

2020 Interim Report  
for the  
Saskatchewan Barley Development Commission,  
Manitoba Crop Alliance,  
and Western Grains Research Foundation

**Project Title:** Contrasting Fungicide Applications and Genetic Fusarium Head Blight Resistance for  
Enhanced Yield and Quality of Barley

(Project # SBDC 5086; MWBGA 2063; WGRF AGR2008)



**Principal Investigator:** Chris Holzapfel

Indian Head Agricultural Research Foundation, PO BOX 156, Indian Head, SK, S0G 2K0

Co-Investigators: Kelly Turkington (AAFC-Lacombe), Ramona Mohr (AAFC-Brandon), Michael Hall (ECRF-Yorkton), and Brianne McInnes (NARF-Melfort)

**Correspondence:** [cholzapfel@iharf.ca](mailto:cholzapfel@iharf.ca) or (306) 695-7761

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**2. Project Numbers:**

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**3. Principal Investigator**

Christopher Holzapfel, MSc, PAg

Research Manager, Indian Head Agricultural Research Foundation (IHARF)

Phone: (306) 695-7761, Email: [cholzapfel@iharf.ca](mailto:cholzapfel@iharf.ca)

Mailing Address: PO BOX 156, Indian Head, SK, S0G 2K0

**4. Collaborators**

Kelly Turkington, PhD

Research Scientist, Agriculture & Agri-Food Canada (AAFC)

Lacombe, AB

Ramona Mohr, PhD

Research Scientist, Agriculture & Agri-Food Canada (AAFC)

Brandon, MB

Michael Hall, MSc, PAg

Research Coordinator, East Central Research Foundation (ECRF)

Yorkton, SK

Brianne McInnes, BSc, AAg

Field Research Director, Northeast Agriculture Research Foundation (NARF)

Melfort, SK

**5. Project Administrator**

Danny Petty, BSc, PAg

Executive Manager, Indian Head Agricultural Research Foundation (IHARF)

Phone: (306) 695-4200, Email: [dpetty@iharf.ca](mailto:dpetty@iharf.ca)

Mailing Address: PO BOX 156, Indian Head, SK, S0G 2K0

**6. Summary:** Include activities during the project period, status of the project (is it on schedule), and any significant observations in related to the progress of the project.

A project was initiated in the winter of 2019-20 to investigate the potential for foliar fungicide applications combined with genetic fusarium head blight (FHB) resistance to enhance both yields and end-use quality of barley. Protocols were finalized in the late winter/early spring with the first field trials established at Indian Head, Yorkton, and Melfort in the spring of 2020. Our intent was to also conduct a trial at Brandon in 2020 but it was delayed due to COVID-19 restrictions. Field trials at a fifth location, Lacombe Alberta, are scheduled to come online in the spring of 2022; however, COVID-19 related disruptions at this location, transfer of cancelled trials in 2020 to 2021 and 2022, and capacity limitations may impact their ability to conduct the field trials as scheduled. We are hopeful that AAFC-

Brandon can have a site in 2021 and no disruptions or delays are anticipated at Indian Head, Melfort, or Yorkton. As a result of these setbacks, the project is currently considered to be behind schedule.

Despite a few minor issues, the field trials went well in 2020 and no specific changes to the field protocols are recommended. The issues encountered were due to human error (i.e., some plots lost to spray drift damage at Melfort) or minor misunderstandings of data collection requirements (i.e., plant counts not completed for all plots at Yorkton). The data that were collected for all plots (unless otherwise specified) included plant density, leaf disease ratings, grain yield, test weight, thousand kernel weight, plump seeds, thin seeds, and deoxynivalenol (DON) accumulation. Collaborating organizations completed the plant density and grain yield measurements in addition to collecting the leaves required for disease ratings. IHARF staff completed all grain quality assessments except DON which was completed by Seed Solutions Laboratory (Swift Current). AAFC staff at Lacombe are completing the leaf disease assessments and this work is currently in progress. All available response data was statistically analyzed and summarized to allow preliminary interpretation of results, identify potential trends or issues, and to help with future groupings of sites for combined statistical analyses (i.e., low versus high disease pressure). Extension activities to date have been minimal due to a combination of COVID-19 restrictions (i.e., could not introduce the project during field days) and the fact that 2020 was the first year of the trial; therefore, no results have been available to share prior to this report.

**7. Methods:** Include approaches, experimental design, methodology, materials, sites, etc. Major changes from original work plan must be indicated and the reason(s) for the change should be specified. Significant changes from the original work plan will require written approval from the Funders.

The specific field protocols and research plan for this project were developed back in 2019 during the letter of intent and full proposal phases, with feedback from the various funding organizations and collaborators. The detailed field protocol that was distributed to collaborators in early 2020 is provided in Schedule 1 of the Appendices and the first field trials were initiated that spring. Due to COVID-19 restrictions, field trials were not initiated at the AAFC-Brandon location. At Lacombe, no field trials were scheduled until the 2022 growing season; however, this location has also experienced major setbacks in their field program due to COVID19 and there is some uncertainty whether they will be able to conduct the trials as originally scheduled. Trials were completed at Indian Head, Melfort, and Yorkton as per the original proposal. A brief description of the methods, along with any further deviations from the original protocols, follows.

The treatments were a factorial combination of three varieties and four fungicide treatments, arranged in a four replicate randomized complete block design (RCBD). The varieties were selected based on their genetic resistance to FHB (according to the Saskatchewan Seed Guide) and were CDC Bow (moderately susceptible; MS), AAC Synergy (intermediate; I), and AAC Connect (moderately resistant, MR). The fungicide treatments were an untreated control, a flag-leaf application targeting leaf disease (Trivapro), an application at full head emergence targeting FHB (Prosaro XTR), and a dual application which received both the flag-leaf stage and heading fungicide applications. The fungicides were applied as per protocol, using field sprayers and a minimum solution volume of 187 l/ha (20 U.S. gal/ac). The treatments were applied on the same date for each variety and no sites reported enough variance in crop stage to suggest that separate application dates might be necessary in future years.

Barley was managed with all factors other than disease intended to be non-limiting and detailed agronomic information for Indian Head, Melfort, and Yorkton is provided in Table A-2 of the Appendices. The target seeding rate at all locations was 300 viable seeds/m<sup>2</sup>, adjusted for seed size and percent germination. All locations used the same seed source. Seed-applied fungicides were permitted at the discretion of site-managers but not required. Fertilizer applications varied by location, but all nutrients were intended to be non-limiting. Weed control measures also varied by location but the intent was to keep the crop reasonably free of weeds throughout the season. The centre rows from each plot were harvested, taking care to avoid potential edge effects (i.e., outside rows or fungicide drift) and areas of the plot affected by wheel tracks. Unfortunately, several plots at Melfort were damaged by spray drift by AAFC staff working in the area. NARF staff assessed the damaged and recommended that data from 10 plots would be affected and that these should be removed prior to any analyses. This was unfortunate but was not due to any wrongdoing of NARF staff and the affected plots were removed prior to any statistical analyses, as per their recommendations.

Various data were collected during the season and from the harvested grain samples. Emergence was assessed by recording the number of plants in 2 x 1 m sections of crop row per plot in late May/early June and converting the values to plants/m<sup>2</sup>. These measurements were not completed for all plots at Yorkton but will be in future years and emergence data were collected from enough treatments to test for varietal differences which is all we intended to do with these measurements. Initial leaf disease pressure and subsequent treatment effects on leaf disease were estimated from a minimum of 10 leaves per plot collected from the control treatments at the flag leaf stage (prior to fungicide application) and for all plots at the late milk/early dough stages. The third leaf from the head was collected for the flag-leaf stage ratings while the penultimate (2<sup>nd</sup> leaf from head) was collected at the later measurement date. Collaborators forwarded their leaves to IHARF staff at Indian Head who coordinated with AAFC-Lacombe to have the leaves rated for scald, net-form net blotch, and other leaf spots (a combination of spot blotch and spot-form net blotch). These samples were only forwarded to AAFC-Lacombe in early March 2020 and results for these measurements are not yet available. Grain yields were determined from the mass of harvested grain and are corrected for dockage and to 13.5% seed moisture content.

All locations forwarded 1 kg of cleaned grain from each plot to IHARF for further quality analyses. Test weights were determined from cleaned sub-samples for each plot using standard Canadian Grain Commission methods and equipment, including a 0.5 litre measure and cox funnel. Test weight values are expressed as g/0.5 L. Thousand kernel weights were determined by counting approximately 1000-1500 seeds using an automated seed counter and weighing them to the nearest 0.00 g. Values were converted to g/1000 seeds. Percent plump and thin kernels were determined from a 200 g cleaned sub-sample and were defined as the proportion of seeds that stayed on top of, or lodged in, a No. 6 slotted sieve (plump) or passed through a No. 5 slotted sieve (thin). Finally, a 250 g sub-sample from each plot was forwarded to Seed Solutions Seed Labs (Swift Current, SK) for deoxynivalenol (DON) determination. These data were reported in parts per million (ppm) to the nearest 0.00 ppm.

At this stage, data from all locations have been formatted for consistency and organized into a master file with basic screening for quality. In order to stay current with results to date and to help facilitate future grouping of sites for combined analyses (i.e., low versus high disease pressure), data from each location were analysed separately and summarized in the Appendices. The data were analysed using the Mixed procedure of SAS with variety (VAR), fungicide (FUNG), VAR x FUNG effects considered fixed and

replicate effects treated as random. No data transformations were explored at this time and, unless there were explicit reasons for doing so (i.e., drift damage at Melfort), no individual data points have been deleted at this stage of the project.

**8. Progress during the reporting period:** (e.g., laboratory, growth chamber, greenhouse, and field experiments; chemical analysis; data analysis; model development). Please briefly indicate what has been done during the reporting period in respect to meeting the stated objectives of the project.

Specific field protocols were finalized and distributed to all collaborators in the early spring of 2020. Seed for the 2020 season was sourced for all sites by ECRF and IHARF staff and distributed as required. Seed information for the 2020 season is provided in Table A-1 of the Appendices.

Field trials were initiated and carried through to completion at three of the four initially scheduled locations (Indian Head, Melfort, and Yorkton). The 2020 location at Brandon was delayed due to COVID-19 restrictions and the location at Lacombe was not scheduled to come online until 2022. At the time of writing, there is still some uncertainty regarding whether AAFC-Brandon will be permitted to conduct the trials in 2021 or whether AAFC-Lacombe will be able to initiate trials in 2022 as originally intended. That said, our collaborators at Brandon are hopeful that they will be able to have a site this coming season. At Lacombe, there are concerns about overall capacity for field trials due to existing commitments and their program being delayed by COVID-19 restrictions whereby cancelled trials in 2020 were transferred to 2021 and 2022,.

Except where otherwise specified, all aspects of the field trials went well in 2020. Issues that were identified have been acknowledged and disclosed. Any problems encountered and, where applicable, corrective actions, are identified below.

1. Spray drift at NARF-Melfort site. This was not caused by NARF staff; however, the parties involved were all well aware of the issue and we are hopeful that this will not occur to any significant degree in future years. Despite our best efforts, such issues can occasionally arise in small plot trial sites where the consequences of off-target movement of pest control products can be substantial and there is little room for either drift or error.
2. Plant counts not completed for all plots at ECRF-Yorkton site. This was due to a misinterpretation of the protocol and was not detected until after it was too late to complete the measurements in the missed plots. Staff have been informed of the need to complete these measurements on all plots in future years, even though it is a relatively unimportant measurement.

Each collaborator completed the plant counts, leaf collections, and yield measurements for their respective sites but forwarded the leaf disease and grain quality samples to IHARF. IHARF completed all the grain quality assessments that could be done in-house and coordinated with Seed Solutions Laboratory (Swift Current, SK) for DON determination on behalf of all sites. IHARF forwarded the leaf samples to AAFC Lacombe who are in the process of completing ratings for net blotch, scald, and other spots (a combination of spot blotch and spot-form net blotch). A minimum of 10 leaves were assessed for each plot. The initial assessments (prior to any fungicide application) were only completed for the control plots while the latter (late milk / early dough stage) were completed for all plots. The initial

ratings are intended to provide information on leaf disease pressure at the time of the flag-leaf fungicide applications while the latter were to assess treatment effects on final leaf disease.

All available data from the 2020 season were analysed using basic statistical procedures and summarized in order to help us identify potential issues as they arise and to better understand results from individual sites. This information will help us determine how to most effectively group locations for any future combined analyses.

**9. Project Progress to date:** (e.g., laboratory, growth chamber, greenhouse, and field experiments; chemical analysis; data analysis; model development; results if available). Please indicate overall project progress since its initiation.

Project progress to date is as described in the previous section since 2020 was the first year of field trials and this is first interim report. Weather data for the 2020 season at Indian Head, Melfort, and Yorkton is provided in Tables A-3 and A-4 of the Appendices. Results tables from the three locations where field trials were conducted in 2020 are provided in Tables A-5 through A-18 of the Appendices and will be briefly discussed for each response variable in this section. The overall F-test results for all locations and response variables are provided in Table A-5

#### Plant Emergence (Table A-6)

These measurements were completed prior to the application of any fungicide treatments, therefore, only variety effects were included in the model. Plant populations were highest at Yorkton but lower at Indian Head and Melfort. At Indian Head, populations were slightly lower for Synergy compared to Bow and Connect while populations were similar for all three varieties for the other two locations. At Indian Head, emergence was initially variable due to the dry conditions.

#### Grain Yield (Tables A-7 and A-8)

Barley yields were highest at Indian Head, intermediate at Melfort, and lowest at Yorkton. Barley yields were affected by variety but not fungicide at both Indian Head and Yorkton. At Melfort, neither variety nor fungicide effects were significant. The VAR x FUNG interaction for grain yield was not significant for any locations. At Indian Head, yields were higher with Synergy and Connect versus Bow while, at Yorkton, yields were higher with Synergy than for either Bow or Connect. At Melfort, the trend was for lower yields with Bow compared to the other two varieties. While fungicide effects were never significant, the tendency was usually for slightly higher yields in the treatments that received a flag leaf application. Overall yield variability at Yorkton was quite high, likely attributable to spatial variability and subtle differences in soil characteristics and moisture availability under the drought conditions.

#### Test Weight (Tables A-9 and A-10)

Test weight was affected by variety at all three locations but never by fungicide treatment and no VAR x FUNG interactions were detected. Numerically, AAC Synergy had the highest test weight at all three locations while CDC Bow consistently had amongst the lowest test weight. Test weight of CDC Connect was more intermediate at Indian Head and Yorkton and like CDC Bow at Melfort.

#### Thousand Kernel Weight (Tables A-11 and A-12)

Thousand kernel weight (TKW) was affected by variety at all locations and by fungicide treatment at Yorkton, but no VAR x FUNG interactions were detected. The fungicide response was also marginally significant at Indian Head ( $P = 0.099$ ). Overall, TKW values appeared to be highest at Indian Head and Yorkton but lower at Melfort. The variety effect was consistent with lower TKW for CDC Bow at all three locations compared to the other two varieties. Although differences between fungicide treatments were

too small to be declared significant individually, the trend was for higher TKW when a flag leaf fungicide was applied. Albeit less consistently, this was also the trend at Indian Head.

#### Plump Kernels (Tables A-13 and A-14)

Percent plump kernels were not affected by variety or fungicide at any of the three locations and there was no VAR x FUNG interaction detected. Overall, Yorkton had the highest percentage of plump kernels (99.0%) while values were slightly lower at Indian Head (97.0%), and intermediate at Melfort (97.8%).

#### Thin Kernels (Tables A-15 and A-16)

Percent thin kernels varied with variety but not fungicide at Indian Head and this variable was not affected by either main effect or the interaction in any other cases. At Indian Head, Synergy had the lowest proportion of thin seeds while values were highest with Connect and intermediate with Bow. Regardless of treatment, the proportion of thin kernels was lowest overall at Yorkton.

#### Deoxynivalenol – DON (Tables A-17 and A-18)

Deoxynivalenol (DON) accumulation was not affected by either variety nor fungicide treatment on their own for any individual locations, but the VAR x FUNG interaction was significant at Yorkton and marginally significant at Indian Head ( $P = 0.082$ ). Under the dry conditions, DON was low for all treatments at all locations, averaging 0.005 ppm at Yorkton, 0.047 ppm at Indian Head, and 0.096 ppm at Melfort. For context, the Brewing and Malting Barley Research Institute (BMBRI) suggests that barley with DON levels over 0.5 ppm will normally be rejected for malt. Under the low disease pressure, no consistent trends for treatment effects on DON were identified. The VAR x FUNG interaction at Yorkton was primarily attributed to low variability (with many 0.00 ppm values) and some inconsistencies amongst fungicide treatments for individual varieties; however, there was nothing to suggest that DON levels were higher, or that the fungicide response was more consistent, for any given variety. Overall, we speculate that FHB pressure was too low for us to detect either meaningful variety differences or consistent fungicide benefits. This does not mean that the results from 2020 are not useful or important. It simply means that, in the absence of the disease, fungicides are much less likely to provide measurable benefits for yield or quality and genetic resistance may be less important than other agronomic considerations. We are hopeful that we will acquire results for a wider range of conditions, including heavier disease pressure, as we move forward with the project.

#### **10. Extension and Communication Activities:** (e.g., extension meetings; papers produced; conference presentations made; photos)

Currently, we have no major extension or communication activities to acknowledge. We had intended to introduce the project during the 2020 IHARF Crop Management Field Day; however, this event was cancelled due to COVID-19 restrictions. At Indian Head and Yorkton, each plot was photographed after heading was complete and prior to harvest. While not part of our required data collection, this is common practice and these photographs often prove useful both as a record of potential issues with plots (i.e., poor establishment, damage to plots, etc.) and for extension purposes. At Yorkton, additional photos were taken of the leaves that were collected for disease assessments. A brief summary of the project rationale, objectives, and results to date will be included in the 2020 IHARF Annual Report and in annual reports of the collaborating organizations, where applicable.

**11. Appendices****Schedule 1 – Example Field Protocol Distributed to All Collaborators for the 2020 Season – Does Not Include Randomization / Field Map****#20-2613: FUNGICIDE APPLICATIONS & GENETIC FHB RESISTANCE FOR ENHANCED YIELD & QUALITY OF BARLEY (YR 1)**

**Objective:** To investigate the potential merits of contrasting foliar fungicide strategies in barley production and the potential for foliar fungicide applications combined with genetic FHB resistance to enhance end-use quality of barley.

**Location:** Indian Head (Lead), Melfort, Brandon, Yorkton & Lacombe (starting in 2022)

**Design:** RCBD with 4 replicates

**Treatments:** 4 fungicide treatments x 3 varieties = 12 treatments x 4 reps = 48 plots plus guards

#	Variety <sup>z</sup>	Fungicide <sup>y</sup>
1	CDC Bow (MS)	1) Untreated (no foliar fungicide)
2	CDC Bow (MS)	2) Flag (0.4 l/ac Trivapro A + 0.12 l/ac Trivapro B)
3	CDC Bow (MS)	3) Head (0.325 l/ac Prosaro XTR)
4	CDC Bow (MS)	4) Dual (Trt 2 and 3 combined – plots receive both applications)
5	AAC Synergy (I)	1) Untreated (no foliar fungicide)
6	AAC Synergy (I)	2) Flag (0.4 l/ac Trivapro A + 0.12 l/ac Trivapro B)
7	AAC Synergy (I)	3) Head (0.325 l/ac Prosaro XTR)
8	AAC Synergy (I)	4) Dual (Trt 2 and 3 combined – plots receive both applications)
9	AAC Connect (MR)	1) Untreated (no foliar fungicide)
10	AAC Connect (MR)	2) Flag (0.4 l/ac Trivapro A + 0.12 l/ac Trivapro B)
11	AAC Connect (MR)	3) Head (0.325 l/ac Prosaro XTR)
12	AAC Connect (MR)	4) Dual (Trt 2 and 3 combined – plots receive both applications)

<sup>z</sup> All locations will use the same seed source on a year-to-year basis. Ratings are for FHB (MS – moderately susceptible; I – intermediate; MR – moderately resistant)

<sup>y</sup> Fungicides should be applied in ~20 U.S. gal/ac at either the flag-leaf stage (Trt 2, 4, 6, 8, 10, & 12) or between 80% head emergence and 3 days after heading is complete (Trt 3, 4, 7, 8, 11, & 12). If necessary, application dates may vary with variety.

**Crop Management:**

- 1) **Drill/Plot Size:** Conserva-Pak / 14' x 35', flagged at 15' (plot size may vary across locations)
- 2) **Cultivar:** As per protocol
- 3) **Seed rate / Date:** 300 viable seeds/m<sup>2</sup>, target early to mid-May seeding
- 4) **Fertility:** NPKS balanced across treatments and non-limiting (target ~100-35-17-17)
- 5) **Crop protection:** Registered pesticides as required to keep weeds and insects non-limiting; fungicides applied as per protocol
- 6) **Harvest:** Straight-combine centre rows when mature and dry. Do not harvest outside rows and there should be no wheel-tracks within the harvest area. Pre-harvest glyphosate should be avoided

if possible. Collaborators may use diquat to assist crop dry-down; however, allowing the crop to mature and dry naturally is the preferred option. Take care during harvest not to cause excessive damage to the barley as this creates challenges for future quality analyses.

**Data collection:**

- 1) **Plant Density:** Count plants in 2 x 1 m sections of crop row after emergence is complete (i.e. approximately 10-14 days after emergence is first noted)
- 2) **Leaf disease ratings:** A minimum of 10 individual leaves per plot for should be collected in all cases. Upon collection, the leaves will be placed flat in long envelopes or submarine bags, dried at room temperature, carefully packaged, and forwarded to AAFC-Lacombe (care of Kelly Turkington) to be rated using established protocols during the fall/winter months. Leaves will be rated for scald, net-form net blotch, and other leaf spots and collections will be completed at two separate times.
  - a. **T1) Early Flag Leaf stage:** To assess early season risk and variety differences, initial ratings will be completed at early flag emergence for the untreated plots only (Trt 1, 5, & 9). These ratings will focus on the 3<sup>rd</sup> leaf from the head.
  - b. **T2) Early dough stage:** All plots are to be rated at this time, at least 7 days after the 2nd fungicide applications but prior to senescence. These ratings will focus on the penultimate leaf (2<sup>nd</sup> leaf from the head).
- 3) **Grain Yield:** Corrected for dockage and to 13.5% seed moisture content
 

*NOTE: All quality measurements to be completed by IHARF. Forward 1 kg cleaned seed per plot (minimum) to: IHARF, #1 Government Rd, Indian Head, SK, S0G 2K0, Attn: Chris Holzapfel.*
- 4) **Test Weight:** Standard CGC methodology, recorded in g/0.5 l
- 5) **Kernel Weight:** Count and weigh a minimum of 1000 seeds, convert to g/1000 seeds
- 6) **Percent Plump & Thin Kernels:** Record (to the nearest 0.1 g) the mass of grain from a 200 g cleaned sub-sample that stays on top of (or lodged in) a No. 6 slotted sieve (plump) or passes through a No. 5 slotted sieve (thin)
- 7) **Percent deoxynivalenol (DON):** Retain a commercially cleaned (i.e. dockage removed) sub-sample & forward to an accredited lab for DON determination (tentatively 250 g – confirm with lab)
  - a. Seed Solutions Laboratory (Swift Current) is the preferred choice, for consistency
  - b. IHARF to retain any leftover grain (approximately 500 g) as a temporary archive, until the project has concluded

**Schedule 2 – Results Tables for the 2020 Field Trials****Table A-1. Specifications for seed used in 2020 field trials at all three locations.**

Attribute	CDC Bow (20)	AAC Synergy (20)	AAC Connect (20)
Germination	97%	97%	97%
Thousand Kernel Weight (g/1000 seeds)	51 g	52 g	52 g

**Table A-2. Selected agronomic information and dates of operations for barley fusarium head blight management demonstrations completed at three locations in 2020.**

Factor / Field Operation	Indian Head	Yorkton	Melfort
Previous Crop	Canola	Canola	Canola
Pre-Emergent Weed Control	894 g glyphosate/ha (May-14)	None	894 g glyphosate/ha + 50 g saflufenacil/ha (May-24)
Seed Treatment	None	None	5 g prothioconazole + 2 g metalaxyl/100 kg seed
Seeding Date	May-14	May-7	May 22
Row Spacing	30 cm	30 cm	30 cm
Fertility (kg N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-S/ha)	115-35-18-18	97-34-0-0	31-36-11-6 (high residual N)
Emergence Counts	Jun-4	May-26 (not all treatments counted in Reps 2-4)	Jun-11
In-Crop Herbicides	5 g halauxifen/ha + 77 g fluroxypyr/ha + 371 g MCPA ester/ha + 62 g pinoxaden/ha (Jun-11)	107 g fluroxypyr/ha + 74 clopyralid + 415 g MCPA ester/ha (May 29) 62 g pinoxaden/ha (Jun-8)	107 g fluroxypyr/ha + 74 clopyralid + 415 g MCPA ester/ha (Jun-23) 62 g pinoxaden/ha (Jul-3)
T1 - Leaf Disease	July 3	Jun-29	July 13
Flag Fungicide	23 g azoxystrobin/ha + 38.6 g propiconazole/ha + 30 g benzovindiflupyr (Jul-3, as per protocol)	23 g azoxystrobin/ha + 38.6 g propiconazole/ha + 30 g benzovindiflupyr (Jul-1, as per protocol)	23 g azoxystrobin/ha + 38.6 g propiconazole/ha + 30 g benzovindiflupyr (Jul-11, as per protocol)
Head Fungicide	100 g prothioconazole/ha + 100 g tebuconazole/ha (Jul-19, as per protocol)	100 g prothioconazole/ha + 100 g tebuconazole/ha (Jul-13, as per protocol)	100 g prothioconazole/ha + 100 g tebuconazole/ha (Jul-24, as per protocol)
T2 – Leaf Disease	Jul-30	Jul-27	Aug-5
Pre-harvest Herbicide	None	894 g glyphosate/ha <sup>z</sup> (Aug 5)	None
Harvest Date	Aug-19	Aug-20	Sep-28

<sup>z</sup> The decision to apply pre-harvest glyphosate at Yorkton-2020 was due to initial drought followed by wet conditions leading to late emerging tillers and variable crop stage. Swathing was not an option and we were not confident that diquat would have been effective under the specific circumstances.

**Table A-3. Mean monthly temperatures along with long-term (1981-2010) averages for the 2020 growing seasons at Indian Head, Melfort, and Yorkton, Saskatchewan.**

Location	Year	April	May	June	July	August	Average
		----- Mean Temperature (°C) -----					
Indian Head	2020	0.3	10.7	15.6	18.4	17.9	15.7 (101%)
	Long-term	4.2	10.8	15.8	18.2	17.4	15.6
Melfort	2020	-2.9	10.1	14.3	18.2	17.6	15.1 (99%)
	Long-term	2.8	10.7	15.9	17.5	16.8	15.2
Yorkton	2020	0.0	10.5	16.4	19.9	18.3	16.3 (107%)
	Long-term	3.2	10.4	15.5	17.9	17.1	15.2

**Table A-4. Mean monthly precipitation along with long-term (1981-2010) averages for the 2020 growing seasons at Indian Head, Melfort, and Yorkton, Saskatchewan.**

Location	Year	April	May	June	July	August	Total
		----- Cumulative Precipitation (mm) -----					
Indian Head	2020	22.0	27.3	23.5	37.7	24.9	113 (46%)
	Long-term	22.6	51.7	77.4	63.8	51.2	244
Melfort	2020	11.1	26.7	103.7	52.4	18.5	201 (89%)
	Long-term	26.7	42.9	54.3	76.7	52.4	226
Yorkton	2020	6.2	16.7	33.6	80.1	49.3	180 (66%)
	Long-term	21.6	51.3	80.1	78.2	62.2	272

**Table A-5. Overall tests of fixed effects for variety (VAR), fungicide (FUNG), and VAR x FUNG for selected barley response variables at three locations in 2020. P-values less than or equal to 0.05 indicate that an effect was significant for the corresponding response variable. P-values below 0.1 are also worth noting.**

Source	Indian Head	Yorkton <sup>z</sup>	Melfort <sup>y</sup>
----- Emergence (p-values) -----			
Variety (VAR)	<0.001	0.321	0.239
----- Yield (p-values) -----			
Variety (VAR)	<0.001	0.010	0.213
Fungicide (FUNG)	0.144	0.250	0.759
VAR x FUNG	0.746	0.504	0.964
----- Test Weight (p-values) -----			
Variety (VAR)	<0.001	0.005	0.002
Fungicide (FUNG)	0.258	0.187	0.957
VAR x FUNG	0.657	0.387	0.974
----- Thousand Kernel Weight (p-values) -----			
Variety (VAR)	<0.001	<0.001	0.005
Fungicide (FUNG)	0.099	0.045	0.436
VAR x FUNG	0.258	0.483	0.841
----- Plump Kernels (p-values) -----			
Variety (VAR)	0.113	0.136	0.976
Fungicide (FUNG)	0.627	0.841	0.413
VAR x FUNG	0.488	0.725	0.805
----- Thin Kernels (p-values) -----			
Variety (VAR)	0.032	0.594	0.355
Fungicide (FUNG)	0.337	0.733	0.689
VAR x FUNG	0.877	0.862	0.409
----- Deoxynivalenol (p-values) -----			
Variety (VAR)	0.559	0.650	0.819
Fungicide (FUNG)	0.642	0.483	0.343
VAR x FUNG	0.082	0.046	0.802

<sup>z</sup> Emergence data not collected for all plots at Yorkton

<sup>y</sup> Ten (of 48) plots had to be discarded at this location due to damage caused by spray drift

**Table A-6. Main effect means for barley variety effects on plant density at three locations in 2020. The target seeding rate for all varieties was 300 viable seeds/m<sup>2</sup>. Main effect means within a location followed by the same letter do not significantly differ (Tukey's range test,  $P < 0.05$ ).**

Main Effect	Indian Head	Yorkton <sup>z</sup>	Melfort
----- Emergence (plants/m <sup>2</sup> ) -----			
Variety			
Bow (MS)	222.3 A	270.4 A	231.4 A
Synergy (I)	194.6 B	278.2 A	213.5 A
Connect (MR)	218.4 A	281.4 A	217.4 A
S.E.M.	6.73	8.35	10.06 <sup>y</sup>

<sup>z</sup> Emergence data not collected for all plots at Yorkton

<sup>y</sup> Overall average S.E.M. (values for individual treatments varied due to missing plots)

**Table A-7. Main effect (variety and fungicide treatment) means for barley grain yield at three locations in 2020. Main effect means within a location followed by the same letter do not significantly differ (Tukey's range test,  $P < 0.05$ ).**

Main Effect	Indian Head	Yorkton	Melfort
<u>Variety</u>	----- Grain Yield (kg/ha) -----		
Bow (MS)	4986 B	2610 B	3394 A
Synergy (I)	5609A	3074 A	3691 A
Connect (MR)	5429 A	2624 B	3630 A
S.E.M.	123.9	124.7	138.0 <sup>z</sup>
<u>Fungicide</u>			
Untreated Control	5378 A	2744 A	3487 A
Flag	5444 A	2998 A	3691 A
Head	5258 A	2647 A	3604 A
Dual	5286 A	2688 A	3505 A
S.E.M.	127.7	140.9	155.0 <sup>z</sup>

<sup>z</sup>Overall average S.E.M. (values for individual treatments varied due to missing plots)

**Table A-8. Individual treatment means (variety by fungicide treatment) means for barley grain yield at three locations in 2020. Means within a location followed by the same letter do not significantly differ (Tukey's range test,  $P < 0.05$ ).**

Treatment	Indian Head	Yorkton	Melfort
<u>Variety - Fungicide</u>	----- Grain Yield (kg/ha) -----		
MS - untreated	4989 bcd	2800 ab	3203 a
MS – flag	5188 a-d	2692 ab	3569 a
MS – head	4830 d	2459 b	3438 a
MS – dual	4938 cd	2489 b	3365 a
I - untreated	5682 a	2900 ab	3772 a
I – flag	5662 a	3629 a	3625 a
I – head	5611 a	2849 ab	3749 a
I – dual	5481 ab	2920 ab	3618 a
MR - untreated	5464 abc	2533 ab	3484 a
MR – flag	5483 ab	2674 ab	3879 a
MR – head	5333 a-d	2633 ab	3624 a
MR – dual	5439 abc	2656 ab	3532 a
S.E.M.	154.7	233.2	250.4

<sup>z</sup>Overall average S.E.M. (values for individual treatments varied due to missing plots)

**Table A-9. Main effect (variety and fungicide treatment) means for barley test weight at three locations in 2020. Main effect means within a location followed by the same letter do not significantly differ (Tukey's range test,  $P < 0.05$ ).**

Main Effect	Indian Head	Yorkton	Melfort
<u>Variety</u>	----- Test Weight (g/0.5 L) -----		
Bow (MS)	324.6 B	326.7 B	334.2 B
Synergy (I)	328.5 A	329.1 A	336.2 A
Connect (MR)	326.8 A	327.9 AB	333.4 B
S.E.M.	0.50	0.50	0.62 <sup>z</sup>
<u>Fungicide</u>			
Untreated Control	325.8 A	326.9 A	334.3 A
Flag	326.7 A	328.3 A	334.8 A
Head	326.7 A	327.9 A	334.7 A
Dual	327.5 A	328.6 A	334.6 A
S.E.M.	0.58	0.58	0.68 <sup>z</sup>

<sup>z</sup> Overall average S.E.M. (values for individual treatments varied due to missing plots)

**Table A-10. Individual treatment means (variety by fungicide treatment) means for barley test weight at three locations in 2020. Means within a location followed by the same letter do not significantly differ (Tukey's range test,  $P < 0.05$ ).**

Treatment	Indian Head	Yorkton	Melfort
<u>Variety - Fungicide</u>	----- Test Weight (g/0.5 L) -----		
MS - untreated	323.5 b	326.9 a	334.3 a
MS – flag	325.7 ab	325.8 a	334.6 a
MS – head	324.4 b	326.1 a	334.2 a
MS – dual	324.9 ab	327.7 a	333.8 a
I - untreated	328.3 ab	327.4 a	335.6 a
I – flag	328.4 ab	330.7 a	336.7 a
I – head	328.1 ab	328.8 a	336.4 a
I – dual	329.4 a	329.7 a	336.0 a
MR - untreated	325.5 ab	326.3 a	333.0 a
MR – flag	326.0 ab	328.5 a	333.0 a
MR – head	327.8 ab	328.6 a	333.5 a
MR – dual	328.1 ab	328.3 a	333.9 a
S.E.M.	1.01	0.99	1.03

<sup>z</sup> Overall average S.E.M. (values for individual treatments varied due to missing plots)

**Table A-11. Main effect (variety and fungicide treatment) means for barley thousand kernel weight at three locations in 2020. Main effect means within a location followed by the same letter do not significantly differ (Tukey's range test,  $P < 0.05$ ).**

Main Effect	Indian Head	Yorkton	Melfort
<u>Variety</u>	----- Thousand Kernel Weight (g/1000 seeds) -----		
Bow (MS)	47.8 B	48.7 B	44.8 B
Synergy (I)	49.1 A	49.7 A	46.3 A
Connect (MR)	49.3 A	49.9 A	46.1 A
S.E.M.	0.16	0.19	0.41 <sup>z</sup>
<u>Fungicide</u>			
Untreated Control	48.4 A	49.0 A	45.9
Flag	49.1 A	49.8 A	45.7
Head	48.7 A	49.2 A	46.0
Dual	48.8 A	49.7 A	45.9
S.E.M.	0.18	0.22	0.45 <sup>z</sup>

<sup>z</sup> Overall average S.E.M. (values for individual treatments varied due to missing plots)

**Table A-12. Individual treatment means (variety by fungicide treatment) means for barley thousand kernel weight at three locations in 2020. Means within a location followed by the same letter do not significantly differ (Tukey's range test,  $P < 0.05$ ).**

Treatment	Indian Head	Yorkton	Melfort
<u>Variety - Fungicide</u>	----- Thousand Kernel Weight (g/1000 seeds) -----		
MS - untreated	47.3 c	48.6 b	44.7 a
MS – flag	48.1 bc	49.0 ab	44.5 a
MS – head	48.1 bc	48.6 b	44.9 a
MS – dual	47.9 bc	48.8 ab	45.3 a
I - untreated	48.9 ab	49.0 ab	45.4 a
I – flag	49.7 a	50.5 a	46.6 a
I – head	48.5 abc	49.2 ab	46.6 a
I – dual	49.2 ab	49.9 ab	46.5 a
MR - untreated	48.9 ab	49.3 ab	45.8 a
MR – flag	49.4 ab	49.9 ab	46.7 a
MR – head	49.6 a	49.9 ab	45.7 a
MR – dual	49.2 ab	50.3 ab	46.3 a
S.E.M.	0.31	0.38	0.66

<sup>z</sup> Overall average S.E.M. (values for individual treatments varied due to missing plots)

**Table A-13. Main effect (variety and fungicide treatment) means for plump kernels in barley at three locations in 2020. Main effect means within a location followed by the same letter do not significantly differ (Tukey's range test,  $P < 0.05$ ).**

Main Effect	Indian Head	Yorkton	Melfort
<u>Variety</u>	----- Plump Kernels (g/100 g) -----		
Bow (MS)	97.0 A	99.0 A	97.8 A
Synergy (I)	97.5 A	99.2 A	97.8 A
Connect (MR)	96.7 A	98.9 A	97.9 A
S.E.M.	0.27	0.16	0.30 <sup>z</sup>
<u>Fungicide</u>			
Untreated Control	96.8 A	98.9 A	97.4 A
Flag	97.1 A	99.0 A	98.2 A
Head	97.2 A	99.0 A	97.9 A
Dual	97.3 A	99.1 A	97.9 A
S.E.M.	0.31	0.16	0.33 <sup>z</sup>

<sup>z</sup> Overall average S.E.M. (values for individual treatments varied due to missing plots)

**Table A-14. Individual treatment means (variety by fungicide treatment) means for plump kernels in barley at three locations in 2020. Means within a location followed by the same letter do not significantly differ (Tukey's range test,  $P < 0.05$ ).**

Treatment	Indian Head	Yorkton	Melfort
<u>Variety - Fungicide</u>	----- Plump Kernels (g/100 g) -----		
MS - untreated	96.6 a	98.8 a	97.6 a
MS – flag	96.4 a	99.1 a	98.2 a
MS – head	97.0 a	99.0 a	97.8 a
MS – dual	98.0 a	98.9 a	97.7 a
I - untreated	97.2 a	99.1 a	96.9 a
I – flag	97.9 a	99.2 a	97.8 a
I – head	97.8 a	99.3 a	98.2 a
I – dual	97.2 a	99.1 a	98.2 a
MR - untreated	96.5 a	98.9 a	97.6 a
MR – flag	96.9 a	98.8 a	98.4 a
MR – head	96.8 a	98.8 a	97.7 a
MR – dual	96.8 a	99.1 a	97.8 a
S.E.M.	0.54	0.22	0.53

<sup>z</sup> Overall average S.E.M. (values for individual treatments varied due to missing plots)

**Table A-15. Main effect (variety and fungicide treatment) means for thin kernels in barley at three locations in 2020. Main effect means within a location followed by the same letter do not significantly differ (Tukey's range test,  $P < 0.05$ ).**

Main Effect	Indian Head	Yorkton	Melfort
<u>Variety</u>	----- Thin Kernels (g/100 g) -----		
Bow (MS)	0.25 AB	0.08 A	0.26 A
Synergy (I)	0.20 B	0.06 A	0.34 A
Connect (MR)	0.29 A	0.08 A	0.28 A
S.E.M.	0.028	0.011	0.060 <sup>z</sup>
<u>Fungicide</u>			
Untreated Control	0.29 A	0.08 A	0.34 A
Flag	0.25 A	0.06 A	0.28 A
Head	0.23 A	0.08 A	0.27 A
Dual	0.27 A	0.07 A	0.27 A
S.E.M.	0.030	0.012	0.065 <sup>z</sup>

<sup>z</sup> Overall average S.E.M. (values for individual treatments varied due to missing plots)

**Table A-16. Individual treatment means (variety by fungicide treatment) means for thin kernels in barley at three locations in 2020. Means within a location followed by the same letter do not significantly differ (Tukey's range test,  $P < 0.05$ ).**

Treatment	Indian Head	Yorkton	Melfort
<u>Variety - Fungicide</u>	----- Thin Kernels (g/100 g) -----		
MS - untreated	0.30 a	0.08 a	0.24 a
MS - flag	0.28 a	0.07 a	0.22 a
MS - head	0.24 a	0.08 a	0.28 a
MS - dual	0.20 a	0.08 a	0.28 a
I - untreated	0.21 a	0.07 a	0.48 a
I - flag	0.19 a	0.05 a	0.41 a
I - head	0.19 a	0.06 a	0.25 a
I - dual	0.21 a	0.08 a	0.22 a
MR - untreated	0.36 a	0.08 a	0.31 a
MR - flag	0.27 a	0.07 a	0.22 a
MR - head	0.26 a	0.10 a	0.29 a
MR - dual	0.27 a	0.06 a	0.30 a
S.E.M.	0.049	0.021	0.093

<sup>z</sup> Overall average S.E.M. (values for individual treatments varied due to missing plots)

**Table A-17. Main effect (variety and fungicide treatment) means for deoxynivalenol (ppm) in barley at three locations in 2020. Main effect means within a location followed by the same letter do not significantly differ (Tukey's range test,  $P < 0.05$ ).**

Main Effect	Indian Head	Yorkton	Melfort
<u>Variety</u>	----- Deoxynivalenol - DON (ppm) -----		
Bow (MS)	0.056 A	0.008 A	0.108 A
Synergy (I)	0.056 A	0.003 A	0.098 A
Connect (MR)	0.028 A	0.004 A	0.081 A
S.E.M.	0.0255	0.0039	0.0306 <sup>z</sup>
<u>Fungicide</u>			
Untreated Control	0.061 A	0.011 A	0.125 A
Flag	0.058 A	0.006 A	0.078 A
Head	0.020 A	0.003 A	0.126 A
Dual	0.048 A	0.002 A	0.054 A
S.E.M.	0.0283	0.0045	0.0351

<sup>z</sup> Overall average S.E.M. (values for individual treatments varied due to missing plots)

**Table A-18. Individual treatment means (variety by fungicide treatment) means for deoxynivalenol (DON) accumulation in barley at three locations in 2020. Means within a location followed by the same letter do not significantly differ (Tukey's range test,  $P < 0.05$ ).**

Treatment	Indian Head	Yorkton	Melfort
<u>Variety - Fungicide</u>	----- Deoxynivalenol - DON (ppm) -----		
MS - untreated	0.143 a	0.033 a	0.085 a
MS - flag	0.040 a	0.000 a	0.100 a
MS - head	0.030 a	0.000 a	0.158 a
MS - dual	0.013 a	0.000 a	0.090 a
I - untreated	0.040 a	0.000 a	0.177 a
I - flag	0.025 a	0.000 a	0.070 a
I - head	0.030 a	0.008 a	0.140 a
I - dual	0.128 a	0.005 a	0.005 a
MR - untreated	0.000 a	0.000 a	0.113 a
MR - flag	0.108 a	0.018 a	0.065 a
MR - head	0.000 a	0.000 a	0.080 a
MR - dual	0.003 a	0.000 a	0.068 a
S.E.M.	0.0449	0.0079	0.0605

<sup>z</sup> Overall average S.E.M. (values for individual treatments varied due to missing plots)