PESAI Annual Report 2021

Funded in part by CAP / ASI program grants

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1. 2021 Public / Industry Partners

Agassiz Soil & Crop Improvement Association, Beausejour

Agriculture and Agri-Food Canada, Portage la Prairie

Agriculture and Agri-Food Canada, Ottawa

Canada Manitoba Crop Diversification Centre

Nutrien Ag Solutions

Manitoba Crop Alliance

Manitoba Crop Variety Evaluation Team

Manitoba Pulse & Soybean Growers Association

Manitoba Agriculture

Parkland Crop Diversification Foundation

Seed Manitoba

University of Manitoba

Saskatchewan Crop Development Centre

Manitoba Flax Growers Association

Westman Agricultural Diversification Organization Inc.

Ducks Unlimited

BASF

Foster Ag Services

Solum Valley Biosciences

Riddell Seed Co.

Rutherford Farms Ltd.

Western Ag Lab

Imperial Seeds

2. PESAI: Who we are?

Prairies East Sustainable Agriculture Initiative Inc. (PESAI) is a not-for-profit organization (incorporated in December 2005) serving the 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 Canada-Manitoba Crop Diversification Centre (CMCDC) – Central Region (Fig. 2.1).

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.

Fig. 2.1. Locations of four diversification centres in Manitoba

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.

Board of Directors: 2021-22

An elected Board comprised of agricultural producers and entrepreneurs from the Eastern Prairie region directs PESAI activities (Table 2.1). Staff from Manitoba Agriculture / PESAI help to carry out PESAI activities (Table 2.2).

Table 2.1. PESAI Board of Directors during 2021 year.

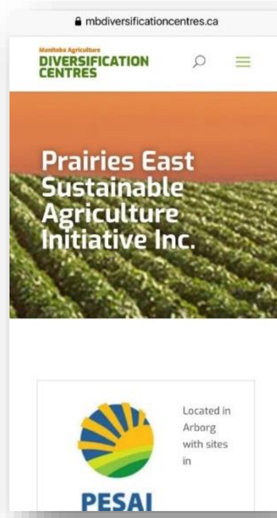
Position	Name	Area	Phone #
Chair	Brian Kurbis	Beausejour	204-268-0239
Vice-Chair	Wayne Foubert	St. Anne	204-232-5069
Secretary	Linda Loewen	Riverton	204-378-2771
Treasurer	Andy Buehlmann	Arborg	204-376-2809
Director	Paul Grenier	Woodridge	204-371-2252
Director	Tim Shumilak	East Selkirk	204-482-5166
Director	Garry Wasylowski	Fraserwood	204-643-5390
Director	David King	Arborg	204-642-2695
Director	Scott Duguid	Arnes	204-641-4806

Table 2.2. PESAI / Manitoba Ag Staff during 2021 crop season.

Position	Name	Organization
Diversification Specialist	Dr Nirmal Hari	Manitoba Agriculture
Diversification Technician	James Lindal	Manitoba Agriculture
Diversification Technician	Justine Pyziak*	PESAI
Summer Research Assistant	Kate LeTexier	PESAI
Summer Technician	Eugene Delorme	PESAI
Summer Research Assistant	Priscillar Wenyika	PESAI
Summer Research Assistant	Joshua Kopec	PESAI

** Justine resigned from the position on Oct 1.*

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



3. PESAI Extension Activities (2021)

PESAI did several extension activities during 2021 to communicate about its research projects. The objectives of these activities are:

- Communicating producers / industry about PESAI research projects and partnership / job opportunities.
- Encouraging participants for PESAI membership.

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

- An announcement of PESAI's project submission deadline was advertised in Eastern and Interlake areas, as well as on social media @PESAIresearch (Follow us on twitter: https://twitter.com/PESAIresearch).
- PESAI's 2021-22 Annual Report was compiled by Manitoba Ag support staff and it was uploaded on DC's website (www.mbdiversificationcentres.ca).
- Individual project reports were also uploaded on DC's website. A total of 16 projects' reports are available on the website.
- PESAI developed two extension videos this year and these videos could be seen on DCs website. First video is on cereal seeding rate project while the other video is related to evaluation of annual forages in the Interlake.

Table 3.1. Summary of PESAI tweets about its research and extension / job activities during 2020-21.

Tweets	Month	Impressions	Retweets
PESAI Annual General meeting	April	740	2
Early pea in Interlake	May	229	0
Cereal emergence	June	251	0
Excess moisture projects	June	2933	4
Soybean / Pea intercropping	July	434	1
MCVET Annual forages	July	2224	3
Cereal varietal trials harvesting	Aug	601	1
Cereal seeding rate project	Aug	1206	3
PESAI Technician Position	Nov	1219	7
MCVET Annual forage results	Nov	909	4
Summer Research Assistant position	Jan	1051	7

Table 3.2. Presentations done by PESAI staff during 2021.

Presentation topic	Where
Excess moisture project update	Extreme moisture group meeting (Nov 17) - ZOOM
Tile drainage research update	Extreme moisture group meeting (Nov 17) - ZOOM

- Small farmer tours (4-5 persons each time) were organized at MCVET soybeans / Nutrient Ag soybeans sites.
- PESAI members received 2021 MCVET evaluation results.
- Crop tour / Soybean research tour were not held this year because of Covid-19 pandemic restrictions.
- Annual general meeting was held on virtually via ZOOM in April 2021. Two new PESAI Directors; Paul Grenier and Garry Wasylowski were elected on the board for three-year terms.

4. Partner Project Report: Foliar Strategies to Generate Severe Iron Deficiency Chlorosis (IDC) in Small Plot Research Trials.

Project duration

- March 1, 2021 to Jan 31, 2022

Collaborators

- N49 Genetics (Kevin Baron Kevin.Baron@solumvalley.com)
- PESAI (Nirmal Hari)
- Murphy et al. (Keith Murphy)
- Manitoba Agriculture (Dennis Lange)

Objectives

- To evaluate a method of forcing symptoms of iron deficiency chlorosis (IDC) in soybean research trials across the Interlake and Red River Valley regions on Manitoba.
- In addition, to directly compare the yield response of IDC resistant and IDC susceptible cultivars (grouped) in response to the applied forcing treatment. IDC is a major stress factor that severely reduces the yield potential of soybeans grown upon calcareous, high pH soils in Manitoba.

Results

1. Background: Application of soil amendments/foliar treatments to generate symptoms of IDC in research trials

Over the 2021 growing season three identical small plot research trials were established in the Interlake and Red River Valley regions of Manitoba at Arborg (PESAI), Balmoral (Solum Valley Biosciences) and Ste. Agathe (Murphy et al.) upon soils with a medium to high risk for developing symptoms of IDC (Fig. 4.1). At each location one of six herbicide tolerant soybean varieties were planted. Three varieties were selected based on previous scores (IDC resistant) in the MPSG soybean IDC nursery, and an additional three varieties included based on scores (IDC susceptible) in the same nursery.

In addition to selecting trial locations with the potential to generate symptoms of IDC, these trial locations were also paired with traditional MPSG variety evaluation trials in 2021. Following seeding operations and emergence, site visits (Kevin Baron) were made to each site to apply a mixture of nitrate, bicarbonate and table salt to the trial area to “force” symptoms of IDC. Similar solutions have been used to generate severe symptoms of IDC in growth room screens of soybean germplasm (Baron, 2021). Field researchers also manipulate soil nitrate level to increase IDC when screening soybean germplasm or performing agronomic assessments of soil of iron (Fe) chelate fertilizers (Wiersma 2010). Throughout June and July 2021 all three research sites were monitored for development of IDC symptoms, ratings collected, trials photographed and drone missions executed to generate a time-course series of images tracking the growth of individual soybean plots. Beyond final site visits in late July, trials were managed and harvested in a similar manner to adjacent MPSG variety evaluation trials.

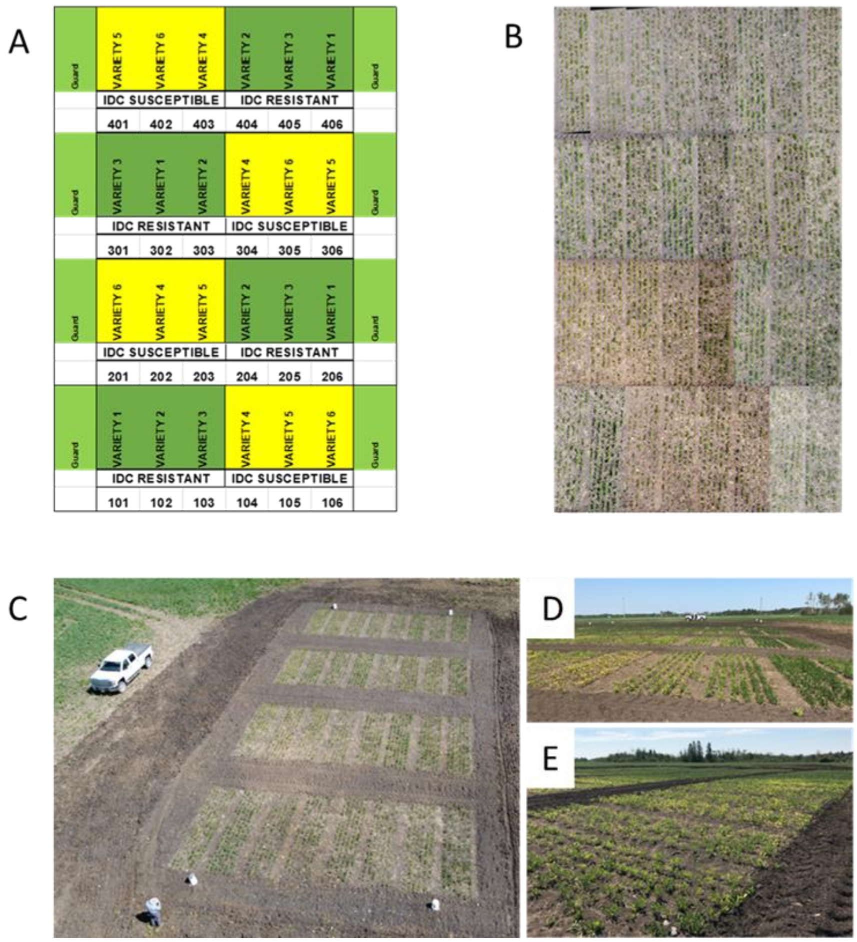


Fig. 4.1. Experimental design (A, B) and aerial drone image (C) (Arborg site) depicting the layout of the small plot trials assessing IDC resistant versus IDC susceptible soybean varieties. At each location, trials consisted of 24 plots totals with 6 varieties of soybean per replicate/block. Within each block 3 IDC resistant varieties (grouped green) were planted beside 3 IDC susceptible varieties (grouped yellow) and surrounded by guard plots. (D,E) Across all three locations IDC symptoms were most severe in an MPSG variety trial situated adjacent to the small plot IDC trial assessing forcing treatments.

2. Yield Assessment of IDC Resistant vs IDC Susceptible Varieties

At all three trial sites (Arborg, Ste. Agathe, Balmoral), soybean plots were taken to harvest with trial means ranging from 14.9 bu/ac to 21.2 bu/ac (Fig. 4.2). These values are significantly below the 10-year provincial average yield for soybean (~ 35 bu/acre, MASC) in Manitoba and reflect the influence that lack of precipitation and drought conditions exerted on the yield of several crops across much of Manitoba. Moreover, comparable MPSG soybean variety trials harvested at these same sites (Ste. Agathe, Balmoral) and evaluating > 40 varieties of herbicide tolerant soybeans generated trials means that did not exceed 25 bu/acre (2021 MPSG Variety Guide).

Although symptoms of IDC were identified, rated and documented at two of three sites over the 2021 growing season, it is important to emphasize that significant differences in the performance of the six varieties (IDC resistant n=3, IDC susceptible n=3) or significance differences between IDC groupings could be attributed to factors other than IDC stress. (e.g. drought stress). It is more likely that drought stress (as opposed to IDC stress) was a more prominent external environmental factor influencing the yield potential and performance of varieties across this set of small plot research trials.

Lack of precipitation and drought conditions presented challenges for IDC ratings at all three locations, in addition to comparable IDC screening sites in Manitoba, North Dakota and Minnesota. In general, extended periods of cool, wet soil conditions early in the season would lead to persistent and prolonged IDC stress. These environmental conditions would also be ideal for a direct yield comparison of IDC resistant versus IDC susceptible germplasm.

Taken together, yield results from all three locations in 2021 indicate that in the absence of adequate precipitation to keep high risk soils (calcareous, high pH) saturated and cool, the risk of developing severe symptoms IDC is diminished and the yield gap between IDC susceptible and IDC germplasm will be diminished. Nonetheless, in spite of the prolonged moisture deficit that extended across the 2021 growing season, at two of three sites (Arborg, Balmoral) it was possible to discern IDC susceptible and IDC resistant germplasm based on visual chlorosis scores (VCS). In addition, for the most severely affected plots, differences in canopy coverage and leaf greenness were quantified.

3. Visual Chlorosis Scores (VCSs) and Drone Imagery to Track Soybean Growth and Monitor Small Plot Trials for Symptoms of IDC or Drought Stress

Following seeding operations subtle differences in IDC symptoms could be identified through visual chlorosis scores (VCS) (1 = green, tolerant 5 = yellow, chlorotic) at both the Arborg (Table 4.1) and Balmoral locations (not shown). However, these symptoms were relatively mild and transient. No visual symptoms of IDC were recorded at the Ste. Agathe site through June and July of 2021. With successive visits to sites in Arborg and Balmoral, initial symptoms of IDC diminished and similar observations were noted for adjacent MPSG variety trials (Fig. 4.3).

Table 4.1. IDC ratings according to visual chlorosis scores (1-5 rating scale) - 2021 Arborg (1 = resistant, green ;5= yellow, chlorotic).

Variety	IDC Group	Visual Chlorosis Score VCS (1-5) Jun 14 2021	Visual Chlorosis Score VCS (1-5) Jun 30 2021
IDC RES Variety 1	RESISTANT	1.6 d	1.7 b
IDC RES Variety 2	RESISTANT	1.7 cd	1.7 b
IDC RES Variety 3	RESISTANT	1.8 c	1.7 b
IDC SUS Variety 4	SUSCEPTIBLE	2.1 ab	1.8 a
IDC SUS Variety 5	SUSCEPTIBLE	2.0 b	1.8 a
IDC SUS Variety 6	SUSCEPTIBLE	2.3 a	1.9 a
CV		6.9	3.5
LSD (0.05)		0.20	0.10
Sign. Diff		YES	YES

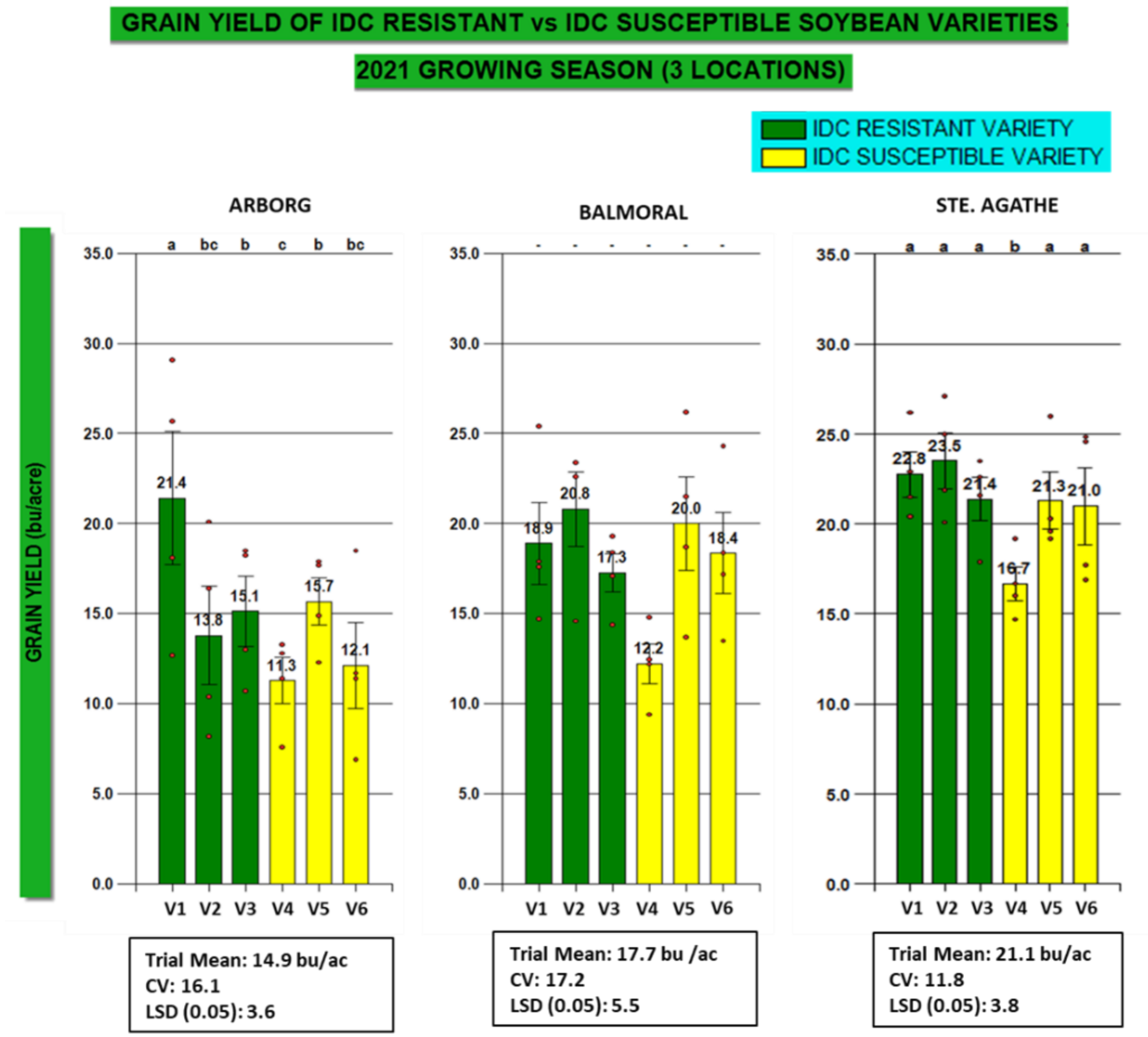


Fig. 4.2. Grain yield of individual IDC-resistant and IDC-susceptible cultivars at Arborg, Balmoral and Ste. Agathe research trial sites over the 2021 growing season. At both Arborg and Ste. Agathe sites, significant differences in yield of individual lines were reported. One specific variety (V4 – IDC susceptible) was consistently ranked as lowest yielding at all three sites. However, this ranking did not appear to related to notable differences in IDC scores across locations.

Collectively, the variety-specific symptoms of IDC and VCSs noted at both Arborg and Balmoral locations provided support that varieties initially selected based on past performance in the IDC nursery would respond appropriately and demonstrate an injury/yield contrast if moderate to severe symptoms of IDC persisted at either location. However, the rapid recovery of all IDC susceptible lines at both locations highlighted that in order for significant yield loss to occur, IDC symptoms must persist from the first trifoliate stage through to the V5/V6 stage of development.

In addition to rating individual plots for visual chlorosis scores (VCSs), trials at each site were further monitored (3x) with drone mapping missions using a DJI Mavic Mini. Mapping missions were then imported into software (Plot Phenix) that enables individual plots to be identified and assessed for quantitative parameters such % canopy coverage, leaf greenness (G/R ratio), or stand counts (Fig. 4.4).

Fig. 4.3. Ground level images of IDC susceptible (foreground) and IDC resistant (background) varieties at the 2021 Arborg site on June 30, 2021 (top) and July 21, 2021 (bottom). These images capture the relatively low IDC pressure/symptoms early in the season, in addition to the recovery and canopy development of plots corresponding to canopy coverage and leaf greenness (G/R) measurements presented in following sections.

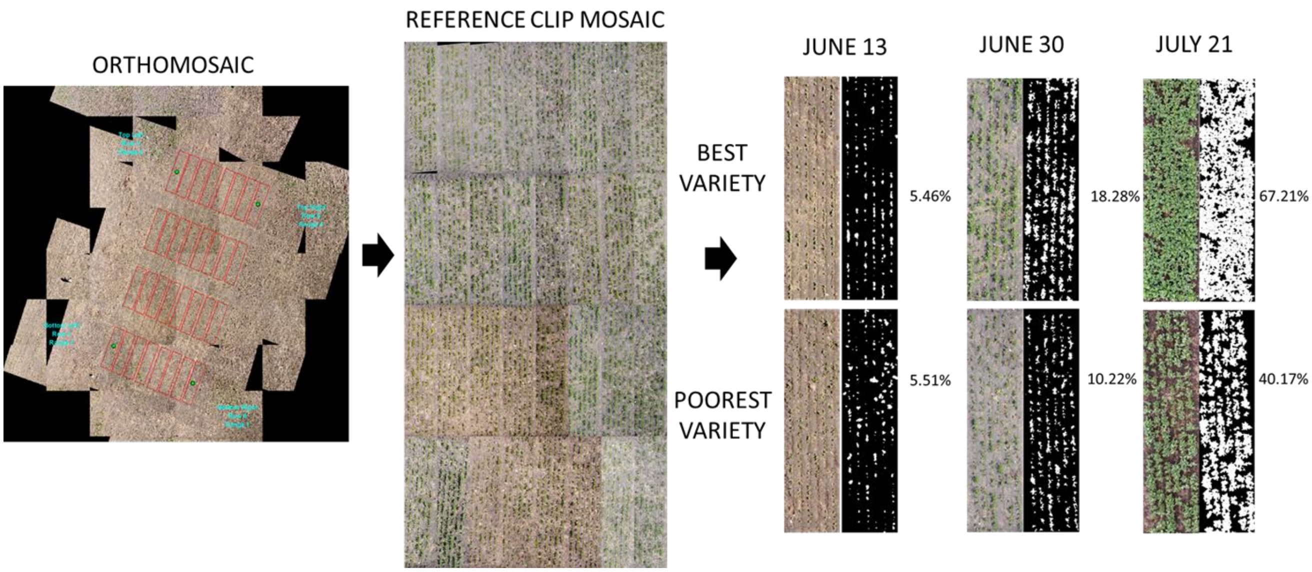


Fig. 4.4. Schematic representation of drone mapping workflow at the Arborg site in 2021 season. Individual mapping missions are gridded and processed into a reference clip mosaic that identifies each individual plot. Each plot is then evaluated for quantitative measurements related to canopy coverage, leaf greenness, stand count, etc.

Traditional visual chlorosis scores (VCS) are subjective based upon the person conducting ratings, and focus largely on the degree of chlorosis/yellowing observed in new vegetative growth. Monitoring canopy coverage scores represents an alternative means to assess the growth and biomass accumulation (or growth inhibition) of soybean varieties in response to IDC or related stresses such as drought, salinity, or waterlogging tolerance. This strategy is being explored and applied to the current project as several public and private soybean breeding programs are currently developing aerial imaging approaches to evaluate and rate soybean germplasm (Dobbels and Lorenz, 2019).

Focusing on software outputs from the Arborg site only, significant differences in canopy coverage (Table 4.2) and G/R ratio (leaf greenness) (Table 4.3) were detected amongst the six varieties evaluated. Note that with successive visits the canopy coverage score for an individual variety continues to increase reflecting the accumulation of biomass and canopy closure noted in pictures (Fig. 4.3). At several time points, canopy coverage and G/R scores of specific IDC resistant varieties exceed those of select IDC susceptible lines.

Overall, time-course assessments of canopy coverage scores are intended to quantify the growth and biomass accumulation of IDC resistant varieties that occurs when IDC susceptible varieties display symptoms of stress leading to growth inhibition. Moving forward N49 Genetics will continue to assess drone imagery and canopy coverage scores as means to monitor the growth, stress tolerance and recovery of soybean varieties in response to IDC and related stresses such as drought, salinity or waterlogging.

Table 4.2. Time-course progression of canopy coverage scores (% cover) - Arborg 2021

Variety	IDC Group	Canopy Coverage Jun 14 2021	Canopy Coverage Jun 30 2021	Canopy Coverage July 21 2021
IDC RES Variety 1	RESISTANT	5.8	16.9 a	61.0 a
IDC RES Variety 2	RESISTANT	5.5	11.4 bc	50.9 bc
IDC RES Variety 3	RESISTANT	4.3	12.0 b	51.0 bc
IDC SUS Variety 4	SUSCEPTIBLE	3.5	10.4 bc	54.4 b
IDC SUS Variety 5	SUSCEPTIBLE	4.0	9.5 cd	47.9 c
IDC SUS Variety 6	SUSCEPTIBLE	4.0	12.0 d	54.8 b
CV		25.3	4.5	6.1
LSD (0.05)		1.7	2.8	4.9
Sign. Diff		NO	YES	YES

Table 4.3. Time-course progression of soybean G/R ratio scores (leaf greenness) - Arborg 2021

Variety	IDC Group	G/R Ratio Jun 14 2021	G/R Ratio Jun 30 2021	G/R Ratio July 21 2021
IDC RES Variety 1	RESISTANT	0.98	1.16 a	1.24 a
IDC RES Variety 2	RESISTANT	1.00	1.15 bc	1.20 ab
IDC RES Variety 3	RESISTANT	0.98	1.16 a	1.18 bc
IDC SUS Variety 4	SUSCEPTIBLE	0.97	1.12 bc	1.21 ab
IDC SUS Variety 5	SUSCEPTIBLE	0.95	1.10 cd	1.19 b
IDC SUS Variety 6	SUSCEPTIBLE	0.96	1.08 d	1.16 c
CV		2.6	4.5	6.1
LSD (0.05)		0.04	2.8	4.9
Sign. Diff		NO	YES	YES

Project findings

The current project sought to assess alternative methods of evaluating iron deficiency chlorosis (IDC) in soybean field research trials and quantify the yield impacts of severe IDC on resistant and susceptible soybean varieties currently grow in Manitoba. However, the overall lack of precipitation at sites for the 2021 growing season limited upper end yield potential, and also hindered the development of moderate to severe levels of IDC stress at these same sites.

Based upon the transient, mild symptoms of IDC stress noted at both Arborg and Balmoral field locations following seeding operations and spring rains, sites selected for the study were conducive to developing severe IDC symptoms. Moreover, the subset of varieties further displayed the intended differential in visible symptoms of chlorosis.

These observations suggest that to reliably screen soybean germplasm for IDC year over year there may be merits to execute related agronomic studies or variety evaluations on high risk soils in conjunction with irrigation infrastructure. Maintaining cool, wet and saturated soil conditions for extending periods in the spring (May to June) may be necessary to consistently generate severe IDC pressure. N49 Genetics is developing such irrigation capacity for the 2022 season. The outcomes of this field project further indicate that downstream IDC screening activities may concentrate on phenotyping germplasm in controlled environments versus field environments. Future efforts aimed at evaluating the yield performance of IDC resistant versus IDC susceptible germplasm may also require alternative experimental designs (e.g higher replication, spatial analysis of yield data) to obtain high quality yield data.

References

Baron K (2021). Soil-based methods to screen soybean plants for resistance to iron deficiency chlorosis (IDC) and seedling vigor on calcareous Manitoba soils. PESAI Project.

Wiersma JV (2010) Nitrate-Induced Iron Deficiency in Soybean Varieties with Varying Iron-Stress Responses. Agron. J. 102:1738-1744.

Dobbels A, Lorenz A (2019) Soybean iron deficiency chlorosis high-throughput phenotyping using and unmanned aircraft system. Plant Methods. 15:97

Acknowledgments

The financial and technical support of the Prairies East Sustainable Agriculture Initiative (PESAI) towards trial execution, purchase of soil amendments and travel/mileage is greatly appreciated. Thanks to Dennis Lange and Keith Murphy for technical advice and contribution towards selecting varieties and trial preparation relative to related soybean variety evaluation and IDC screening efforts.

Materials and methods

Experimental design: Randomized complete block design with treatments arranged in a factorial split-plot design.

Replications: 4; Treatments: six varieties (n=6) assigned to an IDC group (n=2).

Six regionally adapted Round-up Ready soybean cultivars were selected in coordination with MB Provincial Pulse Specialist (Dennis Lange) based on past performance of varieties in the regional IDC rating nursery. Within one week of planting operations, an initial visit was made to apply a combination of granular fertilizer (calcium nitrate, urea) with a spin spreader in addition to foliar treatments (bicarbonate, table salt) with a back pack sprayer and hand boom. Solutions were made based on the amount of product that could practically be dissolved and dispensed.

Data collection

Following the initial application of fertilizer and soil amendments, each site was visited on 2-3 week intervals to photograph sites, rate plots for visual chlorosis scores (VCSs), and execute drone mapping missions.

Efforts were also made to observe and monitor adjacent MPSG variety evaluation trials planted and managed on these same sites, but not receiving supplemental soil amendments/fertilizer to induce symptoms of IDC.

Agronomic management

Trials were managed for weed control, pests, etc. in a manner similar to adjacent MPSG variety trials. Trials were harvested by the respective contract research organ and raw yield data relayed to N49 Genetics.

Seeding date: Arborg: May 27, 2021; Balmoral: May 17, 2021; Ste. Agathe: May 14, 2021

Harvesting date: Arborg: Oct 08, 2021; Balmoral: Sept 25, 2021; Ste. Agathe: Sept 23, 2021.

5. Partner Project Report: Assessment of intercrop blend for forage production

Project Duration

- 2021

Collaborators

- Rock Lake Colony, Grosse Isle, MB
- PESAI funding - $2,000

Objectives of the study

- To determine forage yield potential of forage blend from Dyck seeds and Interlake forage seeds when intercropped with oats.

Fig. 5.1. Poor establishment of intercrop in Oats at Grosse Isle, MB

Results

Intercrops did not establish due to drought and frost. A low spot in the field, however, had intercrops established but were severely damaged by drought / grasshoppers later in the summer. In this spot, most species but the clovers did establish.
By mid-July, oats were cut as green feed due to drought feed shortage. The oats were cut at late milk/early dough stage with hopes of future rain and regrowth. There was not much regrowth as drought prevailed up to second week of August.

Project findings

Rock lake colony intends to try a very similar intercrop project next year, with Barley as the main crop.

Materials and methods

Table 5.1 presents the summary of intercrop blend used for the study. Alfalfa and Italian ryegrass comprised almost half of the blend. This blend was seeded at 10” row spacing on April 30. Oats were seeded (1.5 inches seeding depth) in between the intercrop rows at 20” row spacing in the north-south direction of field at 2.5 bushels per acre seeding rate. The idea was to allow maximum sunlight between the oats for intercrop growth. The oats emergence was nice. The intercrop was seeded at 0.5” depth, but it did not emerge for four weeks.

Table 5.1. Different intercrop species in a forage blend seeded at Grosse Isle, MB.

Species	Species	Species
Alfalfa	Timothy	Creeping root alfalfa
Birdsfoot trefoil	Sainfoin	Double cut red clover
Single cut red clover	Crested wheatgrass	Chickory
Meadows brome grass	Orchard grass	Italian rye grass
Tall fescue	Cicer milk vetch	Purple top turnip
Alsike clover	Tap root alfalfa	Kale

6. 2021 Weather – Arborg & Beausejour sites

During 2021 growing season (May – Aug), Arborg and Beausejour sites received 71 % and 68 % of normal monthly precipitation, respectively (Table 5.1). First trial was seeded on May 6 at Arborg site and on May 14 at Beausejour site. Arborg experienced extremely drier soil conditions after seeding that continued till harvest of most crop types in August (Fig. 5.1 a). Precipitation at Beausejour seemed to be near normal in May but experienced drought like conditions for rest of the growing season. August rainfall (above normal monthly precipitation) was too late for most of the crops as either crops were harvested or were closer to maturity. However, this rainfall benefited soybean plots as some of the late maturity varieties were at pod filling stage.

At Beausejour site, winter cereal and soybean plots received few timely rains during the summer and the yields were relatively good (about 100 bu/acre for winter cereals and 50 bu/ac for soybean plots (Manitoba Crop Variety Evaluation trials (MCVET)). These sites were 7-8 miles away from Beausejour MB Ag weather station and these sites received more rains.

Table 6.1. Seasonal weather summaries at Arborg and Beausejour sites (May 1 – Aug. 31).

Site	Weather variable	Actual	Normal	% of normal
Arborg				
	Growing degree days	1453	1263	115
	Corn heat units	2272	2123	107
	Total precipitation (mm)	209	294	71
Beausejour				
	Growing degree days	1462	1379	106
	Corn heat units	2296	2229	103
	Total precipitation (mm)	192	282	68

Monthly mean air temperature was above normal throughout the growing season at Arborg and Beausejour sites (Fig.5.1 b). Both sites had above normal growing degree days and corn heat units (Table 5.1). Months of May / June / July were extremely dry at Arborg site and that had affected most of the crop types. Canola and flax suffered the most followed by soybeans, forages and cereals.

Severe frost events occurred during late May causing crop injury, delayed emergence and slow crop growth. On May 26 /27, 2021, frost occurred at both sites. At Arborg, a minimum temperature of -6.4°C was recorded and air temperatures below 0°C lasted for 10 hrs. At Beausejour, a minimum temperature of -2.7°C was recorded and air temperatures below 0°C lasted for 9 hrs. Subsequent frost event occurred at Beausejour site on May 27/28. During this frost event, a minimum temperature of -1.4 °C was recorded and air temperatures remained below 0°C for 3 hrs. Frost at Arborg site resulted in injury to oats and flax plots, however, plots recovered from the injury later on.

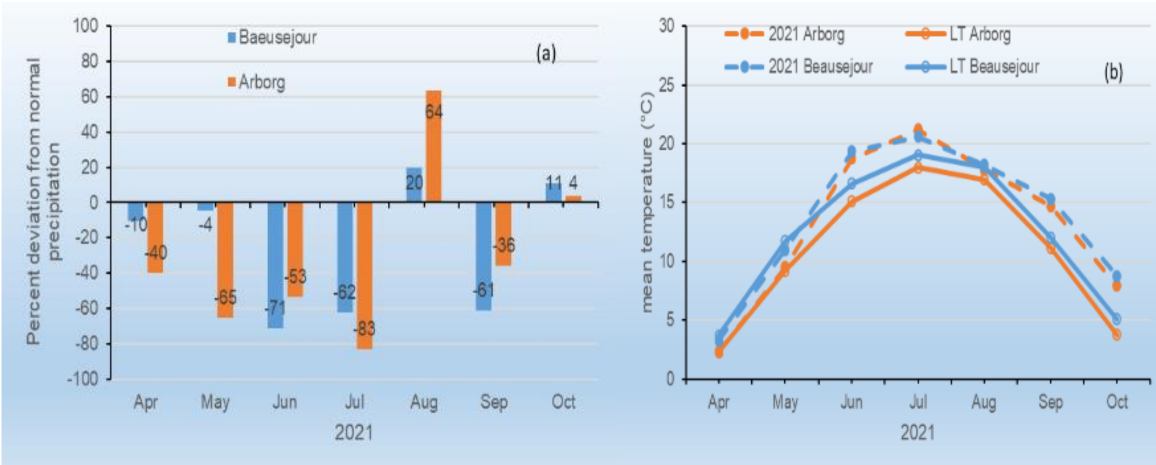


Fig. 6.1. (a) Percent deviation in monthly precipitation (values in bars) from normal monthly precipitation. Positive value indicates above normal monthly precipitation and negative values indicates below normal precipitation (b) monthly mean temperatures (dashed line with filled circle) and normal monthly mean temperature (solid line with open circle) at Arborg and Beausejour sites in 2021.

Soil moisture content at 5 cm, 20 cm, 50 cm and 100 cm depth during growing season of 2021 at Arborg site is shown in Fig 5.2. Soil moisture content at or prior to seeding of crops, in early May, indicates that soil had near to optimum available water 25 % by volume at 5 cm and 20 cm depths. Under normal conditions, the available water content of these heavy clay soils is 28.89 % by volume in top 15 cm soil. However, due to lack of precipitation, soil moisture content at 5 cm depth showed greater fluctuations in May (Fig. 5.2). These dry soil conditions extended to lower soil depths in early June as indicated by a drop in volumetric soil moisture content at 20cm depth. Thus, most of the crops were seeded into relatively dry soil conditions.

A few precipitation events that occurred in the second week of June recharged the surface soil as indicated by a peak in soil moisture content at 5 cm depth and a slight increase in soil moisture content at 20cm depth. A dry period between mid-June and end of July resulted in steep decline in soil moisture content for deeper layers.

Crops suffered from extreme heat in late June and July leading to heat stress in certain crops (Fig. 5.1 b). Extreme drought conditions also resulted in grasshopper infestations though there was minimal weed growth and fusarium incidence on cereals. Plots were sprayed few times during late June / early July for grasshopper's control. Harvest started early and the first crop harvested was MCVET forages on July 26, 2021.

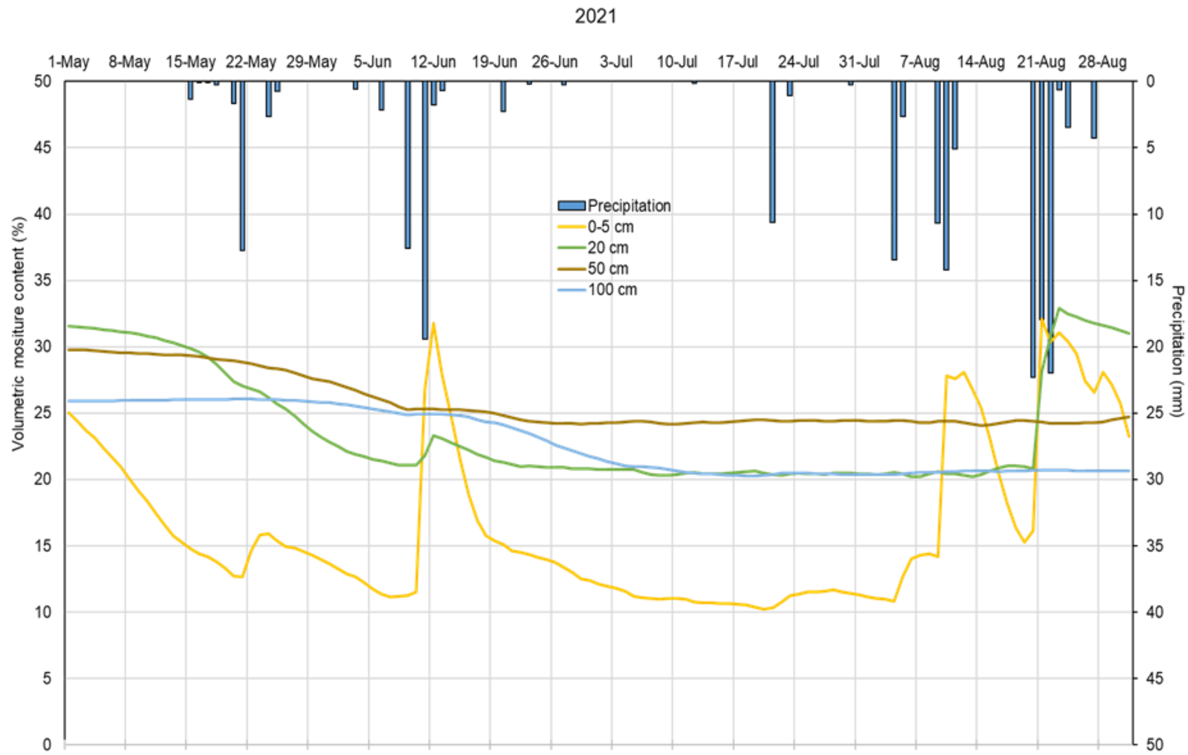


Fig. 6.2. Soil moisture content measured at 5, 20, 60 and 100 cm below grass level (BGL) and amount of precipitation received during 2021 growing season at Arborg site.

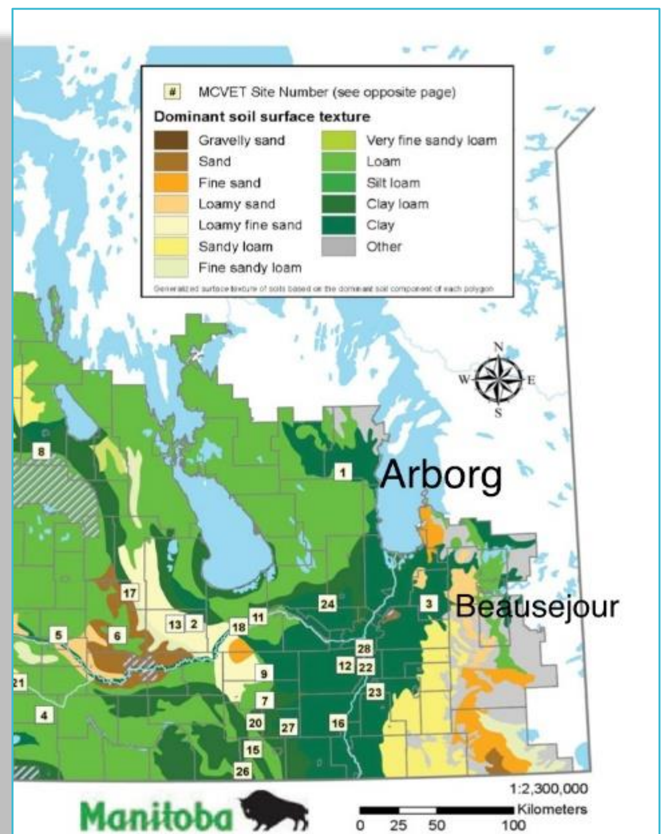
Overall Arborg and Beausejour sites were relatively drier and warmer, leading to significant effect on crop growth and increased grasshopper infestations that subsequently resulted in lower average grain /forage yields than provincial averages.

7. Manitoba Crop Variety Evaluation trials (MCVET)

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.

Picture 1. 2021 MCVET Soybean plots at Beausejour site

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. Hard copies are available at most Manitoba Agriculture and Ag Industry Offices.



PESAI managed two MCVET sites (Arborg and Beausejour) during 2021 growing season. Variety trials of spring wheat, winter wheat, fall rye, oats, barley and soybeans (both roundup ready and conventional) were conducted at both sites (Table 7.1), whereas trials of peas, silage corn, annual forages and flax were conducted only at Arborg site.

Table 7.1. Agronomic management practices followed at PESAI MCVET sites during 2021 growing season.

Site	Crop type	Stubble	Seeding date	Fertilizer applied (N-P-K)	Harvest date	No. of plots
				lb /ac		
Arborg						
	Spring wheat	Fallow	06-May	55-20-0	17-Aug	108
	Oats	Fallow	07-May	55-20-0	18-Aug	27
	Barley	Fallow	07-May	55-20-0	18-Aug	66
	Winter wheat¥	Canola	10-Sep	30-25-0 (100-0-0)§	03-Aug	18
	Fall rye	Canola	10-Sep	30-25-0 (100-0-0)	03-Aug	18
	Peas	Pasture	11-May	3-15-0	17-Aug	63
	Conv. Soybeans‡	Pasture	27-May	4-20-0	29-Sep	60
	RR soybeans‡	Pasture	27-May	4-20-0	29-Sep	132
	Silage corn	Canola	21-May	72-25-0† + 0-35-0	22-Sep	90
	Flax	Wheat	13-May	4-20-0	08-Sep	21
	Annual forages	Fallow	20-May	55-20-0	26-Jul	36
Beausejour						
	Winter wheat¥	Canola	14-Sep	30-25-0 (100-0-0)	13-Aug	18
	Fall rye	Canola	14-Sep	30-25-0 (100-0-0)	13-Aug	18
	Spring wheat	Soybean	14-May	75-25-0	16-Aug	81
	Oats	Soybean	14-May	75-25-0	16-Aug	15
	Barley	Soybean	14-May	75-25-0	16-Aug	33
	Conv. soybeans	Wheat	17-May	3-15-0	27-Sep	60
	RR soybeans	Wheat	17-May	3-15-0	24-Sep	132

¥ winter wheat was seeded in fall 2020

§ fertilizer values in paranthesis were broadcasted in spring.

† fertilizer (N-P-K) was broadcasted before seeding and P =35 lb/ac was band applied with seed.

‡ Conventional and RR soybean plots were written off at Arborg site due to drought, weed and deer damage.

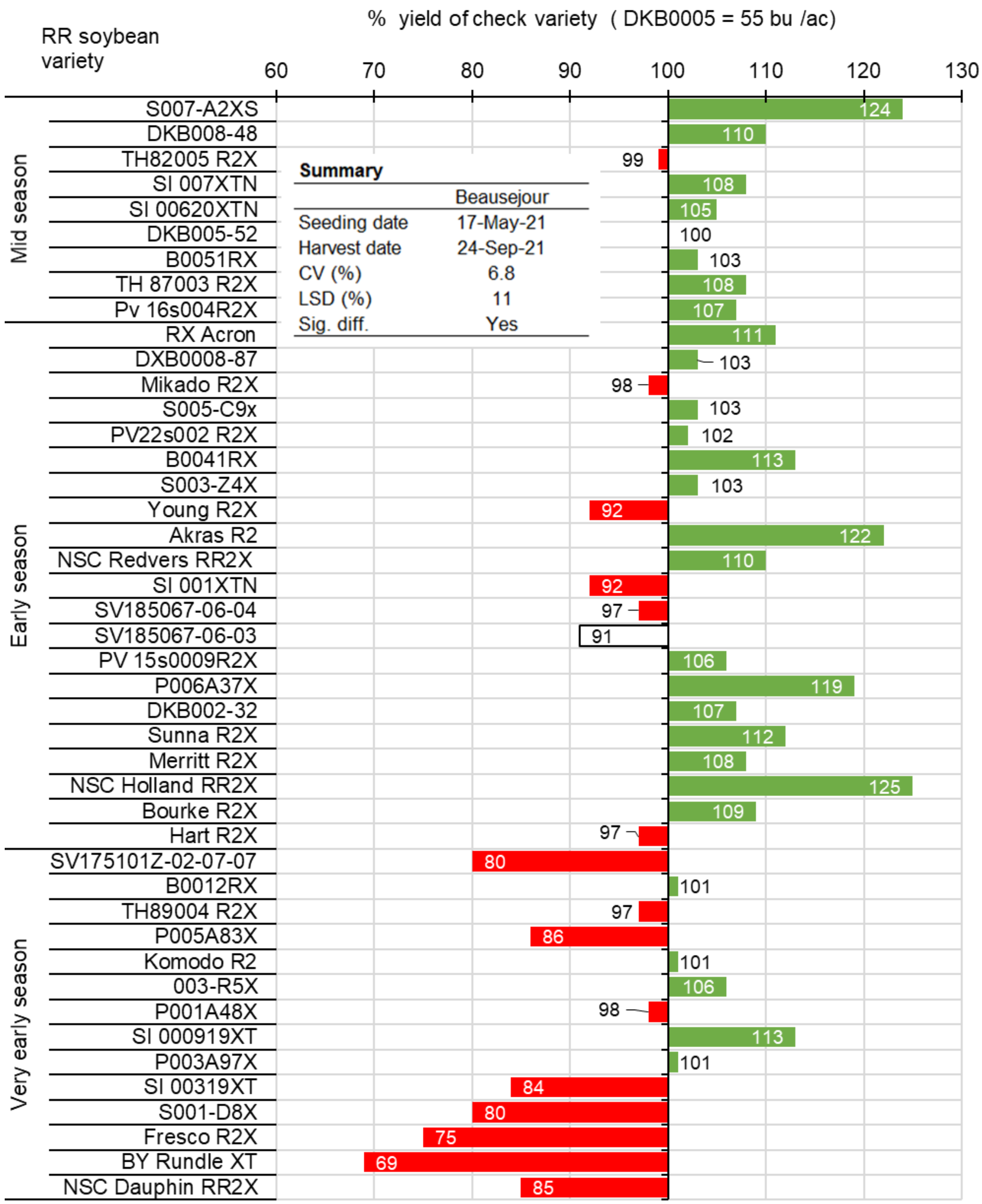


Fig. 7.1. Yield performance of herbicide tolerant soybean varieties as a per cent of the check variety (DKB0005) at Beausejour site. Red bars show yield of a variety lower than the check variety whereas green bars show yield of a variety higher than the check variety.

(Note: Soybean varieties differ in yield if the difference is at least 11 % yield of check variety).

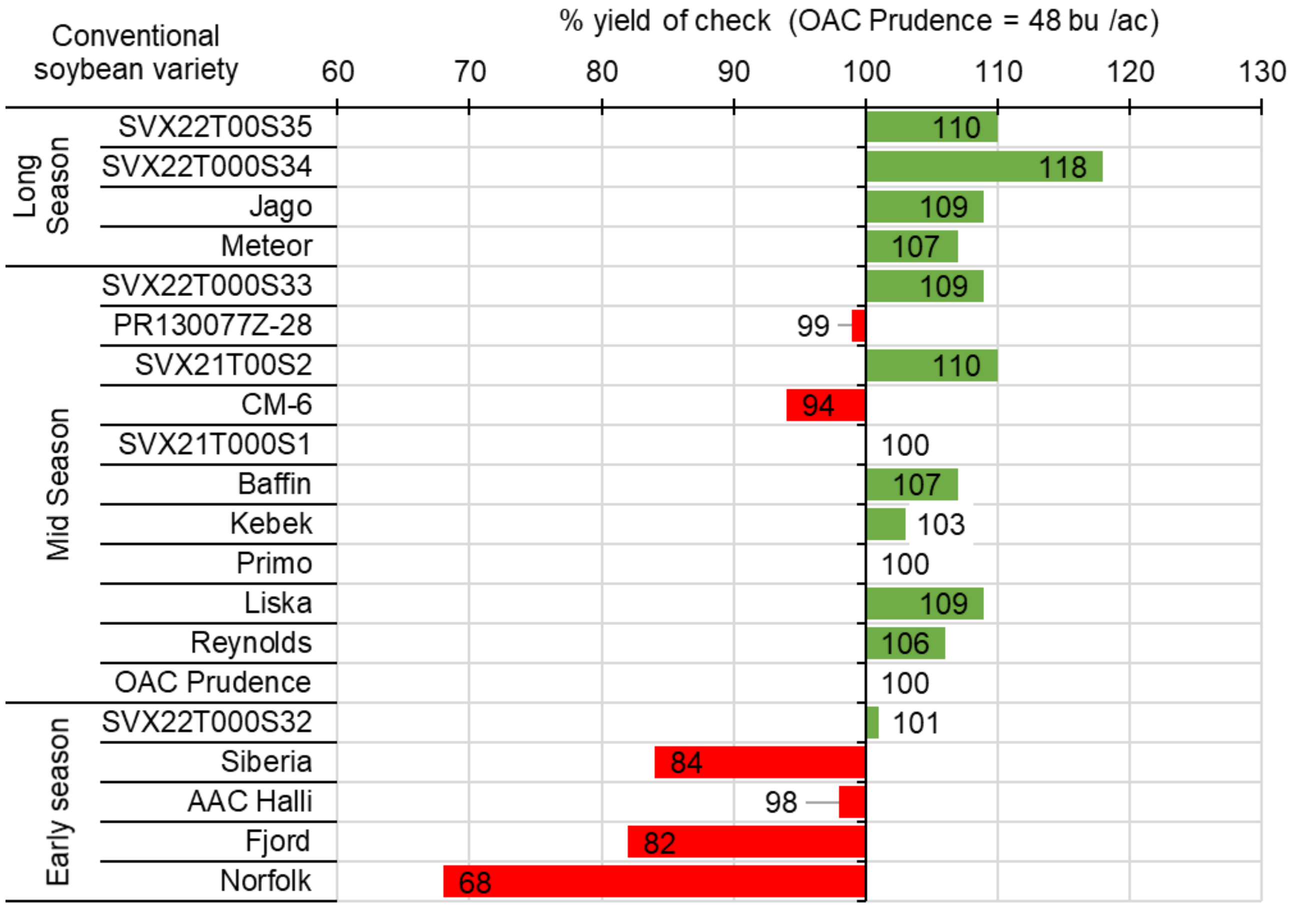


Fig. 7.2. Yield performance of conventional soybean varieties as a per cent of check variety (OAC Prudence) at Beausejour site. Red bars show yield of a variety lower than the check variety whereas green bars show yield of a variety higher than the check variety.

(Note: Soybean varieties differ in yield if the difference is at least 9 % yield of check variety).

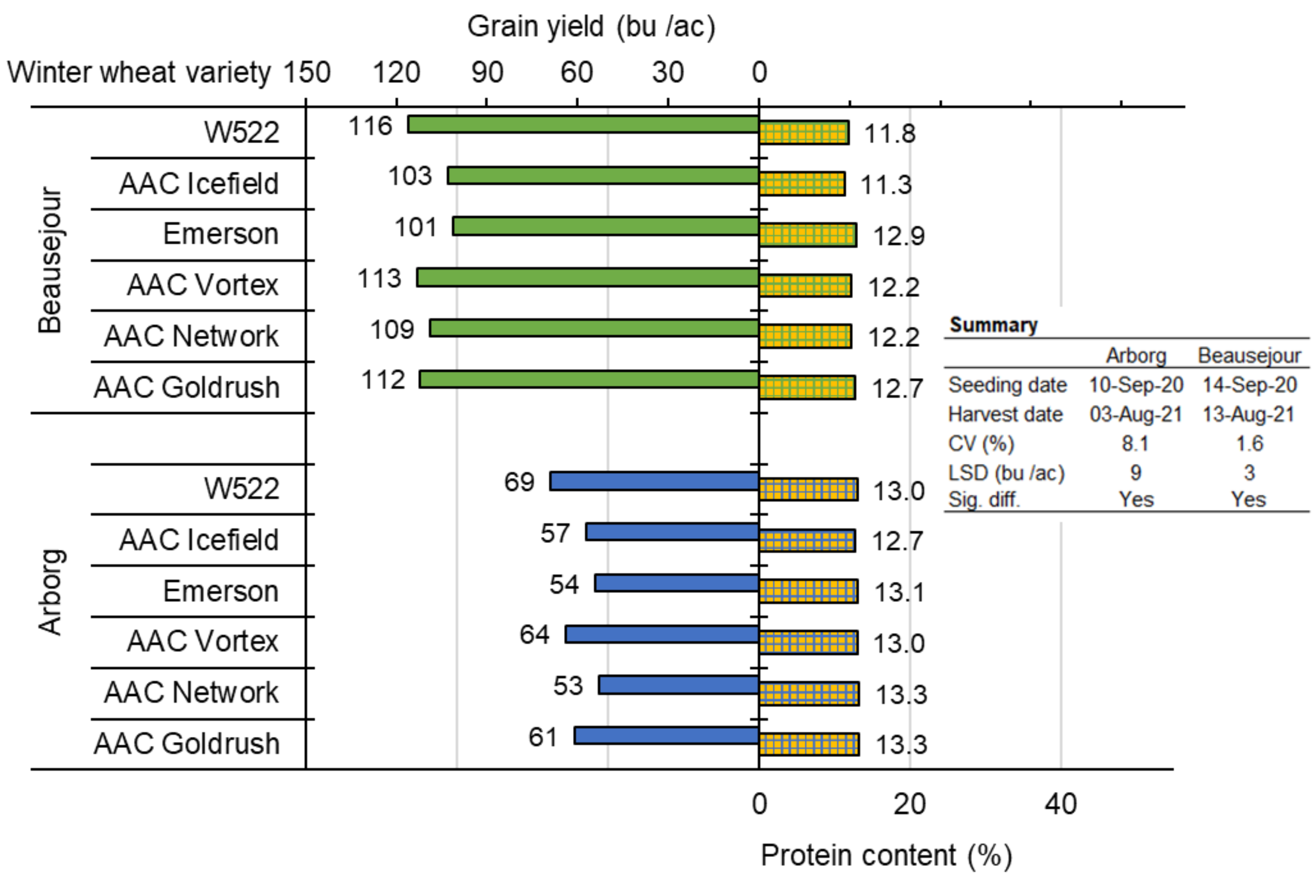


Fig. 7.3. Grain yield (solid bars) and protein content (check pattern bars) comparison of winter wheat varieties tested at Arborg and Beausejour sites in 2021.

(Note: Varieties differ in yield if the difference is 9 bu /ac at Arborg and 3 bu /ac at Beausejour).

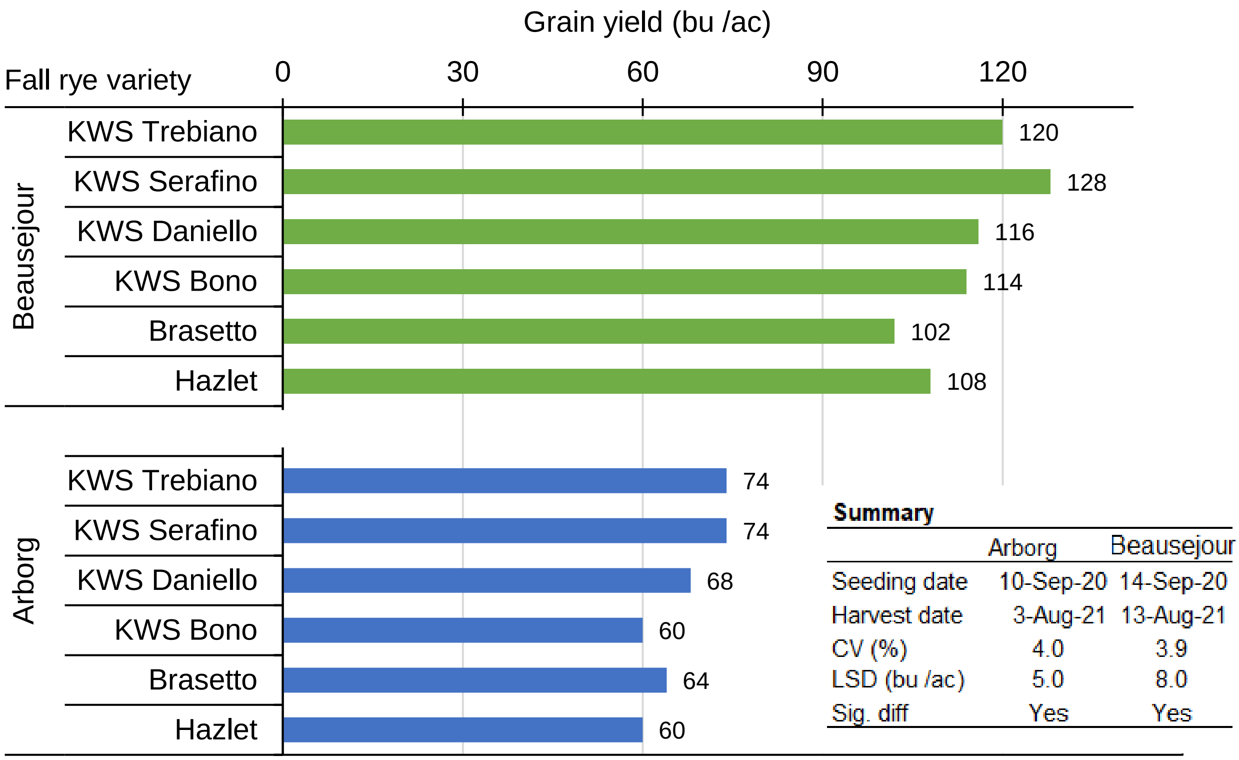


Fig. 7.4. Grain yield comparison of fall rye varieties evaluated at Arborg and Beausejour sites in 2021.

(Note: Varieties differ in yield if the difference is 5 bu /ac at Arborg and 8 bu /ac at Beausejour).

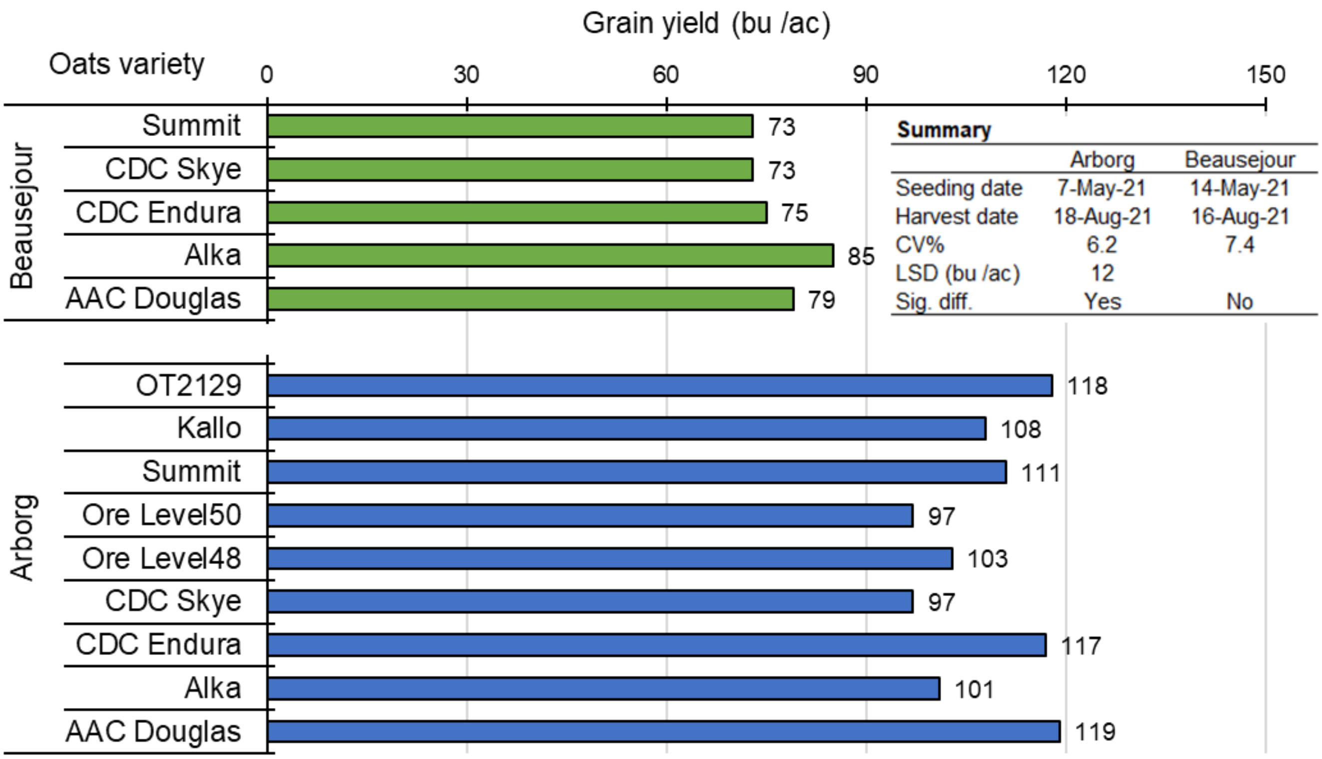


Fig. 7.5. Grain yield comparison of oats varieties evaluated at Arborg and Beausejour sites in 2021.

(Note: Varieties differ in yield if the difference is 12 bu /ac at Arborg. Varieties do not differ in yield at Beausejour site when results were analysed statistically).

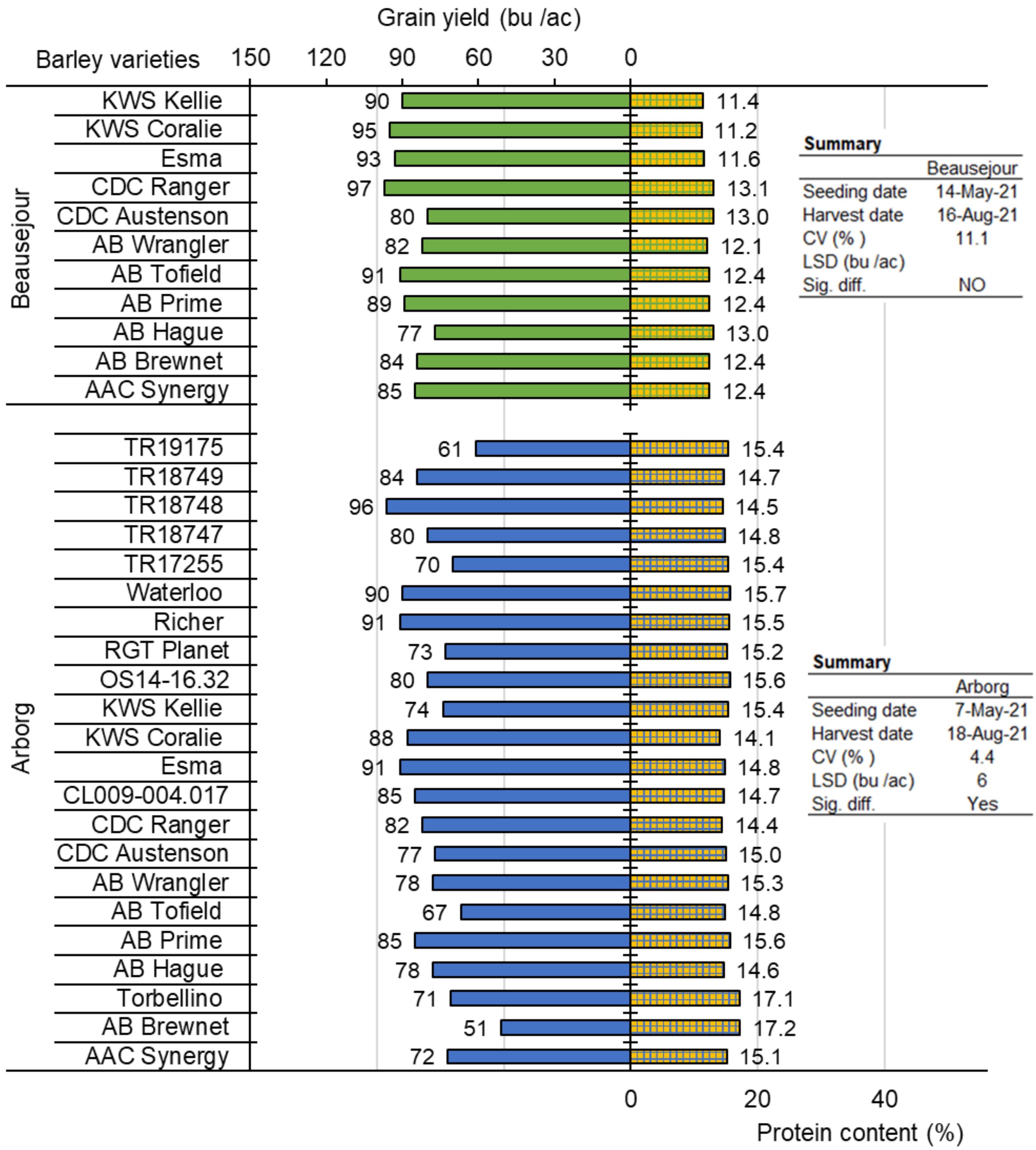


Fig. 7.6. Grain yield (solid bars) and protein content (check pattern bars) comparison of barley varieties evaluated at Arborg and Beausejour sites in 2021.

(Note: Varieties differ in yield if the difference is 6 bu /ac at Arborg. Varieties do not differ in yield at Beausejour site when results were analysed statistically).

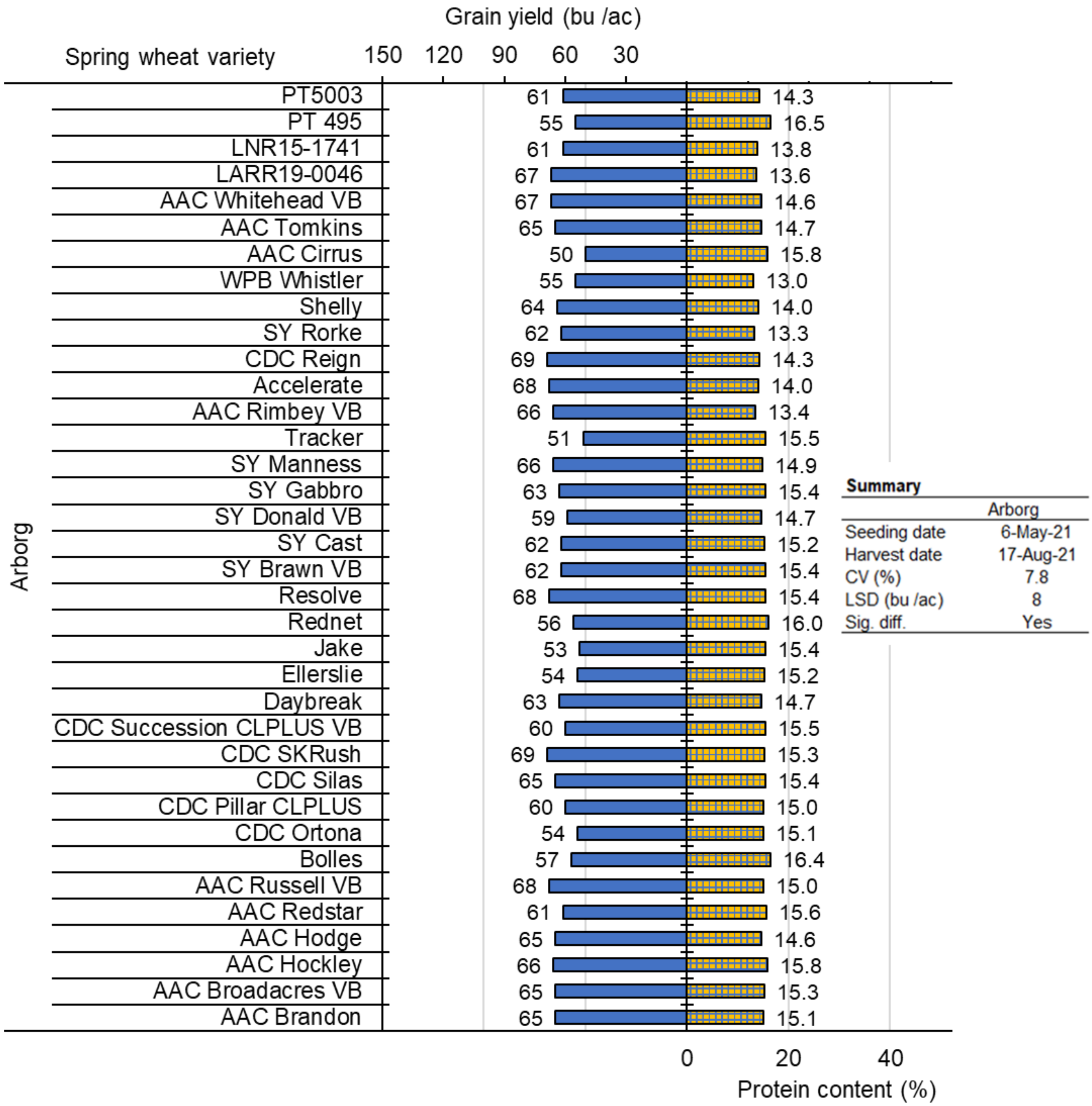


Fig. 7.7. Grain yield (solid bar) and protein content (check patterned bar) comparison of spring wheat varieties evaluated at Arborg in 2021.

(Note: Varieties differ in yield if the difference is 8 bu /ac).

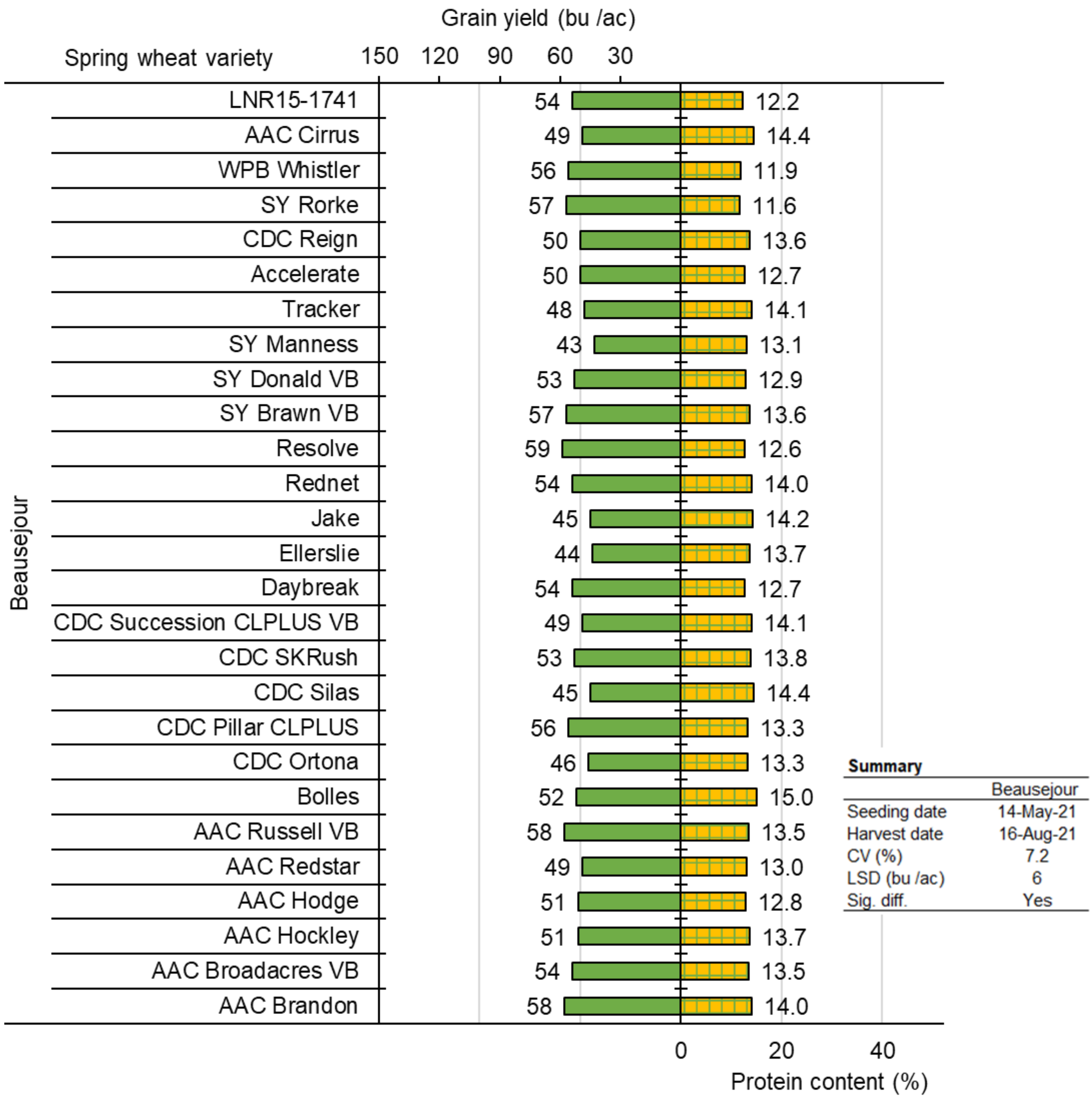


Fig. 7.8. Grain yield (solid bar) and protein content (check patterned bar) comparison of spring wheat varieties evaluated at Beausejour in 2021.

(Note: Varieties differ in yield if the difference is 6 bu /ac).

8. Evaluating silage corn varieties in Interlake region

Project duration

- 2021

Collaborators

- Daryl Rex, Manitoba Crop Alliance

Objectives

To evaluate the yield potential of silage corn varieties in Interlake region.

Results

Variety trials for silage corn were conducted at Elm Creek, St. Pierre and Arborg sites during 2021. At Arborg site, the tested silage corn varieties differed in their yield potential (Table 8.1). The yield varied from 8.3 – 12.0 Mt/acre (at 65% moisture content). Among all varieties tested, MS 8022R recorded the highest yield, while variety HZ 1912 had the lowest yield. Moisture content at harvest also varied (range: 63.3-72.8%) among corn varieties. Similarly, corn varieties also differed in 50% silking period and the variety 932S took greater number of days (84) to reach this stage. The detailed results on quality analysis are presented in the Table 8.1.

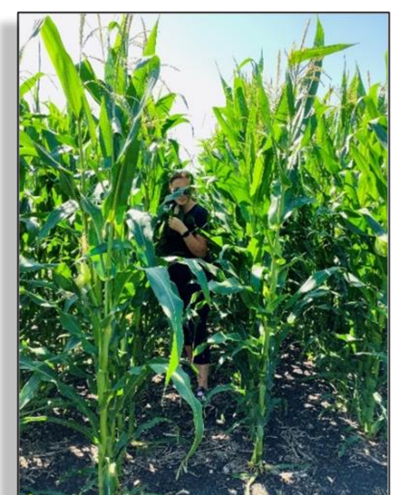
Project findings

Silage corn varieties differed in their yield potential at Arborg site. For more information, please contact Manitoba Crop Alliance.

Background / References / Additional resources

Now with the short-season corn varieties available, producers have more options to grow silage corn in Manitoba especially in the Interlake region. Manitoba Crop Alliance coordinates varietal evaluation of potential new silage corn varieties in the province. These varietal trials were done at different sites in the province and Arborg was one of the evaluation sites. This trial was conducted to see production potential of different silage corn varieties in the Interlake region.

Materials and methods



Experimental design – Randomized complete block design;
Replications: 3
Treatments – 30 silage corn varieties (Table 7.1)
Plot size – 18 m^2; Plant population – 32,000 plants/acre
Data collected – plant stand, 50% silking, yield

Agronomic information

Stubble, soil type – Corn, Heavy clay
Fertilizer applied: N -72 lb /acre; P - 35 lb/acre
Pesticides applied :Glyphosate @0.67 L/acre on June 14 & 29 for the control of weeds.
Seeding date – May 21, 2021; Harvesting date - Sep 22, 2021

Table 8.1. Evaluating silage corn varieties for yield and silage quality (total digestible nutrients (TDN), acid detergent fibre (ADF), neutral detergent fibre (NDF), Milk per acre and Beef per acre) at Arborg site (Adapted from Seed Manitoba 2022, pp112).

CHU	**Hybrid**	**Technology / Genetic Trait**	**Distributor**	**65% Yield**	**Moisture at harvest**	**50% Silk**	**TDN**	**ADF**	**NDF**	**Milk /acre**	**Beef /acre**
				Mt/ac	%	days	%	%	%	lb/ac	lb/ac
2050	DKC20-23RIB	VT2P	DEKALB	8.7	63.3	74	77.0	20.2	36.9	7707	864
2050	Rustler	GT	Greenfield Genetics	9.8	66.4	74	76.9	20.4	39.7	8014	970
2075	DKC21-36RIB	VT2P	DEKALB	9.8	63.9	74	72.2	24.8	44.9	5468	910
2100	TH6875 VT2P	VT2P	Thunder Seed	10.1	67.4	72	75.3	21.8	38.9	7585	973
2100	DKC24-06RIB	VT2P	DEKALB	10.4	65.8	74	75.2	21.9	38.0	8796	1004
2100	CP1440VT2P/RIB	VT2P/RIB	CROPLAN	11.2	66.4	76	78.5	18.9	35.1	10232	1124
2150	TH4076 HDRR	RR2	Thunder Seed	10.0	69.1	78	77.6	19.7	36.4	8019	993
2150	913S	RR2	NorthStar Genetics	10.0	70.2	78	78.6	18.7	37.2	8170	1012
2150	AS1017RR EDF	RR2	PRIDE Seeds	10.5	66.8	78	75.5	21.7	41.5	8526	1016
2200	PS 2320RR	RR2	DLF Pickseed	11.4	65.1	74	77.0	20.2	36.2	8087	1122
2200	PV 61177SRR	RR2	Proven Seed	10.6	68.9	77	76.2	21.0	40.0	8809	1038
2200	PV 61377RIB	VT2P	Proven Seed	10.2	65.9	75	77.2	20.0	37.8	8087	1009
2200	MS 7420R	RR2	Maizex Seeds	11.1	64.1	74	75.9	21.3	39.7	7373	1084
2250	TH4126 RR	RR2	Thunder Seed	10.8	68.2	76	74.7	22.4	41.0	8651	1031
2250	X21080A/VT2P	VT2P/RIB	CROPLAN	9.5	67.1	75	71.1	25.7	45.9	6178	870
2250	PV 61479RIB	VT2P	Proven Seed	9.6	68.2	75	78.3	19.1	35.1	8379	963
2250	MS 8022R	RR2	Maizex Seeds	12.0	69.4	75	76.9	20.4	36.9	9119	1186
2275	PS 2333RR	RR2	DLF Pickseed	9.2	68.6	79	77.3	20.0	39.2	7226	915
2275	DKC29-89RIB	VT2P	DEKALB	9.3	67.3	77	76.7	20.5	39.4	6125	912
2275	A4514RR	RR2	PRIDE Seeds	9.6	68.5	77	72.6	24.4	43.3	7533	898
2300	PS 2420RR	RR2	DLF Pickseed	10.3	68.0	75	75.4	21.7	40.6	6992	993
2300	TH6180 VT2P	VT2P	Thunder Seed	11.8	66.5	77	74	23.0	40.5	9667	1122
2300	CP2123VT2P/RIB	VT2P/RIB	CROPLAN	10.5	66.4	76	75.9	21.3	37.7	7902	1019
2300	A4705HMRR	RR2	PRIDE Seeds	9.9	67.4	73	75.6	21.6	39.1	6496	964
2300	HZ 1710	Agrisure 3010	Horizon Seeds	10.5	71.1	79	77.1	20.1	38.5	8547	1040
2350	932S	RR2	NorthStar Genetics	11.8	72.8	84	74	23.1	42.2	7450	1119
2350	HZ 675	Agrisure 3010	Horizon Seeds	10.5	71.3	79	76.4	20.8	37.0	9312	1026
2375	HZ 1912	Agrisure 3120 EZR	Horizon Seeds	8.3	69.8	79	77.6	19.7	37.9	6658	827
2450	HZ 2220	Agrisure 3010	Horizon Seeds	11.6	69.1	80	77.9	19.5	36.6	9562	1160
			LSD (p = 0.05)	**1.3**	**2.8**	**3**					
			Sig. diff.	**Yes**	**Yes**	**Yes**					

9. Evaluating short season, cold and disease tolerant corn inbred in the Interlake region

Project duration

- 2018-2022

Collaborators

- Lana Reid, AAFC Ottawa

Objectives

Development and release of early maturing cold tolerant corn inbreds with emphasis on the 1800-2000 CHU market.

Project findings

This was the fourth year of testing. Inbred line evaluations will be again done in 2022 and AAFC will share data once the project is completed.

Background / Additional resources

Canada annually produces more than 13 million metric tons of grain corn with a farm gate value greater than $2 billion from 1.3 million ha. Historically, grain corn was concentrated in areas of the country with the highest available heat units and adequate moisture supply (i.e. southern Ontario); however, many production areas in eastern and western Canada have less than 2800 CHU. Production in these heat-limited environments is expanding rapidly as demand for grain corn increases. There is a lack of suitable early hybrids with acceptable early season cold tolerance for these expanding regions. As well, climate change has resulted in a significant increase in common diseases and the arrival of new diseases to Canada. This evolving crisis will affect trade and severely damage growers.
This project aimed to develop and release early maturing cold tolerant corn inbreds with emphasis on the 1800-2000 CHU market. This objective will be achieved using conventional corn breeding methodology enhanced by double haploid inbred production and specialized screening techniques for cold tolerance. Multiple yield trials in Alberta, Manitoba, Quebec, Ontario and PEI are planned.

Materials and methods

Experimental design – Randomized complete block design
Replications: 3; Plot size – 9 m^2
Treatments – Thirty corn lines provided by AAFC Ottawa.
Data collected – plant stand, disease incidence, grain yield, test weight

Agronomic information

Stubble, soil type – Fallow, heavy clay
Fertilizer applied: N – 60 lb /acre and P – 25 lb /acre applied at seeding.
Pesticides applied - Armezon @15ml/acre + Atrazine@0.42L/acre on June 16
Seeding date- May 20, 2021
Harvesting date – Oct 19, 2021

10. Effect of tile drainage on soil temperature in heavy clay soils

Project duration

- 2021

Objectives

To assess the impact of tile spacing's on soil temperature at two soil depths: 1 inch (seeding depth) and 6 inch (rooting depth) in spring.

Results

The soil temperature at two depths was not recorded in the spring or after seeding due to delay in the arrival of soil temperature sensors. However, sensors were installed in June and observations were recorded in late June. Soil temperature (both on the tiles as well as in between tiles) did not differ for 15- and 30-feet wide tile spacing's when compared with non-tiled land (Fig. 10.1). However, 45-feet spaced tiles had slightly greater temperature on the tiles as compared to non-tiled land.

Project findings

This test in 2021 was a preliminary test. This project would be conducted again in 2022 with replicated measurements. Temperature measurements will be commenced around mid-April and will be continued during the seeding / plant establishment phase of the crops.

Background / Additional resources / References

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 a waterlogged / 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. This region in Manitoba is a transition zone between humid climate of the east and arid climate to the west.

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. Thus, soil texture, color, and moisture play important roles in soil temperature through their influence on heat conduction and convection, the two most important processes of heat transport in soil.

This hypothesis regarding influence of tile spacing's 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 different spaced (15', 30' and 45' wide tiles) tiled plots with three replications. In 2022, PESAI will conduct research to answer the following questions –

- Is there any difference in the soil temperature (in top 6 inches of the soil profile) between tiled and untiled land before and during seeding time?
- If the top soils are relatively warmer on tiles during spring, how early producers can start seeding (than on conventional land)?

References

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.

Materials and methods

Soil type: heavy clay

Experiment design: Randomized complete block design

Replications: 3

Treatments – on tile, in-between tiles and control

Three tile spacing's (15-, 30- and 45-feet wide) and non-tiled land.

Measurements - Soil temperature was measured on the tiles as well as in between the tiles during June 21- July 2, 2021. These measurements were compared with temperature from non-tiled land. Soil temperature was measured daily at two soil depths (1 inch & 6 inch) using Omega HH11C thermometer.

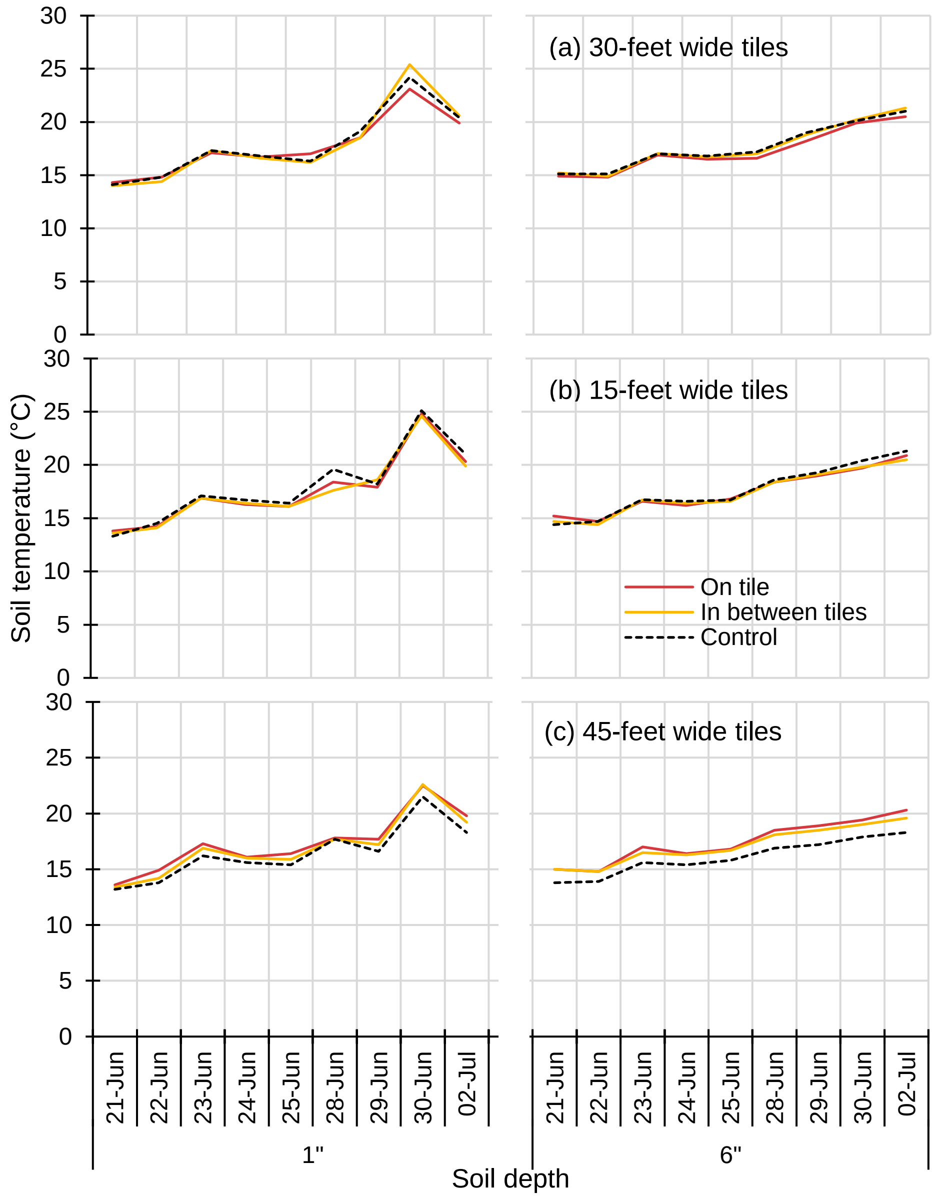


Fig. 10.1. The observed soil temperatures at two soil depths (1-inch and 6-inch) on (a) 30-feet (b) 15-feet and (c) 45-feet spaced tiled plots during late June and early July, 2021.

11. Effect of spring cereal seeding rate on its yield potential

Project duration

- 2017-2021

Collaborators

- Anne Kirk, Manitoba Agriculture
- Manitoba Agriculture Diversification centers

Objectives:

- Determine if target plant stand recommendations should be adjusted for spring wheat, oats, and barley.
- Determine if optimum plant stands differ for individual varieties.
- Assist producers with determining target plant stand and seeding rate for newer spring cereal varieties.

Results

Stand establishment increased as seeding rate increased at most site years. There was no significant difference in plant stand between seeding rate treatments for wheat at Roblin, results will not be shown for this site as a range of plant populations were not established. At many locations plant stands were lower than the target. The exception was Arborg where plant stands ranged from 18-57, 12-47, and 25-35 plants /ft^2 in the barley, oats, and wheat plots, respectively (Table 11.1).

Cereals can compensate for lower plant populations by increasing tillering. Research in which spring wheat plants were given ample room found that stems per plant ranged from 19 to 44 depending on the variety (Wiersma 2014). While cereal cultivars differs in their abilities to tiller, there was no difference in heads per plant between cultivars at the majority of sites (Table 11.2). The actual number of spikes or panicles present at maturity depends on the number of tillers produced and the number that survive to maturity. The effect of drought stress on yield components depends on the timing of drought stress, and early season drought stress reduces yield potential through tiller death (Duggan et al. 2000). This is evident in the results from the Arborg location, where heads per plant were low across all crop types and treatments.

Heads per plant decreased as seeding rate increased, which demonstrates the ability of cereal crops to compensate for reduced plant populations by increasing tillering (Table 11.2). There was no significant difference in heads per plant at target plant populations ranging from 21-39 plants /ft^2 at five out of the eight sites where there were significant differences in heads per plant.

Wheat

There were significant yield differences between wheat varieties at the three locations where yields are reported, with AAC Brandon yielding significantly higher than Faller at two sites (Table 11.3). Yields were generally low at Arborg and Carberry due to drought conditions, with Carberry yields being further reduced as a result of hail.

When averaged across cultivars, there were no differences in wheat yield across plant densities at Melita. At Carberry, yields increased as plant stand increased, with the highest yields being reported at target plant densities of 27 to 39 plants /ft^2 (Table 11.3 and Fig. 11.2). At Arborg, the 9 plants/ft^2 treatment had the lowest yield overall, with 33 plants/ft^2 yielding the highest (Table 11.3 and Fig. 11.2). Actual plant populations ranged from 9 to 30 plants /ft^2 at Carberry, 6 to 19 plants /ft^2 at Melita, and 25-35 plants /ft^2 at Arborg.

Table 11.1. Plant stand (plants /ft^2) for barley, oats, and wheat at the Arborg (Arb), Carberry (Car), Melita (Mel), and Roblin (Rob). Barley varieties are CDC Austenson (A) and AAC Connect (B), oat varieties are CS Camden (A) and Summit (B), and wheat varieties are AAC Brandon (A) and Faller (B).

	Barley				Oats			Wheat			
	Arb	Car	Mel	Rob	Arb	Mel	Rob	Arb	Car	Mel	Rob
	------------------------------ plants/ft^2 ------------------------------										
Variety											
A	40	15	16.3b	18	33	17a	12	29	19	14	11
B	43	14	17.8a	18	29	13b	10	31	21	14	13
LSD‡	-	-	1.3	-	-	2	-	-	-	-	-
Target Plant Population (pl/ft^2)											
9	18e	6d	7f	8c	12e	6f	6f	25d	9e	6d	11
15	36d	10cd	12e	14b	23d	10e	9ef	27cd	15d	10c	12
21	40cd	13bc	15d	17b	29cd	14d	10de	30bc	20c	13b	11
27	47bc	14b	19c	21a	34bc	16c	12cd	33ab	23bc	16b	17
33	53ab	19ab	23b	23a	40b	21b	14bc	33ab	26b	19a	11
39	57a	24a	28a	23a	47a	24a	16a	35a	30a	19a	9
LSD‡	9	5	2	3	7	3	3	5	3	3	-

‡Least significant difference (LSD) values are shown for sites where there is a significant difference (Pr<0.05) between treatments. At sites with significant differences between treatments, means within the same site year followed by the same letter within a column are not significantly different.

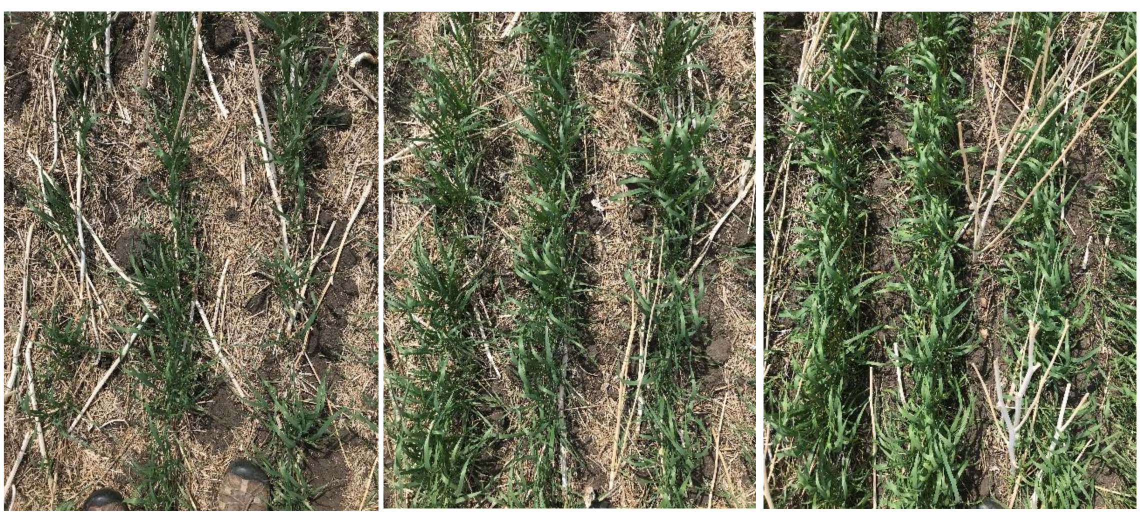


Fig. 11.1. AAC Brandon wheat planted at target plant stands of 9, 21, and 33 plants /ft^2 at Melita in 2021.

Table 11.2. Heads per plant for barley, oats, and wheat at the Arborg, Carberry, Melita, and Roblin. Barley varieties are CDC Austenson (A) and AAC Connect (B), oats varieties are CS Camden (A) and Summit (B), and wheat varieties are AAC Brandon (A) and Faller (B).

	Barley			Oats			Wheat		
	Arborg	Carberry	Roblin	Arborg	Melita	Roblin	Arborg	Carberry	Melita
	---------- Heads/plant ----------								
Variety									
A	0.8	6.0	6.8	0.77	1.7b	6.03	1.1	5.8	2.7
B	0.8	5.7	6.7	0.89	2.2a	6.74	1.2	5.9	2.8
LSD	-	-	-	-	0.2	-	-	-	-
Target Plant Population (pl /ft^2)									
9	1.5a	6.5ab	10.2a	1.2a	3.2a	7.8	1.8a	6.7a	4.3a
15	0.9b	6.8a	7.9b	0.7b	2.2b	6.7	1.3b	5.9b	3.1b
21	0.7c	5.1c	7.2b	0.8b	1.8bc	6.9	1.2b	5.8b	2.6bc
27	0.6c	5.5c	5.7c	0.9b	1.7cd	6.0	0.9c	5.6b	2.3c
33	0.6c	5.7bc	4.5c	0.8b	1.4d	5.8	0.9c	5.5b	2.0c
39	0.5c	5.3c	4.9c	0.7b	1.4d	5.1	0.8c	5.8b	2.2c
LSD‡	0.2	0.9	1.4	0.3	0.4	-	0.3	0.8	0.7

‡Least significant difference (LSD) values are shown for sites where there is a significant difference (Pr<0.05) between treatments. At sites with significant differences between treatments, means within the same site year followed by the same letter within a column are not significantly different. Roblin wheat data is not shown due to high coefficients of variation.

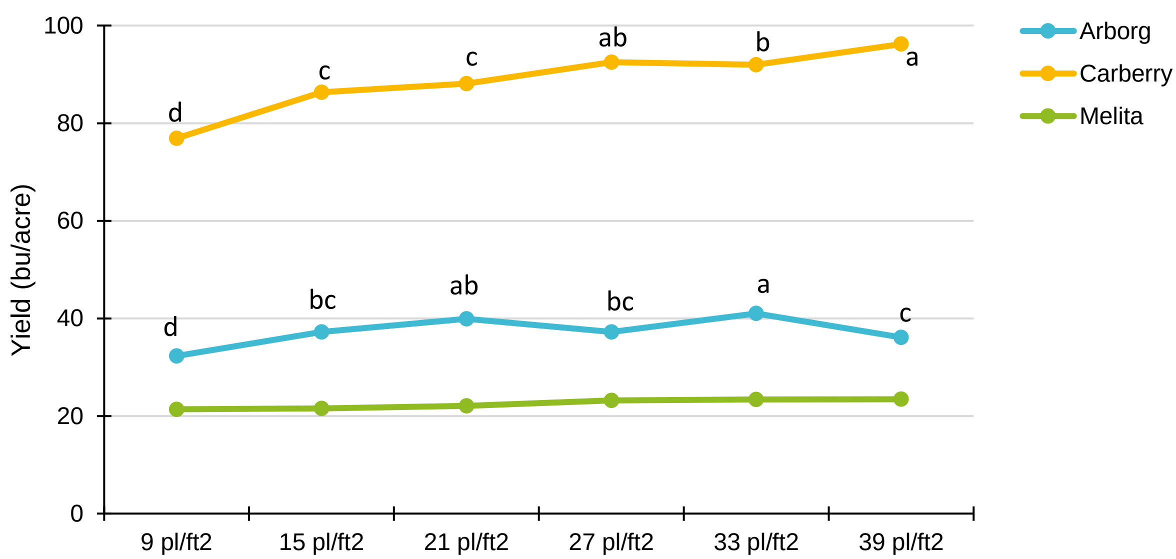


Fig. 11.2. Wheat yield (bu/acre) at six target plant densities at Arborg, Carberry and Melita. Statistically significant differences are shown by letters above the line. Treatments within the same site with the same letter are not significantly different (P<0.05).

Fig. 11.3 shows yield plotted against plant stand, giving context to the results. There was no interaction between seeding rate and cultivar, both cultivars responded similarly to increased seeding rates (data not shown).

Barley

There were no significant yield differences between barley varieties at three of four locations. At Arborg, CDC Austenson yielded significantly higher than AAC Connect (Table 11.3). When averaged across cultivars, there were no significant yield differences between target plant stands at three of the four locations. There were only significant yield differences between target plant densities at Arborg, with the 9 plants /ft^2 treatment yielding significantly lower than the higher target plant densities (Table 11.3 and Fig. 11.4). Actual plant populations ranged from 6 to 28 plants /ft^2 at Carberry, Melita, and Roblin, and 18 to 57 plants/ft^2 at Arborg (Table 11.1 and Fig. 11.5). Fig. 11.5 shows yield plotted against plant stand, giving context to the results and highlighting the higher plant populations at Arborg. There was no interaction between plant density and cultivar, both cultivars responded similarly to increased seeding rates (data not sown).

Oats

There was a significant yield difference between the two oats varieties at two of the three locations, with CS Camden yielding higher than Summit in both cases (Table 11.3). Averaged across cultivars, there was no difference in oats yield across the range of target plant densities at two of the three locations. There were significant yield differences across target plant densities at the Arborg location, but no consistent trend (Fig. 11.6). Oats yield plotted against plant stand is shown in Fig. 11.7. There was no interaction between plant density and cultivar, both cultivars responded similarly to increased seeding rates (data not sown).

This study is a continuation of a research project that took place at Arborg, Carberry, Melita, and Roblin in 2017 and 2018. The oats and barley sites in 2017 and 2018 showed similar yields across a range of plant stands, indicating that the current recommended target plant populations for barley and oats are sufficient. In the wheat trials of 2017 and 2018, there was a general trend of higher yields with increased plant stands, but no significant difference in yields between target plant stands of 21 to 39 plants /ft^2 at four of the five sites.

The 2021 results are similar, in that there were no significant yield differences across the range of plant densities at most sites. There was a general trend of higher yields with higher plant stands at the wheat, barley, and one of the oats sites, although the data indicates that these trends should be taken with caution. There was no significant difference in yields between target plant stands of 21 to 39 plants /ft^2 at nine out of the 10 sites. At all sites, both varieties tested responded similarly to each target plant stand, indicating that similar seeding rate recommendations could be made for both varieties of each crop type studied.

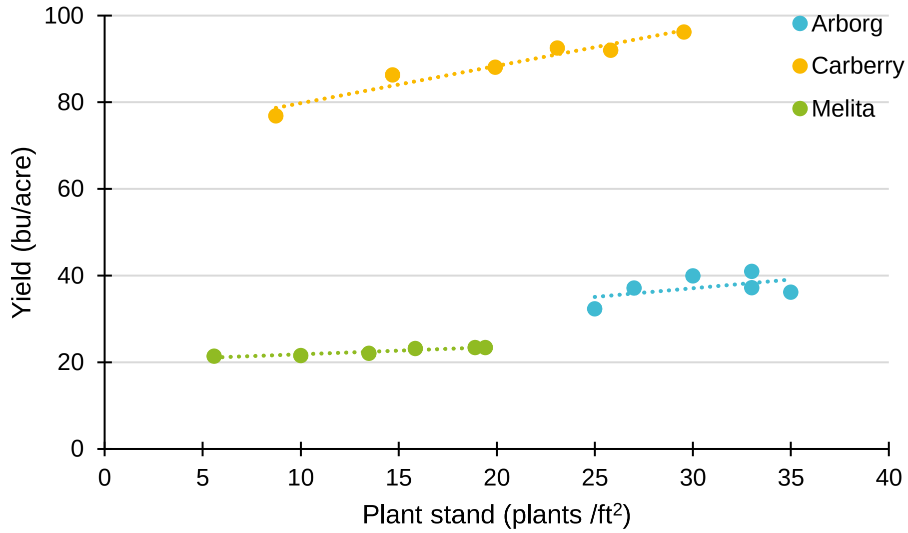


Fig. 11.3. Wheat yield (bu/acre) plotted against actual plant density (plants /ft^2) at Arborg, Carberry and Melita.

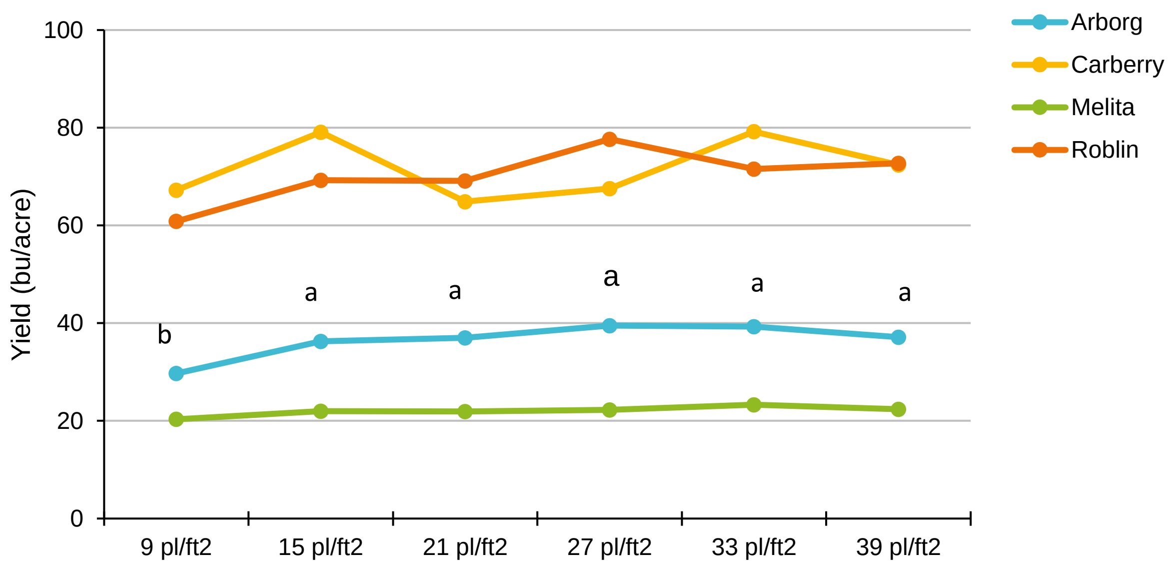


Fig. 11.4. Barley yield (bu /acre) at six target plant densities at Arborg, Carberry, Melita, and Roblin. Statistically significant differences are shown by letters above the line. Treatments within the same site with the same letter are not significantly different (P<0.05).

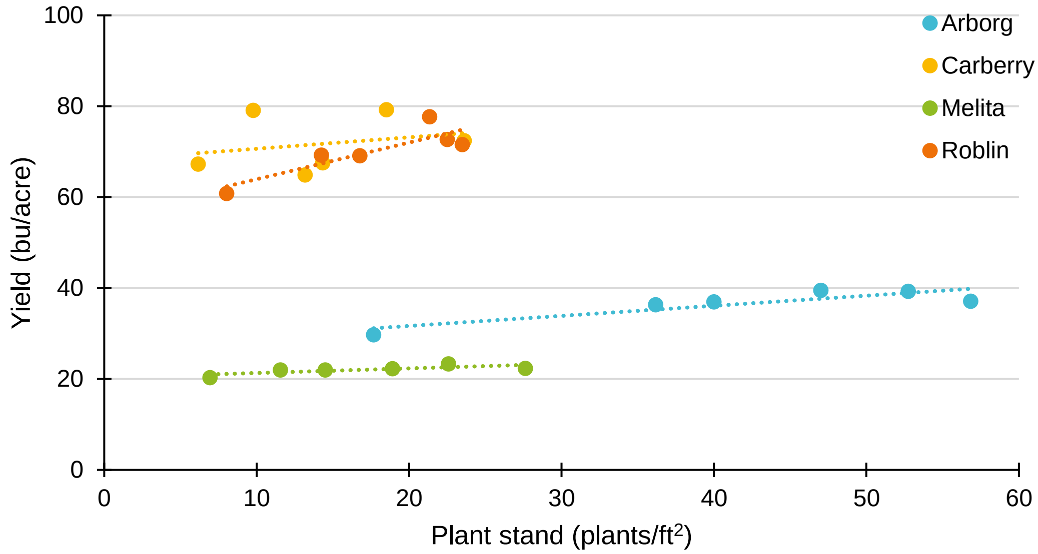


Fig. 11.5. Barley yield (bu /acre) plotted against actual plant density (plants /ft²) at Arborg, Carberry Melita, and Roblin.

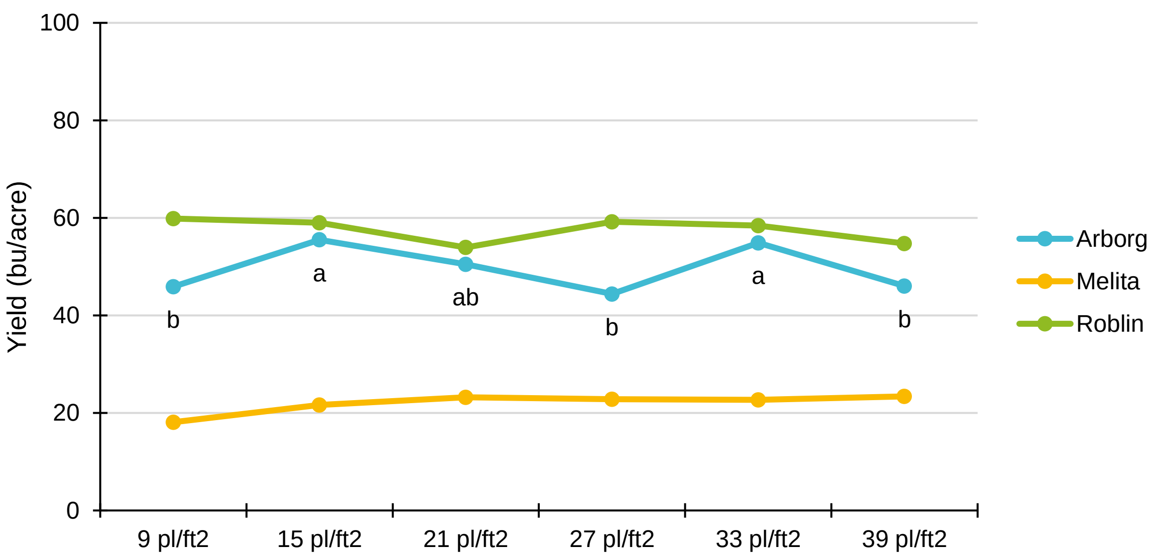


Fig. 11.6. Oats yield (bu /acre) at six target plant densities at Arborg, Melita, and Roblin. Statistically significant differences are shown by letters below the line. Treatments within the same site with the same letter are not significantly different ($P<0.05$).

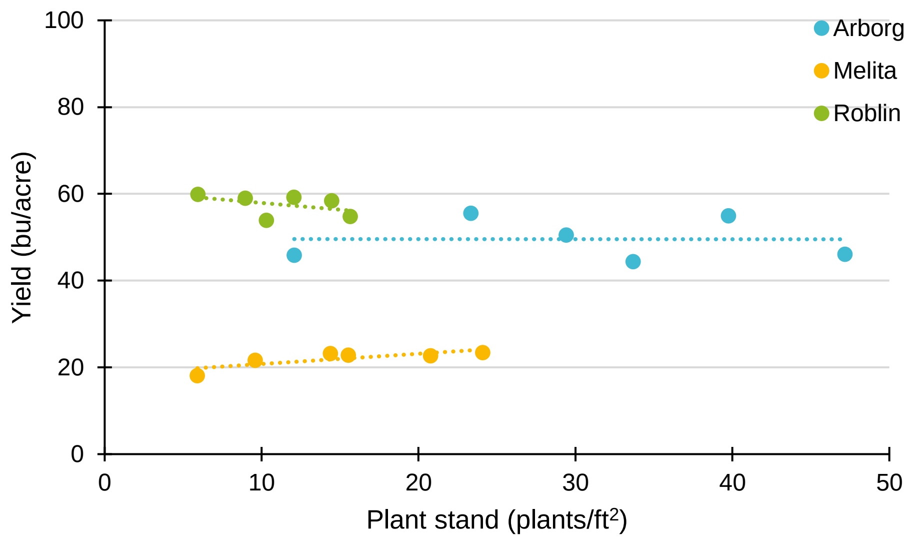


Fig. 11.7. Oats yield (bu /acre) plotted against actual plant density (plants /ft^2) at Arborg, Melita, and Roblin.

Table 11.3. Yield (bushels/acre) for barley, oats, and wheat at the Arborg, Carberry, Melita, and Roblin. Barley varieties are CDC Austenson (A) and AAC Connect (B), oats varieties are CS Camden (A) and Summit (B), and wheat varieties are AAC Brandon (A) and Faller (B).

	Barley				Oats			Wheat		
	Arborg	Carberry	Melita	Roblin	Arborg	Melita	Roblin	Arborg	Carberry	Melita
	---- Yield (bu/acre) ----									
Variety										
A	38.5a	73.9	22.0	70.9	53.8a	21.1	86.9a	38.3a	84.9b	23.6a
B	34.4b	69.5	22.1	69.5	45.3b	22.8	28.1b	36.3b	92.4a	21.4b
LSD‡	2.3	-	-	-	4.1	-	4	2.0	2.7	0.9
Target Plant Population (pl /ft^2)										
9	29.7b	67.2	20.3	60.8	45.9b	18.1	59.9	32.3d	76.9d	21.4
15	36.3a	79.1	22.0	69.2	55.5a	21.6	59.0	37.2bc	86.3c	21.6
21	37.0a	64.9	21.9	69.1	50.5ab	23.2	53.9	39.9ab	88.1bc	22.1
27	39.5a	67.5	22.3	77.7	44.4b	22.8	59.2	37.2bc	92.5ab	23.2
33	39.3a	79.2	23.3	71.5	54.9a	22.7	58.4	41.0a	92.0b	23.4
39	37.1a	72.4	22.4	72.7	46.0b	23.4	54.8	36.1c	96.2a	23.4
LSD‡	4	-	-	-	7	-	-	3.5	4.7	-

‡Least significant difference (LSD) values are shown for sites where there is a significant difference (Pr<0.05) between treatments. At sites with significant differences between treatments, means within the same site year followed by the same letter within a column are not significantly different.

Background

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

References

Crop Production. 2020. Manitoba Agriculture. Available online: https://www.gov.mb.ca/agriculture/crops/production/index.html

Duggan, B.L., Domitruk, D.R., and Fowler, D.B. 2000. Yield component variation in winter wheat grown under drought stress. Can. J. Plant Sci. 80: 739-745.

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

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

Materials and methods

Sites: Arborg, Carberry, Melita, and Roblin (Table 11.4)

Experimental design: Randomized complete block design with factorial treatments and replicated three times

Treatments: Two cultivars of spring wheat, oats, and barley planted at six seeding rates. Target plant populations were 9, 15, 21, 27, 33, and 39 plants /ft^2 (

Table 11.5).

Experiments were separated by crop type. Seeding rates were calculated based on thousand kernel weight and assumed 15% seedling mortality. Carberry oats plots had poor emergence and were terminated.

Data Collection

Plant stand, mortality, heads per plant, and yield.

All sites have lower than normal precipitation over the entire growing season (Table 11.6). Arborg had very low precipitation throughout May, June, and July, which resulted in short plants, few tillers, and low yields overall. Low precipitation was especially evident at all sites in July, where Arborg and Carberry had 20 and 17% or normal precipitation, respectively, and Melita and Roblin has 51 and 52% of normal precipitation, respectively. July was warmer than normal at all locations, and the warm and dry conditions affected plant growth and development. Melita had hail on July 17. It is estimated that the hail resulted in 20% yield loss in the wheat, and 30% yield loss in the barley and oats.

Table 11.4. Site information and agronomic management of wheat, oats and barley experiments at all locations.

Crop		Site			
		Arborg	Carberry	Melita	Roblin
	Soil series	Peguis Clay	Wellwood Loam	Waskada Loam	Erickson Loamy Clay
Wheat					
	Seeding date	07-May	3-May	4-May	6-May
	Harvest date	17-Aug	13-Aug	4-Aug	31-Aug
	Fertility (lb/ac)				
	Residual	93 N, 44 P	12 N, 4 P, 158 ppm K, 12 S	10 N, 14 P, 364 K, 90 S	93 N, 46 ppm P, 709 ppm K
	Applied	60 N, 20 P	78 N, 34 P, 15 K	105 N, 28 P, 20 K, 12 S	96 N, 15 P
Oats					
	Seeding date	10-May	-	6-May	4-May
	Harvest date	18-Aug	-	6-Aug	15-Sep
	Fertility (lb/ac)				
	Residual	93 N, 44 P	-	10 N, 14 P, 364 K, 90 S	162 N, 41 ppm P, 703 ppm K
	Applied	60 N, 20 P	-	112 N, 28 P, 20 K, 12 S	10 N, 15 P
Barley					
	Seeding date	10-May	30-Apr	4-May	6-May
	Harvest date	18-Aug	13-Aug	4-Aug	8-Sep
	Fertility (lb/ac)				
	Residual	93 N, 44 P	12 N, 4 P, 158 ppm K, 12 S	10 N, 14 P, 364 K, 90 S	93 N, 46 ppm P, 709 ppm K
	Applied	60 N, 20 P	78 N, 34 P, 15 K	105 N, 28 P, 20 K, 12 S	31 N, 15 P

Table 11.5. Crop types, varieties, and target plant stands studied.

Crop type	Variety	Target plant stand (pl /ft^2)
Wheat	AAC Brandon	9, 15, 21, 27, 33, 39
	Faller	9, 15, 21, 27, 33, 39
Oats	CS Camden	9, 15, 21, 27, 33, 39
	Summit	9, 15, 21, 27, 33, 39
Barley	AAC Connect	9, 15, 21, 27, 33, 39
	CDC Austenson	9, 15, 21, 27, 33, 39

Table 11.6. Monthly and growing season (May 1 - September 30) summaries. Data from Manitoba Agriculture Growing Season Report web43.gov.mb.ca/climate/SeasonalReport.aspx

Weather variables	Month					
	May	June	July	August	September	Total growing season
Arborg						
Precipitation (mm)	19	39	11	116	34	221
% of Normal precipitation[1]	36	51	20	147	71	69
Growing degree days (GDD)	163	412	502	397	291	1767
% of Normal GDD[1]	80	122	116	103	153	114
Carberry						
Precipitation (mm)	36	74	12	111	8	243
Normal precipitation[1]	75	106	17	158	16	79
Growing degree days (GDD)	156	419	496	389	308	1770
Normal GDD[1]	85	125	117	100	161	116
Melita						
Precipitation (mm)	28	87	35	125	13	289
Normal precipitation[1]	52	86	51	160	38	86
Growing degree days (GDD)	108	426	522	426	323	1878
Normal GDD[1]	88	121	115	103	153	115
Roblin						
Precipitation (mm)	50	62	37	82	16	249
Normal precipitation[1]	111	84	52	148	31	83
Growing degree days (GDD)	148	380	467	360	266	1623
Normal GDD[1]	86	121	119	102	163	116

[1]Based on 30-year averages

12. Developing a risk model to improve the effectiveness of Fusarium Head Blight mitigation in western Canada

Project duration

- 2018-2023

Collaborators

- Dr. Paul Bullock, Department of Soil Science, University of Manitoba

Objectives

- To develop weather-based models to assess the risk of FHB infection and DON in spring wheat, winter wheat, barley and durum crops with different FHB resistance ratings.
- To develop an interactive prairie-wide viewer and FHB/DON risk-mapping tool that is accessible to producers and industry to assist with fungicide application decisions.

Results

The results will be shared after the completion of this project.

Project findings

This was the third year of testing at PESAI site and data were handed over to U of M. Researchers are compiling data from all 15 sites (in three prairies provinces) and will report later on.

Background / Additional Resources/ References

Fusarium Head Blight (FHB) is the most serious fungal disease affecting wheat and other cereals in Western Canada and most cropping areas of the world. Producers can lower FHB risk by growing cereals with higher FHB resistance ratings and with the application of a proper fungicide near the time of anthesis. Fungicide can reduce losses in yield, grade and mycotoxin infection such as deoxynivalenol (DON) when weather conditions favor FHB development, the crop is susceptible and *Fusarium* spp. are present in significant quantities. At the time of fungicide application, weather conditions might not be conducive to FHB infection, that leads to financial loss to the producer due to unnecessary pesticide application in addition to potential environmental side effects. Research has shown that fungicide application does not always provide a tangible benefit.

De Wolf et al (2003) developed a logistic regression model based on the combinations of temperature, relative humidity, rainfall and durations of specified weather conditions for 7 days prior to anthesis to predict FHB incidence. Prediction accuracy of these models ranged from 62-85%. A weather-based decision management tool that alerts producers when FHB risk is high has the potential to improve FHB management with significant financial benefit.

References

De Wolf E.D., Madden L. V. and Lipps P. E. (2003) Risk assessment models for wheat Fusarium head blight epidemics based on within season weather data. Phytopathology 93: 428-435.

Materials and methods

Experimental design: Randomized complete block design.
Replications: 4; Plot size: 8.22m^2

Treatments

- three winter wheat varieties– Emerson, AAC Gateway, Moats
- three spring wheat varieties – AAC Elie, AAC Brandon, Muchmore
- three barley varieties – AAC Connect, AAC Synergy, CDC Copeland
- one durum wheat variety – Strongfield

Data collected

Plant density (at 3-leaf stage), growth stages (starting from BBCH 47 to 49) on weekly basis, spore traps, FHB infection rates, grain yield & moisture, DON levels in grains

During 2021, these trials were established at various sites across three Prairie provinces. Evaluations were done on spring wheat, winter wheat, barley and durum cultivars with different FHB resistance ratings. Weather stations were installed at all the sites for getting intensive weather data for model development.

Agronomic information

Stubble, soil type – Wheat stubble, heavy clay

Soil nutrient levels (lb /acre): N – 122, P– 32, K – 620

Fertilizer applied–

Spring cereals: N -64 lb /acre; P -20 lb /acre;

Winter wheat: N- 30 lb /acre; P-25 lb /acre in fall and
100 lb/ac N was broadcasted in the spring.

Pesticides applied – Silencer @ 34 ml/acre on July 8 for the control of grasshoppers

Seeding date

Spring cereals: May 10, 2021

Winter wheat: Sep 10,2020

Harvesting date –

Spring cereals: Aug 18, 2021

Winter wheat: Aug 12, 2021

13. Does balanced fertility program increases yield of new winter wheat varieties?

Project duration

- 2019-2020

Collaborators

- Ducks Unlimited Canada
- Western Ag Lab

Objectives

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

Results

Winter wheat variety was not found to have a significant effect on wheat yield at any of the individual trial sites (Table 13.1). However, over all four sites, a significant (P = 0.003) grain yield trend was observed. Across all four sites, Wildfire winter wheat produced the greatest average yield, though this yield was not significantly different from that of Elevate winter wheat. AAC Network and W583 varieties were not included in multi-site analysis as these varieties were only included in the Carberry trial.

Winter wheat variety significantly influenced grain protein content at Melita, Roblin and Arborg sites in 2020/2021 growing season. At Melita, protein content of Gateway grain (15.8%) was significantly (P < 0.001) higher than that of Elevate, Goldrush and Wildfire varieties. In Roblin, Gateway winter wheat also resulted in the greatest protein content (16.7%), though this was not significantly different from that of Goldrush winter wheat (16.4%). At Arborg site, no significant difference in protein content was observed among Wildfire (14.4%), Gateway (14.3%) or Goldrush (13.9%) varieties. Combined analysis of grain protein data for all sites showed that Elevate winter wheat had the lowest average grain protein content at all sites, indicating a potential protein content disadvantage of this variety in Manitoba compared to other varieties used in this trial. On the other hand, average protein content of Gateway winter wheat (15.6%) was demonstrated to be greater than all other varieties grown at these sites. Protein content data was not collected for Carberry grain in 2021.

Test weight significantly varied across varieties at the Melita, Roblin, and Arborg sites, as well as across varieties over all four site years. At these sites, the greatest average test weight was observed from Gateway winter wheat.

Fertilizer management practice did not have any significant influence on grain yield at Melita, Roblin, or Carberry sites. In Arborg, winter wheat grown with a balanced fertility practice (50% N in fall) had a significantly (P = 0.034) greater average yield than winter wheat grown with the current producer fertility practice (100% N in spring). No significant effect of fertility practice on winter wheat grain protein content was observed at Melita or Arborg sites, but winter wheat grown using current producer fertility practice at Roblin site had greater average protein

Table 13.1. Analysis of variance for average winter wheat yield (kg ha^{-1}), protein content (%), and test weight (kg hL^{-1}) at Melita, Roblin, Arborg, and Carberry, Manitoba for the 2020/2021 growing season.

Treatment		**Location**													
		Melita			**Roblin**			**Arborg**			**Carberry**		**All Sites**		
Variety	**Fertility**	**Yield**	**Protein**	**Test wt.**	**Yield**	**Protein**	**Test wt.**	**Yield**	**Protein**	**Test wt.**	**Yield**	**Test wt.**	**Yield**	**Protein***	**Test wt.**
Elevate		2134	14.1**d**	72.1**ab**	3862	14.8**c**	60.4**c**	3216	13.0**b**	79.0**b**	5582	69.1	3699**ab**	14.0**c**	70.1**b**
Gateway		1935	15.8**a**	73.0**a**	3377	16.7**a**	63.3**a**	2922	14.3**a**	81.5**a**	5582	70.2	3454**c**	15.6**a**	72.0**a**
Goldrush		2299	15.4**b**	71.0**c**	3428	16.4**a**	62.2**b**	3103	13.9**a**	78.2**b**	5750	69.6	3645**bc**	15.2**b**	70.2**b**
Wildfire		2456	14.9**c**	71.3**bc**	3661	15.7**b**	59.2**d**	2983	14.4**a**	76.9**c**	6597	70.0	3925**a**	15.0**b**	69.3**c**
AAC Network		-	-	-	-	-	-	-	-	-	6545	69.6	-	-	-
W583		-	-	-	-	-	-	-	-	-	5925	70.3	-	-	-
	Balanced	**2077**	**15.1**	71.4**b**	**3478**	15.7**b**	61.4	3167**a**	14.1	78.8	5829	69.3**b**	3628	15.0	70.2**b**
	100% Spring	**2335**	**15.0**	72.3**a**	**3686**	16.1**a**	61.1	2945**b**	13.7	79.0	6164	70.3**a**	3733	14.9	70.7**a**
Elevate	**Balanced**	1855	14.3	71.2**cd**	3706	14.5	60.3	3365	13.4	79.2	5334	68.6	3565**bcd**	14.1	69.8
	100% Spring	2413	13.9	72.9**ab**	4018	15.0	60.4	3068	12.6	78.8	5831	69.6	3832**bc**	13.9	70.4
Gateway	**Balanced**	1778	15.9	73.5**a**	3106	16.9	62.9	3025	14.6	81.5	5609	70.0	3379**d**	15.8	72.0
	100% Spring	2091	15.7	72.6**abc**	3648	16.5	63.6	2820	14.1	81.5	5555	70.4	3529**cd**	15.5	72.0
Goldrush	**Balanced**	2370	15.3	69.8**d**	3575	15.9	63.1	3340	14.0	77.8	6296	69.3	3895**ab**	15.1	70.0
	100% Spring	2227	15.4	72.2**abc**	3281	16.9	61.3	2866	13.7	78.7	5205	69.8	3395**d**	15.3	70.5
Wildfire	**Balanced**	2302	14.9	71.1**cd**	3526	15.4	59.4	2939	14.4	76.7	5923	69.0	3673**bcd**	14.9	69.0
	100% Spring	2610	14.9	71.5**cd**	3797	15.9	58.9	3027	14.4	77.2	7271	70.9	4176**a**	15.1	69.7
AAC Network	**Balanced**	-	-	-	-	-	-	-	-	-	5914	68.8	-	-	-
	100% Spring	-	-	-	-	-	-	-	-	-	7176	70.4	-	-	-
W583	**Balanced**	-	-	-	-	-	-	-	-	-	5901	70.0	-	-	-
	100% Spring	-	-	-	-	-	-	-	-	-	5948	70.6	-	-	-
P values															
	Variety (V)	0.082	**<0.001**	**0.006**	0.221	**<0.001**	**<0.001**	0.176	**0.011**	**<0.001**	0.066	0.113	**0.003**	**<0.001**	**<0.001**
	Fertility (F)	0.075	0.158	0.021	0.252	**0.036**	0.265	**0.034**	0.197	0.493	0.18	**0.001**	0.223	0.824	**0.008**
	V x F	0.353	0.297	**0.035**	0.405	0.115	0.072	0.248	0.721	0.533	0.072	0.482	**0.001**	0.181	0.605
	CV(%)	15	1	1	12	3	1	8	5	1	12	1	11	3	1

content (16.1%) than winter wheat grown using the balanced fertility practice at this site (15.7%). However, combined data analysis of all sites showed no significant influence of fertility management practice on winter wheat grain yield or protein content. Fertility management practice had a significant influence on grain test weight at Melita, Carberry site, and over all site years, with test weight of grain grown under the producer fertility practice significantly greater than that of grain grown under a balanced fertility practice.

Significant variety and fertility practice interactions (variety x fertility) were observed when yield data from all site years was combined, but no significant interactions were observed at individual sites. Over all four site years, Wildfire winter wheat grown under producer fertility practices had the greatest average yield (4176 kg ha^{-1}), though this yield was not significantly different from that of Goldrush winter wheat under balanced fertility practices (3895 kg ha^{-1}). No significant yield differences were observed between fertility practices for Elevate or Gateway winter wheat varieties over four site years. A balanced fertility practice resulted in a greater average yield than the current producer fertility practice for Goldrush winter wheat, though the opposite was true for Wildfire winter wheat. This result may indicate that yields of some winter wheat varieties respond better to a balanced fertility practice than others. At Melita, Gateway winter wheat grown under balanced fertility practice resulted in the greatest average test weight (73.5 kg hL^{-1}), though this test weight was not significantly different from that of Elevate, Gateway, or Goldrush winter wheat grown under producer fertility practices. Protein content of winter wheat was not significantly different among variety and fertility management practice combinations (variety x fertility) at individual sites or when Melita, Roblin, and Arborg protein data was combined.

Background / References

Following decades of extensive work in winter wheat production in North America, many researchers and producers have begun to implement best management practices to obtain higher grain yield and improve profitability in the crop. Management practices presently being implemented to improve winter wheat production include; increasing seeding rate, application of starter fertilizer by banding during seeding, variety selection, pest control (Anderson, 2008) and split application, during planting in fall and at tillering or stem elongation in spring (Schulz et al., 2015). Fertility management, in particular nitrogen and phosphorus, remains 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 that producers aim to achieve. 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. Morris et al. (2018) suggested the implementation of adaptive use of nitrogen to help augment and improve nitrogen application rate decision making by farmers. Therefore, there is a great need to continue with research on the best management practices that can be availed to producers to improve economic returns in winter wheat production. Nitrogen is most often the focus of crop fertility in field studies. However, having a balanced approach and considering other essential nutrients, such as, phosphorus, potassium and sulphur and micronutrients available in the soil, offers great yield potential when nitrogen needs of the crop are met. Perhaps more efficient returns on investment potential can be achieved as fertility management is optimized.

References

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.

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 98:3. https://doi.org/10.1139/cjps-2017-0319

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.

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.

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

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.

Materials and methods

Sites: Melita, Arborg, Carberry and Roblin, Manitoba (Table 12.3).

Experiment design: Randomized complete block design

Replications: 3

Treatments: factorial arrangement of two fertilizer management practices and four to six winter wheat varieties. Fertilizer treatments included:

- Producer practice: 100 lb of nitrogen (urea plus agrotain) per acre applied in spring and 30 lb phosphorus banded at seeding in fall and,
- 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.

In Arborg, wheat was seeded into canola stubble at a depth of 1.0" on September 21, 2020 using a 6-row double disc seed drill. No pre-emergent herbicide was necessary in 2020 at Arborg. Weed pressure was low at the site, hence, no herbicide was applied. Prosaro and Folicur fungicides were applied for foliar diseases. The winter wheat varieties utilized at all sites were; Gateway, Goldrush, Elevate and Wildfire. At Carberry, AAC Network and W583 varieties were also incorporated into the trial.

Table 13.2. Site description and agronomic management for each trial site in the 2020/2021 growing season.

Activity	Site			
	Melita	**Carberry**	**Roblin**	**Arborg**
Cooperator	WADO	CMCDC	PCDF	PESAI
Legal	NW23-3-27W1	South ½ of 8-11-14 W1	NE 20-25-28 W1	NW 16-22-2 E1
Rotation (2 yr.)	Spring wheat – LL Canola	Soybean (2019), Canola (2020)	Barley silage (2019), Oats silage (2020)	Canola – Cereals
Soil series	Ryerson Loam	Ramada Clay Loam	Erickson clay loam	Fyala heavy clay
Field Prep	No till	No till	Vertical tilled	No till
Stubble	LL Canola	Canola	Oats	Canola
Burn off (Date/Rate per acre/Products)	None	09-Sep-20: Roundup 0.67 L + Heat 29 g + Water 40 L sprayed before seeding	None	None
Soil moisture at seeding	Very poor	Fair	Dry	Optimal
Seed date	14-Sep-20	16-Sep-20	18-Sep-20	21-Sep-20
Seed depth (Inches)	0.5	1.0	0.75	1.0
Seeder (drill/planter?)	Knife drill	Knife drill	Disc drill	Disc drill
Topdressing	09-Apr-21	23-Apr-21	16-Apr-21	29-Apr-21
Herbicides (Date, Rate/ ac, Name)	08-Jul-21: 0.5 L Mextrol 450 on flowering canola	09-Sep-21: 0.7 L Glyphosate, 30 g Heat 15-Jun: 0.12 Fitness, 0.4 L Buctril M, 0.5 L Axial	14-Jun-21 0.81 L Curtail M, 0.71 mL Puma	None
Fungicides	none	08-Jul-21: 0.325 L Prosaro	15-Jun-21: 0.202 L Folicur	22-Jun-21: 0.2 L Folicur
Insecticides	17-Jul-21: Coragen, aerial, hoppers	None	None	28-Jun-21: 0.325 L Prosaro
Harvest date	16-Aug-21	12-Aug-21	25-August-21	3-Aug-21
Total precipitation (mm)	222			209

A summary of fall soil tests conducted at Melita, Roblin, Carberry and Arborg, and fertilizer treatments for the 2020/2021 trial are presented in Table 13.3.

Table 13.3. Fall soil test results by site and producer practice (100% N in spring) and balanced practice (50% N in spring) treatments for winter wheat in the 2020/2021 season.

Fall soil test results (lb ac^{-1})				
Nutrient	**Location**			
	Melita	**Roblin**	**Carberry**	**Arborg***
N	11	53	31	93
P	10	71	27	44
K	306	410	48	660
S	36	22	15	582
Zn	1.4	1.1	0.04	0
Producer Practice Application (all N applied in Spring)				
N	100	100	100	100
P	30	30	30	30
K	0	0	0	0
Balanced Practice application recommendations				
(Western Ag Processional Agronomy Laboratory) 50% N applied in fall				
N	130	105	130	161
P	38	20	30	40
K	50	0	100	50
S	0	0	5	0
Zn	0	0	0	0

*Farmers Edge sampling

14. Assessment of Atlas XC in improving soil fertility in spring wheat

Project duration

- 2021

Collaborators

- Nutrien Ag Solutions

Objectives

– To evaluate the effect of Atlas XC along with mono-ammonium phosphate (MAP) on the growth and productivity of spring wheat.

Results

Adding a fertilizer catalyst such as Atlas XC to MAP did not result in any significant difference in plant height, grain yield or grain protein content except root mass. Addition of Atlas XC with MAP increased root mass by 1.6 -1.7 times compared to MAP fertilizer and no MAP treatments (Table 14.1). No difference was observed in nitrogen, phosphorus or sulphur content of the leaves due to addition of MAP with or without Atlas XC catalyst. (Table 14.2).

Table 14.1. Effect of different P treatments on plant height, grain yield, grain protein content and root mass of spring wheat.

Treatment	Plant height	Yield	Protein	Root mass
	inch	bu/acre	%	g
No MAP	22.0	32.7	15.3	0.36 ab
Only MAP	21.8	33.2	15.4	0.33 a
MAP + Atlas	21.7	32.7	15.4	0.56 b
P value	*0.953*	*0.975*	*0.710*	*0.031*
CV (%)	*6.3*	*12.6*	*0.9*	*11.2*
Sig. diff.	*No*	*No*	*No*	*Yes*

Project findings

No differences in grain yield and protein content (%) was observed due to addition of fertilizer catalyst. This might be due to the drought conditions prevailed at the site during growing season of 2021.

Table 14.2. Effect of different P treatments on nitrogen, phosphorus and sulphur content of wheat tissue collected on July 14, 2021 (Values are the means of two replicates).

Treatment	Nitrogen	Phosphorus	Sulphur
	%	%	%
No MAP	2.560	0.180	0.265
MAP	2.775	0.200	0.265
Atlas+ MAP	2.600	0.175	0.260
Pr>F	0.4612	0.758	0.9326
CV (%)	6.9	15.6	4.6
Sig. diff.	No	No	No

Background / Additional information / References

ATLAS XC is a biochemical fertilizer catalyst specifically formulated for use with dry fertilizer blends in canola, cereals, soybeans, peas, lentils and other key crops. This fertilizer catalyst contains concentrated biochemistry to help get more out of applied P&K fertilizers by increasing nutrient availability and enhancing plant health to optimize yield potential (Loveland products).

Research studies had been conducted in Saskatchewan to investigate the performance of fertilizer catalysts that can promote early crop emergence and root growth. At the Glacier FarmMedia Discovery Farm, a field-scale trial was initiated to investigate the performance of two commercially available biochemical fertilizer catalyst products (Atlas XC and Atlas + radiate) in wheat fertility trial in 2019. Atlas XC application did not have a positive impact on wheat emergence, but had positive impact on crop yield in the midst of challenging growing conditions. Higher yields were recorded for both the Atlas (57 bu /ac) and Atlas and Radiate (54 bu /ac) treatments compared to the control (53 bu /ac). An economic analysis revealed its application resulted in the highest margin increase of all the products tested. Though this study had a drawback that it was conducted at one site and for one year, and no statistical analysis on data collected was done, there seems a potential to implement on farms. Therefore, this study was conducted to evaluate these products in the Interlake region.

References

Loveland products https://atlasxc.ca/
https://discoveryfarm.ca/wp-content/uploads/2019/11/2019-Discovery-Farm-Report-Nov-28.pdf

Materials and methods

Experimental design: Randomized complete block design
Replications: 3
Plot size: 8.22m^2
Variety – AAC Brandon
Treatments: 3

- No MAP,
- Only MAP,
- MAP + Atlas XC

Data collected

Plant height, grain yield, protein content and root mass are presented in this report. In-season soil nitrate N in top 0-6 and 6-24 inch soil depth and soil P in top 0-6 inch was analyzed.

Agronomic information

Stubble, soil type; Canola, heavy clay

Soil nutrient status (N:P lb /ac):: 93:44

Fertilizer applied:

- Only 50 lb/ac of N was applied at the seeding in the no MAP plots.
- The other two fertility treatments got 50 lb/ac of N + 25 lb/ac of MAP at the seeding.

Pesticides applied –

- Sprayed Silencer @ 34 ml/acre on July 13 & 29 for grasshoppers control.

Seeding date: May 31, 2021

Harvesting date: Aug 19, 2021

15. Assessment of early planting and tile drainage on the pea production

Project Duration

- 2021

Collaborators

- Dennis Lange, Provincial Pulse Specialist

Objectives

– To evaluate the effect of tile drainage and early seeding on the crop growth and yield of yellow peas.

Results

The effect of tile drainage was observed on plant establishment and days to maturity of the peas. Tiled plots had slightly lower plant population (7.5 pea plants / ft^2) than in non-tiled plots (8.3 pea plants / ft^2). However, peas matured two days earlier on tiled plots than on non-tiled plots when the data were pooled for pea varieties whether grown earlier or at the normal seeding date.

Seeding time did not have any effect on plant establishment. However, peas took four less days to mature when planted at normal seeding time (second week of May). All pea varieties (except Carver) took more number of days to mature when seeded earlier.

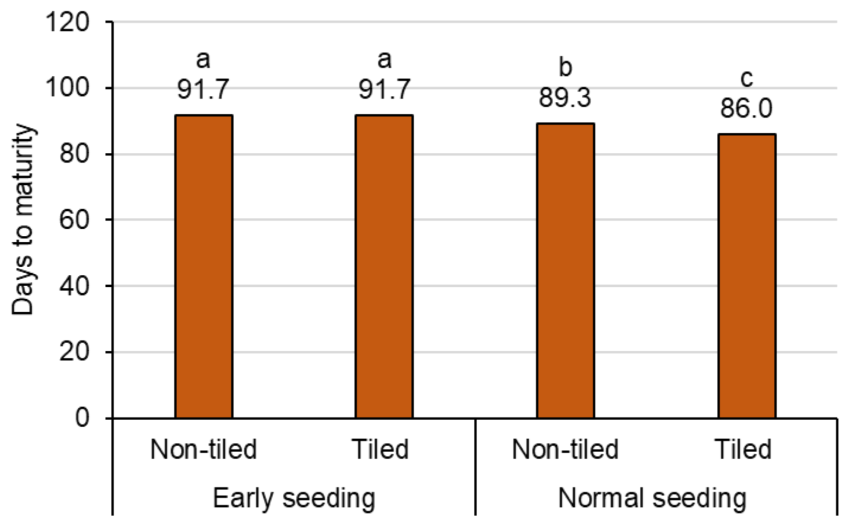


Fig. 15.1 Effect of seeding date and tile drainage on days to maturity of peas at Arborg in 2021.

Days to maturity did not differ between tiled and non-tiled plots when peas were planted earlier (Fig. 15.1). However, peas matured faster on tiled plots when planted at normal seeding time (Fig. 15.1 and Fig. 15.2).

Soil temperature sensors were installed in the plots and observations were taken at two soil depths (1 inch & 6 inches deep) during morning (minimum temperature) and afternoon (maximum temperature) hours in early June.

Tiled plots had significantly higher temperature on certain days (Fig. 15.3). A difference of 0.26 ℃ was observed in minimum soil temperature between tiled and non-tiled plots at 6-inch soil depth on June 4. Similarly, differences in maximum soil temperature was recorded once at 1-inch soil depth and twice at 6-inch soil depth on June 3 & 4.No seed yield data was collected as the plots got severe damage from deer.

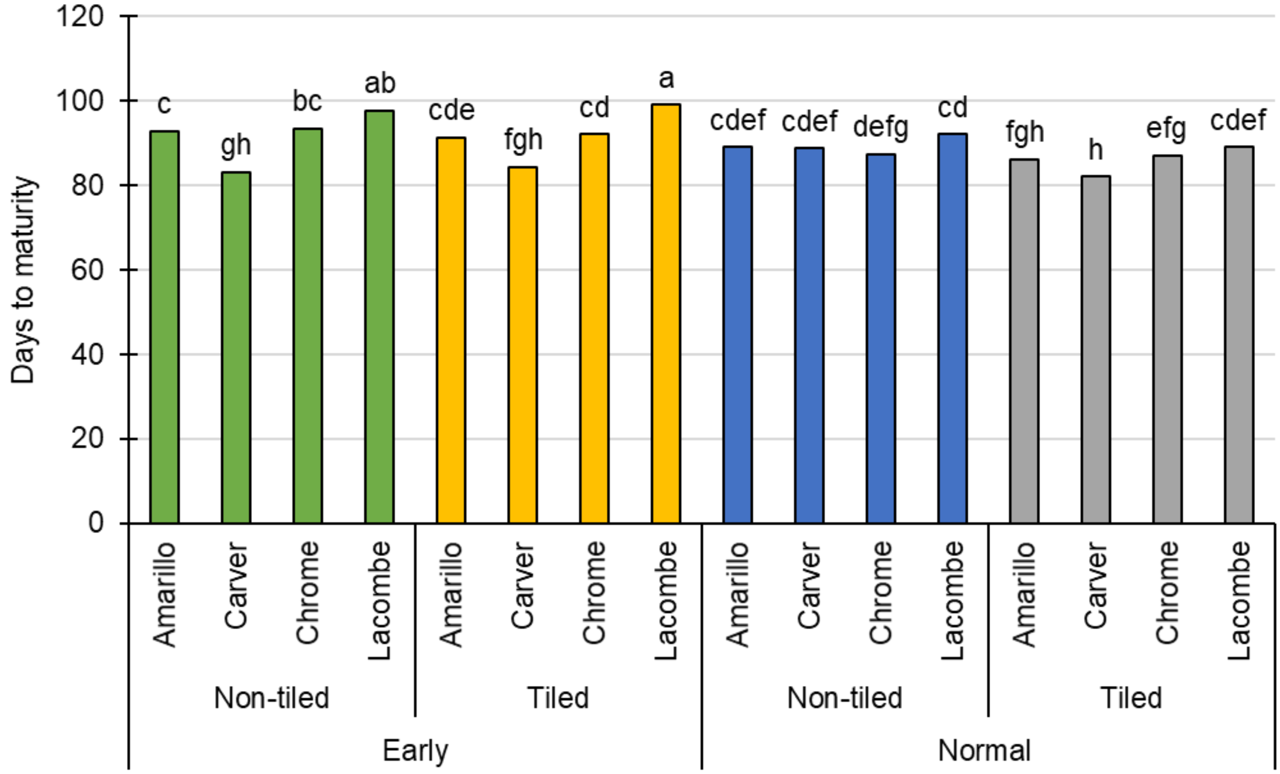


Fig. 15.2. Effect of tile drainage (tiled vs non-tiled) and seeding date (early vs normal seeding dates) on days to maturity of different pea varieties seeded in 2021 at Arborg site. Bars with similar letters matured in similar number of days. Comparison was done using Tukey method at p=0.05.

Project findings

This research will be conducted again in 2022 to evaluate seeding date and tile drainage effects on pea yield. Temperature measurements will commence around mid-April and will continue during the seeding / plant establishment phase of a crop to have more comprehensive information.

Background / Additional resources / References

Water table elevation and soil temperature are important factors in crop production on poorly drained soils, particularly in cold regions. In eastern part of Manitoba, low soil temperatures and high water saturation conditions on heavy clay soils exist during early spring, which sometimes create problems for seeding of the crops.

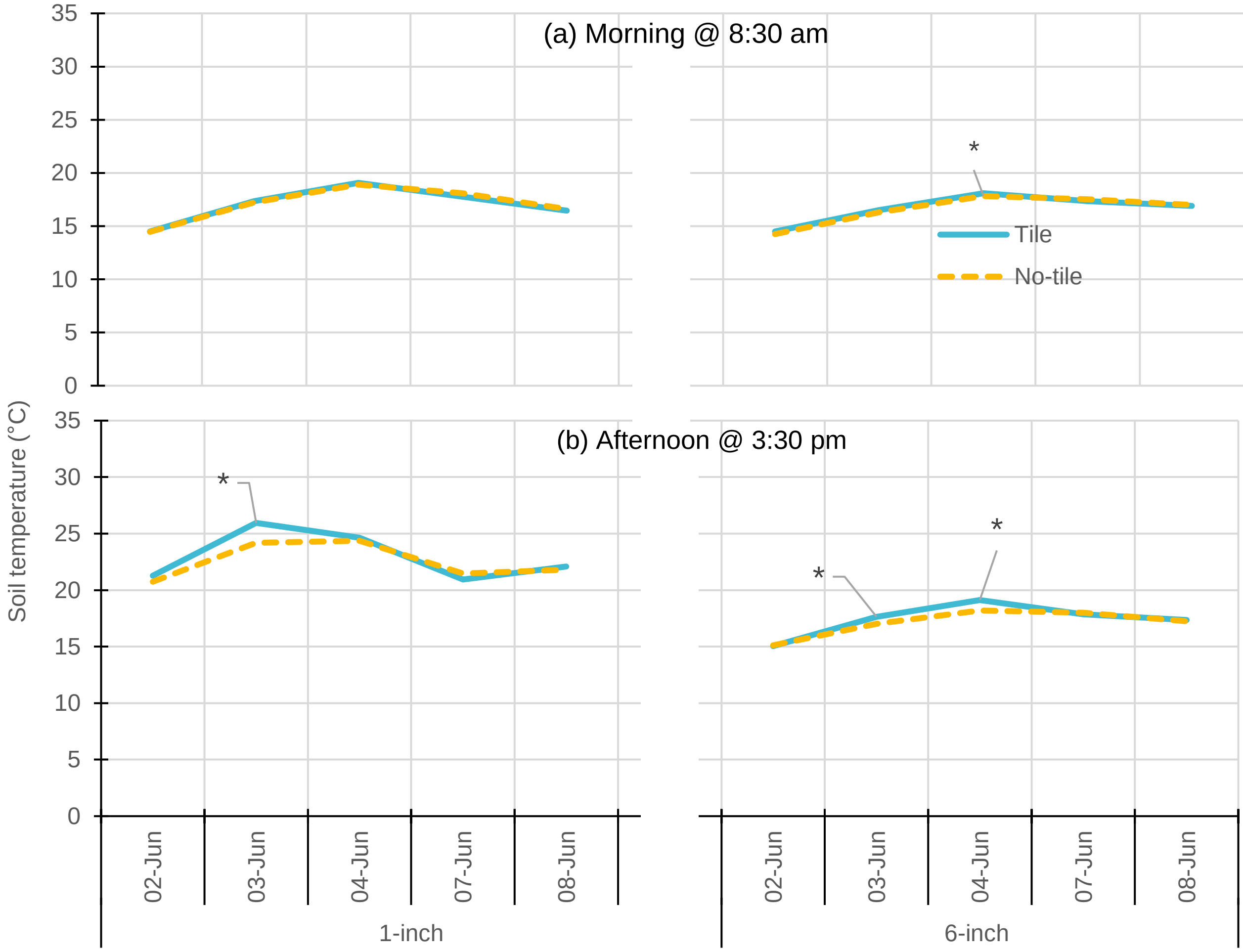


Fig. 15.3. Observed soil temperature measured in (a) morning at 8:30 am and (b) afternoon at 3:30 pm at two soil depths (1-inch and 6-inch) in tiled and non-tiled drainage plots during early June 2021. Asterisk (*) indicate significant difference in soil temperature between tile and non-tiled at individual day (ttest, p<0.05).

Peas can be seeded as early as late April to early May to obtain maximum yield potential. This is because peas are more tolerant to spring frost than other crops because of its hypogeal emergence (pea cotyledons remain underground). In case of frost injury, new shoots will emerge from axillary buds that are protected under the soil surface. Early planting should also help align the time of flowering with cooler air temperatures. As peas are susceptible to excess moisture conditions, therefore pea cultivation in the eastern part of Manitoba is limited due to more precipitation in eastern part than in western part of the province. Pea acreage in eastern part can improved by tile drainage that can help to drain excess moisture out from the root zone of peas.

Recently Roquette, a French based pea protein processing company, built its plant at Portage La Prairie. This facility has given a boost to yellow peas cultivation in Manitoba. Roquette is also offering premium on certain pea varieties. Harvested acres of peas have been increased from 67, 000 in 2015 to 172,400 in 2020, mostly covering the western part of the Manitoba.

A common axiom among drainage practitioners is that tile drainage increases spring soil temperatures in cold and humid climates. This might result in early seeding of peas in Interlake. As PESAI has 30' wide spaced tile drainage facility, this enabled us to explore the following questions:

- What is the yield potential of yellow pea varieties on tiled land in comparison to non-tiled land?
- Can tiles result in early seeding of peas and how it affects yield potential of pea varieties?

Materials and methods

Experiment design: Randomized complete block design
Replications: 3
Treatment design:
Main factor: tiled land (30' spacing) vs non-tiled land
Sub factor: Four Pea varieties (Amarillo, Carver, Chrome, Lacombe)
Sub-sub factor: Early planting (May 4) vs normal seeding time (May 11)
Seeding rate: 80-90 live plants /m^2
Seeding depth – ¾"

Data collection

Emergence, plant establishment, Days to maturity, soil temperature in root zone

Agronomic management

Fertilizer applied: N-P: 0-15 lb /acre with seed
Pesticides sprayed:
Viper @ 400 ml /acre was sprayed on June 8
Silencer @ 34 ml /acre was sprayed on July 16 for grasshoppers

16. Linseed Flax variety evaluation

Project duration

- 2018-2021

Collaborators

- Dr. Helen Broker (flax breeder), U of Saskatchewan
- Crop diversification Centre, Saskatoon

Funding:

- Manitoba Flax Growers Association
- BASF

Objective

– to compare yield and other growth parameters of newly registered flax cultivars (SVPG entries) and experimental lines (FP entries) from University of Saskatchewan, Crop development Centre flax breeding program with check flax varieties.

Results

Significant yield differences were found in the flax varieties / entries tested at Arborg site in 2021. Entry FP2592 had the highest yield while lowest yield was recorded for CDC Dorado. All test entries had similar grain yield as of check variety, CDC Glas. Among the test entries, FP2600 was relatively low yielding line and FP2592 was relatively higher yielding line (Table 17.1). The entries also differed in plant height with the tallest plants recorded in FP2602 plots. In a dry year of 2021, AAC Bright matured earlier than all test entries tested, while FP2592 took 18 more days to mature than AAC Bright.

Project findings

The growing year 2021 was the fourth year of testing for these flax entries. The entries differed in their yield performance, days to maturity and plant height at harvest at Arborg site. A complete project report will be compiled by Dr. Helen Booker.

Background / References / Additional resources

The cultivation of linseed is attractive to growers for seed /oil and straw / fiber. The factors such as environmental variables, phenological traits, plant size and density significantly affected the productivity of linseed (Fila et al 2018). Rainfall is beneficial to seed yield both before and after flowering whereas higher post-flowering air temperature has a negative effect on seed yield. The current coop trial was conducted at diversification centre sites in Manitoba. Other trial sites are located in Alberta, Saskatchewan and Quebec that cover various soil zones and will not be discussed in this report. For more information on this project, flax breeder Dr. Helen Booker can be contacted at 1 -306 – 966 – 5878.

References

Fila, G., Bagatta, M., Maestrini, C., Potenza, E., & Matteo, R. (2018). Linseed as a dual-purpose crop: evaluation of cultivar suitability and analysis of yield determinants. *The Journal of Agricultural Science*, *156*(2), 162-176. https://doi.org/10.1017/S0021859618000114

Materials and methods

Experimental design – Randomized complete block design
Replications: 3
Plot size: 8.22m^2;
Treatments: 14 flax entries (Table 16.1)

Data collected

Plant height, days to maturity, grain yield Data on lodging, stem dry down and determinate growth habit was reported to Dr. Helen Booker's team. Subsamples of grain were sent to CDC Saskatoon for fatty acid and protein analysis.

Agronomic information

Stubble, soil type; Wheat, heavy clay
Soil nutrient status (N-P lb /ac): 122-32
Fertilizer applied (N-P lb /ac): 30-20
Pesticides applied

- Curtail @ 0.81 L /ac applied on June 25, 2021 and July 5, 2021.

Seeding date: Jun 7, 2021
Harvesting date: Oct 26, 2021

Table 16.1. Performance of different linseed flax entries in terms of yield (bu /ac), plant height (inches) and days to maturity at PESAI Arborg during 2021 growing season. Values are the means of three replicates.

	Variety	Yield	% of CDC Glas	Plant height	Days to maturity
		bu /ac		*inches*	
Checks					
	CDC Bethune	13.1 bcd†	78	15.3 b	102.3 bc
	AAC Bright	12.0 cd	72	14.1 b	98.0 c
	CDC Glas (CHECK)	16.7 ab	100	15.0 b	103.0 bc
SVPG entries					
	AAC Marvelous	15.8 abc	95	14.9 b	105.7 b
	AAC Prairie Sunshine	15.6 abc	93	16.3 ab	114.0 a
	CDC Dorado	10.5 d	63	13.8 b	103.7 b
	CDC Rowland	16.4 ab	98	15.3 b	112.7 a
Test entries					
	FP2573	16.8 ab	101	16.7 ab	113.7 a
	FP2591	16.0 abc	96	14.4 b	114.0 a
	FP2592	17.9 a	107	16.7 ab	116.0 a
	FP2600	14.5 abcd	87	16.2 ab	112.7 a
	FP2602	15.7 abc	94	18.3 a	113.3 a
	FP2604	15.7 abc	94	14.8 b	105.3 b
	FP2606	15.5 abc	93	14.9 b	114.0 a
	p-values	<.0001		<.0001	<.0001
	CV (%)	9.5		6.4	1.7

† Means followed by similar letters within a column are not significantly different at $p < 0.005$.

17. MCVET Annual Forages evaluation

Project duration

- 2021

Collaborators

- MCVET
- Shawn Kabak & Tim Clark, ARD

Objective

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

Results

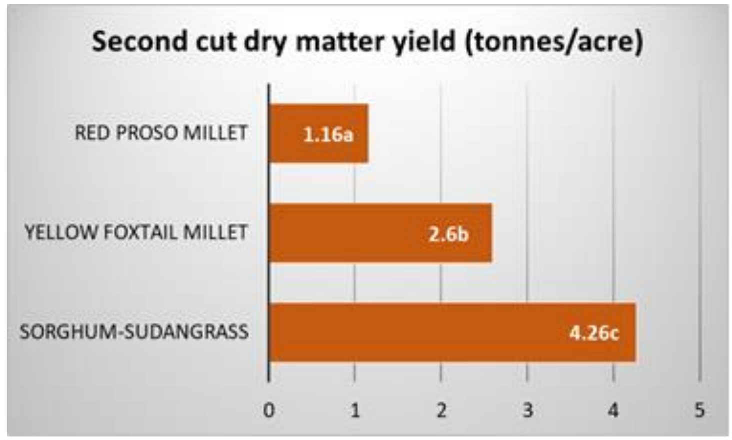


Fig. 17.1. Forage dry matter yield (tonnes /acre) of three millet species at second cut.

Haymaker Oats, Peas/Barley mixture, Peas, Yellow foxtail millet were the top performers in respect of forage yield (Table 17.1). Spring Triticale had the lowest forage yield and crude protein content. Haymaker Oats also had the lowest crude protein content among the forage species. Relative feed values (RFV) was relatively lower in Haymaker oats, Yellow Foxtail millet, red proso millet and sorghum-sudan grass than other forage species evaluated at Arborg. Millets also produced significant amount of forage yield at second cut. Sorghum-Sudan grass produced more forage yield than yellow foxtail and red proso millets (Fig. 17.1).

Table 17.1. Forage species evaluated for forage yield and feed quality at Arborg.

Crop	Variety	Seed rate (seeds/m^2)	Dry matter yield (tonnes/ac)	RFV	CP (%)	TDN (%)
Barley	AB Advantage	250	3.66 bcde	119	12	67
	AB Cattelac	250	3.54 bcd	130	12	70
	AB Hague	250	3.62 bcde	129	12	69
Oats	Arborg	220	3.33 bc	128	11	70
	Haymaker	220	4.04 def	97	10	62
Spring Triticale	Common	265	2.34 a	118	10	67
Peas/Barley	CDC Jasper /AB advantage	40/125	4.55 f	125	13	68
Peas/Oats	CDC Jasper / Arborg	40/110	3.05 b	125	12	68
Peas	DL Delicious	80	3.95 cdef	161	18	67
Yellow Foxtail Millet	Golden German	20 lb /acre	4.31 ef	99	13	66
Red Proso Millet	Cerise	20 lb /acre	3.68 bcde	103	14	66
Sorghum-Sudangrass	Common	20 lb /acre	3.37 bcd	102	14	65
LSD (P =0.05)			0.69			

Project findings

Forage species differed in dry matter forage yield when tested at Arborg site. Spring Triticale had the lowest yield whereas millets and Haymaker Oats produced higher forage yield. Millets also showed potential to produce significant yield during the second cut.

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, Proso millets and hybrids 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).

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

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

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.

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.

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

Experimental design – Randomized complete block design
Replications: 3;
Plot size – 8.22m^2
Treatments – 12 forage species (Table 17.1)
Seeding depth – 0.75 inch
Harvesting stage -

- Barley: early dough
- Oats: early dough
- Triticale: early dough
- Millet /Sorghum: early heading
- Peas- full pod stage
- Mixtures- when earliest crop is soft dough stage

Data collection

Yield was taken using a forage harvester. Wet weight of forage material collected per plot was recorded. A sub sample was taken from each plot and forage material was dried down to calculate % moisture for each plot. A composite sample was taken for each species and sent to Central Testing Lab for feed quality analysis.

Agronomic information

Stubble, soil type – Fallow, Heavy clay
Fertilizer applied: N – 50 (lb /acre) and P - 20 (lb /acre) at the time of seeding
Pesticides applied: Silencer @ 34ml/acre on July 13 and July 29 for grasshoppers control
Seeding date – May 20, 2021
Harvesting date– Aug 6 / Sep 17, 2021

18. Assessment of full season cover crop blend for forage production

Project duration

- 2021

Collaborators

- Fosters Ag Services

Objectives

- Full season cover crop blend from Covers & Co was assessed for forage production on heavy clay soils in Interlake region of Manitoba. This blend was harvested at three different cut times (Early, Normal & Late) to examine the effects on forage yield and quality. Regrowth potential (second cut) for fall grazing was also assessed in the study.

Results

Plots were well established and the cool season grasses dominated the stand (Fig.18.1). Most of the species in the blend were established although plant diversity differences were there.

No differences in forage yield were recorded from the first cut when different cutting time treatments were compared (Table 18.1). Regrowth yield potential, however, was lower when the plots were cut later during the first cut. Cutting time did not have any effect on the overall dry matter forage field for this blend.

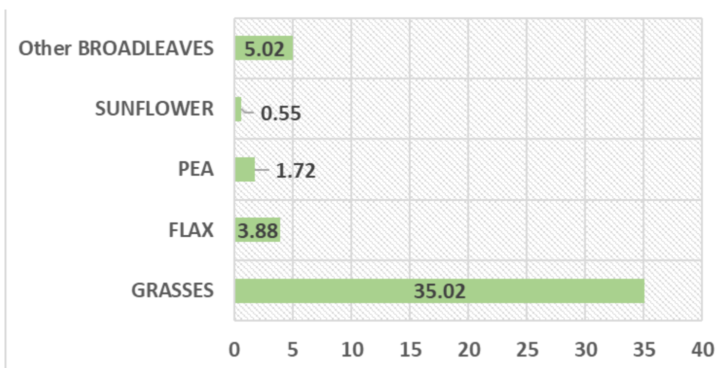


Fig.18.1. Plant diversity (Average no. of plants established / ft^2) at Arborg site.

Feed test results showed a general decline in protein levels with delayed cutting time (Table 18.2). ADF and NDF levels were lower when the blend was cut at the normal time. TDN levels, NE Gain and relative feed value (RFV) were higher when the plots were cut at the normal time. Crude protein, ADF, NDF, TDN and RFV were similar for the second cut irrespective of the first cut treatments.

Project findings

Full season blend produced about 2.5 tonnes /acre of dry matter forage yield during the entire season. It is important to note that 2021 was an extremely dry year at the PESAI site. Cutting time did not have any effect on the overall forage yield. Normal cut time, however, produced relatively good quality forage.

Table 18.1. Dry matter forage yield as affected by different cutting time at Arborg site.

Treatment	Growth stage at cut of				Dry matter forage yield		
	wheat	barley	oats	peas	First cut	Second cut	Total
	-----------------BBCH------------------				-------------------- tonnes / acre --------------------		
Early cut	77	79	73	R5	1.86	0.64b	2.50
Normal	87	87	75-87	R6	2.12	0.54b	2.65
Late cut	92	92	87	R7	2.21	0.27a	2.48
P value					0.07	<0.0001	0.27
CV (%)					11.9	19.5	7.6
Sig. diff.					No	Yes	No

Table 18.2. Effect of different cutting times on the feed quality parameters of the full season blend at Arborg site.

Harvest	Treatment	Dry Matter	Crude Protein	ADF¹	NDF²	TDN³	NE Gain	RFV⁴
		--------------------------------- %				--------------------------------	(Mcal /gain)	
First cut	Early cut	33.5	12.2	30.2	50.7	65.4	0.89	120
	Normal cut	47.4	10.8	26.4	47.0	68.3	0.97	135
	Late cut	67.3	10.1	32.5	53.0	63.6	0.84	112
Second cut	Early cut	19.5	18.1	28.6	47.6	66.6	0.92	130
	Normal cut	17.4	19.2	30.1	46.5	65.4	0.89	131
	Late cut	22.4	18.6	28.6	47.3	66.6	0.92	131

ADF[1] – Acid Detergent Fibre; NDF[2] - Neutral Detergent Fibre; TDN[3] - Total Digestible Nutrients; RFV[4] – Relative Feed Value

Background / References / Additional resources

Cover crops are planted with the intent to build and improve the soil health. Cover crops are usually seeded in diverse annual mixes comprised of five, ten, or even twenty species, although they can include biennial or perennial species (BCRC, 2016). They can be a valuable and quick-growing source of forage for livestock. Cover crops also allow cropland and pastures to be more efficient with water and nutrient cycling, and less reliant on costly inputs such as fertilizer.

In the current study, a blend of warm and cool-season plant species was tested for forage production (Fig. 18.2). This blend was obtained from Covers and Co. and is intended to

Fig. 18.2. Different plant species in the full season blend.

provide high-yielding, high-quality livestock feed while improving soil health and reducing input costs (Covers and Co, 2021). A major benefit of using a multi species cover crop blend is flexibility in harvest timing. Covers and Co has reported dry forage yield of greater than 2.27 tonnes per acre along with relatively good TDN (58-63%) and RFV (115) from the testing of full season blend at few Manitoban sites.

References:

BCRC (2016) https://www.beefresearch.ca/files/pdf/BCRC_Cover_Crops_Fact_Sheet.pdf
Covers and Co (2021) https://www.coversandco.ca/full-season-cover

Materials and Methods

Experimental design – Randomized complete block design.
Plot size – 8.22 m^2 *Varieties* – A blend of 15 species (Fig. 18.2)
Seeding rate – 75 lb /acre; Seeding depth – 0.75 inch
Treatments – Three:

- Early cut (on July 23),
- Normal cut (on Aug 6) and
- Late cut (on Aug 18)

Data collected

Plant species established, crop stage at harvest and dry matter forage yield

Agronomic information

Stubble, soil type – Fallow, Heavy clay
Fertilizer applied – None.
Inoculant rate – 8 lb/acre
Pesticides application: Silencer @ 34ml /acre on July 13 & July 29 for the control of grasshoppers.
Seeding date – May 21, 2021

Fig.18.3. Various plant species of cover crops established during 2021 trial at Arborg.

19. Determining yield potential of annual forages/cover crop mixtures in the Interlake region of Manitoba

Project duration

- 2021

Collaborators

- Imperial Seeds, Fosters Ag Services

Objectives

– This project was planned to determine yield potential of four annual forages when grown in combination with cover crop mixture (TG Extend). Forage quality comparisons were also done in the test.

Results

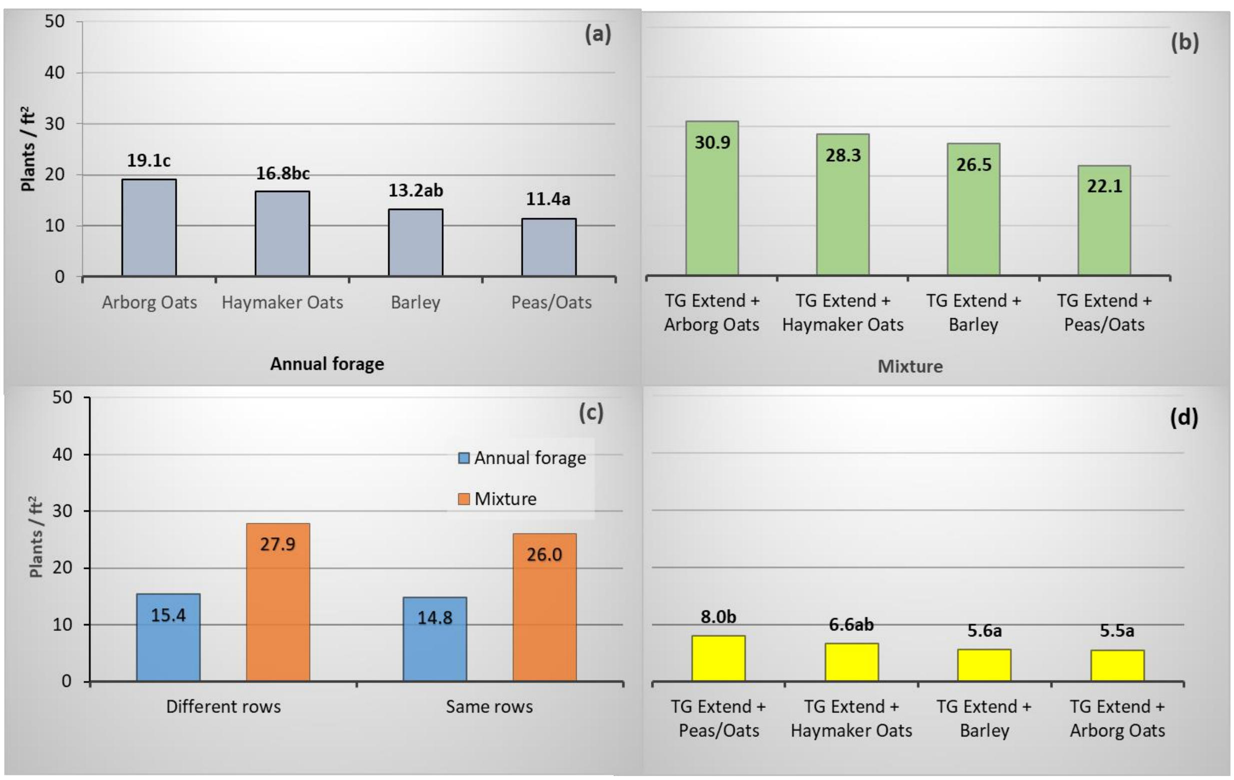


Fig.19.1. Plant establishment after seeding in (a) annual forages (b) annual forage + TG extend (c) different row treatments and (d) establishment of mixture after first cut at Arborg.

When plant establishment was compared after seeding, TG extend/Arborg oats plots had higher oats plant population (Fig 19.1a). Pea/Oats plots had lower number of annual forage plants/ft^2, when grown with cover crop. Plant establishment of annual forages/cover crop mixtures, however, did not differ after seeding (Fig. 19.1b). Similarly, seeding annual forages and cover crops in the same row or different row did not have any effect on plant population of either annual forages or mixture (Fig.19.1 c). When plots were checked for regrowth after first cut, pea/oats plots had higher regrowth than in barley and Arborg oats/cover crop mixtures (Fig.19.1 d).

Table 19.1. Forage dry matter yield of annual forage / cover crop mixtures at first cut, second cut and during the entire season at Arborg.

Annual forage /cover crop mixture	Growth stage at first cut	Forage dry matter yield		
		First cut	Second cut	Total
	BBCH	---------------------*Tonnes /acre*---------------------		
TG Extend + Haymaker Oats	75	1.98 b	0.69 ab	2.65
TG Extend + Arborg Oats	77	1.91 b	0.71 ab	2.47
TG Extend + Barley	83	1.85 b	0.38 a	2.22
TG Extend + Peas/Oats	R4 /75	1.61 a	1.01 b	2.65
p-value		*0.001*	*0.005*	*0.106*
CV%		*7.5*	*20.4*	*8.4*
Sig. diff.		*Yes*	*Yes*	*N0*

Pea/Oats when grown with TG extend produced less forage yield during first cut than all other three mixtures tested (Fig.19.1). On contrary, this mixture produced higher forage yield at second cut. All forage/cover crops combinations were similar in producing forage dry matter yield over the season.

Feed quality analysis showed slight difference in crude protein (%) among different forage/cover crop mixtures tested (Fig. 19.2). In general, second cut had almost two times higher protein than in first cut. Arborg oats and barley / TG extend mixtures had relatively higher total digestible nutrients (TDN, %) and relative feed values (RFV) at first cut than Haymaker Oats and Peas/ Oats and TG extend mixture. Neutral detergent fibre (NDF, %), TDN (%) and RFV did not vary much at second cut.

Project findings

Plant establishment differences were not evident among different annual forages/cover crop mixtures used in this project. These differences, however, were recorded during regrowth in the second cut. Forage yield varied among mixtures at individual cuts, however, all mixtures produced similar yield over the season. The year 2021 was extremely dry year at the site and it might have resulted in relatively lower forage yield irrespective of any mixture tested. Arborg oats and Barley/ TG extend mixtures were better for feed quality at first cut. At the second cut, NDF (%), TDN (%) and RFV did not vary much among different mixtures.

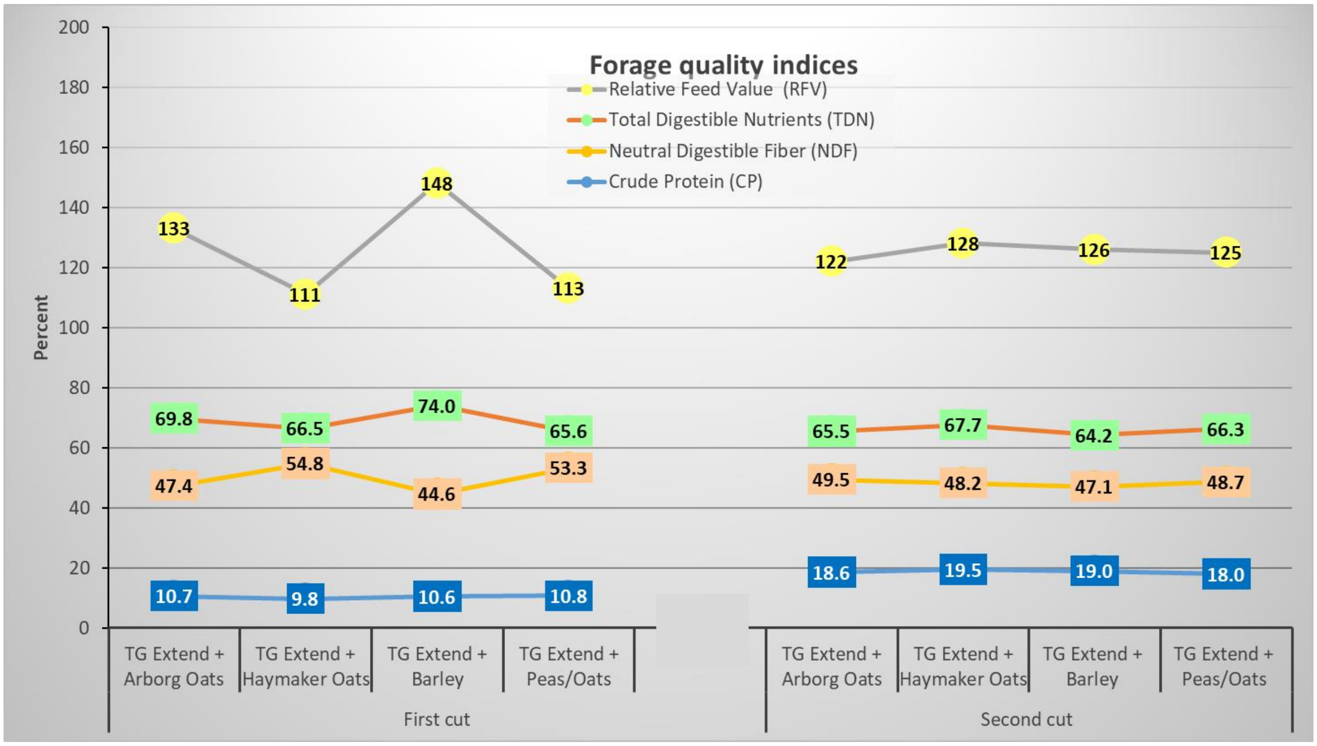


Fig. 19.2. Feed quality results from the first and second cut of different annual forage/cover crop mixtures tested at Arborg site.

Background / Additional resources / References

Cattle producers utilized cereal-legume intercrops for forage production in western Canada (Aasen et al. 2004). In recent years, producers are growing a multispecies annual crop mixture for forage production. A multispecies annual crop mixture can be selected from a diversity of plant families (Polygonaceae, Brassicaceae, Poaceae, and Fabaceae), corresponding to different plant functional groups (Lavorel et al. 1997). Such mixtures are reported to increase forage productivity and nutrient cycling (BCRC 2016). In a recent study from Alberta, three forage/cover crop mixtures had forage yield advantage, better marginal returns and benefit/cost ratio when compared with cereal monocrops (Omokanye et al 2018). Most of the mixtures had >13.0% forage crude protein (CP) compared to less than 12.0% forage CP for monocrops. This study also demonstrated that growing a minimum of three annual crop (cereal, legumes and brassicas) rather than one or two crops, increased forage production and offered a forage-based diet that was able to adequately meet the nutritional requirements of beef cattle in most cases. The top yield mixture had Red proso millet (*P. miliaceum L.*), CDC Haymaker oat variety (*A. sativa L.*), CDC Maverick barley variety (*H. vulgare L.*), 40–10 forage pea variety (*P. sativum L.*), Tillage radish (*R. sativus L.*), Hairy vetch (*V. villosa Roth L.*), Kale (*B. oleracea L*), Crimson clover (*T. incarnatum L.*) and Laser Persian clover (*T. resupinatum L.*).
In the current study, we tested different annual forages in combination with TG extend cover crop mixture from Imperial seeds. This mixture has the following plant species:

- ***Melquatro Italian Ryegrass (25%)*** - this tetraploid variety has high yield potential for hay, silage and grazing. The high sugar content makes it a good candidate for improved digestibility.

- ***Ebena Brand Common Vetch (20%)*** - produces a high protein feed. Also, is an excellent cover crop for nitrogen fixation, erosion control, biomass and weed suppression.
- ***Akela Brand Forage Rape (5%)*** - high leaf to plant ratio and is easily digested. It provides a protein rich, high-quality feed that can be used as late grazing or silage.
- ***Malwira Brand Turnip Rape (5%)*** - offers better flexibility in sowing and grazing times. Regrowth from hybrids is rapid with multiple grazings achievable.
- ***Japanese Millet (20%)*** – very good quality millet that will regrow.
- ***H.O. Brand Crimson Clover (5%)*** - has erect stems, grows quickly. Primary advantages are rapid growth during cool weather, shade tolerance, and nitrogen fixation.
- ***Winner Brand Berseem Clover (5%)*** - an annual legume that resembles alfalfa in appearance and can be used as a cover crop, pasture or hay. Berseem clover is not winter hardy but can create significant biomass and fix large amounts of nitrogen due to its rapid establishment and fast growth (1.5 times that of alfalfa).
- ***Pearl Millet (15%) –*** a high protein annual grass (Family Poaceae) crop of tropical origin. Its seed or entire plant can be used as animal feed. Pearl millet can be grown in less fertile soils and poorer growing conditions where wheat and corn cannot thrive.

References

Aasen A, Baron VS, Clayton GW, Dick AC, McCartney DH. 2004. Swath grazing potential of spring cereals, field pea and mixtures with other species. Can J Plant Sci. 84:1051–1058. doi:10.4141/P03-143.

Lavorel S, McIntyre S, Landsberg J, Forbes TDA. 1997. Plant functional classifications: from general groups to specific groups based on response to disturbance. Trends Ecol Evol. 12:474–478.

Beef Cattle Research Council [BCRC]. 2016. Cover crops as forage for beef cattle. [Accessed 2018 September 11]. http://www.beefresearch.ca/files/ pdf/BCRC_Cover_Crops_Fact_Sheet.pdf.

Akim Omokanye, Herbert Lardner, Lekshmi Sreekumar & Liisa Jeffrey (2019) Forage production, economic performance indicators and beef cattle nutritional suitability of multispecies annual crop mixtures in northwestern Alberta, Canada, Journal of Applied Animal Research, 47:1, 303-313, DOI: 10.1080/09712119.2019.1631830

Materials and methods

Experimental design – Randomized complete block design

Replications – 3;

Plot size – 8.22m^2;

Seeding depth – 0.75 inch

Treatments – Four annual forages;

- Arborg oats (50 lb /ac),
- Haymaker oats (50 lb /ac),
- Austenson Barley (48 lb /ac),
- Peas/Oats (64 lb /ac) grown with TG Extend cover crop mixture (10 lb /ac) either in the same row or different rows.

Data collected

Plant species established (plants /ft^2), crop stage at harvest, forage dry matter yield (FDMY – tonnes /acre), Feed quality testing

For each treatment plot, above ground biomass was harvested from all the rows and weighed fresh. Approximately 1 kg of freshly harvested material (sub-sample) was dried to a constant weight for dry matter (% DM) calculations. The DM calculations were then used to find out forage dry matter yield (FDMY). Feed samples were sent to Central Testing lab to find out crude protein (%), Acid Detergent Fibre (%), Neutral Detergent Fibre (%), Total Digestible Nutrients (%) and relative feed value.

Agronomic information

Stubble, soil type – Fallow, Heavy clay

Fertilizer applied – no fertilizer was applied.

Inoculant applied to Pea plots @ 8 lb /acre

Pesticides applied: Silencer @ 34ml /acre applied on July 13 and July 29 for grasshoppers

Seeding date – May 31, 2021

Harvesting date – Aug 6, 2021

20. Flooding effects on canola growth and yield

Project Duration

- 2019-2021

Collaborators

- Canadian Agricultural Partnership funding
- Curtis Cavers, AAFC Portage la Prairie

Objectives

– To quantify the tolerance and recovery of current cultivars of canola to excess moisture stress, with the intention of identifying a cultivar that has improved tolerance.

– To find out how timing of excess moisture stress affects yield.

Results

Flooding did not affect canola plant stand. However, it did influecnce plant height at maturity and days to maturity. Flooding at early crop stage resulted in taller canola plants (Table 20.1). Canola plots took more days to mature, when flooded at early crop stage. Although lodging differences were evident but logding scores were low enough to cause any significant yield loss. Canola had higher yield when flooded at early crop stage.

Table 20.1. Effect of flooding on canola growth and grain yield at Arborg site.

Treatment	Plant height	Plant stand	Days to maturity	Lodging	Grain yield
	inches	*plants/ft^2*		*1-5 scale*	*bu/acre*
Early Flooding	29.6b	14	96.8c	1.75b	50.7b
Late Flooding	27.4ab	13	73.4a	1.75b	*
No Flooding	26.8a	15	77.2b	1.00a	4.2a
Pr>F					
Flooding	0.0373	0.1204	<.0001	0.035	<.0001
Variety (Flooding)	0.5449	0.5435	0.0004	0.1329	0.2759
CV (%)	9.6	20.7	2.8	50.6	18.1
Sig. diff.	Yes	No	Yes	No	Yes

**no data collected as plots were severely infected by root rots after flooding.*

Among Canola varieties, flooding had similar effects on grain yield, plant stand, plant height and lodging. However, flooding at early crop growth increased days to maturity in L252 and L255 PC varieities only (data not shown).

Project findings

Flooding at the early crop stage resulted in taller plants, delayed maturity and greater canola yield. However, no yield was obtained when plots were flooded at later crop stage. These plots were severely infected by root rots after flooding. All canola varieties benefitted similarly, when crop was flooded at the early crop stage. The year 2021 was a drought year and the control plots only produced 4 bu /acre. The soil moisture was deficit during the whole crop season and early flooding actually benefitted the crop by supplying adequate moisture.

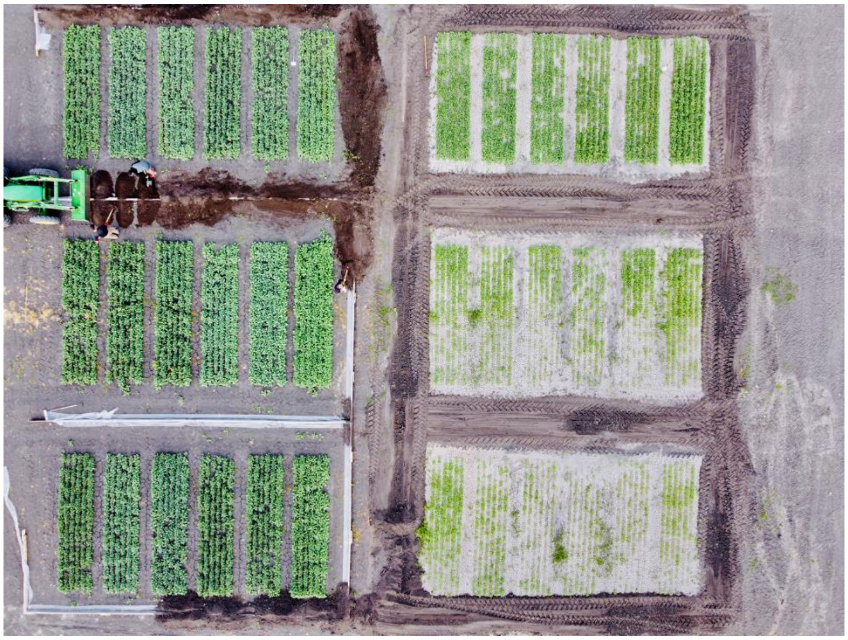


Fig.20.1. Early (right – pale green) and late flooding (left – dark green) plots of different canola varieties as of June 30 (before late flooding treatment).

Background / References / Additional resources

Excessive soil moisture conditions cause significant losses to farmers in Manitoba. Canola is quite susceptible to water logging and shows a yield reduction if exposed to excess moisture during the earlier phase of crop growth. Wet soils cause an oxygen deficiency, which reduces root respiration and growth (Canola Council of Canada). This attributed to reduced nutrient uptake in canola. Zhou and Lin (1995) reported that plant height, stem width and the number of primary branches per plant were decreased by waterlogging at seedling and floral bud appearance stages of canola. Pods per plant and seeds per pod were also reduced, giving 21.3% and 12.5% decrease of seed yield from the control for treatments at the seedling and floral bud appearance stages, respectively. No significant difference in seed yield was observed between the control and treatments applied at flowering and pod formation stages.

References

W. Zhou, and X. Lin (1995) Effects of waterlogging at different growth stages on physiological characteristics and seed yield of winter rape (*Brassica napus L*.). Field Crops Research **44**: 103-110.

Materials and methods

Experimental design – Randomized complete block design
Plot size – 8.22m^2
Treatments –3:
- Early flooding (2-3 leaf stage)
- Late flooding (Early flowering stage)
- No flooding (control)

Varieties-4;

L233P
L234PC
L252
L255PC

Four canola varieties were grown in flooded (early- and late-crop stage) and non-flooded set ups. Early flooding treatments was imposed when canola was at 2-3 leaf stage. These plots were flooded between June 21-28 and a total of 5 inches of flooding was applied in addition to natural precipitation.

Late flooding treatment was applied when the crop was at early flowering stage. Flooding in these plots was started on July 15 and continued until July 20 and a total of 7.5 inches of flooding was applied in addition to natural rainfall.

Data collected

plant stand at harvest, plant height at harvest, days to maturity, lodging and grain yield

Agronomic information

Stubble, soil type – Fallow, Heavy clay

Fertilizer applied –

- Nitrogen: 55 lb /acre
- Phosphorus: 25 lb /acre

Seeding date – May 28, 2021

Harvest date -

Control plots: Aug 27, 2021
Early flooding: Sep 14, 2021

Pesticides applied –

- Silencer @ 34ml/acre was applied on June 14 for flea beetles control
- Silencer @34ml/acre was applied on July 29 (only early flooding set) and on July 13 & Aug 6 (only no flooding set) for grasshoppers control
- Liberty@1.35 L/acre was applied on Jun 25 & July 7

21. Flooding effects on wheat growth and yield

Project Duration

- 2019-2021

Collaborators

- Canadian Agricultural Partnership funding
- Curtis Cavers, AAFC Portage la Prairie

Objectives

– to evaluate the effects of early and late flooding on four commonly grown wheat varieties in Manitoba. Plots were also grown under no flooding conditions as control for comparisons.

Results

Flooding influenced plant height, days to maturity, lodging and the yield of wheat varieties tested at Arborg site (Table 21.1). Wheat plots flooded at early crop stage had taller plants than in control plots. On the contrary, late-flooded plots has shorter plants and took less days to mature. Late flooding also resulted in greater lodging in the plants. Early flooding increased grain yield, whereas late flooding had adverse effect on the grain yield. Grain protein content was higher when the plots were flooded.

Table 21.1. Effect of flooding on wheat growth and grain yield at Arborg site.

Treatment	Plant height	Days to maturity	Lodging	Yield	Protein content
	inches		*1-5 scale*	*bu /acre*	*%*
Early Flooding	28.2c	81.0b	1.00a	51.7c	15.40b
Late Flooding	23.5a	77.3a	1.91b	17.7a	15.58b
No Flooding	26.4b	81.2b	1.00a	40.7b	15.13a
P -value	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
CV (%)	5.2	2.2	25.4	13.5	1.2
Sig. diff.	Yes	Yes	Yes	Yes	Yes

Project findings

Continuous flooding at 2-3 leaf stage benefitted wheat resulting in significant yield increase. This was not a surprise in a drought year like 2021, when the soil moisture was deficit during the entire crop season (Fig. 6.1 and Fig*. 6.2*). Flooding actually benefitted the crop rather than imposing any stress. Flooding at the later crop stage, however, reduced grain yield. The grains were shriveled and had less bushel weight in the late-flooded plots.

Background / References / Additional resources

Wet soils cause an oxygen deficiency and reduction in nutrient uptake. Early flooding can significantly have reduced tillering, plant height, delayed head emergence significantly affecting the grain yield. Excessive soil moisture also delays agronomic operations. The impact of these losses on farm net income is significant. During 1966-2015, excess moisture accounted for 38% of all crop losses in Manitoba (MASC).

Manitoba crop insurance data from 1965-1972 showed clay soils subjected to excess moisture in July experienced the highest yield loss (2-6 bu/ac/day) for barley, oats, wheat and flax crops (Rigaux and Singh,1977).

Additionally, farmers experience loss of nutrients due to extreme moisture as well as loss of soil. Excess water conditions may influence the ability of a plant to take up inorganic nutrients due to the effects on processes associated with solute movement across membranes (Barrett-Lennard 2003). Uptake of essential nutrients such as N, P, and K takes place against gradients of chemical and electrical potential, which requires energy inputs from aerobic respiration; respiration is inhibited under anaerobic conditions making nutrient uptake energetically unfavorable (Greenway and Gibbs 2003). For example, Huang et al. (1995) reported reduced concentrations of N, P, K, Mg, and Zn in wheat shoots under waterlogged conditions (and an increased concentration of these same elements in the wheat roots).

References

Barrett-Lennard, E. G. 2003. The interaction between waterlogging and salinity in higher plants: causes, consequences and implications. Plant Soil 253: 35-54.

Greenway, H. and Gibbs, J. 2003. Mechanisms of anoxia tolerance in plants. II. Energy requirements for maintenance and energy distribution to essential processes. Func. Plant Biol. 30: 999-1036.

Huang, B. R., Johnson, J. W., Nesmith, D. S. and Bridges, D.C. 1995. Nutrient accumulation and distribution of wheat genotypes in response to waterlogging and nutrient supply. Plant Soil 173: 47-54.

Rigaux, L. R. and Singh, R. H. Benefit-cost evaluation of improved levels of agricultural drainage in Manitoba, Volume 1-3, Research Bulletin No. 77-1, Department of Agricultural Economics and Farm Management, University of Manitoba, June 1977.

Materials and methods

Experimental design – Randomized complete block design

Plot size – 8.22 m^2

Varieties –AAC Brandon, AAC Cameron, AAC Viewfield and Cardale

Treatments – 3

- Early flooding (2-3 leaf stage)
- Late flooding (soft dough stage)
- No flooding (control)

Four wheat varieties were grown in flooded (early- and late-crop stage) and non-flooded set ups. Early flooding plots were flooded four times between June 21- 28 and a total of 5 inches of flooding was applied in addition to natural precipitation. Flooding was started, when the wheat crop was at 2-3 leaf stage.

Flooding was started in late-flooded plots on July 21, when the crop was at soft dough stage. Flooding continued until July 27 and a total of 7.5 inches of flooding was applied in addition to natural rainfall.

Data collected

Plant stand, Plant height, days to maturity, lodging, grain yield

Agronomic information

Stubble, soil type – Fallow, Heavy clay

Fertilizer applied –

- Early/Late flooding sets: N-55: P-20 (lb /acre)
- Control set: N-:55 P-20 (lb /acre)

Pesticides applied –

- Pre-emergence burn off using glyphosate @ 0.67L/ac
- Silencer @ 34ml/acre on July 8 (Only no flooding plots) and on July 29 for the control of grasshoppers (Only early flooding plots)

Seeding date

- May 28, 2021

Harvesting date

- No flooding: Aug 19, 2021
- Early flooding: Aug 27, 2021,
- Late flooding: Sep 1, 2021