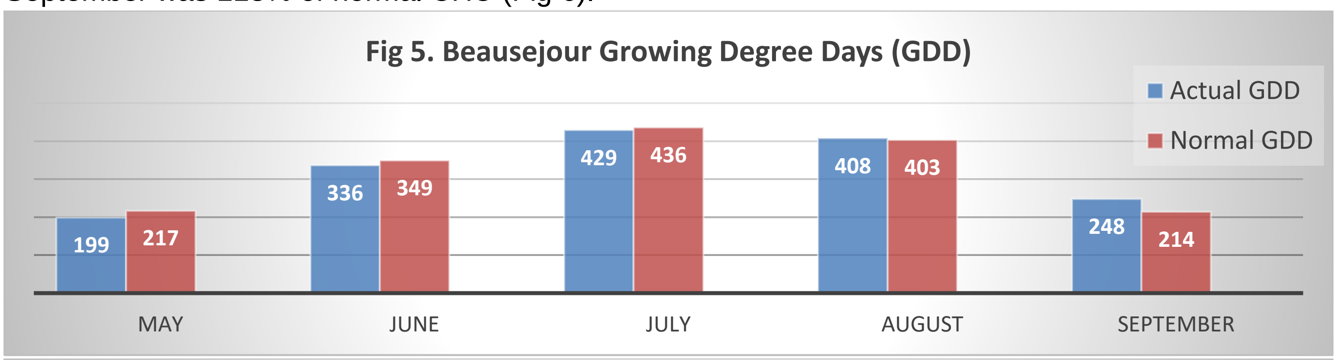
Beausejour Site
Weather data was taken from the Manitoba Agriculture Weather Station located four miles east and four miles north of the Beausejour Research Site. The University of Manitoba installed a weather station at the research site on June 20.

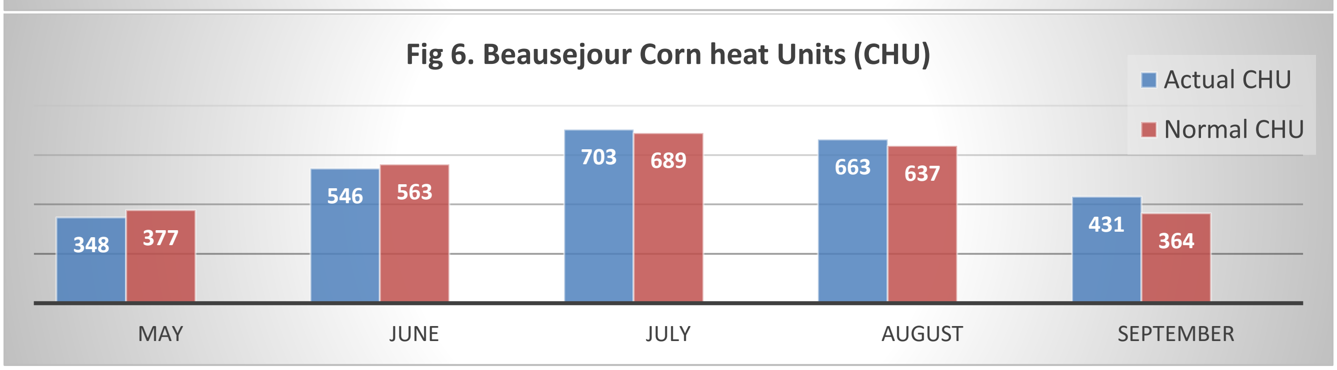
Rainfall
During the 2022 growing season (May 1-September 30) Beausejour received 131% of normal rainfall. Beausejour received 219% of normal rainfall in May. June received slightly below normal rainfall (90%). However, July and August were also above normal with 130% and 211% respectively. September was below normal receiving only 53 % of normal precipitation (Fig 4). The highest daily rainfall occurred on August 15. On that date, Beausejour received 55.7 mm of rainfall.



Growing degree-days & corn heat units

Beausejour site received slightly below normal growing degree-days (GDD) in May, June and July months. August experienced normal GDD while September was slightly above normal with 115% of normal GDD (Fig 5). The same occurred for the corn heat units (CHU). May and June were below normal for CHU where as July and August had slightly above normal CHU. September was 118% of normal CHU (Fig 6).





Beausejour did not receive frost until September 27 (-1.3C) which caused slight damage to immature soybeans.

Evaluating the Yield Potential and Stress Tolerance of Soybeans (*Glycine max*) under Rain fed and Irrigated Conditions in Manitoba

Project Duration: March 1, 2022 to Jan 31, 2023

Collaborators: N49 Genetics (Kevin Baron, Craig Riddell, Rick Rutherford), PESAI (Nirmal Hari), Murphy et al. (Keith Murphy). **This project was partially funded by PESAI.**

Objectives: The objective of this project is to evaluate the yield potential and stress tolerance of soybean varieties varying in iron deficiency chlorosis (IDC) ratings by growing under irrigated and rainfed conditions. IDC is a physiological disorder that limits the yield potential of soybeans when susceptible varieties are grown upon high pH, calcareous soils in Manitoba. This study extends on previous collaborative work between PESAI and N49 Genetics to examine the economic impacts of IDC on soybean production in the Interlake/Eastman regions on Manitoba.

Results

Site selection and selection of soybean varieties

Three field trial locations in the Interlake and Red River Valley regions of Manitoba were identified to host small plot soybean research trials, with each of these locations (Arborg, Fort Whyte, Warren) having soils with the potential to develop severe IDC symptoms.

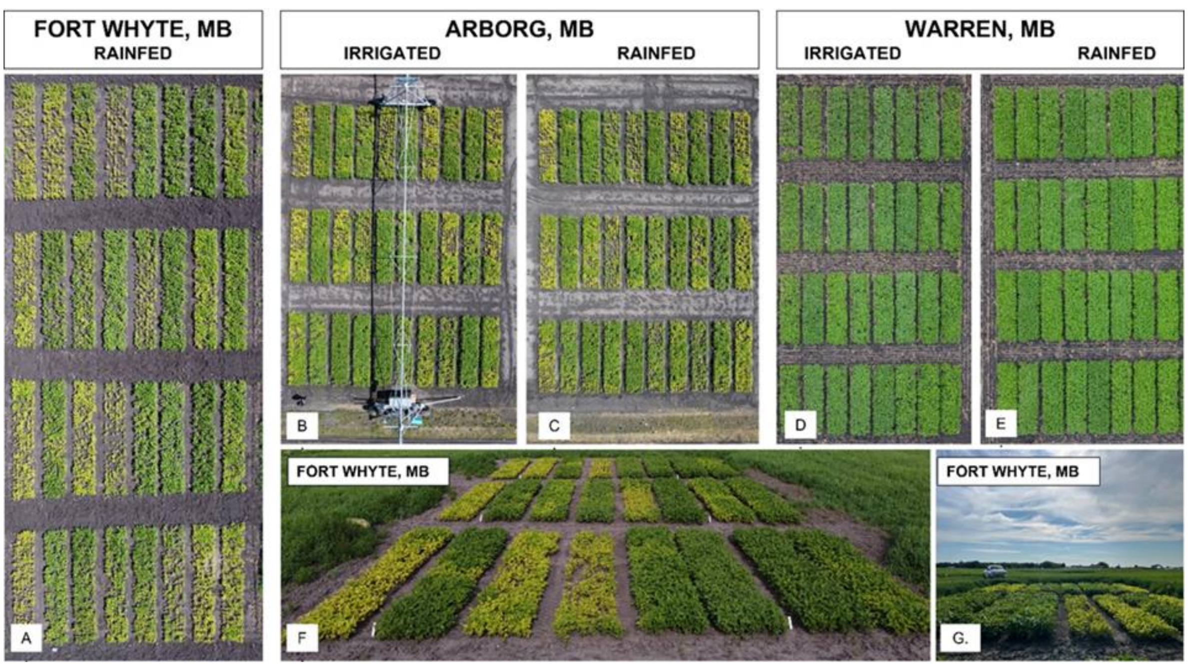


Figure 1. Aerial and ground-based images of rainfed and irrigated small plot research trials located at Fort Whyte (A,F,G), Arborg (B, C), and Warren (D,E) sites over the 2022 growing season. At both Fort Whyte and Arborg locations, commercial IDC susceptible (SUS) varieties within trials displayed visible symptoms of chlorosis and leaf yellowing (Figure 1F) characteristic of IDC, whereas tolerant (TOL) and semi-tolerant (ST) display less prominent symptoms. In contrast, for both rainfed and irrigated Warren trials (D,E) visible symptoms of IDC were less apparent.

At the Arborg (PESAI) and Warren (Solum Valley Biosciences) locations small plot variety evaluation trials (n=24 plots per trial) were further duplicated into non-irrigated and irrigated assessments of the same IDC tolerant and IDC susceptible soybean varieties. At the Fort Whyte location, the same experimental layout as the Arborg and Warren sites was utilized but with only a non-irrigated (rainfed) comparison of varieties (see Figure 1).

In 2021, N49 Genetics worked with PESAI (Arborg), Murphy et al. (Ste. Agathe) and Solum Valley Biosciences (Balmoral) to establish related small plot trials comparing IDC tolerant vs IDC susceptible soybean lines at multiple sites in Eastern Manitoba. However, 2021 being a dry year, was not ideal to evaluate soybean germplasm under **severe** IDC stress.

For the 2022 season, a similar set of herbicide tolerant varieties (n=6) varying in IDC tolerance ratings were planted into a randomized complete block design, allocating 4 replicates per variety. The same series of IDC tolerant (n=2), semi-tolerant (n=2), and susceptible (n=2) varieties were assessed in all trial locations. The selection of varieties was based on past assignment of IDC ratings to these varieties in the MPSG variety guide. As saturated soil conditions and cool temperatures in spring are factors that exacerbate iron deficiency chlorosis (IDC) on high risk soils, the use of irrigation equipment was proposed as a means to generate more consistent and reliable ratings for IDC in 2022.

Yield assessment of IDC tolerant and IDC susceptible soybean varieties

At all three field sites, rainfed and irrigated soybean trials were taken to harvest with mean grain yield ranging from 49.6 to 55.0 bu/acre (See Figures 2-6). These yield values are notably higher than the 10-year provincial average yield (~ 34-36 bu/acre, sourced MASC) for soybean in Manitoba. Visual chlorosis scores (VCSs) recorded at the Arborg and Fort Whyte sites in 2022 ranged from 1.1- 4.5 on a per plot basis, with averages reported in Table 1 and Table 2.

Arborg

For the non-irrigated rainfed site at Arborg, the trial mean yield was 54.6 bu/acre (Figure 2). When IDC susceptible varieties (grouped) were contrasted with the IDC tolerant and semi-tolerant varieties (grouped), the IDC susceptible grouping yielded 11.6 bu/acre lower. The yield of IDC susceptible line V5 was significantly less than all tolerant or semi-tolerant lines (V1-V4) in the trial, where as IDC susceptible line V6 was inferior only to V3.

For the adjacent irrigated test at Arborg, the trial mean yield across the same 6 varieties was 55.1 bu/ac (Figure 3). However, the IDC tolerant or semi-tolerant varieties (grouped) in the irrigated trial yield yielded ~ 4.7 bu/acre higher (= 63.6 bu/acre) than a similar grouping of varieties in the rainfed trial (58.8 bu/acre). In contrast, the average yield of the IDC susceptible grouping in the irrigated test was 38.0 bu/acre, or 25 bu/acre lower than IDC tolerant or semi-tolerant material managed under similar irrigated conditions. Both IDC susceptible varieties had significantly lower yield than IDC tolerant or semi-tolerant varieties.

Collectively, these observations suggest that the use of supplemental irrigation enabled the IDC tolerant or semi-tolerant material to achieve greater yield potential, or prolonged the period of IDC stress experienced by susceptible varieties early in the season. However, it is important to note that differences in the severity of chlorosis scores between rainfed and irrigated trials were not apparent at the time of ratings, although chlorosis scores clearly distinguished tolerant and susceptible material (Table 2). In spite of clear visual symptoms of IDC at the Arborg site and yield reductions reported for susceptible lines, the final yield of semi-tolerant lines at harvest equalled or exceeded that of tolerant lines in both the rainfed and irrigated comparisons (Figure 2 and 3). We did not observe a step-wise decline in the yield of semi-tolerant lines relative to tolerant lines, suggesting semi-tolerant lines were able to recovery or compensate from symptoms of IDC early in the season, whereas susceptible lines did not.

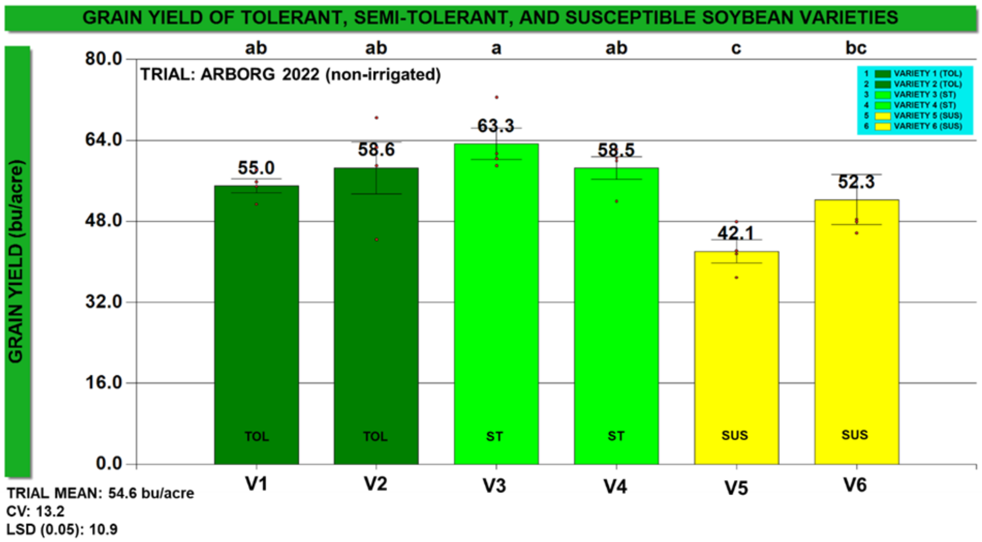


Figure 2. Grain Yield (bu/acre) of IDC Tolerant (TOL), Semi-Tolerant (ST) and Susceptible (SUS) Soybean varieties grown in 2022 at Arborg (PESAI) under rainfed (Non-Irrigated) conditions.

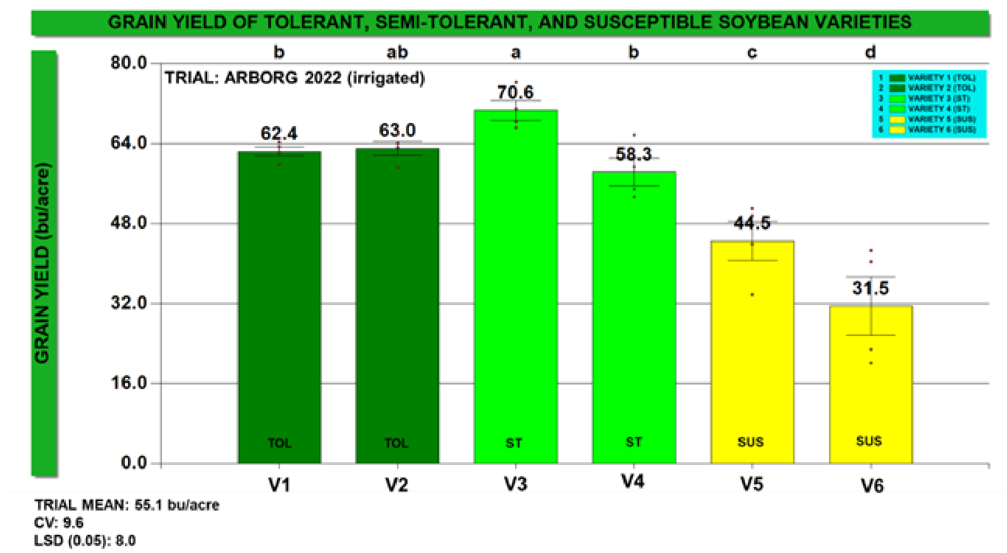


Figure 3. Grain Yield (bu/acre) of IDC Tolerant (TOL), Semi-Tolerant (ST) and Susceptible (SUS) Soybean varieties grown in 2022 at Arborg (PESAI) under Irrigated conditions.

Fort Whyte

At the Fort Whyte location (rain-fed only) the trial mean yield was 44.5 bu/acre across all 6 varieties examined. However, individual IDC susceptible varieties in the trial yielded significantly less than all tolerant or semi-tolerant entries (Figure 4), with the IDC susceptible group averaging 15.9 bu/acre less than the combined yield of the IDC tolerant and semi-tolerant group (= 49.9 bu/acre). Similar to Arborg site, semi-tolerant lines did not yield less than the tolerant group, whereas visible symptoms of IDC and significant yield reductions were readily apparent for the susceptible varieties (Table 1). Based on repeated site visits and visual chlorosis ratings, the Fort Whyte location **appeared** to be the location with the most severe and prolonged IDC pressure throughout the season and was monitored more intensively using digital tools.

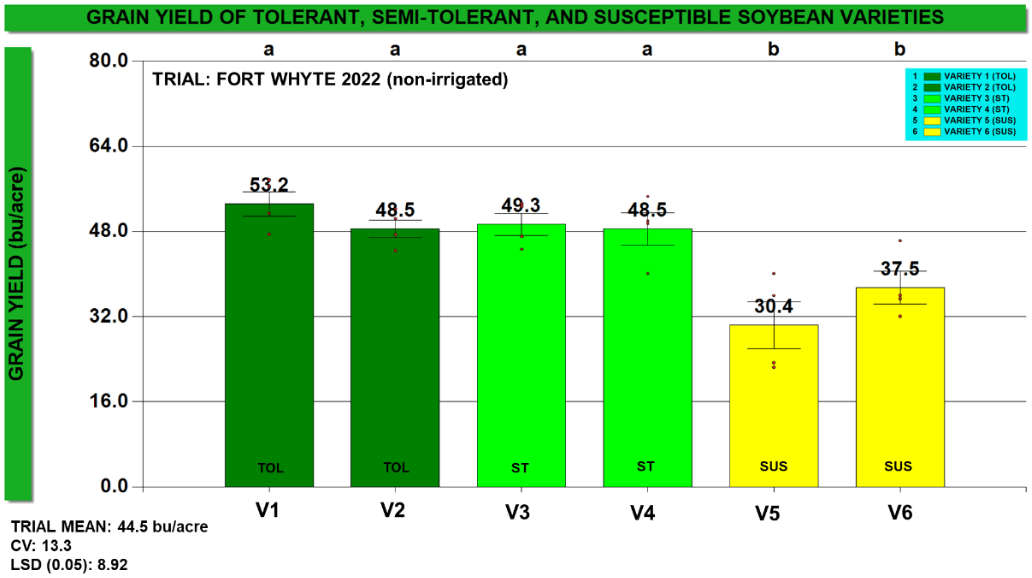


Figure 4. Grain Yield (bu/acre) of IDC Tolerant (TOL), Semi-Tolerant (ST) and Susceptible (SUS) Soybean varieties grown in 2022 at Fort Whyte (Murphy et al.) under rainfed (Non-Irrigated) conditions.

Warren

In contrast to the Arborg and Fort Whyte sites, Warren field site (both rainfed and irrigated sets) did not display persistent symptoms of IDC. However, trial mean yields at Warren (44.5 & 53.8 bu/acre) (Figure 5 & 6) were comparable to the range of yields reported at Arborg and Fort Whyte sites. No significant differences in the yield potential of IDC susceptible versus IDC tolerant lines were detected for the rainfed (Figure 5) or irrigated (Figure 6) trials at Warren. The lack of IDC symptoms at the Warren site demonstrated that the IDC tolerant, semi-tolerant and susceptible variety groupings had comparable yield potential in the absence of IDC stress.

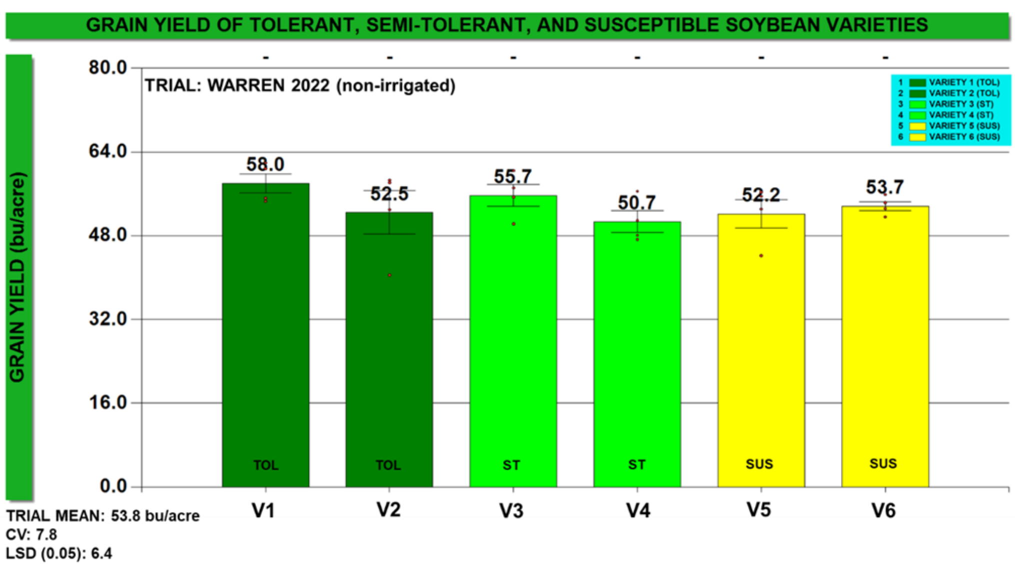


Figure 5. Grain Yield (bu/acre) of IDC Tolerant (TOL), Semi-Tolerant (ST) and Susceptible (SUS) Soybean varieties grown in 2022 at Warren (Solum Valley Biosciences) under rainfed (non-Irrigated) conditions.

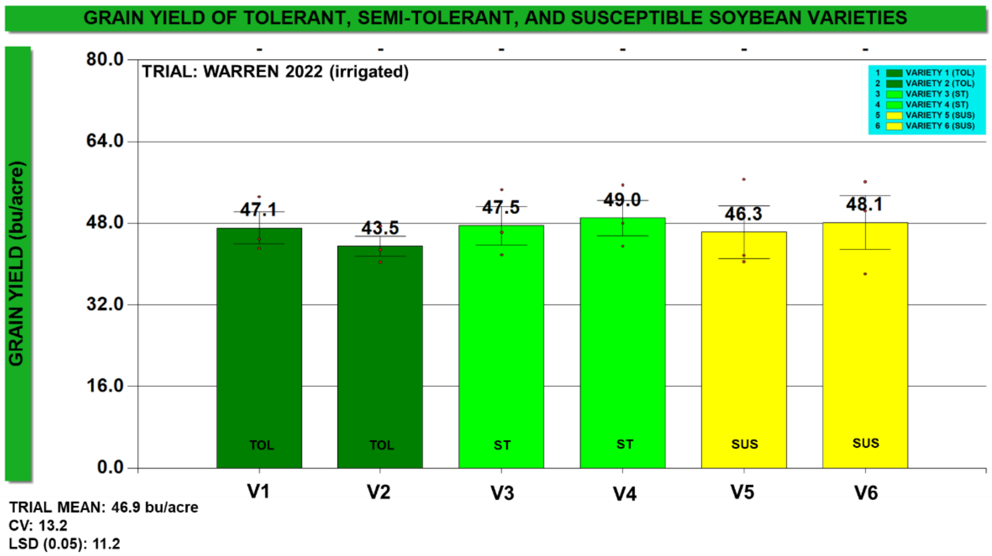


Figure 6. Grain Yield (bu/acre) of IDC Tolerant (TOL), Semi-Tolerant (ST) and Susceptible (SUS) Soybean varieties grown in 2022 at Warren (Solum Valley Biosciences) under irrigated conditions.

The lower yields obtained from the irrigated trial at Warren should be noted, as the repeated application of irrigation treatments did not force IDC symptoms as intended, and may have represented a waterlogging stress which uniformly delayed all cultivars. In addition, the irrigated trial at Warren sustained wildlife damage which led to exclusion of one replicate of data for final yield assessments. Nonetheless, the paired assessments at Warren provided valuable insights in the yield potential of IDC susceptible varieties in the absence of severe IDC stress.

Visual chlorosis scores, chlorophyll meter readings and digital tools to assess canopy coverage and leaf greenness

In addition to yield values and chlorosis ratings recorded at the Fort Whyte (Table 1) and Arborg (Table 2) sites over the 2022 season, N49 Genetics monitored canopy coverage and leaf greenness using handheld sensors (AtLEAF, Canopeo) and a java-based program (Field Analyzer) to obtain plot metrics from aerial images of plots.

Figure 7 displays the interface and workflow of Canopeo and Field Analyzer in evaluating ground level or aerial (drone) images of IDC tolerance trials. In Figure 7A, Canopeo outputs of ground level images occur side by side for the two lowest and two highest yielding plots at Fort Whyte, with fractional canopy coverage scores (%) and yields listed for each plot. The interface of Field Analyzer in Figure 7B displays a grid overlay upon individual plots, and the DCGI (dark colour green index) and canopy coverage (%) score for the selected plot. In Figure 7C, capturing an entire range of the rainfed IDC trial at Arborg, visual symptoms of chlorosis and delayed canopy closure are apparent for IDC susceptible plots and contrast with the leaf greenness and canopy closure of IDC tolerant material.

Where traditional visual chlorosis ratings distinguished IDC tolerant and IDC susceptible material at the Fort Whyte (Table 1) and Arborg (Table 2) field locations, AtLEAF chlorophyll meter readings and dark colour green index (DCGI) values obtained through Field Analyzer identified similar trends and significant differences (Table 1; Table 2). Similarly, canopy coverage (%) values obtained for overhead drone images (see Figure 7c) and oblique Canopeo measurements (Figure 7A) agreed with visual observations of delayed row closure, growth inhibition, and reduced height for IDC susceptible varieties.

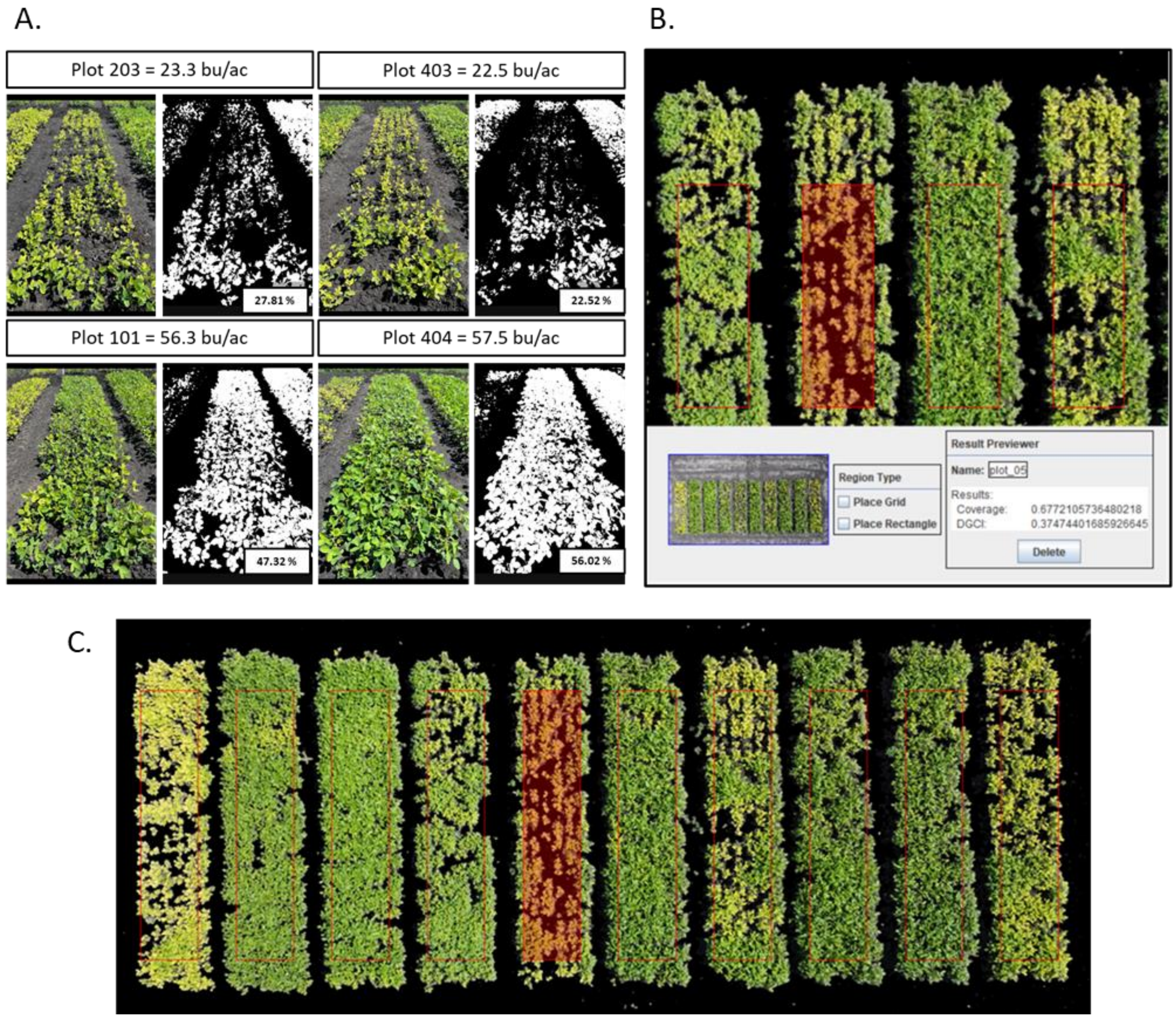


Figure 7. Digital image analysis tools to assess commercial soybean varieties for quantitative differences in metrics associated with iron deficiency chlorosis (IDC), leaf greenness and canopy coverage. A. Oblique images of soybean plots captured from the ground using the Canopeo app for fractional green canopy cover (FGCC). B. Interface of FieldAnalyzer software depicting overlay of plot grid from aerial drone image of IDC trial at Arborg, in addition to canopy coverage dark colour green index (DCGI) outputs. C. Aerial drone image of a single range (10 plots) within 2022 Arborg IDC trial demonstrating visual differences in leaf greenness and canopy coverage of tolerant, semi-tolerant and susceptible lines, in addition to overlay of Field Analyzer grid.

Over the 2021 and 2022 growing seasons the set of digital imaging tools and software programs evaluated by N49 Genetics have provided value insights towards assessing the performance of commercial soybean cultivars, and provide a more quantitative, non-subjective mean of assessing genetic material for traits associated with yield and stress tolerance. For example, there is often a specified developmental window where specific tools or digital techniques capture informative or actionable data, and scenarios where metrics obtained are of little value. For example, canopy coverage assessments following mid season row closure of IDC tolerant and susceptible lines are of little value. However, visual chlorosis ratings or dark colour green index (DGCI) values can still be obtained from aerial images of these plots following row closure. In contrast, canopy coverage evaluations provide important information on biomass accumulation and seedling growth in advance of chlorosis symptoms appearing on first trifoliate leaves.

TABLE 1. FORT WHYTE FIELD SITE. VISUAL CHLOROSIS SCORES, DARK COLOUR GREEN INDEX (DCGI) and CANOPY COVERAGE SCORES (%) DETERMINED BY FIELD ANALYZER. AtLEAF HAND HELD CHLOROPHYLL METER AND CANOPEO iphone App

FORT WHYTE 2022

FORT WHYTE RAINFED TRIAL SITE

VARIETY		VISUAL CHLOROSIS SCORE (VCSs)* (1-5 Rating)	AtLEAF LEAF GREENNESS (Chlorophyll Meter)	DCGI Field Analyzer Aerial Drone Image AVERAGED**	CANOPY COVERAGE (%) Field Analyzer Aerial Drone Image AVERAGED**	FRACTIONAL GREEN CANOPY COVER (%) Canopeo - Ground Based AVERAGED**
V1	TOLERANT	1.66 d	41.5 a	0.47 a	0.44 a	65.4 a
V2	TOLERANT	1.81 cd	39.8 a	0.46 a	0.46 a	65.5 a
V3	SEMI-TOLERANT	2.15 bc	36.0 ab	0.43 b	0.46 a	63.8 a
V4	SEMI-TOLERANT	2.47 b	37.1 a	0.45 ab	0.48 a	60.8 a
V5	SUSCEPTIBLE	3.21 a	27.0 c	0.39 c	0.32 b	38.9 b
V6	SUSCEPTIBLE	3.29 a	30.0 c	0.37 c	0.46 a	45.8 b
CV %		14.0	11.7	4.5	8.9	15.2
LSD (0.05)		1.23	6.24	0.029	0.05	12.9
Sign. Diff		Yes	Yes	Yes	Yes	Yes

*= Visual chlorosis score (1 = green leaves, tolerant) (5 = severe chlorosis/yellowing, stunted)

**= Values are averages derived from three successive visits and flights to obtain DGCI, Canopy Coverage, and Visual Chlorosis Ratings

4 Dates: July 8, July 16, July 20, Aug 8

Project Findings

Developing irrigated versus rainfed strategy to identify and select stress tolerant soybean lines and characterize commercial cultivars is an ongoing effort of N49 Genetics. For growers in the Interlake and Red River Valley region of Manitoba, the yield differentials reported in the current study on an absolute (bu/acre) or percent (%) basis may serve to gauge local assessment of losses incurred due to IDC.

Key findings

- For three of five research trials established in 2022, moderate to severe symptoms of IDC rated by visual chlorosis scores (VCSs) at Arborg and Fort Whyte were associated with yield reductions of 11.6 to 25.6 bu/acre.
- For two trials located at Warren that did not display IDC symptoms early in the 2022 season, the yield of IDC susceptible lines (grouped) was not significantly different than the same set of IDC tolerant and semi-tolerant lines (grouped).
- The use of irrigation infrastructure, timely rainfall events, and attention to site selection were integral to generate a strong selection pressure to properly characterize commercial varieties for IDC.
- N49 Genetics further developed the use of handheld sensors, iPhone apps and aerial (UAV) imaging equipment and software to obtain quantitative information of the performance of soybean varieties relative to traditional yield assessments and visual chlorosis scores (VCSs).

Early in the season, IDC ratings and visual chlorosis symptoms were similar for adjacent irrigated and rainfed trials at Arborg, with supplemental irrigation occurring in August. However, yield values end of season and the spread between IDC tolerant and susceptible material was notably different between adjacent trials.

TABLE 2. ARBORG FIELD SITE. VISUAL CHLOROSIS SCORES, DARK COLOUR GREEN INDEX (DCGI) and CANOPY COVERAGE SCORES (%) DETERMINED BY FIELD ANALYZER SOFTWARE FOR NON-IRRIGATED (RAINFED) AND IRRIGATED TRIALS							
		ARBORG 2022 RAINFED (NON-IRRIGATED) TRIAL SITE			ARBORG 2022 IRRIGATED TRIAL SITE		
VARIETY	IDC RATING	VISUAL CHLOROSIS SCORE (VCSs)* (1-5 Rating)	DCGI Field Analyzer AVERAGED**	Canopy Coverage Field Analyzer AVERAGED**	VISUAL CHLOROSIS SCORE (VCSs)* (1-5 Rating)	DCGI Field Analyzer AVERAGED**	Canopy Coverage Field Analyzer AVERAGED**
V1	TOLERANT	1.91 c	0.42 a	0.65 b	2.05 c	0.38 b	0.54 a
V2	TOLERANT	1.86 c	0.40 ab	0.68 a	1.78 d	0.37 b	0.53 a
V3	SEMI-TOLERANT	1.96 c	0.41 ab	0.68 a	1.78 d	0.39 a	0.54 a
V4	SEMI-TOLERANT	2.00 c	0.40 ab	0.68 a	1.98 cd	0.37 bc	0.52 a
V5	SUSCEPTIBLE	2.58 b	0.39 b	0.58 c	2.68 b	0.36 c	0.49 b
V6	SUSCEPTIBLE	3.03 a	0.35 c	0.66 ab	3.30 a	0.29 d	0.52 a
CV %		10.1	3.3	2.5	7.8	2.9	3.7
LSD (0.05)		0.34	0.019	0.024	0.27	0.02	0.03
Sign. Diff		Yes	Yes	Yes	Yes	Yes	Yes

*= Visual chlorosis score (1 = green leaves, tolerant) (5 = severe chlorosis/yellowing, stunted)

**= Values are averages derived from three successive visits and flights to obtain DGCI, Canopy Coverage, and Visual Chlorosis Ratings

3 Dates: July 2, July 8, July 26

References

1. Patrignani & Ochsner (2015). Canopeo: A Powerful New Tool for Measuring Fractional Green Canopy Cover. *Agron. J*, 107:2312-2320.
2. Purcell, L.C. (2000) Soybean canopy coverage and light interception measurements using digital imagery. *Crop Sci.*, 40: 834-837.
3. Zhu et al. (2012) Comparing SPAD and atLEAF values for chlorophyll assessment in crop species. *Can. J. Soil. Sci.* 92:645-648.
4. Field Analyser User Guide. Green Research Services LLC. https://turfanalyzer.com/#field_analyzer_resources

Materials and Methods

- Six regionally adapted herbicide tolerant soybean cultivars were selected based on past performance and characterization of varieties for IDC ratings in the regional MPSG nursery; 2 tolerant lines, 2 semi-tolerant lines & 2 susceptible lines.
- Experimental design for each trial (rainfed or irrigated) was a randomized completed block (RCB), with four replicates per variety. Modifications were done to the Arborg trials to assign four replicates to three ranges.
- Two sites (Arborg, Fort Whyte) displaying moderate to severe symptoms of IDC were visited with greater frequency (3-4 visits) than the Warren site to rate plots more intensively for visual chlorosis scores (VCSs), take AtLEAF chlorophyll reading and capture ground-based and aerial images.
- Excluding supplemental irrigation trials were managed for weeds and pests according to practices applied to MPSG variety evaluation trials.

Site	***Planted***	***Harvested***	***Irrigation***
Forte Whyte	June 7	Oct 10	No irrigation
Arborg	May 25	Oct 11	Total of 3.1 inches applied on July 26, Aug 8 & 12
Warren	June 3	Oct 10	Total of 4.3 inches on June 22, June 27 and Aug 6

Acknowledgments

The financial and technical support of Prairies East Sustainable Agriculture Initiative (PESAI) towards trial execution, mileage, and plot work at Warren and Fort Whyte locations is greatly appreciated. Thanks to Keith Murphy for technical assistance and contributions towards variety selection and IDC screening at the Fort Whyte location.

Manitoba Crop Variety Evaluation Trials

PESAI is one of the many sites of MCVET program. MCVET facilitates variety evaluations of different crop types at various sites within Manitoba. The purpose of the MCVET trials is to grow both familiar (check varieties) 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 collected, combined, and summarized in the 'Seed Manitoba' guide. Seed Manitoba guide and the websites www.seedinteractive.ca and www.seedmb.ca provide valuable variety performance information for Manitoba farmers.

PESAI managed two MCVET sites (Arborg and Beausejour) during 2022 growing season. Variety trials of spring wheat, winter wheat, fall rye, oats, barley and soybeans (both herbicide tolerant and conventional) were conducted at both sites (Table 1), whereas trials of peas, silage corn, annual forages, flax and canola were conducted only at Arborg site. Due to the extreme wet conditions during spring & summer, the peas, silage corn, canola and flax trials were written off. For the 2023 growing season, PESAI will also conduct sunflowers and grain corn variety trials in Beausejour.

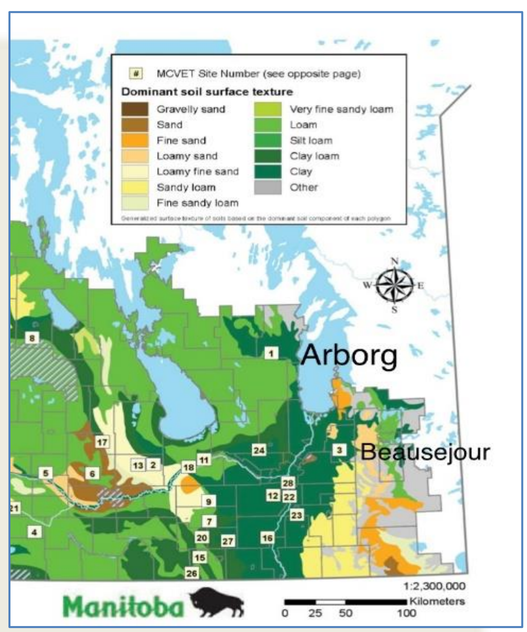
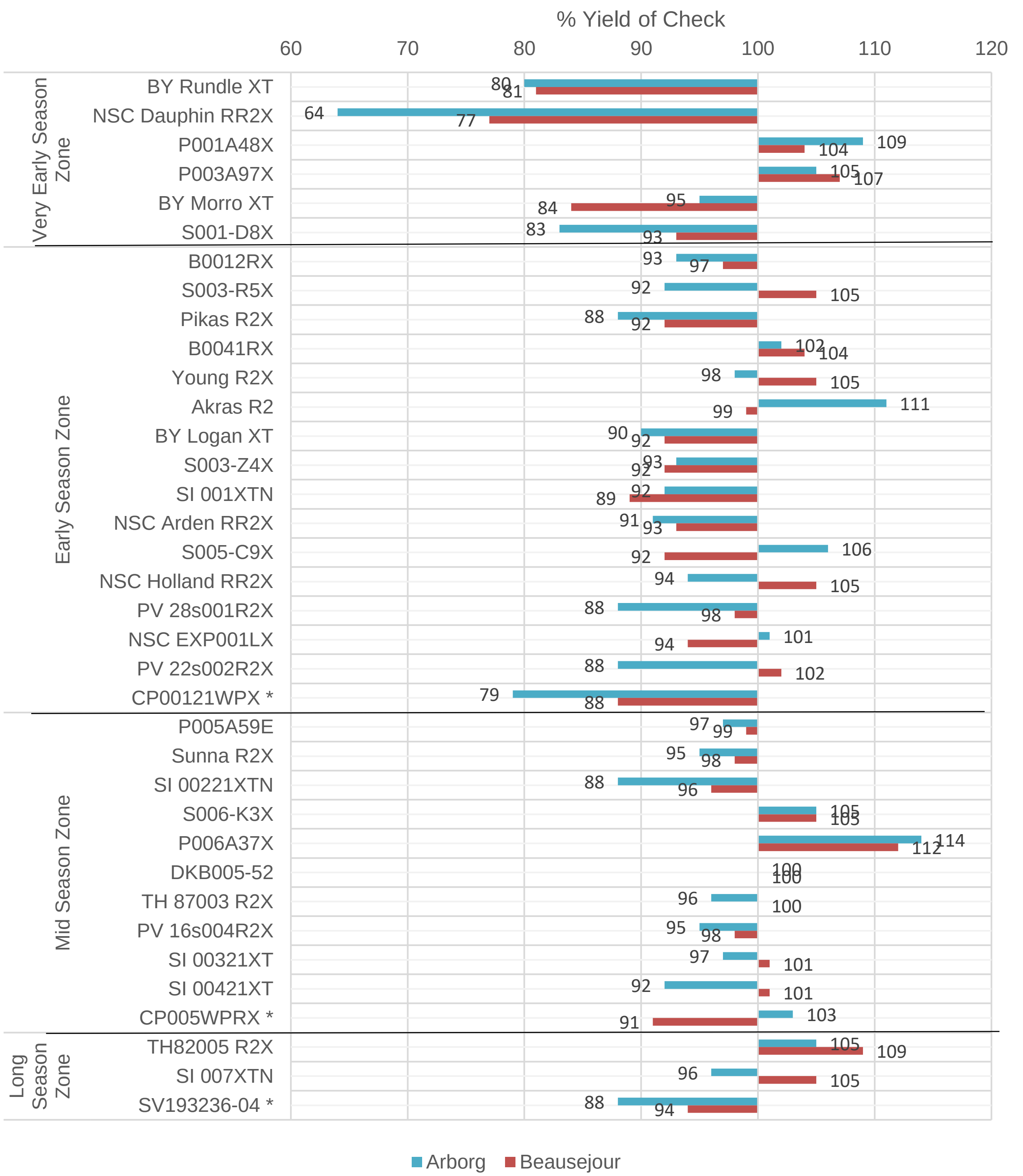


Table 1. Agronomic details of 2022 MCVET trials conducted at Arborg & Beausejour sites.

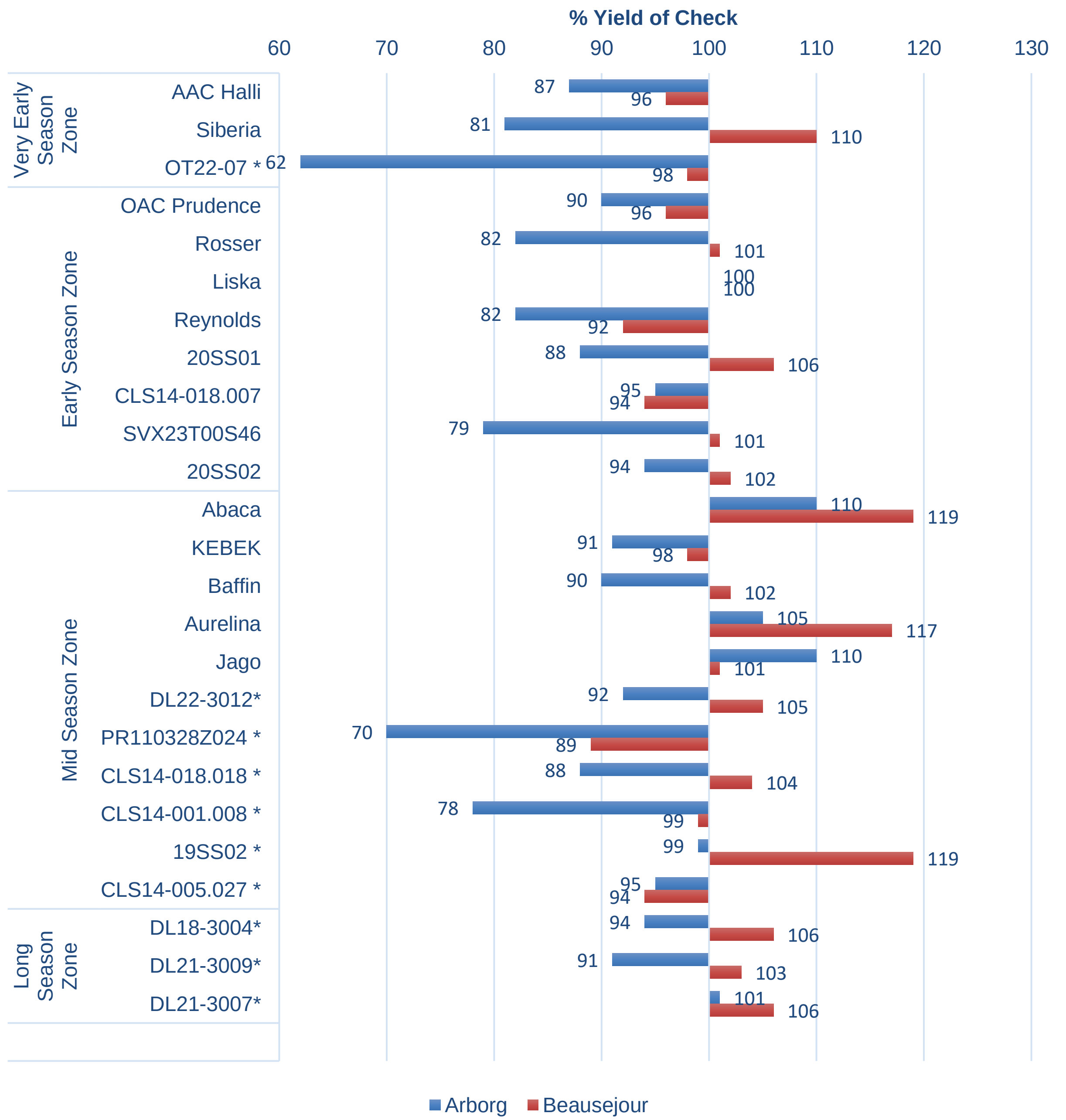
	Stubble	Soil Fertility (N-P)	Seeding Date	Fertilizer Applied	Harvest Date	No of Plots
Arborg		lbs/ac in top 0-24 inches of soil		N – P (lbs/ac)		
Spring Wheat	Canola	212-36	24-May	30-20-0	02-Sep	54
Oats	Canola	212-36	24-May	30-20-0	22-Sep	33
Barley	Canola	212-36	24-May	30-20-0	31-Aug	72
Winter Wheat	Canola	260-36	09-Sep	22-21-0	18-Aug	15
Fall Rye	Canola	260-38	09-Sep	22-21-0	18-Aug	12
Peas	Canola	56-52	25-May	0-20-0	Written Off	75
Conv. Soybeans	Canola	56-52	26-May	0-20-0	11-Oct	72
HT Soybeans	Canola	56-52	26-May	0-20-0	11-Oct	111
Silage Corn		18-108	08-Jun	92-13-0	Written Off	108
Flax	Wheat	220-40	May 25	23-20-0	Written Off	48
Forages	Wheat	220-40	24-May	30-20-0	29-Jul (red proso), 8-Aug (most), 12-Aug (golden germen)	45
Beausejour						
Winter Wheat	Canola	60-10	15-Sep	30-25-0	10-Aug	15
Fall Rye	Canola	60-10	15-Sep	30-25-0	10-Aug	12
Spring Wheat	Canola	60-10	27-May	23-15-0	14-Sep	42
Oats	Canola	60-10	27-May	23-15-0	14-Sep	18
Barley	Canola	60-10	27-May	23-15-0	14-Sep	48
Conv. Soybeans	Canola	60-10	27-May	0-24-0	20-Oct	72
HT Soybeans	Canola	60-10	27-May	0-24-0	07-Oct	111

Fig 1. Performance of Herbicibe Tolarent Soybean Varieties at Arborg and Beausejour sites



Yield of check variety (DKB005-52) is 59 bu/ac at Arborg & 66 bu/ac at Beausejour.
Varieties differ in yield if the difference is greater than 13% at Arborg and 10% at Beausejour.

Fig 2. Performance of conventional soybean varieties at Arborg and Beausejour sites.



Yield of check variety (Liska) is 67 bu/ac both at Arborg & Beausejour sites.
Varieties differ in yield if the difference is greater than 10% at Arborg and 11% at Beausejour.

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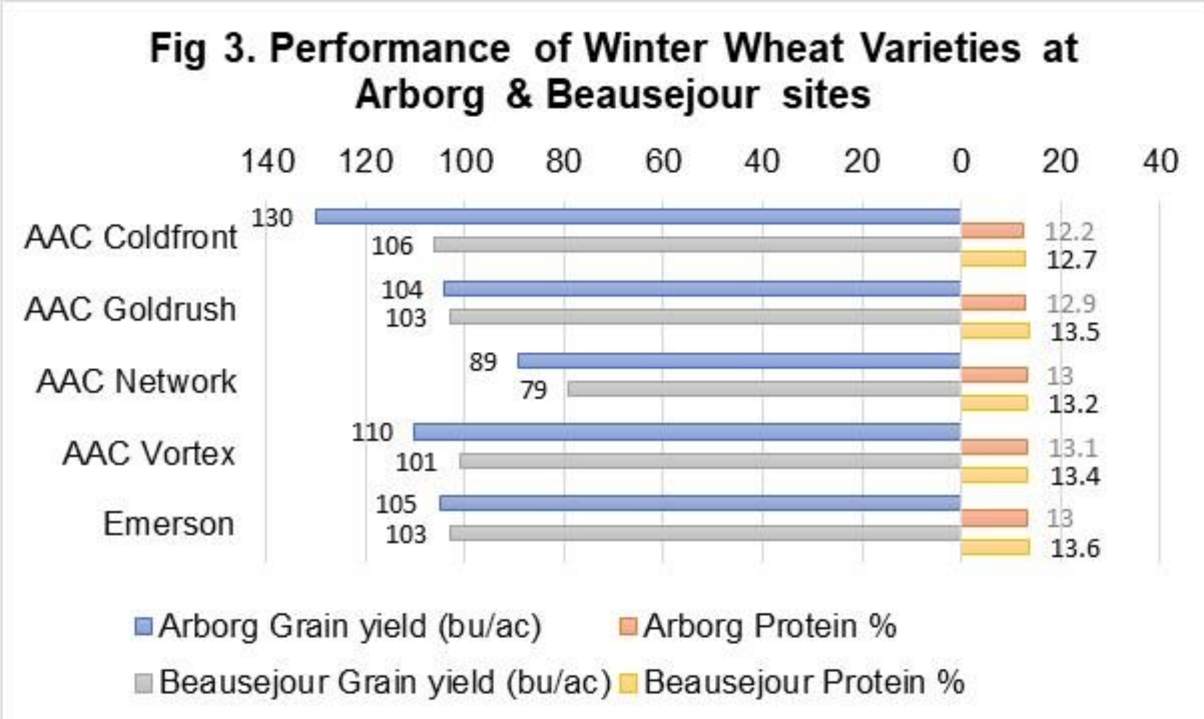
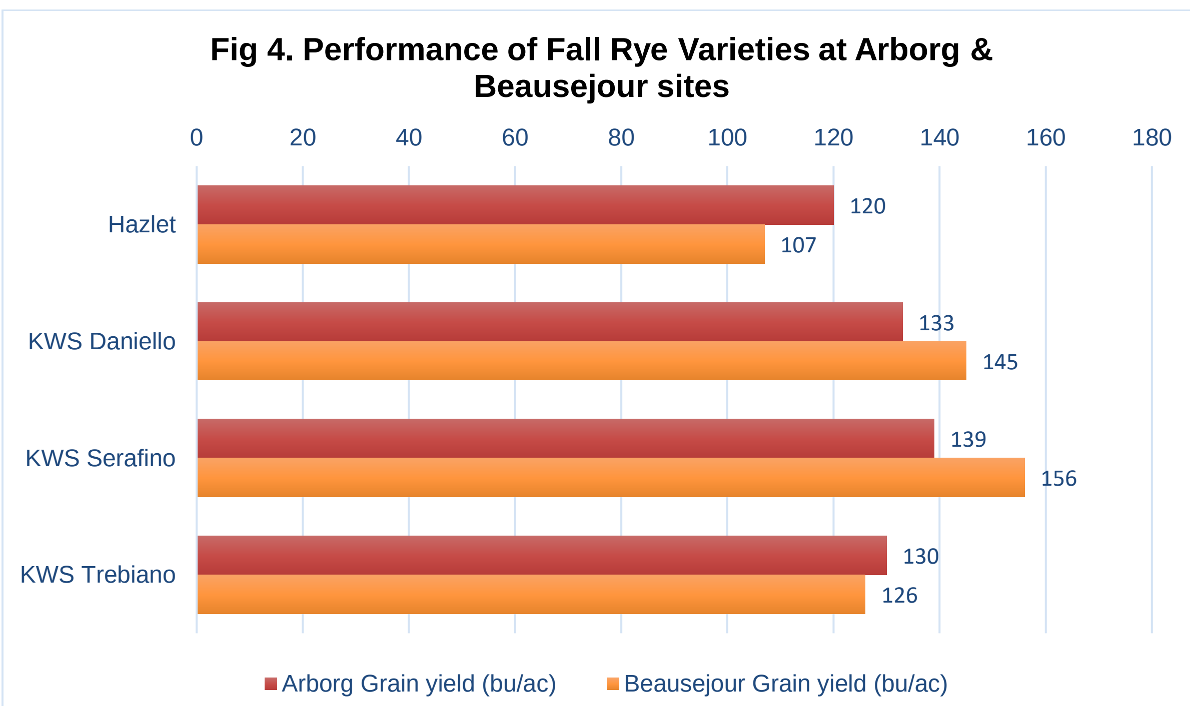
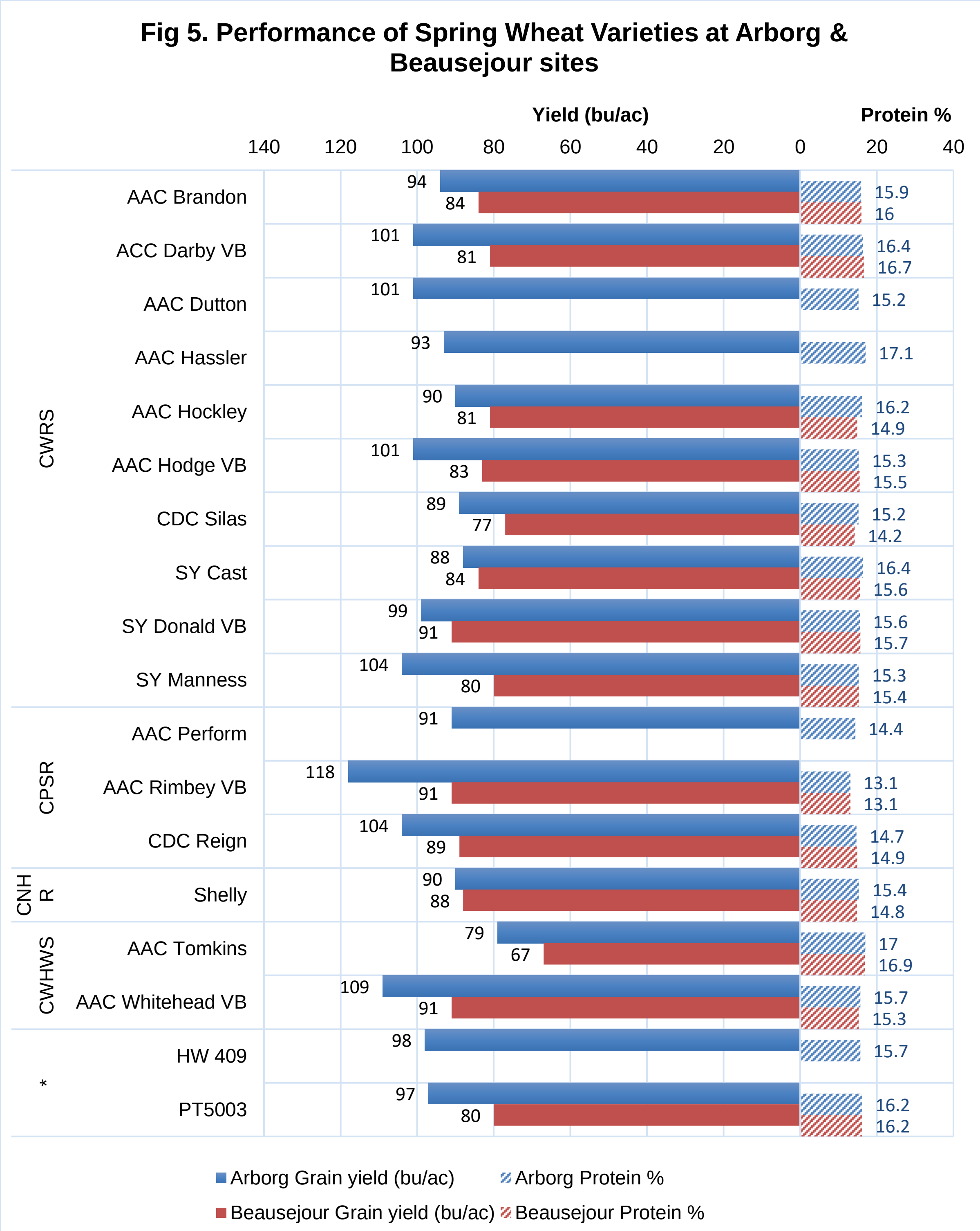


Varieties differ in grain yield if the difference is greater than 8 bu/ac at Arborg site. Winter wheat varieties do not differ in yield at Beausejour site.

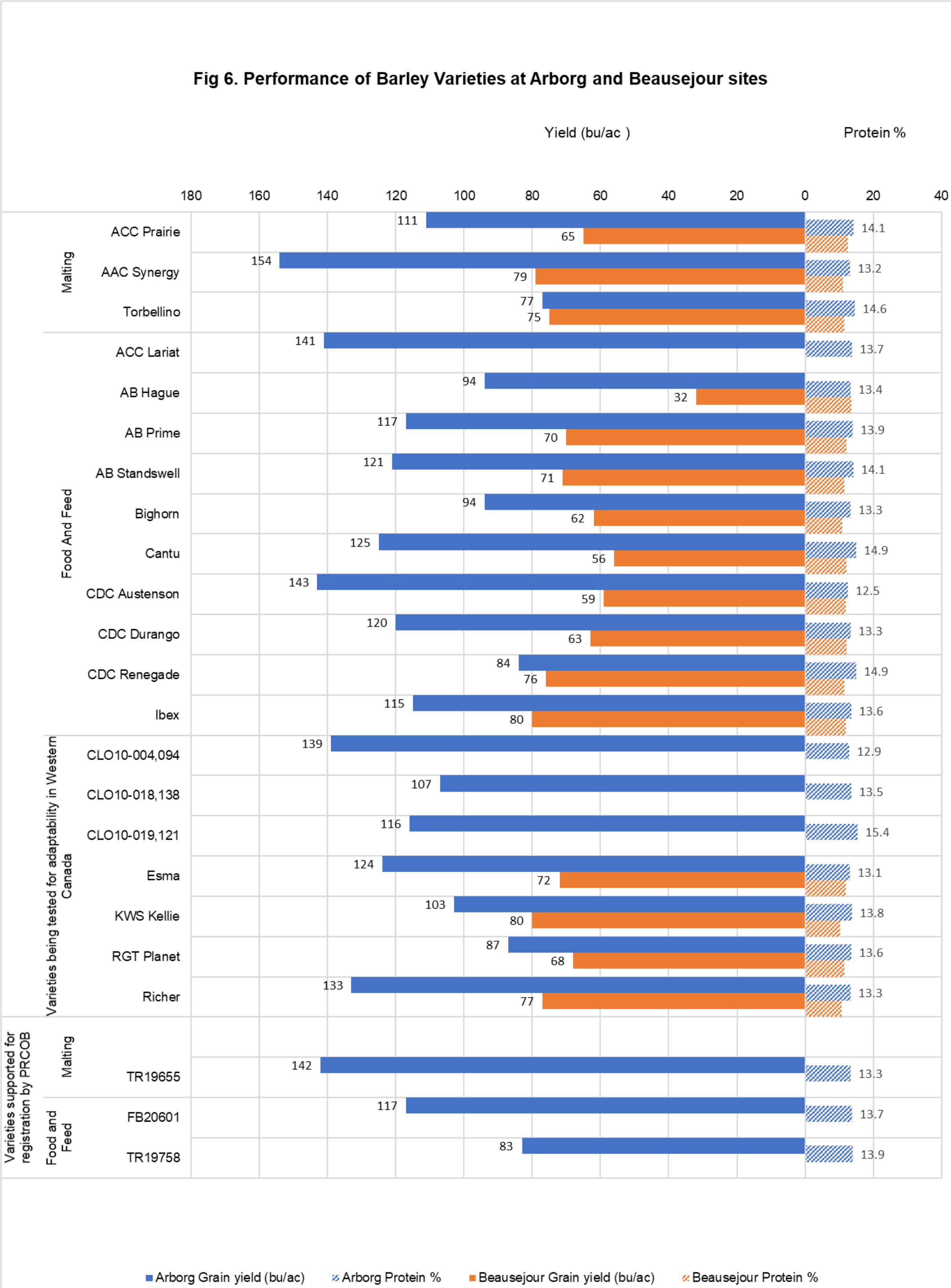


Varieties differ in grain yield if the difference is greater than 12 bu/ac at Arborg site & 22 bu/ac at Beausejour site.

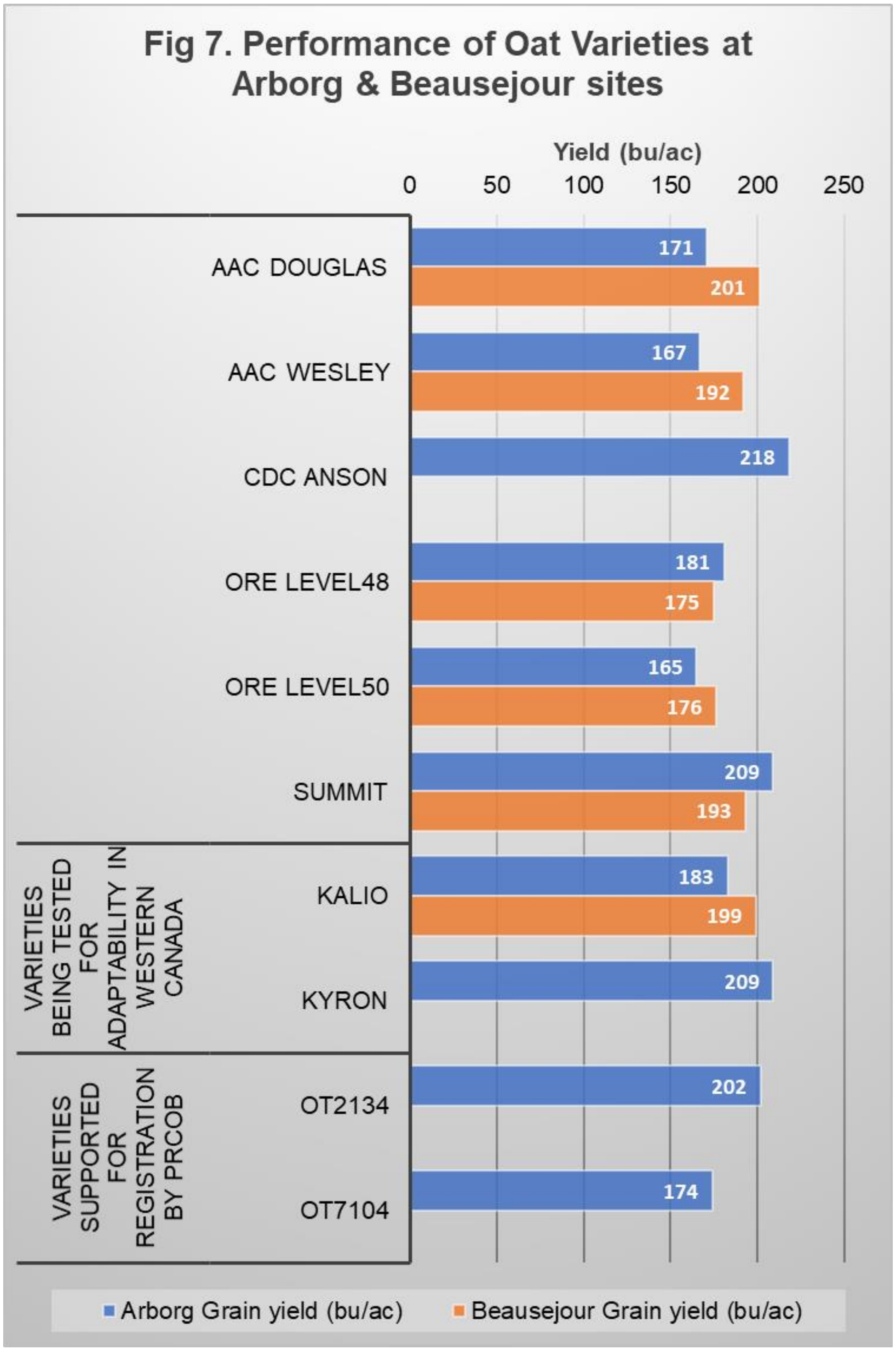


Varieties differ in grain yield if the difference is greater than 14 bu/ac at Arborg site & 9 bu/ac at Beausejour site.

CWRS – Canada Western Red Spring; CPSR – Canada Prairie Spring Red; CNHR – Canada Northern Hard Red; CWHWS – Canada Western Hard White Spring; * - Varieties supported for registration by the PRCWRT.



Varieties differ in grain yield if the difference is greater than 16 bu/ac at Arborg site & 14 bu/ac at Beausejour site.



Varieties differ in grain yield if the difference is greater than 19 bu/ac at Arborg site.
Oat varieties do not differ in grain yield at Beausejour site.

PESAI Extension Activities (2022-23)

PESAI was finally able to organize few extension events after most of the pandemic restrictions were eased up by spring 2022. PESAI does these events for two objectives:

1) Communicating producers / Ag industry about PESAI research projects and partnership / job opportunities.
2) Encouraging participants for PESAI membership.

Manitoba Agriculture staff assisted PESAI in all aspects of extension events, including:

- PESAI accepts innovative research proposals from local organizations and PESAI Board decides to fund some of them every year. An announcement of PESAI's project submission deadline was advertised in Eastern and Interlake areas, as well as on social media.
- PESAI's 2022-23 Annual Report was compiled by Manitoba Ag / PESAI staff and it was uploaded on Diversification Centre (DC)'s website (www.mbdiversificationcentres.ca).
- Individual project reports were also uploaded on DC's website. A total of 16 project reports are available on the website.
- PESAI developed two extension videos this year and these videos could be watched on DC's website. First video is on Corn-legume intercropping project while the other video is related to evaluation of annual forages in the Interlake region.
- During 2022-23, DC's website received 13,947 views, which were 31% greater than views in previous fiscal year. The start of monthly DC's Newsletter made a significant difference, as it alone received 2,372 views in the fiscal year. PESAI is contributing to this newsletter every month. PESAI home page was visited by 483 users.
- PESAI tweeted 26 times about its research and extension / job activities during 2022-23. These tweets made 3,018 impressions. The posts were retweeted 48 times. PESAI tweets can be accessed using twitter handle @PESAIresearch.
- PESAI had its Annual Crop tour held on July 26, 2022. More than 60 participants attended the tour and they interacted with speakers on tile drainage, regenerative Ag and other talks.

Table 1. List of the speakers and the topics covered at PESAI Crop tour.

Growing soybeans / peas in a wet year	*Terry Buss, Manitoba Ag*
Regenerative Ag Approach	*Scott Beaton, Farmer from S. Interlake*
Annual forages / mixtures for forage production	*Pamela Iwanchysko, Manitoba Ag*
Organic acids in oat production	*Tim Dyck, Canadian Agronomics Inc.*
Impact of drain spacing on the salinity of clay soils	*Sampson Boateng, U of M*
IDRAINMOD simulation of drain spacing impact on canola yield in heavy clay soils	*Emeka Ndulue, U of M*

The tour was covered by ***Manitoba Cooperator*** *and* ***The Western Producer****.*

- A soybean research tour was organized at PESAI plot site in Beausejour on September 13, 2022 where 25 people attended. Soybean variety selection and soybean agronomic issues were discussed during the tour.

A glimpse from PESAI Crop Tour held on July 26.

- PESAI manned a booth entitled “Manitoba’s Diversification Centres” at Ag Days (Jan 2023) and Crop Connect Conference (Feb 2023), with its counter-parts from other areas of the province: Parkland Crop Diversification Foundation (PCDF) – Parkland Region, Westman Agriculture Diversification Organization (WADO) – Southwest Region and Manitoba Crop Diversification Centre (MCDC) – Central Region.
- PESAI’s Annual General Meeting was held on April 20, 2022 at Oak Hammock Marsh Interpretive Centre. Blain Hjertass from ‘Understanding Ag’ was the guest speaker and he shared his experience on ‘Why producers should think about practicing Regenerative Agriculture on their farms’.
- PESAI has set up its booth at Brokenhead River Ag Conference (Feb 1, 2023) and South Interlake Crop Day events (January 4, 2023).
- *PESAI members were sent 2022 MCVET evaluation results in December 2022.*
- *PESAI sent its staff to attend the following conferences for the professional development:*
  - *Regenerative Ag Conference - Brandon (Nov 2022)*
  - *Manitoba Agronomists Conference – Winnipeg (Dec 2022)*
  - *Crop Connect Conference – Winnipeg (Feb 2023)*

Assessing effects of iQ Granular Starter, Humic acid and AnneMaxx on Oats Grain Production

Project Year – 2022

Objectives – Evaluating effects of various organic acid products on oats grain production when applied at the planting time.

Collaborators – Tim Dyck, Canadian Agronomics Inc**.**

Results

There was no effect on the plant height & lodging, when different organic acid products were applied to oat plots in addition to recommended fertilizers (Table 1). Similarly, these products were not able to demonstrate any yield gain in comparison to check plots in the current study.

Table 1. Effect of AnneMaxx, iQ 3-4-3 & Humic acid products on the plant height, lodging and grain yield of Oats at Arborg site.

Treatment (Rate)	***Plant height (inches)***	***Lodging (1-5 scale; 5 – flat on the ground)***	***Grain Yield (bu/ac)***
AnneMaxx @ 15 lbs/ac	*53.8a*	*2.5a*	*163.7a*
iQ 3-4-3 @ 50 lbs/ac	*53.4a*	*1.8a*	*170.7a*
Humic Acid @ 20 lbs/ac	*55.6a*	*2.2a*	*171.5a*
Humic Acid @ 50 lbs/ac	*53.8a*	*2.3a*	*170.3a*
Check (No organic acids)	*54.9a*	*2.5a*	*168.9a*
Significant Difference	*No*	*No*	*No*
P value	*0.577*	*0.759*	*0.956*

Project Findings

The testing at Arborg site did not show any improvement in the oats grain yield, when different organic acid products were applied in addition to recommended fertilizers.

Background / Additional resources / References

Humic compounds such as fulvic acid and humic acid are formed by chemical and microbial degradation of plant and animal material and are a principal component of soil organic matter (Canellas *et al*. 2015). In general, the application of fulvic and humic acid fertilizer amendments have been shown to enhance root growth, increase nutrient uptake, alleviate stress and increase yield in various crops (Canellas *et al.* 2015). However, studies conducted in Ontario on dry bean (*Phaseolus vulgaris* L.) in 2010 and 2011 using fulvic acid (LX7®, MTS Environmental Inc.) or humic acid (Plant XL®, Alpha-Agri) fertilizers showed no response. Twenty fulvic acid field trials and 15 humic acid field trials indicated that these fertilizers were ineffective, as plant vigour, height, 100-seed weight and yield were similar to a control treatment (Mahoney *et al* 2017).

Broadcast pre-plant or post-plant application of leonardite did not affect the emergence, chemical composition, or yield of wheat or canola in Manitoba (Dilk 2002). The efficiency of phosphorus (P) fertilizer was studied with and without humic acid, derived from leonardite. Application of leonardite in a P fertilizer band significantly increased the P concentration of canola tissue in the early stages of development. However, the increase in P concentration did not result in an increase in yield.

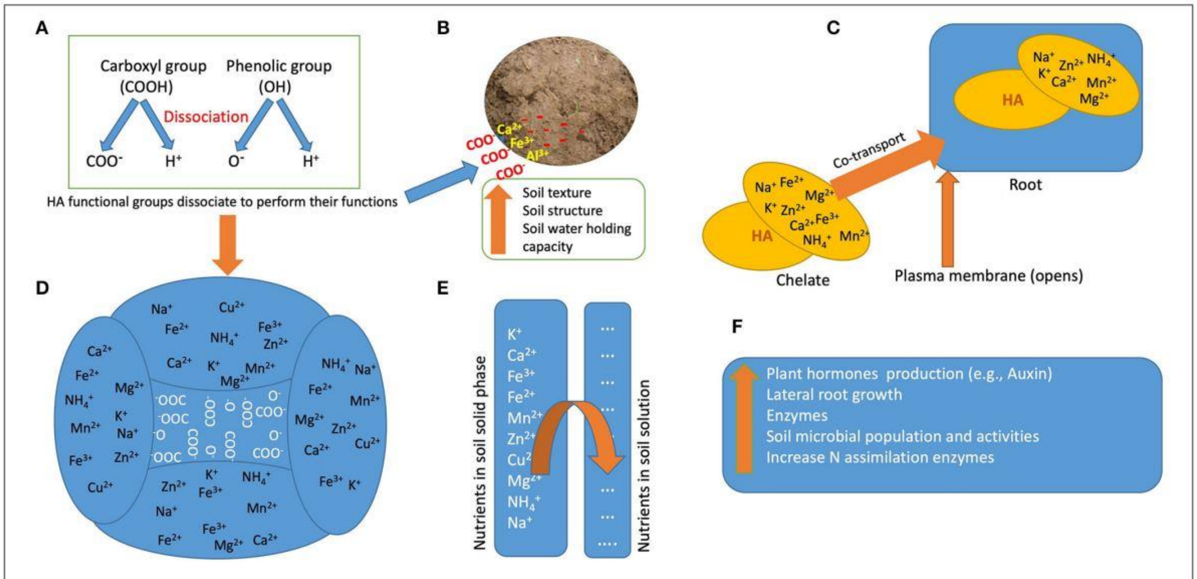


FIGURE 2 | Model summarizing the mechanisms and functions of humic acids (HA) in soils and plants; **(A)** dissociation of functional groups of HA; **(B)** hydrophilic ends of dissociated groups form a bridge between metal ions and soil surface; **(C)** humic acids chelate cationic nutrients and transport them through root's plasma membrane; **(D)** hydrophilic ends of dissociated group attract cations (increase soil cation exchange capacity); **(E)** humic acids replenish nutrients in the soil solution (increase soil buffering capacity); **(F)** other functions of HA.

Figure 1. Model adapted from Ampong et al. (2022).

There is a recent review article on the use of humic acids (HA) in crop production. This review compiled by Ampong et al. (2022) has summarized that HA application has potential significant effects on crop agronomic performance and soil quality parameters. This review identified several factors that affect HA performance in crops and soils; the most influential of them is the HA source. The HA chemical and molecular structure, solubility and other factors such as application rate, soil and crop type also affect HA effects on crop performance.

In the current study, iQ 3-4-3 granular product was tested. iQ is an organic layer poultry compost, starter fertilizer approved by Organic Materials Review Institute (OMRI). Canadian Agronomics Inc., who markets this product, revealed that iQ increases porosity, organic matter/carbon, and microbial activity in the soil (Canadian Agronomics website).

Coarse HA is a mined, screened and dried Leonardite, a concentrated form of humic acids (Canadian Agronomics Website). This website reported that coarse HA improves the environment of soil's biology, resulting in improved soil structure, increased water retention, elevated nutrient chelation & microbiology stimulation. Granular humic acid is granulated humate containing 51.65% humic acid and 3.07% fulvic acid.

References

1) https://canadianagronomics.ca/iq-granular-starter/
2) KJ Mahoney, C McCreary, D Depuydt, CL Gillard (2017) Fulvic and humic acid fertilizers are ineffective in dry bean. *Canadian Journal of Plant Science*, 97(2): 202-205, https://doi.org/10.1139/cjps-2016-0143
3) Canellas LP, Olivares FL, Aguiar NO, Jones DL, Nebbioso A, Mazzei P, Piccolo A. (2015) Humic and fulvic acids as biostimulants in horticulture. *Sci. Hortic.* **196**: 15-27.
4) Dilk SB (2002). Agronomic evaluation of leonardite on yield and chemical composition of Canola and Wheat. Masters Thesis, Dept of Soil Sciences, University of Manitoba.

5) Ampong K, Thilakaranthna MS and Gorim LY (2022) Understanding the Role of Humic Acids on Crop Performance and Soil Health. *Front. Agron*. 4:848621

Materials and Methods

Experimental Design – Randomized Complete Block Design with three replications.
Treatments –

1) Humic acid at 20 lbs/acre with the seed.
2) Humic acid at 50 lbs/acre with the seed.
3) iQ 3-4-3 Granular Starter at 50 lbs/acre with the seed.
4) AnneMaxx Granular(AMGR) at 15 lbs/acre with the seed.
5) Check plots with no application of any organic acid product.

Plot size – 8.22m^2
Data collected – plant stand, plant height at maturity, lodging and grain yield

Agronomic info
Stubble, soil type – Fallow, heavy clay
Fertilizer applied – Soil nutrient levels (lbs/acre): N – 61, P – 50
Applied at planting (lbs/acre): N – 22, P -20
Pesticides applied – Pardner @ 0.4L/acre on June 22.
Seeding/harvesting date – June 7/ Sept 22

Optimizing Nitrogen Fertility Recommendations in Winter Wheat

Project Year: 2022

Collaborators: Ducks Unlimited Canada (Ken Gross, Alex Griffiths, Elmer Kaskiw), Manitoba Agriculture (John Heard)

Objectives

- Update the winter wheat fertility recommendations in the Manitoba Soil Fertility Guide.
- To compare spring broadcast only application, to fall and spring split application of nitrogen for yield and protein.
- To see if there are varietal differences in nitrogen use efficiency between AAC Wildfire and AAC Vortex.

Background

Following decades of extensive work in winter wheat production in North America, many researchers and producers have begun to implement best management practices to obtain higher grain yield and improve profitability in the crop. Management practices presently being implemented to improve winter wheat production include increasing seeding rate, application of starter fertilizer by banding during seeding, variety selection, pest control and split application, during planting in fall and at tillering or stem elongation in spring (Anderson, 2008; Schulz et al., 2015).

Fertility management, in particular nitrogen and phosphorus fertility, remains an integral part of the overall management package aimed at achieving higher yields in winter wheat (Halvorson et al. 1987). Recommended fertilizer management, particularly nitrogen management, differs widely in winter wheat production, but the crop's nitrogen demand is correlated to yield potential and availability of moisture in dryland production systems (Beres et al., 2018). Compared to spring wheat, winter wheat presents more challenges in development as a result of its higher nitrogen demand during the long vegetative phase, hence the reason why it requires 25 to 50% more N than spring wheat in the Prairies (Fowler et al., 1989). The ideal fertility management package would help counteract the escalating cost of winter wheat production per unit area, which is the main goal of winter wheat producers. There is still a knowledge gap on the rates and timing of nitrogen fertilizer application, particularly in Western Canada, that result in improved yield without compromising grain quality and economic returns.

Therefore, there is a great need to continue with research on the best management practices which can be extended to producers to improve economic returns in winter wheat production. Nitrogen is most often the focus of crop fertility in field studies. However, having a balanced approach and considering other essential nutrients, such as phosphorus, potassium, sulfur and micronutrients available in the soil, offers great yield potential when nitrogen needs of the crop are met. Perhaps more efficient return on investment potential can be achieved as fertility management is optimized.

Methods and Materials

This study was established at Melita, Roblin and Arborg, Manitoba.

In Arborg, the trial was established on heavy clay soil in canola stubble. The trial design consisted of two variety and seven fertility treatments, replicated three times, that were laid out factorially in a complete randomized block design. The plots were seeded on September 14th, 2021, at a rate of 33 plants/ft^2 and a depth of 0.5-inches. All plots were harvested on August 17th, 2022. The remaining agronomic details can be found in Table 1b.

Data collected throughout the growing season included soil tests at time of seeding, emergence counts, lodging scores, heights, yield, grain moisture, test weight, and protein. Data was analyzed with Minitab 18.1 statistical software using a GLM ANOVA with Fishers Least Significant Difference at a 0.05 level of significance. A test for equal variance was used to determine if data could be combined.

Table 1a. *Fall soil test results by site and fertilizer recommendations for winter wheat.*

	Fall Soil Test Results (lbs/ac)			Producer Practice Application (All N applied in Spring)			Balance Practive Application Recommendations* (50% of N applied in Fall)		
	Melita	Roblin	Arborg	Melita	Roblin	Arborg	Melita	Roblin	Arborg
N	35	24	36	100	100	100	120	106	110
P	31	48	18	30	30	30	30	15	35
K	132	61	11	0	0	0	0	33	60
S	42	29	20	0	0	0	0	0	0
Zn	0.45	0.64	0.12	0	0	0	0.09	0	0.40

*Balance application practice based on recommendations from the Western Ag Professional Agronomy Laboratory

Treatments

Fertilizer treatments included:

1. Check – No fertilizer applied except starter phosphorus

Balanced fertility practice: *Nitrogen was applied as per Western Ag recommendations based on soil test results, and application was split with 50% N banded at seeding and the other 50% N (urea plus Agrotain) broadcasted in spring. In addition, site specific P, K, S, and micronutrient recommendations were applied (see Table 1a). There are five N treatments under balanced fertility practice, which are as follows:*

2. 60 Kg ha^{-1} nitrogen, split 50:50
3. 90 Kg ha^{-1} nitrogen, split 50:50
4. 120 Kg ha^{-1} nitrogen, split 50:50
5. 150 Kg ha^{-1} nitrogen, split 50:50
6. 180 Kg ha^{-1} nitrogen, split 50:50

Producer practice*:*

7. 120 Kg ha^{-1} nitrogen all applied in spring

Variety treatments:

1. AAC Wildfire – Highest yielding winter wheat on the market
2. AAC Vortex – New Emerson replacement with disease resistance & winter hardiness

Fall nitrogen treatments used a 50/50 blend of ESN and urea while spring treatments were broadcasted urea that was treated with Agrotain. All five split applications had 50% of the rate being applied in the fall, and 50% of the rate being applied in the following spring. All spring applications were applied on April 6th, 2022. Each site where this trial was grown used slightly different agronomic practices and had different growing conditions which are outlined in the following Table 1b.

Table 1b. *Agronomic practices and description of sites in the 2021-22 Ducks Unlimited Winter Wheat Fertility Trial in Melita, Roblin, and Arborg.*

Location	Melita	Roblin	Arborg
Cooperator	WADO	PCDF	PESAI
Legal	SW22-3-27W1	NE20-25-28W1	River Lot-37-22-02E
Rotation (2 yr.)	2020: S. Wheat 2021: Liberty Link Canola	2020: Oat Silage 2021: Round Up Ready Canola	2021: Liberty Link Canola
Soil Series	Waskada Loam	Erickson Clay Loam	Heavy Clay
Soil Test Done? (Y/N)	Yes	Yes	Yes
Field Prep	None	None	None
Stubble	Yes. LL Canola	Yes. RR Canola	Yes. LL Canola
Burn off	Yes	Yes	None
(Date/Rate per acre/Products)	Sep. 10 - Round Up (0.67L/ac) + Heat LQ (20mL/ac)	Sep. 16 - Round Up (0.67L/ac) + Heat LQ (37mL/ac) + Merge (0.4gal/ac)	
Soil Moisture at Seeding	Good	Dry	Good
Seed Date	10-Sep	16-Sep	14-Sep
Seed depth (Inches)	0.5	0.5	0.5
Seeder (drill/planter?)	Air Drill	Disc Drill	Disc Drill
Errors at seeding	None	None	None
Topdressing Date	04-Apr	End of May	06-Apr
Herbicides: (Date, Rate/ ac, Name)	May. 27 - Achieve (0.2L/ac) + Turbocharge (0.5%) + Mextrol (0.5L/ac)	July 15 - Bentazon (0.105gal/ac)	Sep. 22 - Pardner (480mL/ac)
Fungicides	Jun. 3 - Prosaro (325mL/ac)	None	Jun. 30 - Prosaro (325mL/ac)
Insecticides	None	None	Matador (34mL/ac)
Harvest Date	12-Aug	25-Aug	17-Aug
Total Precipitation (Seeding to Harvest)	369mm	437mm	617mm

Results

Effect of variety on grain yield, protein & test weight

Variety had significant ($P < 0.001$) effect on winter wheat yield at the Roblin site in 2022 (Table 2). Wildfire produced greater yield than Vortex at Roblin. Across the two site years, Wildfire produced the greatest average yield, and this yield was significantly ($P < 0.001$) different from that of Vortex.

Winter wheat variety significantly influenced grain protein content at the Roblin and Arborg sites in the 2021/2022 growing season. At both sites, protein content of Vortex was greater than that of Wildfire. The differences were not significant at the Melita site. This indicates a potential protein content disadvantage of Wildfire in Manitoba compared to the other variety used in this trial.

Test weight significantly varied across the two varieties at the Melita and Arborg sites. At these sites, the greatest average test weight was observed from Vortex.

Effect of fertility on grain yield, protein & test weight

Fertilizer management practice had a significant influence on grain yield at the Melita and Roblin sites. In Melita, winter wheat grown with the current producer fertility practice (100% N in spring) had a significantly ($P < 0.001$) greater yield as compared to balanced fertility practice (50% N in fall). At Roblin, the spring fertility yield (6515 kg ha^{-1}) had the greatest yield, though it was not significant different from balanced (50% N in fall) applications of 150, and 180kg ha^{-1} of N.

There was no significant effect of fertility on grain yield at the Arborg site. When Roblin and Arborg site years were combined, the balanced (50% N in fall) fertility practice of 150 kg ha^{-1} had the greatest yield (7351kg ha^{-1}), though it was not significantly different that the yield of the balanced fertility practices of 120 and 180kg ha^{-1}, or the current producer fertility practice of 120kg ha^{-1} applied in the spring.

Significant effects of fertility practice on grain protein content were observed at the Melita and Roblin sites, but not in Arborg. Winter wheat grown at the Roblin and Melita sites, were found to have significantly ($P < 0.001$) higher grain protein contents (12.3% and 12.7%) using the current producer fertility practice (120 Kg/ha of N in the spring) than using balanced fertility practices.

Fertility management practice had a significant influence on grain test weight at the Roblin and Arborg sites. In Roblin, the test weight of grain grown under the check rate of fertilizer (no added N) was significantly ($P = 0.005$) higher (70.5kg hL^{-1}) than the balanced fertility practice of 180 kg ha^{-1} and producer fertility practice. In Arborg, the test weight of grain grown under the balanced fertilizer practice of 60 kg/ha^{-1} was significantly ($P < 0.001$) higher (73.1kg hL^{-1}) that the other fertility practices but was not significantly different from the balanced fertility practice of 90 kg/ha^{-1}. However, when data from Roblin and Arborg sites was combined and analyzed, no significant influence of fertility management practice on winter wheat grain test weight or protein content was observed.

Effect of variety x fertility interaction on grain yield, protein & test weight

No significant variety and fertility practice interactions (variety x fertility) were observed for grain yield at three tested sites. However, when Roblin and Arborg site yield data was combined and analyzed, Wildfire grown with the current producer fertility practice (100% N in spring) was found to have a significantly ($P = 0.037$) higher yield (7476kg ha^{-1}) than four of the other fertility treatments in the trial.

In Arborg, the protein content of Vortex grown under the check rate of fertilizer (no added N) was significantly ($P = 0.022$) higher (13.8%) that the other fertility practices interactions but was not significantly different from Vortex grown with a balanced fertility practices of 150 kg ha^{-1} & 180 kg ha^{-1}.

Variety-fertility interactions were significant for test weight at only Roblin & Arborg sites.

Project Findings

Overall, results from the 2021-22 growing season indicate that current producer fertility practice (100% N in spring) resulted in greater yield at Melita site, where as it was at par with some (at Roblin site) or all other balanced fertility practices (at Arborg site). In the balanced fertility practice, N rates of 120 kg ha^{-1},150 kg ha^{-1} & 180 kg ha^{-1} resulted in greater grain yield than lower N rate treatments or check.

Protein content was greater in the winter wheat produced using producer fertility practice at Melita & Roblin sites where as Arborg site did not have any effect of fertility on grain protein content.

It was difficult to find a pattern when looking at test weight; at some sites test weight was higher in balanced fertility programs, then at a different site it was higher under the current producer practice. Environmental conditions seemed to influence the characteristics of the two varieties of winter wheat under the different fertility practices. Also, grain protein content and test weight across the sites were not able to be combined then analyzed because the values were too variable. This implies that the geographical area could also be a factor affecting the performance of the winter wheat.

Continued field study is necessary to further evaluate the performance of new winter wheat varieties under fertility management strategies, and to effectively develop fertilizer management recommendations that winter wheat producers in different areas of the province can implement in their production systems.

References

1) Anderson, R. L. 2008. Growth and Yield of Winter Wheat as Affected by the Preceding Crop and Crop Management. *Agronomy Journal* 100 (4): 977-980.

2) Beres, B. L., Graf, R. J., Irvine, R. B., O'Donovan, J. T., Harker, K.N., Johnson, E. N., Brandt, S., Hao, X., Thomas, B. W., Turkington, T. K., and Stevenson, F. C. 2018. Enhanced Nitrogen Management Strategies for Winter Wheat Production in the Canadian Prairies. *Canadian Journal of Plant Science* 98: 683-702. https://doi.org/10.1139/cjps-2017-0319

3) Fowler, D. B., Brydon, J., and Baker, R. J. 1989. Nitrogen fertilization of no-till winter wheat and rye. I. Yield and agronomic responses. *Agron. J.* 81: 66–72.

4) Halvorson, A.D., Alley, M. M., and Murphy, L. S. 1987. Nutrient Requirements and Fertilizer Use: In Wheat and Wheat Improvement – *Agronomy Monograph (13) 2nd Edition.* Madison, WI 53711, USA.

5) Morris, T.F., Murrell, T. S., Beegle, D. B., Camberato, J., Ferguson, R., Ketterings, Q. 2018. Strengths and limitations of nitrogen recommendations, tests, and models for corn. *Agron. J.* 110:1–37. doi:10.2134/agronj2017.02.0112

6) Schulz, R., Makary, T., Hubert, S., Hartung, K., Gruber, S., Donath, S., Dohler, J., Weiss, K., Ehrhart, E., Claupein, W., Piepho, H. P., Pekrun, C., and Müller, T. 2015. Is it necessary to split nitrogen fertilization for winter wheat? On-farm research on Luvisols in South-West Germany. *J. Agric. Sci.* 153(4): 575–587.

__Table 2.__ Results including yield, protein, and test weight from the 2021-22 Ducks Unlimited Winter Wheat Fertility Trial in Melita, Roblin, and Arborg.

Treatment			Location									Arborg & Roblin Combined*
			Melita			Roblin			Arborg			
			Yield (kg ha⁻¹)	Protein (%)	Test Wt. (kg hL⁻¹)	Yield (kg ha⁻¹)	Protein (%)	Test Wt. (kg hL⁻¹)	Yield (kg ha⁻¹)	Protein (%)	Test Wt. (kg hL⁻¹)	Yield* (kg ha⁻¹)
Variety	Wildfire	1	5266	10.7	77.5b	6232a	11.4b	68.40	8185	12.8b	71.2b	7195a
	Vortex	2	5053	10.8	78.5a	5731b	12.3a	69.50	7803	13.4a	73.0a	6767b
Fertility	check	1	3031f	10.2c	77.5	5034c	11.0c	70.5a	7646	13.1	72.2c	6340c
	60	2	4366e	10.1c	78.0	5706b	11.0c	69.9a	8030	12.9	73.1a	6868b
	90	3	4844d	10.4bc	77.5	6005b	11.8b	70.1a	7808	13.0	73.0ab	6906b
	120	4	5312c	10.5bc	77.9	6042b	12.0b	68.4abc	8180	12.9	72.3bc	7111ab
	150	5	5799b	10.5bc	78.5	6507a	11.9b	69.6ab	8195	13.2	71.6cd	7351a
	180	6	5955b	10.9b	78.3	6065ab	12.3ab	67.8bc	8056	13.5	70.8d	7060ab
	Spring120	7	6810a	12.3a	78.1	6515a	12.7a	66.5c	7948	13.2	71.7c	7232ab
Variety x Fertility		1,1	3230	10.1	77.0	5386	10.6	70.4ab	8386	12.4f	71.7cd	6886bcd
		1,2	4532	10.1	77.6	5800	10.5	70.1ab	8109	12.6ef	72.9ab	6955abcd
		1,3	5192	10.4	76.6	6578	11.0	69.9ab	8155	12.7def	72.4bc	7367ab
		1,4	5525	10.5	77.3	6028	11.6	66.3cd	8505	12.6ef	71.3de	7266abc
		1,5	5740	10.5	78.4	6648	11.4	68.3abc	8295	13.0cde	69.9f	7472a
		1,6	6095	10.8	78.0	6188	12.1	66.1cd	7700	13.3bc	69.8f	6944abcd
		1,7	6545	12.3	77.3	6999	12.2	67.9bcd	7953	13.2bcd	70.4ef	7476a
		2,1	2831	10.3	77.9	4683	11.4	70.5ab	6906	13.8a	72.7abc	5795e
		2,2	4199	10.2	78.4	5612	11.4	69.6ab	7950	13.3bc	73.3ab	6781cd
		2,3	4495	10.5	78.5	5431	12.6	70.3ab	7460	13.3bc	73.6a	6446d
		2,4	5099	10.5	78.4	6056	12.3	70.5ab	7856	13.2bc	73.3ab	6956abcd
		2,5	5857	10.5	78.6	6365	12.5	70.9a	8095	13.4abc	73.3ab	7230abc
		2,6	5815	11.1	78.6	5942	12.5	69.4ab	8412	13.6ab	71.8cd	7177abc
		2,7	7076	12.3	78.9	6030	13.1	65.1d	7943	13.2bc	73.0ab	6987abcd
P-Values	Variety		0.074	0.465	<0.001	<0.001	<0.001	0.064	0.065	<0.001	<0.001	<0.001
	Fertility		<0.001	<0.001	0.251	<0.001	<0.001	0.005	0.676	0.060	<0.001	<0.001
	V x F		0.132	1.000	0.599	0.110	0.384	0.025	0.108	0.022	0.011	0.037
	CV%		7.2	4.7	1.01	6.5	3.8	2.6	7.46	2.34	0.91	7.19

Values followed by the same letter are not significantly different by Fisher's mean separation method at 95% confidence.

*Does not include Melita site

Cereal-Peas Intercropping: Effects of Seeding Rate on Grain / Forage Yield

Project Duration - 2022 & ongoing

Objectives

To determine the effects of seeding rate of cereal-pea intercrops on forage & grain yield in comparison to their mono crops.

Results

Plant establishment

Both cereals and peas exhibited competition when grown together in different seeding rate treatments (Fig 1). Both barley & oats had highest plant population/m^2 when grown as mono crops. Cereal establishment was significantly reduced when their seeding rate had been reduced to half (in 75-50 & 100-50 treatments) in the intercrop. Their establishment also suffered when they were grown at 75% of the normal seeding rate along with full rate of peas. On contrary, pea establishment did not suffer because of intercrop competition except in 75-75 seeding rate treatment (in pea-oat intercrop).

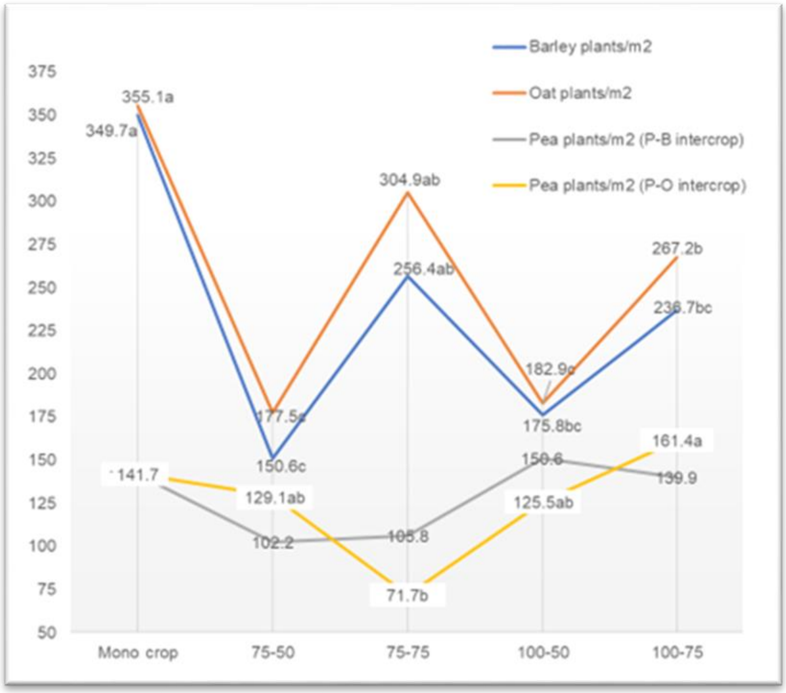


Figure 1. Plant establishment (plants / m^2) in different seeding rate treatments of pea-barley & pea-oat intercrops.

Plant height

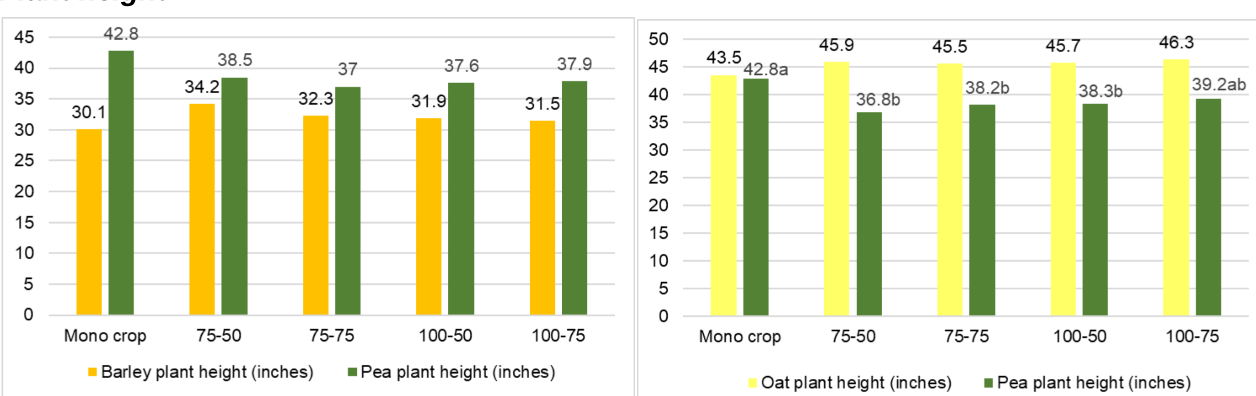


Figure 2. Effect of pea-barley (left) & pea-oat (right) intercrops on the height (inches) of both crops.

Intercrop competition did not affect plant height both for peas and barley at all the seeding rates tested (Fig 2). Similarly, when peas and oats were grown together, it did not affect oats height.

However, pea plants were shorter when grown with oats in 75-50, 75-75 and 100-50 seeding rate treatments.

Grain Yield, Land equivalent ratio (LER) & Revenues

Peas were not competitive either with barley or oats and pea yield was significantly reduced in all intercrop treatments (Tables 1 & 2). When peas were added even at full seeding rate (100%) in both intercrops, pea yield was still lower than pea mono crop.

Barley & oat mono crops produced highest grain yield and their yield was lower when grown with any seeding rate of peas (Tables 1 & 2). Land equivalent ratios (LER) were above 1 in pea-barley intercrop treatments except in peas-barley (100-75) treatment. All pea-oats intercrop treatments had LER > 1 indicating that intercrops produced more than mono crops.

Both barley & oat mono crops were ranked top in the marginal revenues (Tables 1 & 2). Seeding rate of 75-75 both for pea-barley & pea-oats intercrops was ranked second in the marginal revenues.

Table 1. Grain yield, LER & revenues as affected by different seeding rate treatments of pea-barley intercrop.

Cropping treatment (% seeding rate*)	Pea Yield (bushels/acre)	Barley Yield (bushels/acre)	Land Equivalent Ratio**	Gross Revenue ($/ac)	Marginal Revenue ($/ac)	Ranking
Peas-Barley (75-50)	15.4b	68.5bc	1.03ab	696.8	551.0	3
Peas-Barley (75-75)	13.8b	81.0b	1.12a	766.7	611.0	2
Peas-Barley (100-50)	16.3b	63.9cd	1.00ab	675.2	508.3	4
Peas-Barley (100-75)	16.3b	54.5d	0.91b	607.0	435.3	6
Barley Mono (100)	-	102.5a	-	743.1	669.8	1
Peas Mono (100)	43.8a	-	-	569.4	437.4	5
Significant Difference	YES	YES	YES			
P	<0.0001	<0.0001	0.021			

*Normal Seeding rate for Barley & Peas – 250 & 80 plants/m², respectively.

** - Land equivalent ratio (LER) = $\frac{\text{yield of intercrop species 1}}{\text{yield of monocrop species 1}} + \frac{\text{yield of intercrop species 2}}{\text{yield of monocrop species 2}}$

Profit margins were calculated as follows: Gross revenue ($/ac) = Yield x Market price

Marginal revenue *($/ac) = Gross revenue – Seed – Fertilizer – Pesticide – Separation ($0.25/bu)*
(Market prices from Manitoba Agriculture 2023 Costs of Production: $13.00/bu peas, $7.25/bu barley)

Dry matter forage yield & quality

When different seeding rate treatments of pea-barley and pea-oat intercrops were compared for dry matter forage yield (Fig 3), they did not differ from mono crops of peas, barley and oats. Pea mono crop had highest crude protein whereas oats and barley mono crops were lower in crude protein (Fig 4). Generally, pea-oat intercrops had greater crude protein than pea-barley intercrops. Total digestible nutrients were greater for pea and barley mono crops than in intercrops.

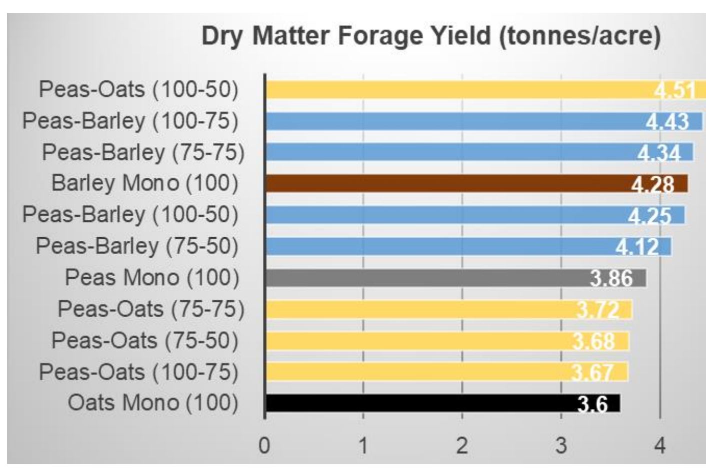


Fig 3. Forage yield comparisons among different seeding rate treatments.

Table 2. Grain yield, LER & revenues as affected by different seeding rate treatments of pea-oat intercrop.

Cropping treatment (% seeding rate*)	***Pea Yield (bushels/acre)***	***Oats Yield (bushels/acre)***	***Land Equivalent Ratio*** ***	***Gross Revenue ($/ac)***	***Marginal Revenue ($/ac)***	***Ranking***
Peas-Oats (75-50)	*21.4b*	*118.7bc*	*1.19a*	*871.7*	*711.4*	*4*
Peas-Oats (75-75)	*17.6b*	*132.1b*	*1.19a*	*889.3*	*719.1*	*2*
Peas-Oats (100-50)	*22.5b*	*109.1c*	*1.15a*	*838*	*657.8*	*5*
Peas-Oats (100-75)	*22.4b*	*124.6bc*	*1.24a*	*914.2*	*718.2*	*3*
Oats Mono (100)	*-*	*169.4a*	*-*	*847*	*730.4*	*1*
Peas Mono (100)	*43.8a*	*-*	*-*	*569.4*	*426.2*	*6*
Significant Difference	*YES*	*YES*	*NO*			
P	*0.005*	*<0.0001*	*0.880*			

**Normal Seeding rate for Oats & Peas – 250 & 80 plants/m^2, respectively.*

*** - Land equivalent ratio (LER) = <u>yield of intercrop species 1</u> / yield of monocrop species 1 + <u>yield of intercrop species 2</u> / yield of monocrop species 2*

Profit margins were calculated as follows: Gross revenue ($/ac) = Yield x Market price

***Marginal revenue** ($/ac) = Gross revenue – Seed – Fertilizer – Pesticide – Separation ($0.25/bu)*
(Market prices from Manitoba Agriculture 2023 Costs of Production: $13.00/bu peas, $5.00/bu oats)

Project Findings

Although mixed grain intercropping can provide agronomic benefits, it also poses a number of practical challenges with respect to crop production, harvest, and grain handling (Struckman *et al.* 2021). In the current study, pea-barley intercrops and mono crops of peas and barley had some lodging issues. On contrary, pea-oat intercrops did not have any lodging. Oats had been reported to support lodge-prone pea varieties throughout the growing season until harvest (Struckman *et al.* 2021).

Peas seeded at full seeding rate did not provide any yield advantage or gain in marginal revenues during the current study. Actually when peas were seeded at 75% of the recommended seeding rate along with similar seeding rate for accompanying cereal crop, it resulted in better marginal revenues for the intercrop. Both

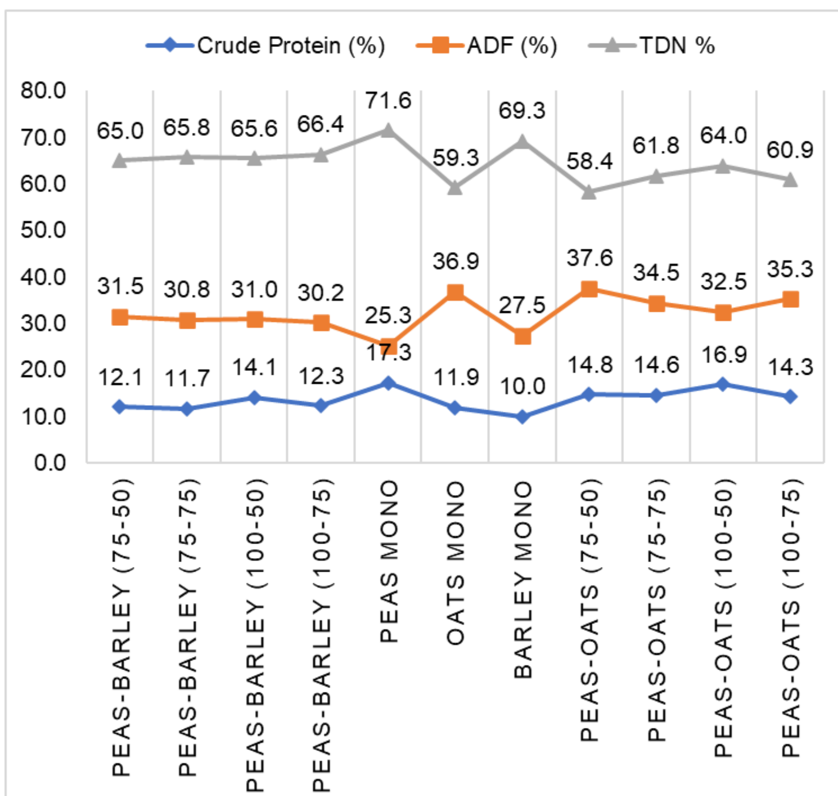


Fig 4. Forage quality parameters as affected by intercrop treatments.

in pea-barley & pea-oats intercrops, seeding rate treatment of 75-75 was ranked second in the marginal revenues (after mono crops). Similar conclusions were made by Struckman *et al.* (2021), when they recommended that oat seeding rates in an oat-pea intercrop should not exceed 60% of standard oat monocrop rates. Otherwise oats will tend to crowd out the peas in the stand as the growing season progresses.

In general, pea-oats intercrops had better marginal returns than pea-barley intercrops. Lauk & Lauk (2008) also reported that pea-oats intercrops were better than pea- barley & pea-wheat intercrops in terms of grain yield. However, for forage yield, all mono crop & intercrop treatments were similar. Crude protein content was improved when peas were grown with oats or barley.

Land equivalent ratios were greater than one in most intercrop treatments. This is promising as it means that growing two crops together might be more economical than growing mono crops. The present study was done on a site where soil nitrogen levels were quite high. It would be interesting to repeat this test on a low nitrogen site to see nitrogen fixation benefits of legume intercrops.

No herbicides are labelled for simultaneous use in pea-oats and pea-barley intercrops. Therefore, weeds must be well-controlled during the previous growing season and/or through a pre-emergence herbicide ahead of seeding.

Background / References / Additional Resources

Intercropping refers to growing a mixture of non-legume and legume crops. Intercropping has several benefits, such as yield stability and reduced risk of crop failure due to crop diversity, lower input costs due to less fertiliser and pesticide usage, improved grain yield and economic returns and grain quality (Sahota & Malhi, 2012).

Previous study from Ontario showed that without applied nitrogen, grain yields, protein concentration and sustainability of economic returns improved with barley-pea intercropping compared to barley and pea sole crops (Sahota & Malhi, 2012). Another study done on oat-pea intercropping across the prairies and North Dakota (Struckman *et al.* 2021) concluded that this intercrop has a potential to reduce nitrogen fertilizer use.

The objectives of the current study was to investigate the effects of intercropping oats & barley with pea on grain / forage yield, land equivalency ratio and economic returns in Interlake region of Manitoba.

Fig 5. Pea - barley intercrop plot at Arborg site.

References

1. Struckman L. *et al.* (2021). Oat-Pea Mixed Grain Intercropping on the Canadian Prairies and U.S. Northern Plains. https://oatnews.org/oatnews_pdfs/2020/Oat-Pea%20Report_May%202021.pdf

2. Sahota TS & Malhi SS (2012). Intercropping barley with pea for agronomic and economic considerations in northern Ontario. *Agricultural Sciences* 3(7): 889-895.

3. Lauk R & Lauk E (2008). Pea-oat intercrops are superior to pea-wheat and pea-barley intercrops. *Acta Agriculturae Scandinavica Section B - Soil and Plant Science* 58: 139-144.

Materials and Methods

Experiment design: Randomized complete block design
Treatments: The following mono & intercrop treatments were tested.

Crop(s)	*% of standard seeding rate for mono crop*	*Varieties used*
Peas-Barley	*75-50*	*AAC Carver - AAC Connect*
Peas-Barley	*75-75*	*AAC Carver - AAC Connect*
Peas-Barley	*100-50*	*AAC Carver - AAC Connect*
Peas-Barley	*100-75*	*AAC Carver - AAC Connect*
Peas mono	*100*	*AAC Carver*
Oats mono	*100*	*CS Camedon*
Barley mono	*100*	*AAC Connect*
Peas-Oats	*75-50*	*AAC Carver - CS Camedon*
Peas-Oats	*75-75*	*AAC Carver - CS Camedon*
Peas-Oats	*100-50*	*AAC Carver - CS Camedon*
Peas-Oats	*100-75*	*AAC Carver - CS Camedon*

In intercrop treatments, both crops were seeded in the same row with row to row spacing as 9 inches. The 1.3m^2 forage portion of the each plot was harvested on July 29th at early dough stage for the oats and barley.
Replications: three
Fertilizer: Soil fertility: N-P: 212-36 (lbs/acre)
Applied with the seed: N-P: 22-20 (lbs/acre)
Pesticides sprayed:
Aug 25 – Glyphosate @ 0.67L/acre (desiccant)
Data collection **-** Plant establishment, plant height, grain & forage yield, forage quality
Seeding / Harvesting date: May 24 / Sep 6

Marginal revenues are based on the following input costs -
Seed cost: Barley - $29 / acre, Oats -$30 / acre, Pea - $88/acre
Fertilizer – N - $1.085 / lb ($1100 / tonne Urea); P - $0.905 / lb ($1300 / tonne MAP)
Pesticides – glyphosate @ 0.67 L/acre ($4.5/acre) for desiccation
Seed separation cost - $0.25 / bushel

Assessment of Corn-Legume Intercrops for Forage Production & Quality

Project Duration - **2022 & ongoing**

Objectives

Determining forage yield potential when corn is grown with other legumes. Five legume species; berseem clover, pinto beans, soybeans, hairy vetch & peas were evaluated in this study.

Results

Forage yield: Legume intercrops did not have any effect on the height of corn at harvest. In terms of dry matter forage yield, corn / berseem clover intercrop was superior to corn/pinto beans intercrop, but was similar to all other intercrops and corn mono crop (Table 1).

Table 1. Corn height & forage yield when corn is grown either alone or with other legumes.

Treatment	***Corn Height at harvest (inches)***	***Dry Matter Forage Yield (tonnes/ac)***	***Crop stage at harvest (legumes)***
Corn	*92.7*	*4.7ab*	*-*
Corn / Berseem clover	*100.0*	*5.7b*	*Late Flowering*
Corn / Soybeans	*100.2*	*5.4ab*	*R6.5*
Corn / Peas	*100.7*	*5.2ab*	*R7*
Corn / Hairy Vetch	*100.7*	*4.9ab*	*Late flowering (no pods)*
Corn / Pinto beans	*95.6*	*3.9a*	*R8*
Sig. Difference	*No*	*Yes*	
P Value	*0.917*	*0.035*	

Forage quality: Corn- legume Intercrops did not differ from corn mono crop in terms of Acid detergent fibre (ADF), Neutral detergent fibre (NDF), Total digestible nutrients (TDN) and Relative feed value (RFV) (Table 2). However, Corn/soybean intercrop had greater crude protein than corn mono and corn/pinto bean intercrops.

Table 2. Effect of different legume intercrops (with corn) on forage quality parameters.

Treatment	***Crude Protein (%)***	***ADF %***	***NDF%***	***TDN%***	***RFV***
Corn	*7.86b*	*30.3*	*48.2*	*66.3*	*126*
Corn / Berseem clover	*10.70ab*	*36.6*	*49.3*	*59.6*	*115*
Corn / Soybeans	*11.34a*	*30.3*	*45.6*	*66.3*	*135*
Corn / Peas	*10.08ab*	*33.3*	*48.7*	*63.0*	*116*
Corn / Hairy Vetch	*10.02ab*	*30.4*	*42.1*	*66.2*	*124*
Corn / Pinto beans	*7.97b*	*31.3*	*49.7*	*65.3*	*118*
Sig. Difference	*Yes*	*No*	*No*	*No*	*No*
P Value	*0.018*	*0.407*	*0.531*	*0.409*	*0.601*

Project Findings

Planting legumes with corn did not increase / decrease forage yield as compared to corn mono crop. When soybeans were planted with corn, it resulted in improvement in crude protein content.

Producers often modify their feeding strategies during the annual production cycle of the beef cow to align with her energy and protein needs as she moves through the cycle. For example, lower quality feeds such as straw reduce costs during Phase 3, when the cow's nutritional requirements are at her lowest. In Phase 4, as the rumen has less room for feed due to the growing fetus, she will benefit from higher quality feed such as good quality alfalfa hay or some grain to provide extra energy. A common rule of thumb is 55-60-65% for total digestible nutrients (TDN) and 7-9-11% for crude protein (CP) for early, mid and late gestation (Beef and Forage Technical Bulletin, 2021). In the current study, only corn-soybean and corn-berseem clover intercrops met nutritional requirements of a beef cow for all gestation periods.

The trial site had high nitrogen in the soil and this might have negatively impacted legumes to fix nitrogen and exhibit effects on forage quality. In the current study, both corn & legumes were planted and harvested at the same time. Harvesting time of legumes plays an important role in forage quality of the intercrop. Future research will be done to assess the effects of legumes on corn silage in a low soil nitrogen environment.

Fig 1. Corn / Berseem clover intercrop plot at Arborg site.

Background / References / Additional Resources

Corn forage can fit well in the grazing system as it meets the nutritive requirements of beef cows in mid- and late-stage pregnancy (Omokanye, 2019). Usually corn forage had lower CP content than other cereal crops across the Canadian prairie environments (Lardner *et al.*, 2017). Several studies have indicated that corn forage protein concentrations would not normally be adequate for beef cattle diet at all physiological stages (Lardner *et al.*, 2017; Omokanye, 2016).

Intercropping corn with legumes provide several advantages such as improved forage yield and forage nutritive value. Corn intercropped with cowpea (*Vigna ungiuculata*) and bean (*Phaseolus vulgaris*) were far more effective than monocrop corn to produce higher dry matter yield and roughage for silage with better quality (Geren *et al.*, 2008). In a recent study from Alberta, Omokanye *et al.* (2020) reported that crude protein levels were improved in several corn-legume intercrops as compared to corn mono crop. Forage yield, however, did not increase with the intercropping.

The current study was designed to assess viability of corn (*Zea mays L.*) intercrops to improve the forage crude protein (CP) of corn forage for beef cattle production. A corn monocrop was compared with five corn-legume intercrops.

Definitions

Acid detergent fibre (ADF) – *A chemical analysis that estimates the total fibre (including indigestible lignin) in the feed. A high ADF indicates reduced digestibility and likely lower voluntary feed intake.*
Crude protein (CP) – *An estimate of the total protein content of a feed determined by analyzing the nitrogen content of the feed and multiplying the result by 6.25. Crude protein includes true protein and non-protein nitrogen sources such as ammonia, amino acids and nitrates.*
Neutral detergent fibre (NDF) – *An insoluble fraction containing all plant cell wall components left after boiling a feed sample in a neutral detergent solution. A high NDF indicates lower digestibility and voluntary feed intake.*

References

1. Geren H, Avcioglu R, Soya H and Kir B (2008) Intercropping of corn with cowpea and bean: Biomass yield and silage quality. *African Journal of Biotechnology* Vol. 7 (22), pp. 4100-4104.

2. Beef and Forage Technical Bulletin (2021). Manitoba Agriculture. https://www.gov.mb.ca/agriculture/livestock/pubs/beef-forage-tech-bulletin-mar.pdf

3. Lardner, H. A., Pearce, L., & Damiran, D. (2017). Evaluation of low heat unit corn hybrids compared to barley for forage yield and quality on the Canadian Prairies. *Sustainable Agriculture Research*, 6, 90–102).

4. Omokanye, A. (2019). Cover crop cocktails for livestock feed. In: *Cocktail Cover Crop Workshop*, Debolt, Alberta. 5 Feb. 2019. High Prairie, AB: Peace Country Beef and Forage Association.

5. Omokanye, A. (2016). Peace corn field trials: Research update. In: *East Peace Beef Cattle Day*, High Prairie, AB. 30 Nov. 2016. High Prairie, AB: Peace Country Beef and Forage Association.

6. Akim Omokanye, Buthaina Al-Maqtari, Herbert A. Lardner, Guillermo Hernandez, Kabal S. Gill, Lekshmi Sreekumar, Alan Lee (2020) Forage potential of corn intercrops for beef cattle diets in northwestern Alberta. *Crop Forage & Turfgrass Mgmt.* 2020;6: e20056.

Materials and Methods

Experiment design: Randomized complete block design
Treatments: Corn mono crop (24,000 plants/acre) was compared with the following five intercrop treatments for forage yield –

Corn-Berseem Clover (24,000 plants / acre – 7.5 lbs / acre)
Corn-Soybeans (24,000 plants / acre – 135,000 plants / acre)
Corn-Peas (24,000 plants / acre – 2,40,000 plants / m^2)
Corn-Pinto Beans (24,000 plants / acre – 75,000 plants / acre)
Corn-Hairy Vetch (24,000 plants / acre – 18.25 lbs / acre)

Corn was planted using wintersteiger corn planter in 30 inches apart rows. Afterwards, two rows of legume (9-10 inches apart) were planted in between every two rows of corn using a garden seeder. Berseem clover & hairy vetch were broadcasted followed by light raking to ensure seed-soil contact.

Replications: three

Fertilizer: Soil fertility: N-P: 220-40 (lbs/acre)

Applied with the seed: N-P: 23-13 (lbs/acre)

Pesticides sprayed:

July 13 – Glyphosate @ 0.1L/acre (Corn mono crop)

Basagran Forte @ 0.91 L/acre (all intercrop treatments)

Data collection **-** Plant establishment, corn height & forage yield

Seeding / Harvesting date: June 7 (corn), June 8 (legumes) / Sep 26

Determining Effects of Sub-Surface Drainage and Late Seeding on the Crop Growth and Yield of Peas

Project Year - 2022

Objectives : To evaluate the effect of tile drainage & late seeding on crop growth & yield of peas.

Results

Peas grown over tiled plots emerged earlier than in plots without any drainage (Fig 1). Seeding dates did not differ in pea emergence time when plots were grown without drainage. However, when grown over tiles, late seeded (June 9) peas emerged earlier in comparison to pea plots seeded on May 26. Tiles have showed significant effect on the plant establishment (Fig 2) and tiled plots have better plant survival.

Fig 1. Days to emergence as influenced by drainage & seeding time.

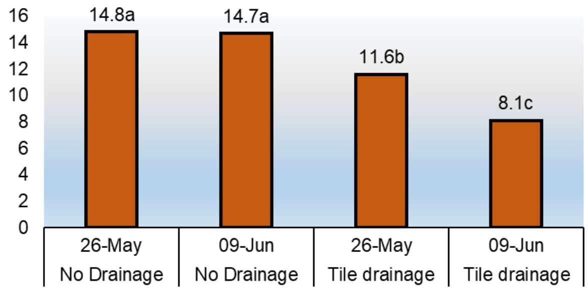
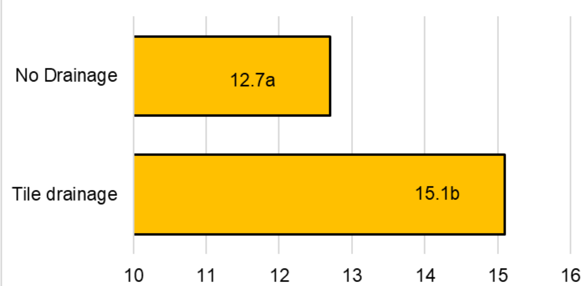


Fig 2. Plant establishment (No of plants / ft^2) as affected by drainage.



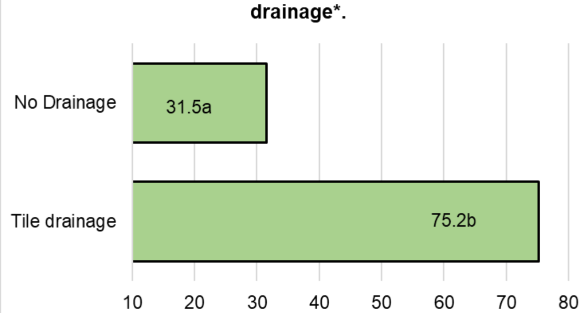
Drainage caused rapid growth of peas and resulted in less number of days to flower (Table 1). Pea plants were stunted by excessive moisture & were significantly shorter in plots without drainage.

Table 1. Effect of tile drainage on days to flowering & plant height of peas at Arborg site.

Treatment	***Days to Flowering***	***Plant Height (inches)***
No Drainage	*53.5a*	*26.7b*
Tile Drainage	*49.6b*	*36.2a*
Significant Difference	*Yes*	*Yes*
P Value	*<0.0001*	*<0.0001*

Peas produced significantly higher grain yield when grown on the tiled plots (Fig 3.). The plots from June 9 planting in the non-drainage set were severely damaged by spring flooding. The data from June 9 planting (both tiled & non-tiled sets) were excluded from the final analysis. The results shown in fig 3 are only from May 26 planting date.
When seeding dates & pea varieties were compared for grain yield over tiles, there was no

Fig 3. Peas grain yield (bu/acre) as affected by drainage*.



difference in grain yield and the interaction was non-significant (Table 2). Peas produced good yield (range: 69.8 – 82.5 bu/acre) over the tiles.

Project Findings

During the 2022 growing season (May 1-Sept 30), Arborg site received 150% of the normal rainfall. Excessive amounts of snowfall over the winter led to spring overland flooding in the area. In addition to the excessive snowfall, Arborg site received above average rainfall for the months of May (204%), June (141%) and July (304%). This excessive rainfall resulted in flooding of some pea plots in non-drainage set of this test.

PESAI site has heavy clay soil with challenges in subsurface drainage. It is evident from the current study that tile drainage significantly influenced plant emergence & survival along with positive influence on other growth parameters of peas. Pea plots grown over tiles produced greater grain yield irrespective of planting time and pea variety.

Planting date did not have any effect on the grain yield, when peas were grown over the tiles. Even late-planted peas (on June 9) produced good yield on tiles.

Table 2. Seeding date - variety interactions for grain yield (bu/acre) when peas grown over tiles.

Seeding date	***Variety***	***Grain Yield (bu /acre)***
May 26	*CDC Lewochko*	*78.3a*
May 26	*AAC Carver*	*77.3a*
May 26	*AAC Beyond*	*70.1a*
June 9	*CDC Lewochko*	*69.8a*
June 9	*AAC Carver*	*77.9a*
June 9	*AAC Beyond*	*82.5a*
Significant Difference		*No*
P Value		*0.322*

Background / References

Pea harvested acreage increased from 67,000 acres in 2015 to 172,400 acres in 2020, mostly covering the western part of the province. This can be partially attributed to the establishment of a pea protein processing plant built by Roquette. Peas thrive in relatively dry soil conditions and are susceptible to root rot in wet soils. It is recommended to choose fields with well-drained, coarse textured soils that are not prone to waterlogging (Manitoba Pulse & Soybean Growers). However, soils in the eastern & Interlake regions of the province have more clay content and have issues with sub-surface drainage.

Tile drainage has been utilized successfully to improve sub-surface drainage in many states of US. This has not been used frequently in the Canadian Prairies, however, an increasing frequency of excess moisture events has caused farmers to install tile drains at an accelerated rate to tackle the unprecedented waterlogging conditions at their farms (Asante & Ashton, 2021). The cost of installing a tile drainage structure varies significantly in different areas and is very site specific. Costs of installation with a contractor in Western Canada can vary from $900 - $1200/acre, generally 2/3 material costs and 1/3 labour costs (Asante & Ashton, 2021).

PESAI site has plots with 30’ wide tiles underneath. This enabled us to explore if tiles can benefit pea cultivation in heavy clay soils of Interlake region. Peas are recommended to plant early in Manitoba, but here in this study we have evaluated how tiles affect late planting of peas.

References

1. Michael Asante & Bill Ashton (2021). ADAPTING RISK TO RESILIENCE. RURAL DEVELOPMENT INSTITUTE. Brandon University, Brandon, MB *https://www.brandonu.ca/rdi/files/2021/08/Report-2-Study-Report-of-Economic-Costs-and-Benefits.pdf*

2. Manitoba Pulse & Soybean Growers (2021). Pea Production guidelines. *https://www.manitobapulse.ca/wp-content/uploads/2017/04/Pea-Production-Guidelines-June-2018-FINAL_WR.pdf*

Materials and Methods

Experiment design: Split-split plot design

Main factor: Tiled land (30’ spacing) vs Non-tiled land

Sub factor: Two seeding dates (May 26 & June 9)

Sub-sub factor: Three pea varieties (CDC Lewochko, AAC Carver & AAC Beyond)

Replications: three

Seeding rate: 80-90 live plants /m^2

Seeding depth – ¾”

Fertilizer: N-P: 0-20 lbs/acre applied with the seed

Pesticides sprayed:

June 20 – Basagran Forte @ 0.91L/acre

July 12 – Centurion @ 125 ml/acre

Data collection

Emergence, plant establishment, Days to flower, plant height & grain yield

Seeding / Harvesting dates : May 26 & June 9 / Sep 27

Intercropping with Soybeans and Peas in the Interlake

Project Duration: 2019-2022

Collaborators: Kristen Macmillan, U of M

Objectives

1. Gain experience in intercropping: observe and evaluate agronomic performance of intercropping compared to monocrops.
2. Evaluate yield, land equivalent ratio (LER) and profitability of intercropping compared to monocrops.
3. Overall, start a knowledge base on if and how intercrops can be utilized in cropping systems in the Interlake and Manitoba.

Results

This was the fourth year of experimenting with intercropping in the Interlake region of Manitoba. Treatments included three seeding rate combinations of pea-canola, soybean-flax, pea-flax and pea-oat compared to pea, canola, flax, soybean and oat monocrops. Results of the 2022 experiment including treatment descriptions, agronomic practices, yield, gross and marginal revenues, and general observations are listed in Tables 2 and 3. The pea-oat intercrop was sampled for total dry matter and forage nutrient analysis (Table 4). **The 2022 growing season at Arborg was exceptionally wet with 168% of normal growing season precipitation (Table 1) compared to 69% of normal precipitation in 2021.** Due to high precipitation in May, the trial was seeded on June 8 and seeds were placed shallower. Overland flooding due to frequent rain after seeding resulted in some seeds being moved with floodwater. Twelve plots were lost, and ten treatments were affected (one treatment was lost, full pea, ¼ flax) due to flooding from June 11 to June 27, 2022. In addition, canola plant stand was significantly reduced due to flea beetle damage. Crop yields were below average for pea, canola, and soybean while flax and oat yields were above average.

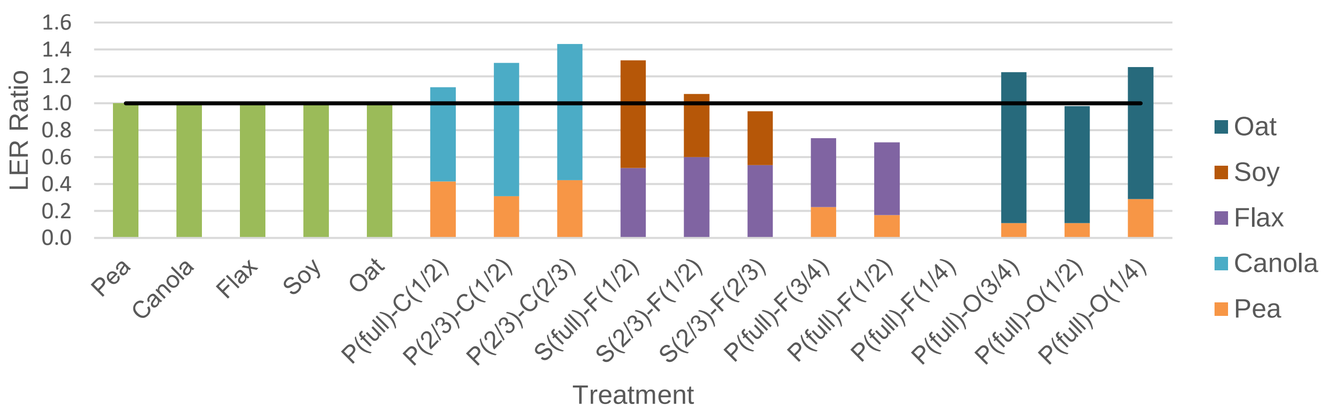


Figure 1. *Average total Land Equivalent Ratio (LER) for each intercrop treatment composed of each partial LER crop component (n=3) at Arborg, MB in 2022.*

In 2022, the LER values for most of the intercropped treatments, except pea-flax, are greater than 1 indicating that they over-yielded their mono-cropped counterparts (Fig 1.). With high commodity prices, all crops produced positive marginal revenue. Marginal revenue was highest for monocrop oats and pea-oat intercrops, followed by monocrop flax and monocrop peas.

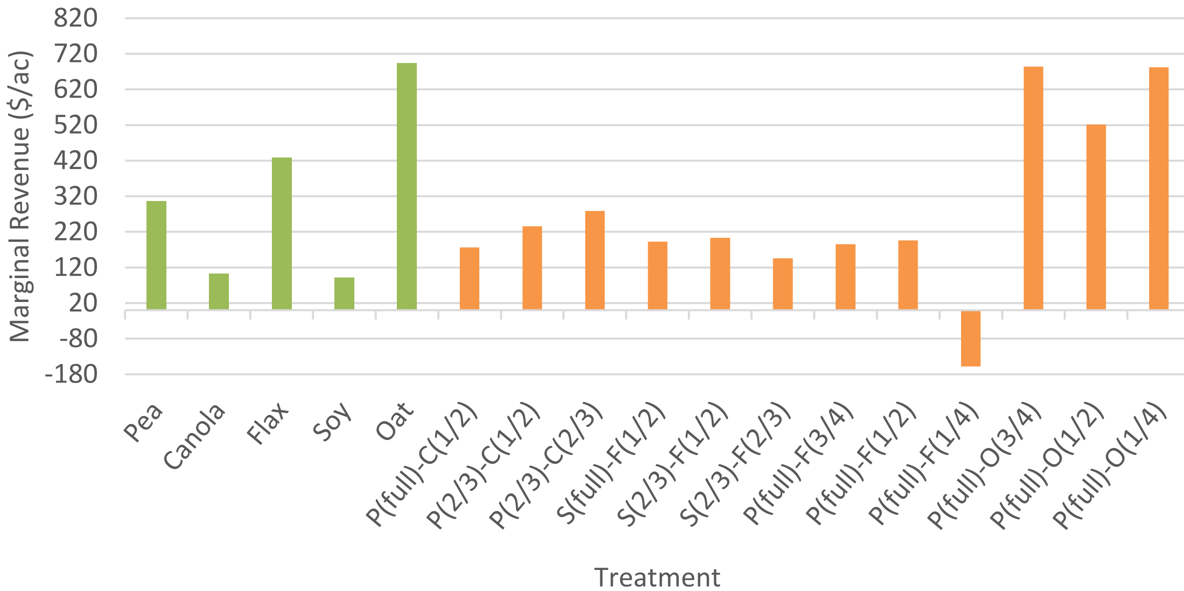


Figure 2. *Average marginal revenue of monocrop and intercrop treatments at Arborg, MB in 2022.*

Project Findings

Highlights of intercrop performance across the four years of study at Arborg (2019-2022) are as follows.

- **Pea-canola** intercrop has consistently over-yielded, with LER from 1.07-1.65. Among the seeding rate treatments, seeding peas at 2/3 rate and canola at ½ to 2/3 rate has resulted in the greatest marginal revenue. Profitability ranking of pea-canola intercropping has been variable but often intermediate between pea and canola monocrops. Flea beetles have been a major constraint for both monocrop and intercrop canola.
- **Soybean-flax** produced an LER >1 in 1 out of 4 years (2022) and has ranged from 0.55-1.31. Profitability ranking of this intercrop has been lower or intermediate compared to soybean and flax monocrops. In 3 out of 4 years, seeding soybean at 2/3 rate and flax at ½ rate has performed better than the other seeding rates.
- **Pea-flax** intercropping has been inconsistent with LER ranging from 0.71-1.49. In 2 out of 4 years, LER has been close to 1.0 and profitability ranking has been similar to monocrop peas and flax. Maintaining a full pea seeding rate and reducing flax to a ¼ or ½ rate has resulted in greater marginal revenue among seeding rate treatments.
- **Pea-oat** intercrops have been the most profitable intercrop on average over the 4 years tested, even in years when LER was below 1. LER has ranged from 0.89 to 1.68. The performance of the seeding rate combinations has been variable year to year. All seeding rates tested maintain a full pea rate with the oat rate ranging from ¼ to ¾.

Although grain varieties were used, forage nutrient analysis was collected to demonstrate the value of using the crop as an alternative feed source.

Table 4. *Forage nutrient analysis of oat monocrop and pea-oat intercrop from Arborg 2022. Samples were collected on July 26, 2022 at pea flowering (R2) and oat heading (inflorescence).*

	Feed Basis	Oat	Full pea, ¾ oat	Full pea, ½ oat	Full pea, ¼ oat
Acid Detergent Fibre (%)	As Fed	35.04	32.90	33.61	31.58
Calcium (%)	As Fed	0.23	0.54	0.40	0.73
Crude Protein (%)	As Fed	14.62	15.29	15.72	17.05
Digestible Energy (Mcal/kg)	As Fed	2.19	2.32	2.29	2.40
Dry Matter (%)	As Fed	88.39	88.98	89.15	89.51
Magnesium (%)	As Fed	0.23	0.31	0.27	0.38
Metabolizable Energy for Cattle (Mcal/kg)	As Fed	1.82	1.93	1.90	1.99
Moisture (%)	As Fed	11.61	11.02	10.85	10.49
Net Energy for Gain (Mcal/kg)	As Fed	0.57	0.65	0.63	0.70
Net Energy for Lactation (Mcal/kg)	As Fed	1.12	1.19	1.17	1.23
Net Energy for Maintenance (Mcal/kg)	As Fed	1.07	1.16	1.14	1.22
Neutral Detergent Fibre (%)	As Fed	52.17	47.65	49.11	41.77
Non-Fibre Carbohydrates (%)	As Fed	12.06	16.43	14.69	21.03
Phosphorus (%)	As Fed	0.25	0.29	0.29	0.28
Potassium (%)	As Fed	3.13	3.21	3.11	2.95
Sodium (%)	As Fed	0.55	0.30	0.44	0.35
Total Digestible Nutrients (%)	As Fed	49.75	52.62	52.03	54.55
Relative Feed Value	Dry Matter	91.67	104.67	100.67	123.33
Total Dry Matter (lbs/ac)	Dry Matter	3337.20	1431.09	1360.63	1125.15

Table 2. *Seeding rates, varieties, seed depth, plant stand, plant height, yield and profit of intercrop treatments in 2022 at Arborg, MB.*

No.	Treatment	Crop	Seed rate strategy	Variety	Seeding rate (seeds/m²)	Plant stand* (plants/m²)	Height (cm)	Yield † (bu/ac)	Land Equivalent Ratio ¥	Gross ‡ revenue ($/ac)	Marginal revenue ‡ ($/ac)	Profit Rank
1	Pea	Pea	Full	AAC Chrome	100	61	84	34.5	1.00	$449	$307	6
2	Canola	Canola	Full	BY 5125 CL	108	11	101	15.4	1.00	$262	$103	15
3	Flax	Flax	Full	CDC Glas	700	361	69	24.2	1.00	$558	$428	5
4	Soybean	Soybean	Full	NSC Watson	49	13	43	13.7	1.00	$219	$92	16
5	Oats	Oats	Full	Souris	355	183	120	150.8	1.00	$754	$693	1
6	Pea-canola	Pea Canola	Full 1/2	AAC Chrome BY 5125 CL	100 54	33 9	67 101	14.4 10.7	1.11	$370	$177	13
7	Pea-canola	Pea Canola	2/3 1/2	AAC Chrome BY 5125 CL	66.7 54	22 12	57 86	10.7 15.3	1.30	$399	$236	8
8	Pea-canola	Pea Canola	2/3 2/3	AAC Chrome BY 5125 CL	66.7 72	30 24	72 99	14.8 15.6	1.44	$458	$279	7
9	Soy-Flax	Soybean Flax	Full 1/2	NSC Watson CDC Glas	49 350	16 208	51 67	10.9 12.5	1.31	$462	$193	11
10	Soy-Flax	Soybean Flax	2/3 1/2	NSC Watson CDC Glas	32.7 350	14 241	50 66	6.4 14.6	1.07	$439	$203	9
11	Soy-Flax	Soybean Flax	2/3 2/3	NSC Watson CDC Glas	33 467	17 406	49 69	5.5 13.2	0.95	$391	$145	14
12	Pea-Flax	Pea Flax	Full 3/4	AAC Chrome CDC Plava	100 525	33 165	73 69	7.9 12.3	0.74	$385	$185	12
13	Pea-Flax	Pea Flax	Full 1/2	AAC Chrome CDC Plava	100 350	40 97	59 65	5.9 13.2	0.71	$379	$196	10
14	Pea-Flax	Pea Flax	Full 1/4	AAC Chrome CDC Plava	100 175	5 49	56 58	No data, plots lost due to flooding				
15	Pea-Oat	Pea Oat	Full 3/4	AAC Chrome Souris	100 266	49 125	73 99	3.7 169.2	1.23	$894	$684	2
16	Pea-Oat	Pea Oat	Full 1/2	AAC Chrome Souris	100 177	33 96	54 117	3.7 131.7	0.98	$706	$522	4
17	Pea-Oat	Pea Oat	Full 1/4	AAC Chrome Souris	100 89	37 46	63 123	10.1 147.7	1.27	$869	$682	3

*Optimum plant stands for monocrops: peas (7-8 plants/ft² or 70-80 plants/m²), canola (5-7 plants/ft² or 50-70 plants/m²), flax (37-56 plants/ft² or 396-599 plants/m²), soybean (4 plants/ft² or 40 plants/m²) and oats (18-23 plants/ft² or 194-248 plants/m²).

† Long-term average crop yields in the Bifrost-Riverton municipality: 38.9 bu/ac peas, 30.1 bu/ac canola, 18.5 bu/ac flax, 30.6 bu/ac soybean and 88.3 bu/ac oats (MASC, 1993-2022). 2022 Crop yields in RM: 38.2 bu/ac peas, 22.2 bu/ac canola, 8.2 bu/ac flax (2021), 30.0 bu/ac soybean and 82.6 bu/ac oats (MASC, 2022).

‡ ***Gross revenue ($/ac)*** = Yield x Market price; ***Marginal revenue ($/ac)*** = Gross revenue – Seed – Fertilizer – Pesticide – Separation ($0.25/bu)
(Market prices from Manitoba Agriculture 2023 Costs of Production: $13.00/bu peas, $17.00/bu canola, $23.00/bu flax, $16.00/bu soybean and $5.00/bu oats)

¥ Land equivalent ratio (LER) = $\frac{\text{yield of intercrop species 1}}{\text{yield of monocrop species 1}} + \frac{\text{yield of intercrop species 2}}{\text{yield of monocrop species 2}}$

Table 3. *Seeding depth, weed control, fertility and general notes/observations of intercrop treatments in 2022 at Arborg, MB.*

No.	Treatment	Crop	Seed rate	Depth	Herbicides/weed control	Fertilizer applied*	General notes and observations
1	Pea	Pea	Full	1.5”	Pre-emerge: Authority 480 In-crop: Odyssey Ultra NXT	15 lbs/ac P_2O_5	First pea aphid recorded July 26. Pea aphid counts reached economic threshold. Sprayed with Matador Aug 26.. Harvested October 11.
2	Canola	Canola	Full	0.75”	Pre-emerge: Authority 480 In-crop: Odyssey Ultra NXT	60 lbs N/ac 15 lbs/ac P_2O_5 15 lbs S/ac	Sclerotinia disease risk very low. Harvested October 19. Very low plant population.
3	Flax	Flax	Full	0.75”	Pre-emerge: Authority 480 In-crop: Basagran Forte, Centurion	15 lbs/ac P_2O_5	Harvested October 11.
4	Soybean	Soybean	Full	1.25”	Pre-emerge: Authority 480 In-crop: Glyphosate 540	15 lbs/ac P_2O_5	Soybean IDC assessment values were low (some yellowing observed). Harvested October 19.
5	Oats	Oats	Full	1.5”	Pre-emerge: Authority 480 In-crop: Buctril M	60 lbs N/ac 15 lbs/ac P_2O_5	Harvested October 19.
6	Pea-canola	Pea Canola	Full 1/2	0.75”	Pre-emerge: Authority 480 In-crop: Odyssey Ultra NXT	15 lbs/ac P_2O_5	First pea aphid recorded July 26. Pea aphid counts reached economic threshold. Sprayed with Matador August 26 to control pea aphids. Harvested October 11 and 19. Very low canola plant population.
7	Pea-canola	Pea Canola	2/3 1/2	0.75”		15 lbs/ac P_2O_5	
8	Pea-canola	Pea Canola	2/3 2/3	0.75”		15 lbs/ac P_2O_5	
9	Soy-Flax	Soybean Flax	Full 1/2	1.25” 0.75”	Pre-emerge: Authority 480 In-crop: Basagran Forte, Centurion	15 lbs/ac P_2O_5	Soybean IDC assessment values were low (some yellowing observed). Harvested October 11 and 19.
10	Soy-Flax	Soybean Flax	2/3 1/2	1.25” 0.75”		15 lbs/ac P_2O_5	
11	Soy-Flax	Soybean Flax	2/3 2/3	1.25” 0.75”		15 lbs/ac P_2O_5	
12	Pea-Flax	Pea Flax	Full 3/4	0.75”	Pre-emerge: Authority 480 In-crop: Odyssey Ultra NXT	15 lbs/ac P_2O_5	First pea aphid recorded July 26. Pea aphid counts reached economic threshold. Sprayed with Matador August 26 to control pea aphids. Harvested October 19.
13	Pea-Flax	Pea Flax	Full 1/2	0.75”		15 lbs/ac P_2O_5	
14	Pea-Flax	Pea Flax	Full 1/4	0.75”		15 lbs/ac P_2O_5	
15	Pea-Oat	Pea Oat	Full 3/4	1.5”	Pre-emerge: Authority 480 In-crop: hand-weeded	15 lbs/ac P_2O_5	First pea aphid recorded July 26. Pea aphid counts reached economic threshold. Sprayed with Matador August 26 to control pea aphids. Harvested October 11 and 19.
16	Pea-Oat	Pea Oat	Full 1/2	1.5”		15 lbs/ac P_2O_5	
17	Pea-Oat	Pea Oat	Full 1/4	1.5”		15 lbs/ac P_2O_5	

*Inoculant (seed placed): Nod XL LQ, Nod Peat (1t) applied for all pea treatments; Optimize ST (1.5t) applied for all soybean treatments.

Background information

Intercropping is the practice of seeding, growing and harvesting two or more crops together. The concept is to utilize crop combinations that complement one another through mechanisms such as resource use efficiency, potentially resulting in over-yielding and greater profitability compared to monocropping. Careful consideration needs to be given to how the crops are seeded, managed, harvested, and separated. The most common intercrop grown commercially in Manitoba is pea-canola. Beginning in 2019, we started to test pea-canola, soybean-flax, pea-flax and pea-oat intercrop combinations at Arborg, MB. For each intercrop combination, 2-3 seeding rate ratios were tested and compared to pea, soybean, canola, flax and oat monocrops.
To assess the productivity of intercrops compared to their component crops grown in monoculture, the land equivalent ratio (LER) is used. LER is a ratio of the individual crop yields from the intercrop divided by the respective monocrop yield. It is desirable to achieve a LER > 1 which indicates over-yielding (more land would be required to produce the same yield with individual monocrops compared to the intercrop). Gross and marginal revenues are also calculated because seasonal growing conditions and market prices are important variables that affect the productivity, yield and economic return of cropping in a given year. Evaluating intercrops on LER alone can be misleading when monocrop yields are exceptionally low.

Materials and Methods

The intercropping trial was seeded into canola stubble on June 08, 2022 at Arborg, MB with a plot seeder (R tech double disc) on 9” row spacing. All intercrops were seeded in the same, mixed row except soybean-flax where soybean was seeded down the mid-row fertilizer tube to achieve row separation (4.5”). Soil type at the research site is a heavy clay (Fyala series) and background soil test levels were 260 lbs N/ac and 19 ppm P_2O_5. Specific agronomic practices used for each intercrop treatment are listed in Tables 2 and 3. The experimental design is a RCBD with three replicates.

Table 1. *Seasonal growing degree-days, crop heat units, precipitation, and temperature at Arborg in 2022 (in brackets, % of normal GDD, CHU, rainfall & mean daily temp).*

	May	***June***	***July***	***August***	***May-August***
*Growing degree days**	*176 (86%)*	*333 (99%)*	*503 (116%)*	*470 (122%)*	*1484 (109%)*
*Crop heat units**	*295 (80%)*	*545 (96%)*	*741 (104%)*	*702 (110%)*	*2285 (100%)*
*Precipitation, mm**	*112 (211%)*	*116 (149%)*	*186 (308%)*	*39 (49%)*	*454 (168%)*
Mean daily temperature, °C	*10.4 (10.0)*	*16.1 (15.8)*	*21.2 (18.6)*	*20.2 (17.5)*	*17.0 (15.5)*

†Long-term average daily temperature in Arborg (climate.weather.gc.ca, 1981-2010)
Sources: https://web43.gov.mb.ca/climate/SeasonalReport.aspx

Figure 3. *Pea-Canola treatment (plot 215) taken on August 11, 2022*

Figure 4. *Soybean-Flax treatment (plot 212) taken on August 11, 2022.*

Figure 5. *Pea-Flax treatment (plot 206) taken on August 11, 2022.*

Figure 6. *Pea-Oat treatment (plot 201) taken on August 11, 2022.*

Evaluating Warm / Cool season Grasses with Legumes for Forage Production

Project Duration: 2022 & ongoing

Objectives

To evaluate different cereal-legume intercrops for forage yield potential as compared to when they are grown as mono crops.

Results

These results are based on only one replication as the other two replications were wiped out by spring flooding. Hairy vetch had poor yield when grown alone or intercropped with cereal grasses. In mono crops, Italian ryegrass, berseem clover and Proso millet had lower forage yield than Oats, Barley and Japanese millet during first cut (Fig 1).
When berseem clover and hairy vetch were grown with warm season cereals (Italian ryegrass, Proso & Japenese millet), it resulted in greater forage yield than mono crops of these cereal grasses. However, it did not result in greater forage yield when these legumes were grown with oats and barley.

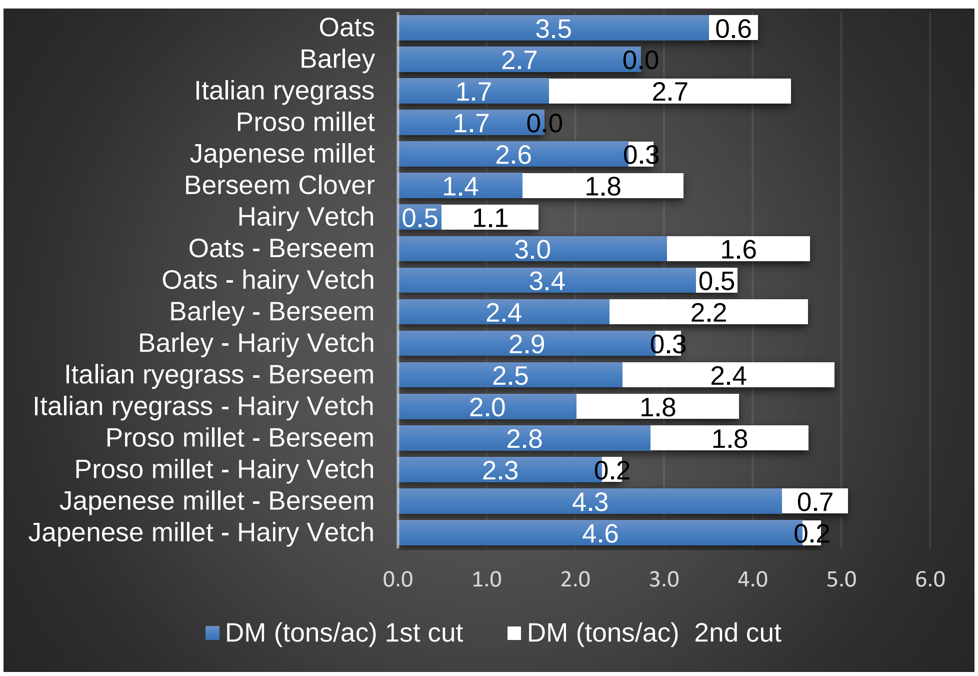


Fig 1. Dry Matter Forage yield of grass & legume monocrops & intercrops tested in Arborg during 2022.

During second cut, Italian ryegrass and berseem clover had good forage yield both as mono crops as well as when grown together. Berseem clover grew nicely in most intercropping treatments during second cut. Both berseem clover and Italian ryegrass tolerated mild frost in the fall whereas Japanese and Proso millets did not.

Project Findings

Excess moisture after seeding proved to be detrimental to many plots in the test. Proso millet did not establish well in wet soil conditions (Fig 2). Baltensperger (1996) also reported that it does not grow well under water stress due to shallow root system. It headed out earlier and that might have contributed in reducing yield potential in comparison to other cereal species.

Similarly, Hairy vetch did not establish well during the test both in mono and intercrop plots. On the other hand, other cereals like oats, barley, Japanese millet and Italian ryegrass had good plant establishment in the wet soils. Berseem clover seems to like moist soils.

Oats, Barley and Japanese millet produced relatively good forage yield during first cut when grown as mono crops. Italian ryegrass had lower yield during the first cut but it regrew very well in the second cut. It tolerated mild fall frost in contrast to Japanese millet which did not survive the frost.

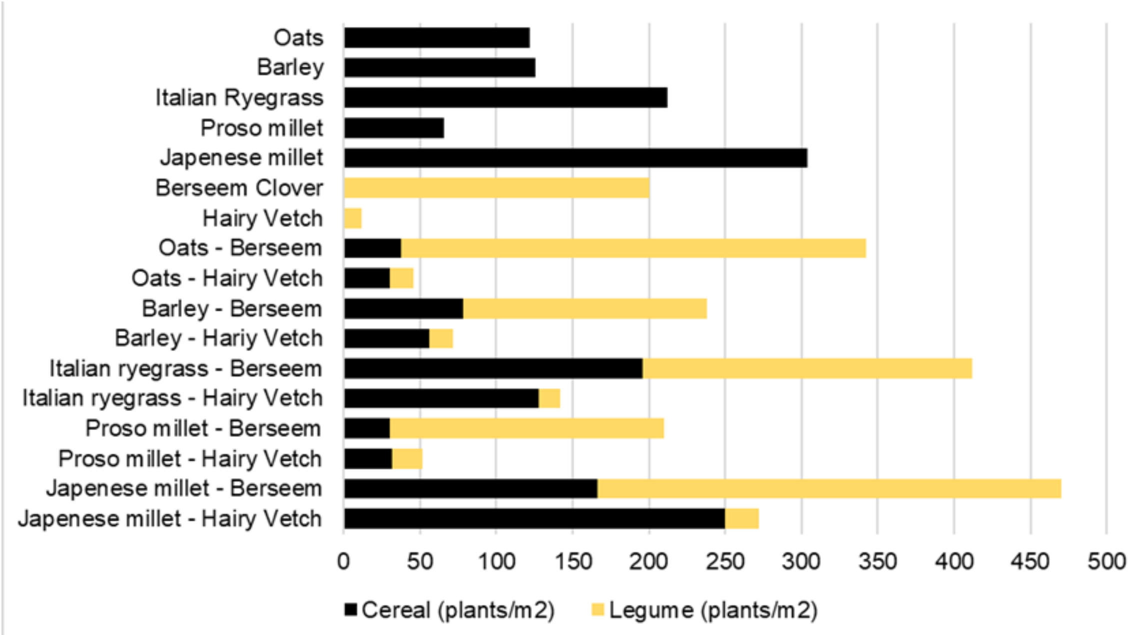


Figure 2. Plant establishment (no of plants / m²) of different forage species at Arborg site during 2022.

Generally, Intercropping increased forage yield for mixtures with warm season grasses but not with cool season cereals (oats, barley). Berseem clover grew well during the second cut both in mono and intercrop plots. This clover also tolerated mild frost in the fall.

This preliminary study will help in refining our selection of forages and forage mixtures for the 2023 season. We found Italian ryegrass – berseem clover intercrop as a good option for second cut forage production as both crops can tolerate mild frost events. More research will be planned on these combinations during 2023 to see forage potential and soil health benefits.

Background / References / Additional Resources

Annual forage crops can be used as a good source of quality forage. There are many annual crops and options available to producers but these choices also depend on the weather conditions. There is evidence that cool and warm season annual cereals differ in their yield potential depending on the crop season (McCartney *et al.* 2009). If the growing season is cool and wet, it benefits oats and barley. However, when it is warm and wet, it favours some of the millets.

In Alberta, Omokanye *et al.* (2019) compared annual crop mixtures and monoculture cereal crops (controls) for forage yield and quality for beef cattle production. They suggested that growing an annual crop mixture with diverse plant functional groups compared to a monoculture cereal, can be used to improve forage production.

In the current study, we compared different cool & warm season cereals with hairy vetch and berseem clover for their forage potential. Warm season cereals used in the study have the following characteristics:

Proso millet - Proso millet has a panicle type seed head, awns, coarse stems and is less leafy than foxtail millet, and consequently has a lower palatability for grazing than foxtail millets (McCartney *et al.* 2009). Proso millet may grow from 50 to 150 cm high, is a short-season crop with a low water requirement, and grows further north (up to 54N) than the other millets. Compared with foxtail millets, proso millet is quite prolific with volunteer plants, has more aggressive seedling vigour and quickly covers the ground to out-compete weeds.

Japanese millet - Japanese millet is coarser and grows more rapidly under cool conditions than foxtail millet (McCartney *et al.* 2009). Seedlings establish quickly and tiller profusely, and it could be grown on waterlogged soils and survived short periods of submersion (Koch and Mitchell 1988). It does not show characteristics that are suitable for extending the grazing season in the prairies.

Italian ryegrass - Italian ryegrass is a biennial originating from northern Italy. It is leafy and tillers readily, which makes it suitable for pasture and green manure. This crop does not usually set seed, and will not overwinter in western Canada (McCartney *et al.* 2008).

References

1. McCartney, D., Fraser, J. and Ohama, A. (2009) Potential of warm-season annual forages and *Brassica* crops for grazing: A Canadian Review. *Can. J. Anim. Sci.* 89: 431- 440.
2. Omokanye, A., Lardner, H., Sreekumar, L., and Jeffrey, L. (2019) Forage production, economic performance indicators and beef cattle nutritional suitability of multispecies annual crop mixtures in North western Alberta, Canada. *Journal of Applied Animal Research* 47: 303-313.
3. Koch, D. W. and Mitchell, J. R. (1988) Potential of Japanese millet as an initial crop in a no-till forage renovation program. *Agron. J.* 80: 471 - 474.
4. McCartney, D., Fraser, J. and Ohama, A. (2008) Annual cool season crops for grazing by beef cattle. A Canadian Review. *Can. J. Anim. Sci.* 88: 517 - 533.
5. Baltensperger, D.D. (1996) Foxtail and proso millet. p. 182–190. In J. Janick (ed.) *Progress in new crops.* ASHS Press, Alexandria, VA.

Materials and methods

Experimental design – Randomized complete block design
Replications: Three, but two of them were drowned out.
Treatments –

Five cereals: Japanese millet (*Echinochloa esculenta*), Proso Millet (*Panicum milaceum*), Italian ryegrass (*Lolium multiflorum*), Barley (*Hordeum vulgare*), Oats (*Avena sativa*).

Two legumes: Berseem clover (*Trifolium alexandrinum*), Hairy vetch (*Vicia villosa*)

Plot size – 8.22m^2
Data collected – plant stand, plant height, forage yield

Agronomic information

Stubble, soil type: wheat, Heavy clay
Fertilizer applied: N -20 lb /acre; P - 20 lb/acre (at seeding)
Seeding date: June 9, 2022
Seeding rate: Oats (100 lbs/ac), Barley (120 lbs/acre), 20 lbs/ac for Japanese milet, Proso millet & Italian Ryegrass; Berseem clover (10 lbs/ac) & Hairy vetch (25 lbs/ac).
For intercropping plots, 75% of the mono crop seeding rates were used.
Harvesting date: 1st cut- Aug 15, 2022, 2nd cut - Sept 28th 2022

Teff Forage Evaluation

Project Duration: May 2021 – October 2022

Objectives: To evaluate different seeding rates of teff for forage production potential

Collaborators: Parkland Crop Diversification Foundation, PESAI

Background

Teff *(Eragrostis tef)* is a warm-season annual grass that originates in northeast Africa, where it is grown for grain and forage production. As a forage, the crop is notable for its high protein content and palatability, as well as its potential for high yields. The crop is relatively new to Manitoba. For a detailed examination of teff forage nitrogen and irrigation requirements, see this Pacific Northwest Extension Publication.

This report is for the period of 2021-2022. In 2021, the test was done at Roblin and examined the yield potential for teff forage, seeded at 5 lb/ac and 7 lb/ac. This was compared with the yield for barley greenfeed. Two cuts were taken for both seeding rates, and all treatments were tested for nutrient values.

In 2022, the test was done at Roblin and Arborg sites, and included seeding rates of 4 lb/ac, 5 lb/ac, 6 lb/ac and 7 lb/ac. Two cuts of forage were taken for each seeding rate. Additionally, a single late cut treatment was also kept (for all 4 seeding rates) for comparisons. Roblin site was also able to harvest teff grains in early October.

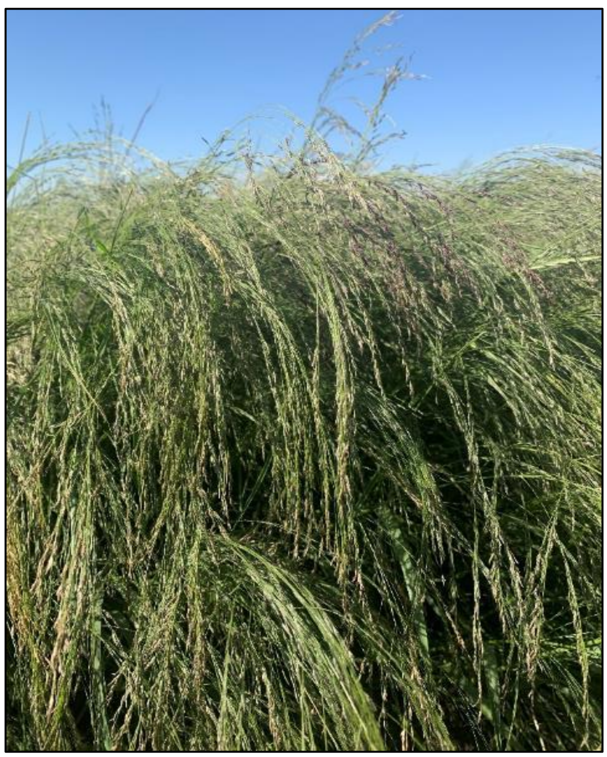


Figure 1: (a) 1st cut teff hay (Roblin, July 15, 2022) (b) 2nd cut teff hay (Roblin, Sept 28, 2021)

Figure 2: (a) 2nd cut teff hay (Roblin, Sept 28, 2021) *(b) 1st cut teff hay (left) and 2nd cut teff hay (right)*

Results

Total hay yields (15% moisture) for Roblin site are shown in Figure 3, along with the average barley green feed (single-cut) yield. In 2021, barley yield was signifincalty lower than teff treatments. However in 2022, barley greenfeed yields were greater than hay from any of the teff seeding rate treatment. When teff seeding rates were compared for forage yield from single late cut (green bars), there was no difference. In dual cut (orange & brown bars) treatments, forage yields were signifincalty lower when teff was planted at seeding rate of 7 lbs/ac. Single late cut yielded lower forage than dual cut system irrespective of any seeding rate used.

Arborg results are shown in figure 4. Barley forage yield was significantly higher than forage from any of the teff seeding rate treatment. Dual cut system (orange & brown bars) consistently produced greater forage yield than single late cut (green bars) system irrespective of any seeding rate used. Seeding rate of teff did not have any effect on forage yield.

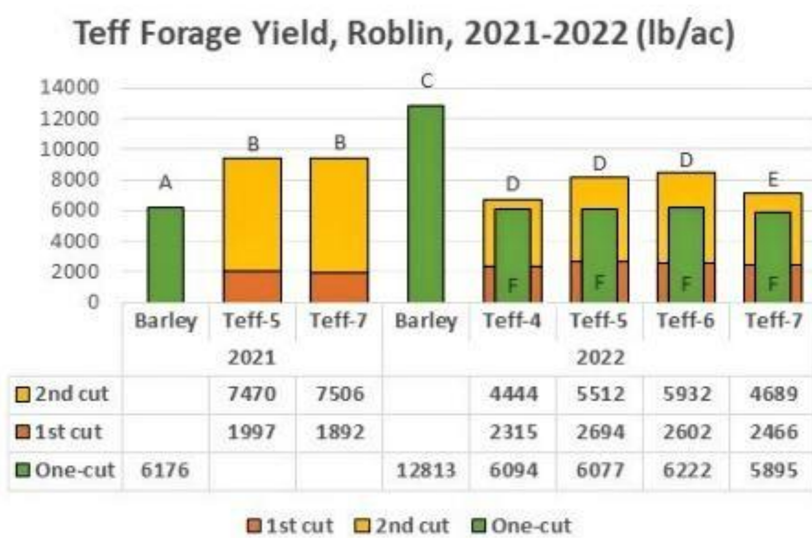


Figure 3: Roblin 2021-2022 yield (lb/ac, 15% moisture) for 1st cut, 2nd cut, and single-cut teff by seeding rate (lb/ac), plus yield for barley greenfeed for comparison.

Table 1 shows the cost per treatment, including the cost of cutting the hay. Table 2 shows the feed values for teff and barley treatments by cut, as well as animal feed requirements for beef. Table 3 shows mineral content by treatment.

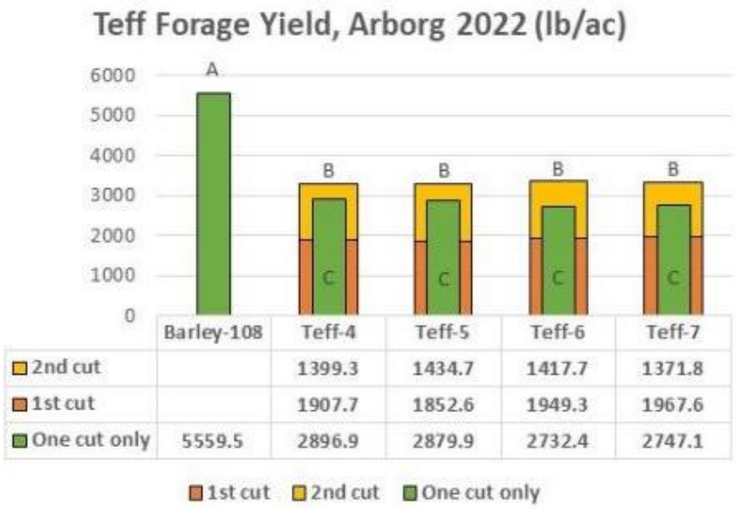


Figure 4: Arborg 2022 yield (lb/ac, 15% moisture) for 1st cut, 2nd cut, and single-cut teff by seeding rate (lb/ac), plus yield for barley greenfeed for comparison.

Table 1: Cost of production by treatment for teff and barley by seeding rate and cut

Treatment	***Seeding cost ($/lb)***	***Seeding rate (lb/ac)***	***Cutting cost ($/ac)****	***Seeding plus cutting cost ($/ac)***
Barley (single cut)	*0.29*	*108*	*17.55*	*49.05*
Teff (single cut)	*4.99*	*4*	*17.55*	*37.51*
		5		*42.50*
		6		*47.49*
		7		*52.48*
Teff (Two cuts)	*4.99*	*4*	*35.10*	*55.05*
		5		*60.04*
		6		*65.03*
		7		*70.02*

* *Based on an average of costs for disc bine and sickle mower cuts from the Manitoba Agriculture Cost of Production for Farm Machinery.*

*Table 2: Feed values for teff and barley by cut compared to animal feed requirements**

Entry	*% Crude Protein*	*% TDN*
Teff 1st cut	*20.9*	*69.2*
Teff 2nd cut	*11.4*	*59.9*
Barley	*10.5*	*69.9*
*Animal feed requirements***		
Mature cows		
Mid gestation	*7*	*50-53*
Late gestation	*9*	*58*
Lactating	*11-12*	*60-65*
Replacement heifers	*8-10*	*60-65*
Breeding bulls	*7-8*	*48-50*
Yearling bulls	*7-8*	*55-60*

** Feed values from Central Testing Laboratory, Winnipeg, ** Animal feed requirements developed by Elisabeth Nernberg (Manitoba Agriculture).*

*Table 3: Mineral content for feed by treatment**

Treatment	Mineral									
	(%)					(ppm)				
	Ca	P	Mg	Na	K	Mo	Cu	Zn	Mn	Fe
Teff (1st cut)	0.77	0.22	0.16	0.04	2.25	2.41	9.00	21.36	26.10	138.15
Teff (2nd cut)	0.51	0.23	0.24	0.02	1.62	1.20	4.72	20.05	22.82	110.44
Barley	0.33	0.21	0.14	0.26	1.49	1.17	3.60	17.27	23.80	90.55

** Central Testing Laboratory, Winnipeg*

Observations

In 2021, the yields for barley greenfeed averaged about half of the barley yields for 2022, largely due to the exceptionally dry growing conditions and poorly timed precipitation at Roblin site. Nevertheless, the teff was able to thrive in these conditions, and yielded well.

In 2022, better growing conditions for barley resulted in good yields. Despite improved moisture conditions, the teff yields were lower (in Roblin) than in 2021, likely due to lower overall heat units (about 93% of 2021). This reflects teff's preference for heat, but also indicates that it is tolerant of both dry and wet growing conditions.

The timing and number of hay cuttings impact not only hay quantity and quality, but also the overall cost of production. More cuttings cost more, but with the advantage providing more yield. Timing of the second teff cutting is important. At Roblin and Arborg, the first cut was in mid- to late-July. However, the second cut in Arborg (Aug 23, 2022) occurred more than one month before the second cut in Roblin (Sept 28, 2021 and Oct 6, 2022). This likely explains the relatively lower yields observed for the second cut in Arborg.

The individual costs for the different treatments (Table 1) are used to identify the relative cost of production, which shows the cost of producing each treatment, relative to the cost of producing barley greenfeed. Because different amounts of land are required to achieve the same relative yield, the cost of land has been included, estimated at $60/acre. The cost to produce the same amount of hay, TDN and protein at Roblin (relative to barley greenfeed) in 2021 is shown in Figure 5. The costs for Roblin in 2022 are shown in Figure 6, and for Arborg in Figure 7.

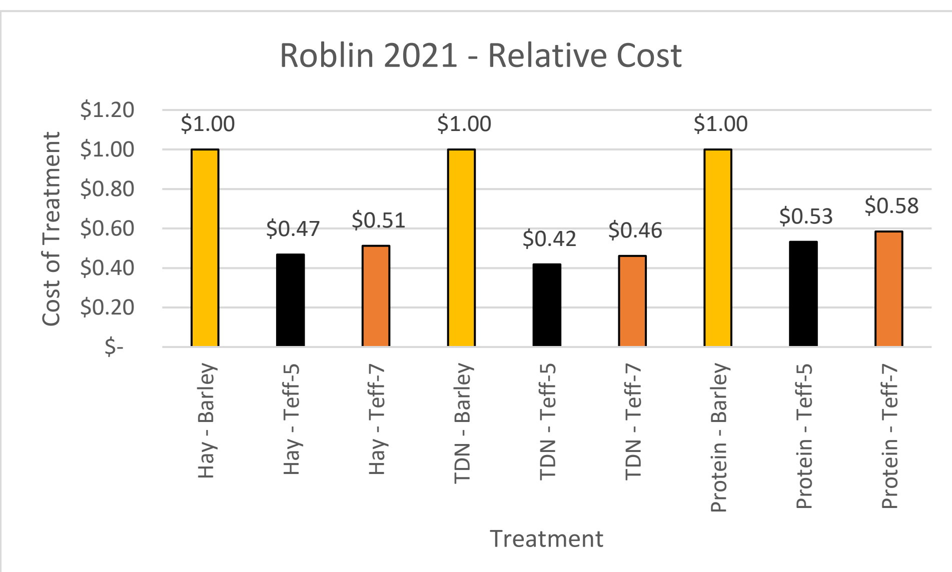


Figure 5: Roblin 2021 relative cost of production for hay, TDN and protein, including cost of seed, cutting, and land rental (estimated at $60/acre). Comparison is for barley greenfeed.

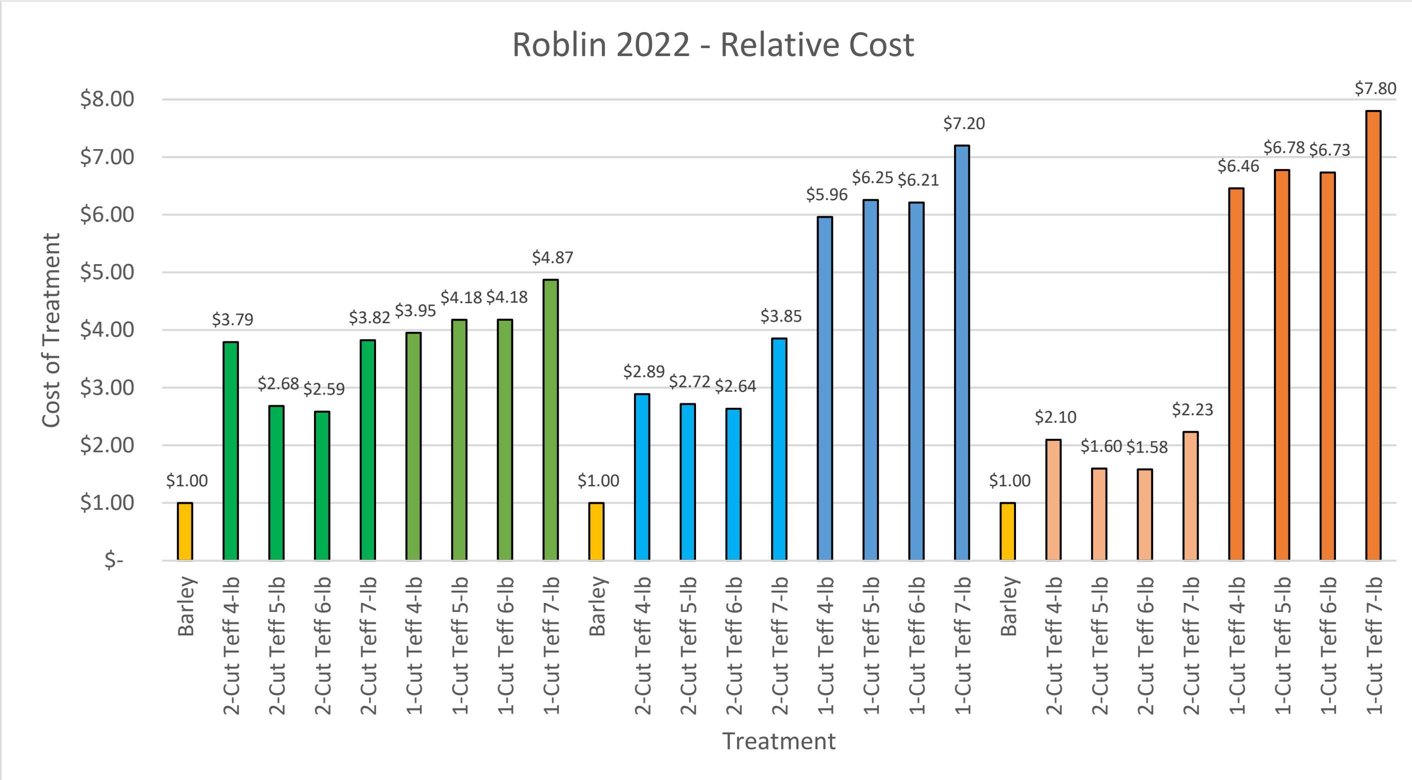


Figure 6: Roblin 2022 relative cost of production for hay (green bars), TDN (blue bars) and protein (orange bars), including cost of seed, cutting, and land rental (estimated at $60/acre). Comparison is for barley greenfeed.

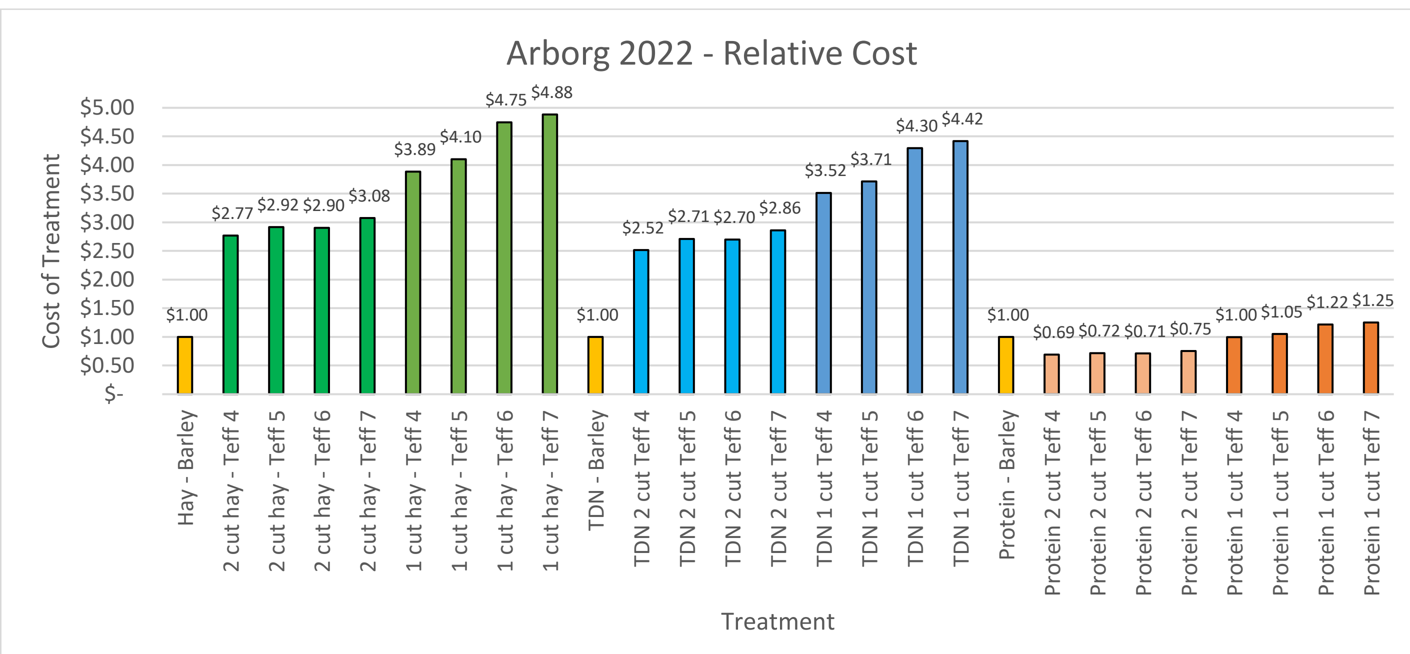


Figure 7: Arborg 2022 relative cost of production for hay, TDN and protein, including cost of seed, cutting, and land rental (estimated at $60/acre). Comparison is for barley greenfeed.

The relative cost of production is highly influenced by the yield of barley greenfeed. In 2021, when dry conditions resulted in low barley yields, the relative cost of production for teff was low (about half the cost of barley greenfeed). However, under the more favorable conditions for barley in 2022, the relative cost for producing teff increases considerably. The only category in which the cost of production for teff compared favorably to barley in 2022 was for protein in a two-cut system. In fact, the cost of production for protein at Arborg was lower for teff than for barley. Further, although barley greenfeed provided more protein overall than some treatments, because of the lower concentration in the forage, animals would have to consume more forage to obtain the same amount of protein. This highlights the strategic role that teff may play for some producers as a source of high quality forage.

Note that the cool temperatures at Roblin at the time of the second cut resulted in elevated levels of nitrates (0.5 percent). Producers should consult a livestock specialist and exercise caution when feeding forage with high nitrate content to livestock to avoid exceeding safe levels.

The large difference in performance between 2021 and 2022 shows that more testing is needed before conclusions can be drawn about the performance of teff for forage. Additionally, testing is needed to identify the agronomic best management practices, including seeding date and fertility.

Materials & Methods

Table 4: Activities and dates.

	PCDF		PESAI
	2021	2022	2022
Seeding	May 14	May 26	June 10
1st cut (teff)	July 15	July 28	July 15
2nd cut (teff)	Sept 28	Oct 6	Aug 23
Single cut (teff)		Oct 6	Aug 23
Barley	Aug 11	Aug 4	Aug 8

Table 5: 2022 Fertility Information.

	Available	Added	Type
PCDF			
N	120 lb/ac	10 lb/ac	46-0-0
P	52 ppm	10 lb/ac	11-52-0-0
K	670 ppm		
PESAI			
N	61lb/ac	50 lb/ac	46-0-0
P	50lb/ac	15 lb/ac	11-52-0-0
K			

No herbicide applied (hand weeded)

Soil Temperature as affected by Drainage Spacing in Heavy Clay Soils of Manitoba

Project Year - 2022

Objectives

To assess the effect of sub-surface tile drainage on the soil temperature at two soil depths: 1 inch (seeding depth) and 6 inch (rooting depth) in the spring.

Results

Soils were cooler at 6-inch depth than at 1-inch during the entire period of study (Fig 1-4). When the weekly soil temperature data were analysed, there were no differences among drainage treatments and non-tiled plots except during June 13-17, when 30 and 45 feet drainage plots had warmer soils (at 6-inch depth in the afternoon; Fig 4) than non-tiled plots.

Soil temperature differences between drainage treatments and non-tiled plots were more evident at 1-inch depth than at 6-inch depth (Fig. 5). Air temperature fluctuations near the soil surface might have an impact on soil temperature at 1-inch depth. A difference of almost 2°C were recorded between tiled and non-tiled plots at certain dates when measured at 1-inch soil depth. These differences in soil temperature were quite less (about 0.8°C) at soil depth of 6-inch. A dry spell during the first few days of June coincided with relatively warmer tiled plots at both soil depths (Fig. 5).

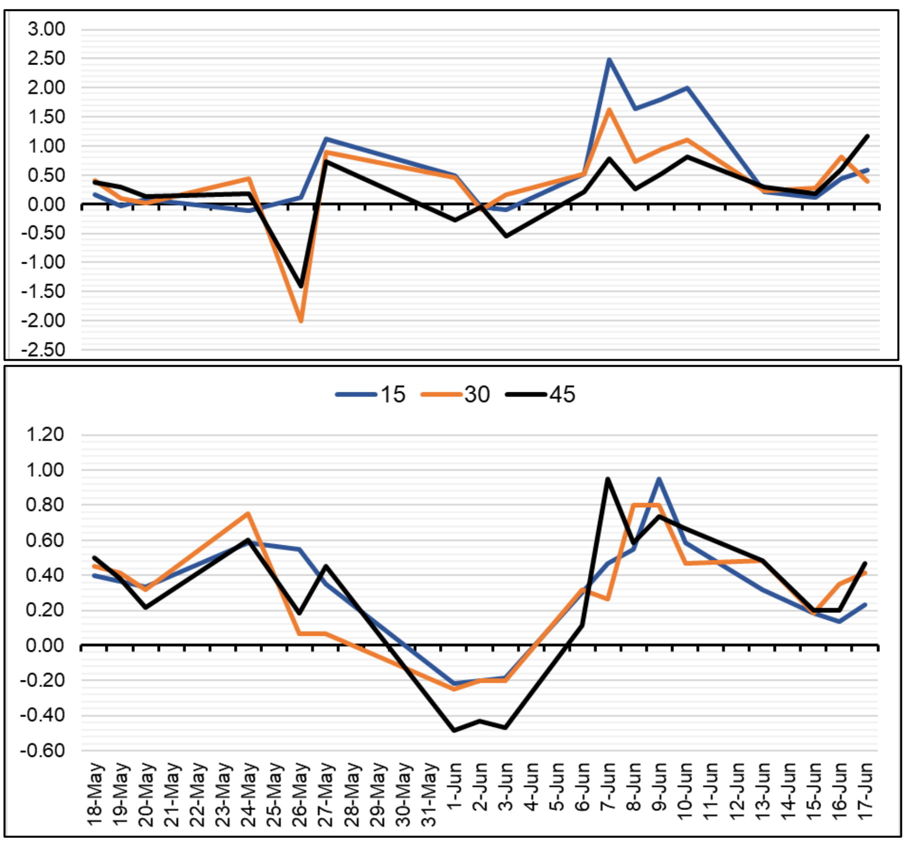


Fig 5. Soil temp differences (°C) between tiled (tile spacings of 15', 30' & 45') and non-tiled plots at 1 inch (upper) & 6 inch (lower) soil depths.

Project Findings

Drainage plots were relatively warmer than non-tiled plots but this trend was not consistent during the course of the study. Statistical significant differences in soil temperature were recorded only in the last week of study (June 13-17).

During the period of study, PESAI site received 187% of the normal rainfall. This exceptionally high rainfall might have some role in lack of temperature differences among drainage treatments and non-tiled control plots. Foth (1990) reported that removal of soil water caused soil to warm up more quickly in the spring. Miller and Donahue (1990) stated that if the

Fig 1: Soil temp (C) comparisons among tiled vs non-tiled plots at 1-inch depth between 8.30-9am.

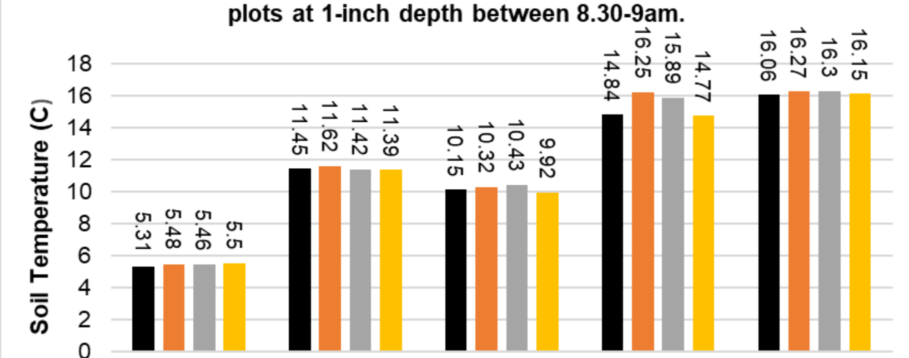


Fig 2: Soil temp (C) comparisons among tiled vs non-tiled plots at 6-inch depth between 8.30-9am.

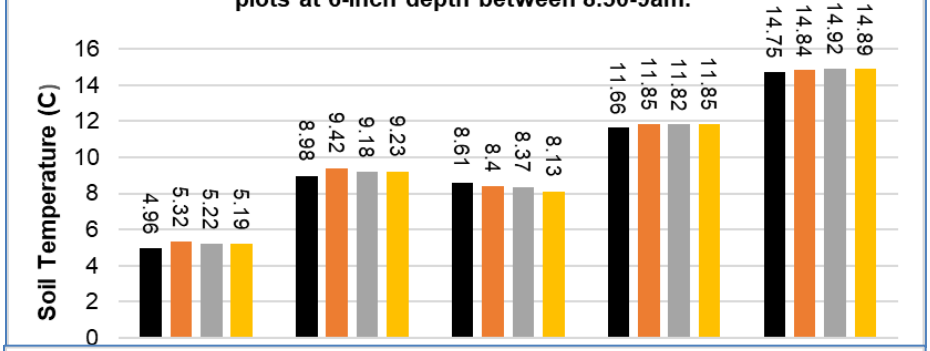


Fig 3: Soil temp (C) comparisons among tiled vs non-tiled plots at 1-inch depth between 3.30-4pm

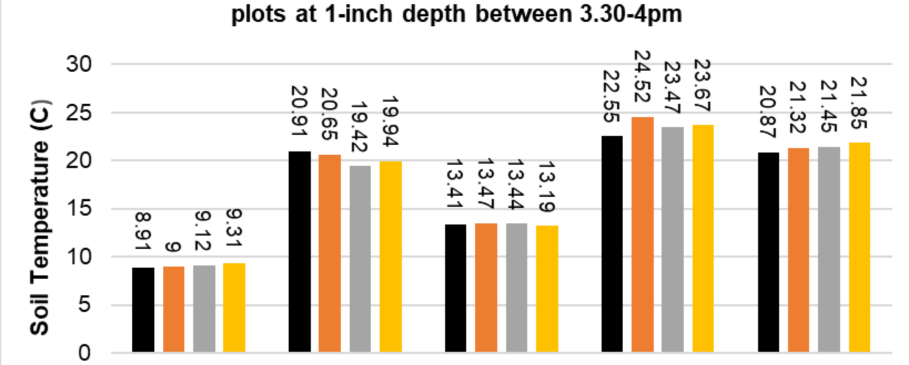
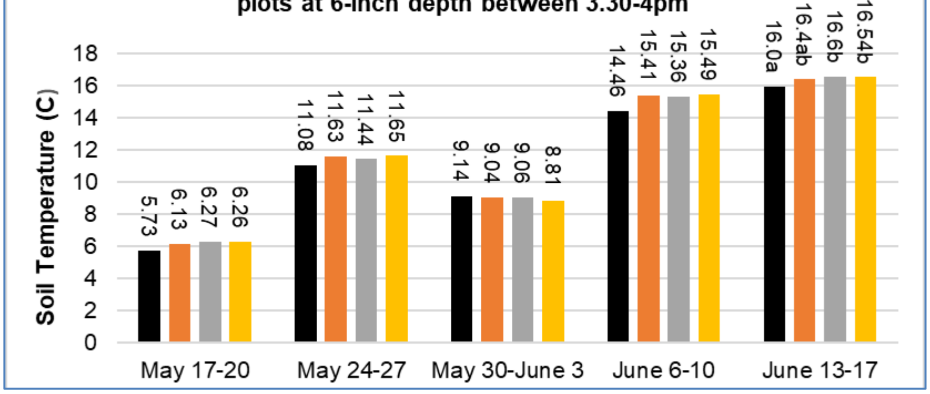


Fig 4: Soil temp (C) comparisons among tiled vs non-tiled plots at 6-inch depth between 3.30-4pm



soil water content is high, much more heat is needed for temperature change because the heat capacity of water is three to five times more than for soil minerals. This phenomenon is noticed in the current study when tiled plots (irrespective of drainage spacing) were relatively warmer in the dry spell occurred during early June.

During 2023, PESAI is planning to extend measurements to deeper soil layers for soil temperature differences. PESAI is also planning to extend this study throughout the crop season to examine soil temperature variations on the tiles.

Background

Removal of excess moisture or water in a waterlogged agricultural field facilitate timely field operations such as seeding and spray. Simultaneously, drainage either natural or artificial decreases heat capacity of the soil, raises soil temperature, thereby warms up and dries the soil quickly. Soil temperature governs the types and rates of chemical reactions in the soil. It also strongly influences biological processes, such as seed germination, seedling emergence and growth, root development, and microbial activity in the soil.

Tile drainage is considered an important agriculture practice to remove excess water or soil moisture from saturated agricultural fields. Tile drainage practice is quite common in Mid-west and Northern Great Plains of United States. In Canada, this practice is common in Quebec and Ontario. In Manitoba, tile drainage is not common in Red River Basin. On top of that, clay content of 70-80 %, makes it worse in the Interlake region of Manitoba.

A common axiom among drainage practitioners is that tile drainage increases spring soil temperatures in cold and humid climates. In Minnesota, Jin *et al.* (2008) evaluated the influence of different tile spacing's (narrow vs. wide tiles) on soil temperature at various soil depths during cropping season. They concluded that soil temperature differences (especially in May / June) were more evident on narrow tiles and in the fine textured soil. These researchers attributed temperature differences between a wet soil and a dry soil to soil type rather than soil moisture content. The greatest observed increases in soil temperature occurred during May and June, with a maximum temperature increase of about 4 °C. The most significant temperature increases occurred at 30 and 60 cm depths. Temperature differences at these depths were coincidental with the depths at which the largest observed differences in shallow water table occurred between drained and undrained treatments.

This hypothesis regarding influence of drainage spacing on soil temperature in heavy clay soils has not been tested in Manitoba. PESAI site in Arborg has heavy clay soil with clay content of 70-80%. This site has three drainage spacings (15', 30' and 45' wide tiles) with replicated plots. This study was conducted from mid May to mid June to investigate soil temperature differences (in top 6 inches) between tiled and untiled plots.

References

1. *Jin, C. X., Sands, G. R., Kandel, H. J., Wiersma, J. H., & Hansen, B. J. (2008). Influence of subsurface drainage on soil temperature in a cold climate. Journal of Irrigation and Drainage Engineering, 134(1), 83-88.*

2. *Foth, H. D. (1990). Fundamentals of soil science, Wiley, New York*

3. Miller, R. W., and Donahue, R. L. (1990). Soils: An introduction to soils and plant growth, 6th Ed., Prentice-Hall, Englewood Cliffs, N.J.

Materials and Methods

The experimental treatments were comprised of non-tiled treatment and three subsurface drainage spacings: 15, 30 and 45 feet. Each treatment has three replicated plots. A fixed spot was used on each plot to take temperature measurements daily during May 17- June 17. On tiled plots, temperature was measured on the tiles. A thermocouple was poked into soil surface at 1 and 6 inch depths and measurements were taken using OMEGA HH101 reader. During morning, measurements were taken during 8.30-9am where as afternoon measurements were taken during 3.30-4pm.

Soil temperatures were evaluated at the two measurement depths for all drainage treatments and compared with non-tiled plots. ANOVA was used to test the significance of the soil temperature differences at each measurement depth, among the drainage treatments.

MCVET Annual Forages

Project Year - 2022

Collaborators

- MCVET
- Shawn Kabak & Tim Clark, Manitoba Agriculture

Objectives

To test registered varieties of annual forages for yield and feed quality.

Results

Sorghum, Peas/oats mixture (CDC Lewochko – CDC Arborg), and spring triticale were the top performers in respect to dry matter forage yield (Fig 1). Red proso millet, golden german millet and AB Hague variety of barley had significantly lower forage yield. Sorghum had the lowest crude protein content. Barley varieties and red proso millet had higher total digestible nutrients.

Project Findings

Forage species differed in dry matter forage yield when tested at Arborg site. Red Proso Millet had the lowest yield whereas Sorghum and Peas/Oats intercrops produced higher forage yield. With a very wet spring in Arborg, some of the millets seemed to not grow much and entered into reproductive mode earlier.

Background / References / Additional Resources

Cool season annual forage crops such as oats, fall rye, rye grass, barley, wheat, winter triticale, winter wheat are being used and researched extensively in Canada. (McCartney *et al.* 2008). Warm season annual forage crops include corn, sorghum, sorghum-sudan, millets, brassica crops, hybrids, turnips and other root crops are being considered as potential and need to be researched for forage use in Canada (McCartney *et al.* 2009). Grazing season in the Prairies had been extended by some farmers with the adoption of methods such as stockpile grazing, swath grazing, bale grazing and corn grazing over the winter (Hewitt *et al.* 2016). A study done by May *et al.* (2007) in south western Saskatchewan found that warm season species such as Golden German foxtail millet yielded similar forage biomass to oats and barley under normal conditions. On the other hand, this study also concluded that warm season crops of sorghum-sudangrass are not suitable for swath grazing in Saskatchewan due to poor and inconsistent emergence at either early (May 15) or late (June 10) seeding dates. However, sorghum –Sudan grass and Proso millets had advantage over corn for their drought tolerance (McCartney *et al.* 2009).

Proso millet is considered advantageous to replace a failed seeded crop as it matures rapidly. Oats and barley dry forage yield were out yielded by Proso and Crown millet forage dry matter yields under moderate precipitation and by Golden German foxtail millet yields under high precipitation. In addition, crude protein (CP) concentration of Proso, Crown and Golden German foxtail millet (93-97 g kg-1 DM) were sufficient to meet nutritional requirements for cattle winter grazing and weathering in the swath did not reduce feed quality (May *et al.* 2007).

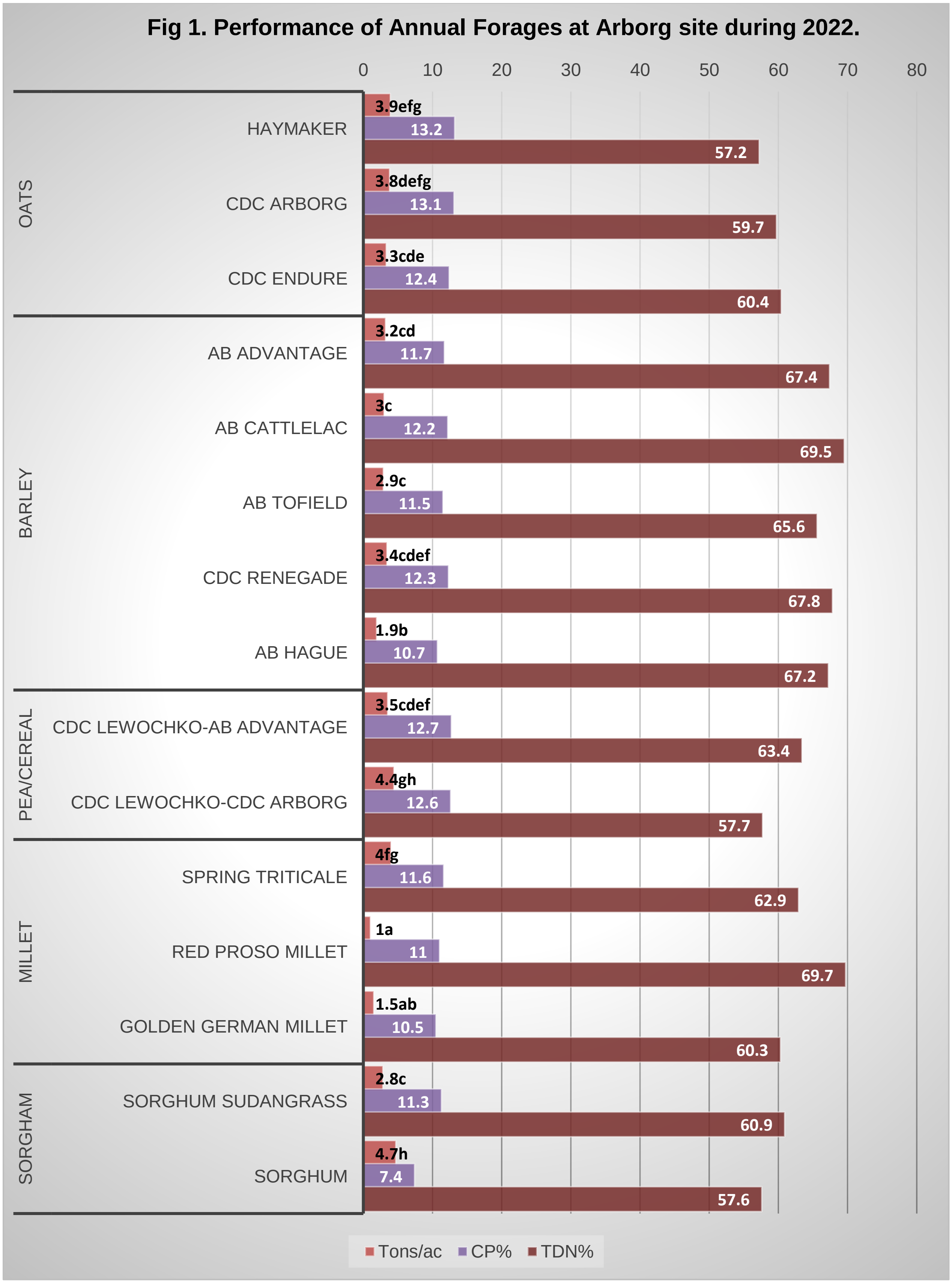


Fig 1. Performance of Annual Forages at Arborg site during 2022.
0
10
20
30
40
50
60
70
80
OATS
HAYMAKER
3.9efg
13.2
57.2
CDC ARBORG
3.8defg
13.1
59.7
CDC ENDURE
3.3cde
12.4
60.4
BARLEY
AB ADVANTAGE
3.2cd
11.7
67.4
AB CATTLELAC
3c
12.2
69.5
AB TOFIELD
2.9c
11.5
65.6
CDC RENEGADE
3.4cdef
12.3
67.8
AB HAGUE
1.9b
10.7
67.2
PEA/CEREAL
CDC LEWOCHKO-AB ADVANTAGE
3.5cdef
12.7
63.4
CDC LEWOCHKO-CDC ARBORG
4.4gh
12.6
57.7
MILLET
SPRING TRITICALE
4fg
11.6
62.9
RED PROSO MILLET
1a
11
69.7
GOLDEN GERMAN MILLET
1.5ab
10.5
60.3
SORGHAM
SORGHUM SUDANGRASS
2.8c
11.3
60.9
SORGHUM
4.7h
7.4
57.6
Tons/ac
CP%
TDN%

Under Manitoban conditions, Hewitt *et al.* (2016) assessed seven annual forages (oats, barley, fall rye, annual rye, corn, soybeans, and foxtail millet) for nutritive value and yield potential for stockpile grazing. They found that crude protein content was highest in fall rye (21.0%), followed by soybeans (17.0%) and was lowest in corn (8.3%). Conversely, corn, on average, exhibited the highest yield and TDN of all treatments. Despite an average yield of Golden German foxtail millet of 10.9 t DM ha^{-1}, CP concentration (8.3%) and TDN (56%) were low relative to the other annual treatments. In the Interlake region of Manitoba, higher forage yield was recorded either in cereals grown alone or in blends (Oats and Barley together), however, higher protein content was recorded in cereal / peas blends (PESAI Annual report 2020).

References

1. McCartney, D., Fraser, J. and Ohama, A. 2008. Annual cool season crops for grazing by beef cattle. A Canadian Review. *Can. J. Anim. Sci.* 88: 517-533
2. McCartney, D., Fraser, J. and Ohama, A. 2009. Potential of warm-season annual forages and Brassica crops for grazing: A Canadian Review. *Can. J. Anim. Sci.* 89: 431-440.
3. May, W. E., Klein, L., Lafond G. P., McConnell, J. T. and Phelps, S. M. 2007. The suitability of cool and warm season annual cereal species for winter grazing in Saskatchewan. *Can. J. Plant Sci.* 87: 739-752.
4. Hewitt, B.S., McGeough, E.J., Cattani, D., Ominski, K.H., Crow, G.H., and Wittenberg, K.M. 2016. Evaluation of seven annual forages for fall stockpiled grazing in beef cattle. *Proc. 10th International Rangeland Congress*, Saskatoon, SK, July 2016.

Materials and Methods

The trial was established in Arborg on wheat stubble in heavy clay soil. Plots were organized in a randomized complete block design with 15 forage treatments. Plots were seeded on May 24th with R-Tech plot seeder. Fertilizer was applied at the rate of N30-P20 (actual lbs / acre). The nitrogen was mid row banded and the phosphorus was applied in seed row according to soil test results (N220-P40).

Basagran Forte at 0.91L/ac was applied on July 12th for weed control and Matador was sprayed at 34ml/ac on July 15th for grasshopper control. The 7.53m^2 plots were harvested as follows

July 29th - Red Proso,
August 8th - Oats, barley, triticale, pea combos
August 12th - Golden germen millet
August 25th - the Sorghum's.
Data collected included dry matter forage yield and forage quality test.

Wheat-Phacelia Intercrops: Does Seeding Rate of Phacelia affects Wheat Grain Yield?

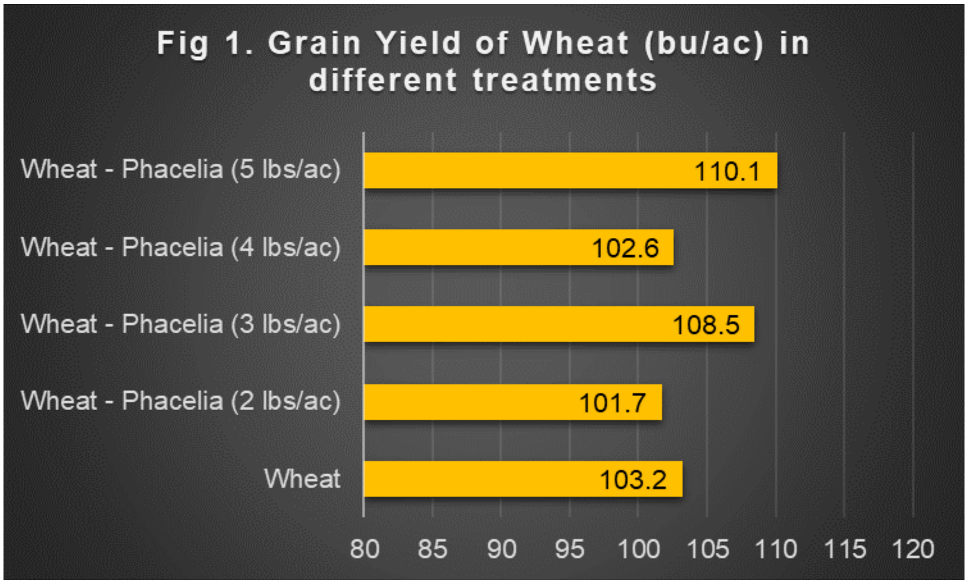
Project Year: 2022

Objectives: To evaluate the effect of different seeding rates of phacelia on the grain yield of intercropped spring wheat.

Collaborators: James Frey, PCDF

Results

Phacelia did establish well in different treatments, however, phacelia seeding rate did not have any effect on wheat grain yield (Fig 1.).



Project Findings

It looks like wheat is quite competitive to phacelia and its yield potential was not influenced by phacelia at any of the seeding rates tested. Further, it appears as increasing the seeding rate for phacelia creates the potential for harvesting some phacelia seed. However, three important considerations must be noted for phacelia seed production:

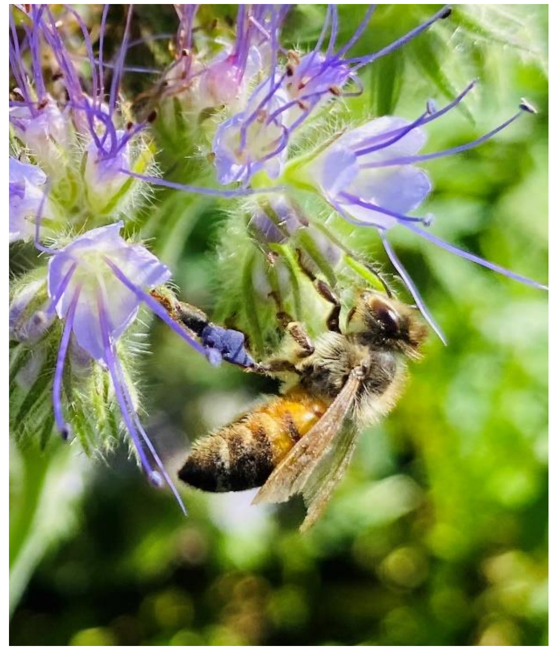
1. Because phacelia flowers continuously throughout the summer, the maturity of seeds varies. This means that harvest seed may not fully mature, reducing the germination rate. Further, some mature seed may fall to the ground before harvest.
2. Because phacelia seed is smaller and lighter in weight than wheat seed, harvesting both seeds together likely requires retaining more chaff in the harvest sample, and will require careful cleaning.
3. There are no registered herbicides for phacelia. Intercropping wheat (a grass) and phacelia (a broadleaf) will require careful site selection and a pre-emergent non-residual herbicide application.

Background

Phacelia is a broadleaf plant that produces abundant flowers throughout the growing season, making it attractive to pollinator species. Honey producers prize the crop for its long flowering period and light honey quality. Conversely, cereals crops such as wheat rely on wind for pollination, and do not provide attractive habitat for pollinators. Intercropping wheat and phacelia increases in-crop diversity, provides pollinator habitat in cereals crops, and may attract beneficial natural enemies for the management of wheat midge & aphids. For a detailed summary of phacelia cultivation, see this USDA Plant Guide.

This trial evaluates intercropping wheat and phacelia, and the effect of different rates of phacelia on wheat yield. The seeding rate for wheat for all treatments was 1.75 bu/acre, targeting 25 plants/ft^2. The rate for phacelia ranged from 2 lb/acre to 5 lb/acre.

Materials and Methods



Experimental Design – Randomized Complete Block Design with three replications.
Treatments – Testing different seeding rates of phacelia in wheat – phacelia intercrops.

1) Wheat only (1.75 bu/ac)
2) Wheat – Phacelia (2 lbs/acre)
3) Wheat – Phacelia (3 lbs/acre)
4) Wheat – Phacelia (4 lbs/acre)
5) Wheat – Phacelia (5 lbs/acre)

Plot size – 8.43m^2
Data collected – plant stand & grain yield of wheat

Agronomic info

Stubble, soil type – Fallow, heavy clay
Fertilizer applied – Soil nutrient levels (lbs/acre): N – 61, P – 50
Applied at planting (lbs/acre): N – 50, P -20
Seeding/harvesting date – June 7/ Sept 22

Hemp Variety Evaluations

Project Year – 2022

Objectives - To evaluate industrial hemp varieties for the National Hemp Variety Field Trials.
Collaborators - Canadian Hemp Trade Alliance (CHTA), James Frey (PCDF)

Results

There were two trials for hemp variety testing this year, grain & dual purpose trial. The yield results are shown in Table 1. In grain variety trial, PCDF data was not accepted due to high variability in the results. Arborg site did not have any differences among varieties for seed yield where as Melita site showed varietal differences. All sites had varietal differences for seed yield in dual purpose trial.

Table 1: Grain yield (lb/ac) of different hemp varieties at Arborg, Roblin & Melita during 2022.

Variety	*PCDF Roblin*	*PESAI Arborg*	*WADO Melita*
Grain Trial			
CRS-1	-	*2125*	*2122 c*
Henola	-	*2284*	*2164 c*
Stalker	-	*1893*	*1633 b*
X59	-	*2370*	*1641 b*
Bountiful	-	*1663*	*948 a*
% CV		*16.2*	*14.5*
Significant difference		*NO*	*YES*
Seeding Date		*May 25*	*May 24*
Harvesting Date		*Sep 27*	*Sep 6*
Dual Purpose Trial			
CRS-1	*1362 bc*	*1941 c*	*2286 e*
Alyssa	*1688 cd*	*1739 b*	*2145 d*
Bialobrzeskie	*709 a*	*1078 a*	*1144 a*
Canda	*1441 bc*	*1590 bc*	*1951 bc*
Scarlett	*1091 ab*	*1516 b*	*1988 c*
Silesia	*1849 d*	*1566 bc*	*1849 b*
% CV	*19.9*	*16.0*	*4.4*
Significant Difference	*YES*	*YES*	*YES*
Seeding Date	*May 27*	*May 25*	*May 24*
Harvesting Date	*Sep 26*	*Sep 27*	*Sep 6*

** Check = CRS-1, repeated for both Grain and Dual Purpose entries.*
Means contain different letters are statistically different at P (0.05).

Table 2 shows fibre yield comparisons for different varieties at MCDC & WADO sites. Table 3 presents cannabidiol and cannabigerol content information.

Table 2: Fibre yield by variety (lb/ac) at different sites during 2022.

	MCDC		PCDF		PESAI		WADO		Mean (All Sites)
Variety	**Lb/ac**	**% Check***	**Lb/ac**	**% Check***	**Lb/ac**	**% Check***	**Lb/ac**	**% Check***	**Lb/ac**
Dual Purpose entries†									
CRS-1	*8853.4*	*100.0*	-	-	-	-	*3117.4*	*100.0*	*5985.4*
Alyssa	*7711.1*	*87.1*	-	-	-	-	*3919.0*	*125.7*	*5815.1*
Bialobrzeskie	*10477.4*	*118.3*	-	-	-	-	*3161.9*	*101.4*	*6819.7*
Canda	*8866.8*	*100.2*	-	-	-	-	*2850.2*	*91.4*	*5858.5*
Scarlett	*9572.0*	*108.1*	-	-	-	-	*3518.2*	*112.9*	*6545.1*
Silesia	*9790.9*	*110.6*	-	-	-	-	*3161.9*	*101.4*	*6476.4*
% CV	*15.3*	-	-	-	-	-	*15.2*	-	-

** Check = CRS-1, repeated for both Grain and Dual Purpose entries*
† Results were excluded for Fibre Yield at PCDF and PESAI due to high % CVs, which reduce the reliability of the results.

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

	Cannabidiol (CBD)				*Cannabigerol (CBG)*			
	PCDF	*PESAI*	*MCDC*	*WADO*	*PCDF*	*PESAI*	*MCDC*	*WADO*
CRS-1	*1.42*	*1.17*	*2.26*	*1.50*	*0.09*	*0.04*	*0.08*	*0.08*
Alyssa	*0.88*	*0.80*	*2.05*	*0.95*	*0.08*	*0.04*	*0.05*	*0.05*
Bialobrzeskie	*1.41*	*1.07*	*1.92*	*1.40*	*0.06*	*0.03*	*0.04*	*0.04*
Bountiful	*1.38*	*1.30*	*2.64*	*2.02*	*0.04*	*0.03*	*0.06*	*0.06*
Canda	*0.91*	*0.60*	*1.99*	*1.35*	*0.05*	*0.02*	*0.05*	*0.05*
Henola	*1.42*	*1.09*	*1.94*	*1.85*	*0.07*	*0.04*	*0.09*	*0.09*
Marina	*0.97*	-	-	-	*0.02*	-	-	-
Stalker	*1.84*	*1.62*	*3.03*	*2.11*	*0.07*	*0.04*	*0.09*	*0.09*
Scarlett	*1.51*	*1.14*	*1.97*	*1.44*	*0.07*	*0.03*	*0.06*	*0.06*
Silesia	*0.70*	*0.78*	*1.27*	*0.86*	*0.02*	*0.03*	*0.03*	*0.03*
Visoka	*0.84*	-	-	-	*0.02*	-	-	-
X-59	*1.25*	*0.86*	*1.95*	*1.72*	*0.03*	*0.01*	*0.04*	*0.04*

** Derived from leaf and flower parts from upper 20 cm of plant (Source: InnoTech Alberta)*

Project Findings

Diversification Centres host hemp variety trials from CHTA to generate information on agronomic and yield parameters. During 2022, tested hemp varieties showed differences for grain yield at most sites. The yields and other performance characteristics are related to climatic conditions for each site. A summary of climate information for each site is in Table 4.

Table 4: Growing season report for Diversification Centres (2022).

	MCDC % Normal	**PCDF % Normal**	**PESAI % Normal**	**WADO % Normal**
Rainfall (mm)	*118*	*106*	*152*	*53*
Crop Heat Units	*108*	*109*	*109*	*108*
Growing Degree Days	*111*	*111*	*116*	*111*

**MB Agriculture Growing Season Report, https://web43.gov.mb.ca/climate/SeasonalReport.aspx*

In eastern and central Manitoba, the 2022 season began with large amounts of precipitation, which delayed seeding for MCDC and PESAI. In general, hemp is vulnerable during the early growth stages to excessive soil moisture. Lack of moisture during seed development will affect access to soil nitrogen and reduce yield. Nevertheless, hemp is a resilient crop that generally performs well in a range of climates and growing conditions. For more general information on hemp production, see the CHTA e-guide.

Background

This report provides a summary of hemp variety trials conducted at the Manitoba Diversification Centres during 2022 funded by CHTA. Established in 2003, the CHTA is a national organization that aims to develop the Canadian hemp industry. CHTA membership includes farmers, processors, suppliers, consultants, researchers, industry associations and government. The project aims to provide the hemp industry with third-party validated agronomic information for current or pending cultivars on the List of Approved Cultivars. Although this report focuses on the Manitoba Diversification Centre sites, but in 2022, the National Hemp Variety Field Trials were conducted at 13 sites across Canada (QC = 1, ON = 1, MB = 5, SK = 1 and AB = 5).

Materials and methods

Experimental Design: Random Complete Block Design
Entries: 5 grain entries and 6 dual purpose entries, 4 replications
Fertility information (Arborg site): Soil tests (N –P in lbs /ac): 212-36
Applied (N-P in lbs/ac): 30-20
Pesticides applied: Pardner @ 0.4L/acre on June 22.

General information
Seed provided by variety owner or representative.
Seeding rate: 150 pl/m^2
Target seeding date: middle of May
Target fertility: 120-40 N-P; K and S followed local recommendations for wheat
Seeding depth: Up to 1.5 inches, into moisture

Data collected
Grain yield: All varieties, adjusted to 10% moisture.
Fibre yield: All stems for 1m row/plot, dried and stripped of leaf material.
Cannabinoids: 4 heads (top 20 cm) per plot, analysed at InnoTech Alberta.