2022 Final Report

from the

Saskatchewan Barley Development Commission

Project Title: Enhanced Barley Variety Trials-Fungicide

Principal Investigators:

Mike Hall[1], Heather Sorestad[1], Chris Holzapfel[2], Christiane Catellier[2], Gary Hnatowich[3], Gursahib Singh[3], Brianne McInnes[4], Bryan Nybo[5], Amber Wall[5], Robin Lokken[6], Jessica Enns[7]

[1]East Central Research Foundation, Yorkton, SK
[2]Indian Head Agricultural Research Foundation, Indian Head, SK
[3]Irrigation Crop Diversification Corporation, Outlook, SK
[4]Northeast Agriculture Research Foundation, Melfort, SK
[5]Wheatland Conservation Area Inc., Swift Current, SK
[6]Conservation Learning Centre, Prince Albert, SK
[7]Western Applied Research Corporation, Scott, SK

Project Identification

1. **Project Number:** 20211030
2. **Producer Group Sponsoring the Project:** Saskatchewan Barley Development Commission
3. **Project Location(s):** Yorkton, Indian Head, Melfort, Outlook, Prince Albert, Scott and Swift Current, SK
4. **Project start and end dates (month & year):** April 2022 to February 2023
5. **Project contact person & contact details:**

Mitchell Japp, Research and Extension Manager

Saskatchewan Barley Development Commission
Phone: 306 535 4536
Email: mjapp@saskbarley.com

Mike Hall, Research Coordinator

East Central Research Foundation/Parkland College
Box 1939, Yorkton, SK, S3N 3X3
Phone: 306-621-6032
Email: m.hall@parklandcollege.sk.ca

Objectives and Rationale

6. **Project objectives:**

The objective of this demonstration is to compare the responsiveness of 3 malt and 3 feed barley varieties to fungicide applied at heading (FHB timing). The malt varieties to be screened include AAC Synergy, AAC Connect, CDC Fraser, and the feed varieties include CDC Austenson, Claymore, and Oreana. These varieties were selected as they are increasing in popularity based on 2021 insured seeded acres (Canadian Grain Commission). This demonstration project is part of a series of projects proposed by SaskBarley to generate variety specific recommendations for barley management.

7. **Project Rationale:**

The response of cereals to differing levels of management can differ between varieties. In wheat for example, Dr. Sheri Strydhorst has identified varieties that are most responsive to additional management inputs (such as higher seeding rates, higher fertilizer rates, plant growth regulator and fungicide application). In one of Dr. Strydhorst's projects, yield responses to additional management ranged from 6-17% depending on variety - this is valuable information for producers[1]. Link to data

More specific to this demonstration, yield responsiveness of cereals to fungicide can vary with variety. For example, Kumar et al. evaluated the impact of stripe rust resistance in wheat and barley[2]. Data from Lacombe and Olds in 2014, found fungicide could prevent significant barley

yield losses from stripe rust of 51.3% and 26.4% for the susceptible variety H98077001 and moderately susceptible variety Mahigan, respectively. However, the yield loss prevention for the resistant variety Seebe was only 11% and was not statistically significant.

At Melfort in 2011, work by NARF found fungicide application increased yield for the barley varieties Harrington and AC Metcalfe, but not for the more leaf spot resistant variety, Newdale [3].

Varietal screening in this demonstration with fungicide will not include either AC Metcalfe or CDC Copeland as these varieties are declining in popularity and will be irrelevant in the future. This study will focus on newer varieties, which are increasing in popularity. These include the malt varieties AAC Synergy, AAC Connect and CDC Fraser, which constituted 17%, 4% and 2% of insured barley acres in Saskatchewan, respectively (Canadian Grain Commission, 2021). The feed varieties selected include CDC Austenson, Claymore and Oreana, which were grown on 17%, 5% and 3% of Saskatchewan's insured barley acres, respectively.

Table 1. lists the levels of varietal resistance to prevalent barley diseases for the varieties selected in this study. There is a range of resistance to fusarium head blight, with the feed variety Oreana being rated as susceptible to Claymore and AAC Connect being moderately resistant. All varieties excepting CDC Fraser are susceptible to Scald. However, CDC Fraser is only a little better with a rating of moderately susceptible. Resistance to leaf blotch diseases is variable between varieties. Overall, the malt varieties appear to have better leaf blotching disease packages than the feed varieties.

Table 1. Varietal Resistance to Selected Barley Diseases

Variety	Nettled Net Blotch	Spotted Net Blotch	Spot Blotch	Scald	FHB
AAC Synergy	MR	R	R	S	I
AAC Connect	I	MR	MR	S	MR
CDC Fraser	MR	R	MR	MS	I
CDC Austenson	MS	R	MR	S	I
Claymore	S	I	I	S	MR
Oreana	S	MR	I	S	S

R=Resistant; MR=Moderately Resistant; I=Intermediate; MS=Moderately Susceptible; S=Susceptible

Past study has revealed that the value of fungicide to prevent yield loss from common barley leaf disease and FHB can vary between varieties. However, the introduction of new varieties with better levels of resistance means this information needs to be continually updated. This information will become part of a variety specific approach to crop management recommendations being developed by SaskBarley.

[1] https://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/crop16234/$FILE/sheri-strydhorst-improving-agronomic-input-efficiency-review.pdf

[2]Krishan Kumar, Kequan Xi, Thomas K. Turkington, Mazen Aljarrah & Flavio Capettini (2019) Yield responses in spring wheat and barley cultivars, varying in stripe rust resistance in central Alberta, Canadian Journal of Plant Pathology, DOI: 10.1080/07060661.2019.1680443

[3]Variety & Fungicide Effects on Wheat and Barley. AgriARM Applied Research Management factsheet January 2014.

8. Methodology:

The trials were established at each location as a split-plot design with 4 replicates. The main plot factor compared no fungicide against an application of fungicide at early heading for the control of leaf disease and FHB. The subplot factor was variety. All individual treatments are listed in table 2 below. N rates at each site were matched to the standard rate used in the "Enhanced Barley Variety Trials-Fertility" study. This meant target rates of soil N (0-24") + added N equalled 100 lb N/ac at Swift Current (low yielding group), 120 lb N/ac at Scott, Indian Head and Prince Albert (mid-range group), and 130 lb N/ac at Yorkton, Melfort and Outlook (high yielding group). Every treatment also received equal amounts of P and K based on soil test recommendations to be non-limiting. Herbicide and possibly insecticide selection were at the discretion of the site manager to ensure pests were non-limiting to yield. All trials are considered "small plot", but plot size varied between locations based on available equipment. Depending on plot width, either the whole plot or only 4 or 5 centre rows were harvested using a small plot combine. Seeding rates for each variety were based on TKW and germination tests to target 300 live seeds/m^2. Dates of field operations for each site are listed in Table 3.

Table 2. Treatment list for project (Fungicide by Barley Variety)

#	Variety	Type	Fungicide[1]
1	AAC Synergy	Malt	None
2	AAC Connect	Malt	None
3	CDC Fraser	Malt	None
4	CDC Austenson	Feed	None
5	Claymore	Feed	None
6	Oreana	Feed	None
7	AAC Synergy	Malt	Yes
8	AAC Connect	Malt	Yes
9	CDC Fraser	Malt	Yes
10	CDC Austenson	Feed	Yes
11	Claymore	Feed	Yes
12	Oreana	Feed	Yes

[1]Fungicide applied was to be either be Prosaro or Caramba, applied at early heading (FHB timing).

Table 3. Dates of field operations and products used in 2022.

Operations in 2020	**Indian Head**	**Melfort**	**Outlook**	**Prince Albert**	**Swift Current**	**Yorkton**	**Scott**
Pre-seed/ pr-emergent herbicide application	**May 22** (0.67 l/ac Roundup Weathermax HC)	**May 12** (Liquid Avadex) **May 21** (0.67 l/ac Roundup Transorb HC 640)	**May 2** (1 l/ac Glyphosate)	**May 21** (1 l/ac Roundup Transorb)	**May 4** (Glyphosate @ 360 g ai/ac + Aim @40 ml/ac + Merge @ 1 l/100l)	**None**	**May 9** (1 l/ac Glyphosate + AIM)
Seeding Date	**May 16**	**May 16**	**May 10**	**June 3**	**May 17**	**May 23**	**May 12**
Emergence Counts	**June 1**	**June 7**	**May 30**	**June 22**	**June 14**	**June 7**	**May 25**
In-crop Herbicide Application	**June 11** (Pixxaro A + B + Axial)	**June 22** (Axial) **June 28** (Prestige XL)	**June 8** (Buctril M + Puma)	**June 28** (Infinity + Puma Advance)	**June 8** (Liquid Achieve + Buctril M + Carrier Adj.)	**June 8** (Akito and Axial separate passes)	**June 16** (Axial Ipak)
Fungicide Application	**July 9** (Decis 5 EC for grasshoppers) **July 17** (Prosaro XTR)	**July 18** (Caramba)	**July 7** (Prosaro)	**July 22** (Caramba)	**July 14** (Prosaro)	**July 20** (Caramba)	**July 11** (Caramba)
Leaf senescence ratings	**July 27**	**July 27**	**July 18**	**Aug 3**	**July 27**	**Aug 3**	**July 21**
Lodging Rating	**August 29**	**Sept 2**	**Aug 3**	**Aug 22**	**Aug 15**	**Sept 2**	**Aug 9**
Desiccation	**None**	**None**	**None**	**None**	**None**	**None**	**None**
Harvest	**Sept 1**	**Sept 14**	**Aug 17**	**Sept 6**	**Aug 16**	**Sept 2**	**Aug 18**

9. Results:

Growing Season Weather

Mean monthly temperatures and precipitation amounts with long-term (1981-2010) averages for the 6 sites are listed in Tables 4 and 5. In 2022, the season at all sites was warmer than the long-term historical average. Precipitation varied greatly from historical norms between sites. Yorkton, Indian Head, and Melfort received above average seasonal precipitation. In contrast, Swift Current, Scott and Outlook received less than average rainfall. The low rainfall at Outlook was inconsequential to yield as the deficit was replaced by irrigation.

Table 4. Mean monthly temperatures and long-term (1981-2010) normals for the 2022 growing seasons at 6 sites in Saskatchewan.

Location	Year	May	June	July	August	Avg. / Total
		----------*Mean Temperature (°C)* ----------				
Indian Head	2022	10.9	16.1	18.1	18.3	15.8
	Long-term	**10.8**	**15.8**	**18.2**	**17.4**	**15.6**
Melfort	2022	9.9	15.2	18.2	18.7	15.5
	Long-term	***10.7***	***15.9***	***17.5***	***16.8***	***15.2***
Outlook	2022	11.8	16.3	19.8	20.6	17.1
	Long-term	***11.5***	***16.1***	***18.9***	***18***	***16.1***
Prince Albert	2022	10.5	15.5	18.3	18.5	15.7
	Long-term	***11.4***	***15.9***	***18.5***	***17.1***	***15.7***
Swift Current	2022	10.9	15.9	19.8	20.9	16.9
	Long-term	***10.9***	***15.3***	***18.2***	***17.6***	***15.5***
Yorkton	2022	10.6	15.7	18.6	18.9	16
	Long-term	***10.4***	***15.5***	***17.9***	***17.1***	***15.2***
Scott	2022	10	15	18.3	18.9	15.6
	Long-term	***10.8***	***14.8***	***17.3***	***16.3***	***14.8***

Table 5. Precipitation amounts along with long-term (1981-2010) normals for the 2022 growing seasons at 6 sites in Saskatchewan.

		---------- *Precipitation (mm)* ----------				
Indian Head	2022	97.7	27.5	114.5	45.9	285.6
	Long-term	***51.7***	***77.4***	***63.8***	***51.2***	***244.1***
Melfort	2022	90.8	78.1	34.9	36.5	240.3
	Long-term	***42.9***	***54.3***	***76.7***	***52.4***	***226.3***
Outlook	2022	30.4	69.4	51.4	8	159.2
	Long-term	**43.2**	**69.3**	**57.6**	**44.2**	**214.3**
Prince Albert	2022	17.9	75.7	63.7	37.8	195.1
	Long-term	***40.4***	***79.6***	***84.6***	***42.9***	***247.5***
Swift Current	2022	51.2	37.7	90.4	7.5	187
	Long-term	***44.1***	***74.5***	***51.9***	***43.2***	***213.7***
Yorkton	2022	137.9	57.9	38.4	90.8	325
	Long-term	***51***	***80***	***78***	***62***	***272***
Scott	2022	11	57.1	86.5	32.1	186.7
	Long-term	***38.9***	***69.7***	***69.4***	***48.7***	***226.7***

Statistical analysis

Data were analyzed with the R statistical program, version 4.2.2 (R Core Team 2022), using the *lme4* package (Bates et al. 2015) for fitting mixed-effects models, the *lmerTest* package (Kuznetsova et al. 2017) for assessing model fit and treatment differences, and the *emmeans* package (Length 2023) for means separation. Data from all site-years were combined for a multi-site analysis. To assess the overall response across environments and determine the presence of significant site interactions, mixed effects models were fitted for each response variable with site, variety and fungicide treatment, all two-way interactions, and the three-way interaction as fixed effects, and replicate within site, and fungicide (main split-plot) within replicate within site as random effects. If significant site interactions were identified, then sites were analyzed separately, with variety, fungicide, and the variety by fungicide interaction as fixed effects, and replicate and fungicide within replicate as random effects. Fungicide and interactions with fungicide were not included as fixed effects for plant density. Leaf disease and lodging were log-transformed to meet the assumptions of normality and homogeneity of variance of the model residuals. Estimated marginal means were determined and means were separated using multiple pairwise comparisons with the Tukey method for P-value adjustment and the Satterthwaite method for determining degrees of freedom. Treatments were considered significantly different at $P<0.05$.

Table 6. F-test results of mixed-effects model analysis of all crop response variables assessing the presence of site interactions with each treatment and combination of treatments. Effects are considered statistically significant if P<0.05 and significant effects are bolded for emphasis.

	Plant density	Leaf Disease	Lodging	Yield	Protein
Fixed effects	----------	----------	*Pr(>F)*	----------	----------
Variety (V)	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Fungicide (F)	-	**<0.001**	**0.022**	0.150	0.630
Site (S)	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
V x F	-	0.295	0.168	**0.018**	0.487
V x S	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.098
F x S	-	**0.031**	0.556	**0.048**	0.227
V x F x S	-	0.711	0.491	**0.007**	0.498

Plant density

There was a significant variety by site interaction (Table 6), so sites were analyzed individually (Table 7). Four of seven sites had differences in plant density between varieties, while three sites had no significant differences between varieties (Table 7). At Melfort and Scott, only the emergence of AAC Synergy was significantly higher than the other varieties, which did not significantly differ from each other. There was more variation in emergence between varieties at Swift Current and Yorkton which could have had some minor impacts on yield potential.

Table 7. Tests of significance and estimated marginal means for the effect of variety on plants/m^2 at each site individually. F-test results for individual sites are considered significant at P<0.05. 'S.E.' indicates the standard error. Letters indicate the separation of the estimated marginal means within individual sites.

	Indian Head	Melfort	Outlook	Prince Albert	Scott	Swift Current	Yorkton
P(>F)	0.131	**0.001**	0.657	0.109	**<0.001**	**0.008**	**0.003**
S.E.	7.94	6.72	13.2	10.7	3.88	6.08	11.9
Variety	----------	----------	----------	*plants/m^2*	----------	----------	----------
AAC Synergy	222	220 a	100	241	226 a	168 ab	281 a
AAC Connect	207	182 b	112	220	196 b	154 b	270 ab
CDC Fraser	194	183 b	124	233	191 b	181 a	220 c
CDC Austenson	211	182 b	105	240	202 b	153 b	235 bc
Claymore	220	178 b	118	251	198 b	174 ab	241 abc
Oreana	204	185 b	109	252	200 b	170 ab	245 abc

Leaf Disease

There were significant variety by site and fungicide by site interactions (Table 6), so sites were analyzed individually (Table 8). Tabulated estimated marginal means for all fixed effects at all sites with means separation are provided in the appendix (Table A-1). Percent leaf disease was log-transformed prior to analysis and transformed values are shown in the figures.

While levels of leaf disease were not high at any location, the main effect of fungicide application significantly reduced the presence of leaf disease at all locations except Swift Current (Table A-1). However, there was a significant interaction between fungicide and variety at Indian Head. While the level of leaf disease was reduced for all varieties with fungicide, the reduction was not significant for CDC Fraser and nominally, the reduction was greater for Oreana (Figure 1). Oreana had a higher level of leaf disease incidence. Based on regional information Oreana has a poorer disease package (Table 1). It is rated as "Susceptible" to Netted Net Blotch which is a common leaf disease issue for barley. The incidence of leaf disease also varied between varieties at the other locations. At Melfort, more leaf disease was associated with Claymore and Oreana and less disease was associated with AAC Synergy and Fraser (Figure 2). Again, this is in keeping with regional information was shows the leaf disease resistance package for Claymore and Oreana is much poorer compared to AAC Synergy and CDC Fraser. Oreana was also found to have significantly more leaf disease than the other varieties at Prince Albert and Indian Head (Table A-1, Figure 2). At Yorkton, both Oreana and Claymore had significantly more leaf disease than the other varieties.

Table 8. The effect of variety and fungicide application on leaf disease at individual sites. F-test results are considered significant at P<0.05.

	Indian Head	Melfort	Outlook	Prince Albert	Scott	Swift Current	Yorkton
Fixed effects	---------- *Pr(>F)* ----------						
Variety (V)	**<0.001**	**<0.001**	0.350	**<0.001**	**0.021**	0.784	**<0.001**
Fungicide (F)	**<0.001**	**<0.001**	**<0.001**	**0.016**	**<0.001**	0.173	**<0.001**
V x F	**0.032**	0.281	0.631	0.471	0.178	0.442	0.881

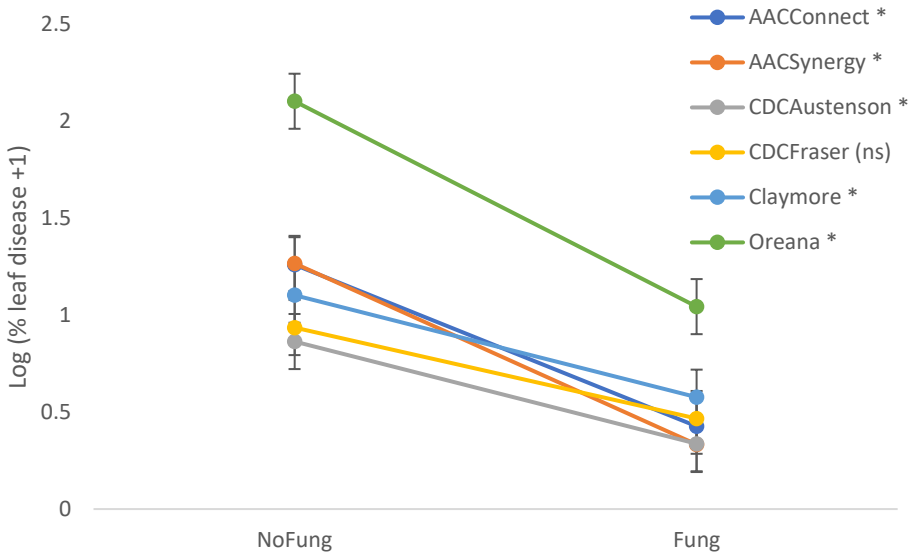

Figure 1. The interactive effect of variety and fungicide application on leaf disease at Indian Head. An asterisk shown beside the variety name indicates that the leaf disease was significantly different with and without fungicide application. NS indicates that leaf disease did not differ with fungicide application. Error bars indicate the standard error.

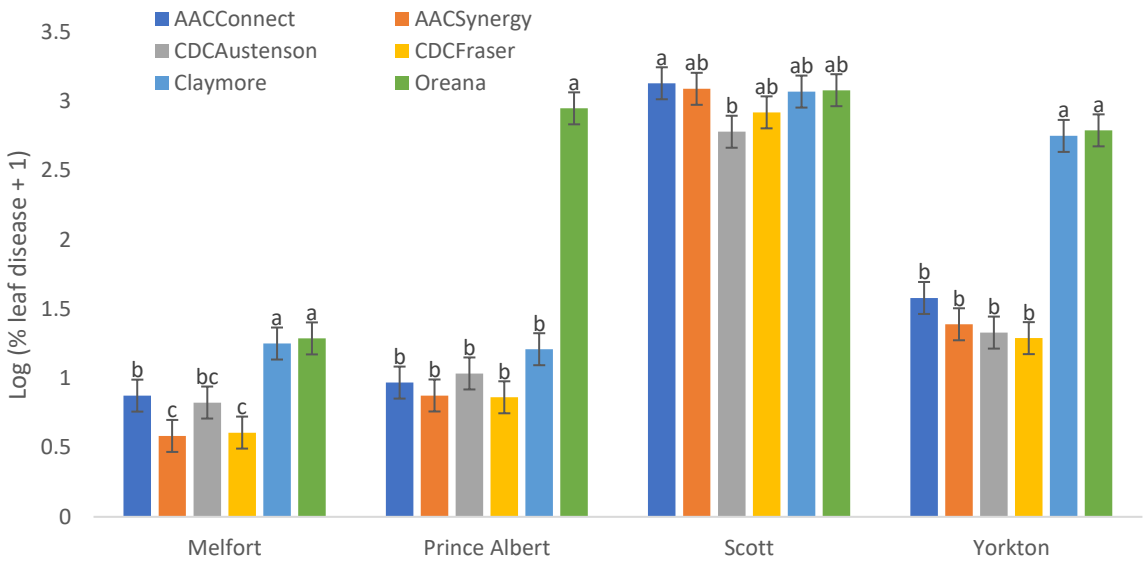

Figure 2. The effect of variety on leaf disease at Melfort, Prince Albert, Scott, and Yorkton. Letters indicate the separation of means within individual sites. Error bars indicate the average standard error for all sites.

Lodging

There was a significant variety by site interaction (Table 6), so sites were analyzed individually (Table 9). Lodging was absent or did not differ between treatments at Melfort, Scott, Prince Albert and Swift Current. Tabulated estimated marginal means for all fixed effects at all sites (with observed lodging) and means separation are provided in the appendix (Table A-2). Lodging was log-transformed prior to analysis and transformed values are shown in the figures.

At Yorkton, lodging for CDC Austenson was significantly more than AAC Connect or AAC Synergy (Figure 3). Based on regional information, AAC Synergy with a rating of "Fair" resistance to lodging would not have been expected to perform so well. However, the levels of lodging for all varieties are extremely low. At Indian Head there was an interaction between variety and fungicide. The level of lodging was numerically reduced by the application of fungicide for Claymore and Oreana compared to the other varieties (Figure 4). While Claymore and Oreana are rated as having very good resistance to lodging they also have poor resistance to leaf disease. However, levels of lodging were minor for all treatments at Indian Head.

Table 9. The effect of variety and fungicide application on lodging at individual sites. F-test results are considered significant at P<0.05.

	Indian Head	Outlook	Prince Albert	Yorkton
Fixed effects	---------- *Pr(>F)* ----------			
Variety (V)	**<0.001**	0.637	Na	**0.027**
Fungicide (F)	0.066	0.277	Na	0.182
V x F	**0.008**	0.164	Na	0.728

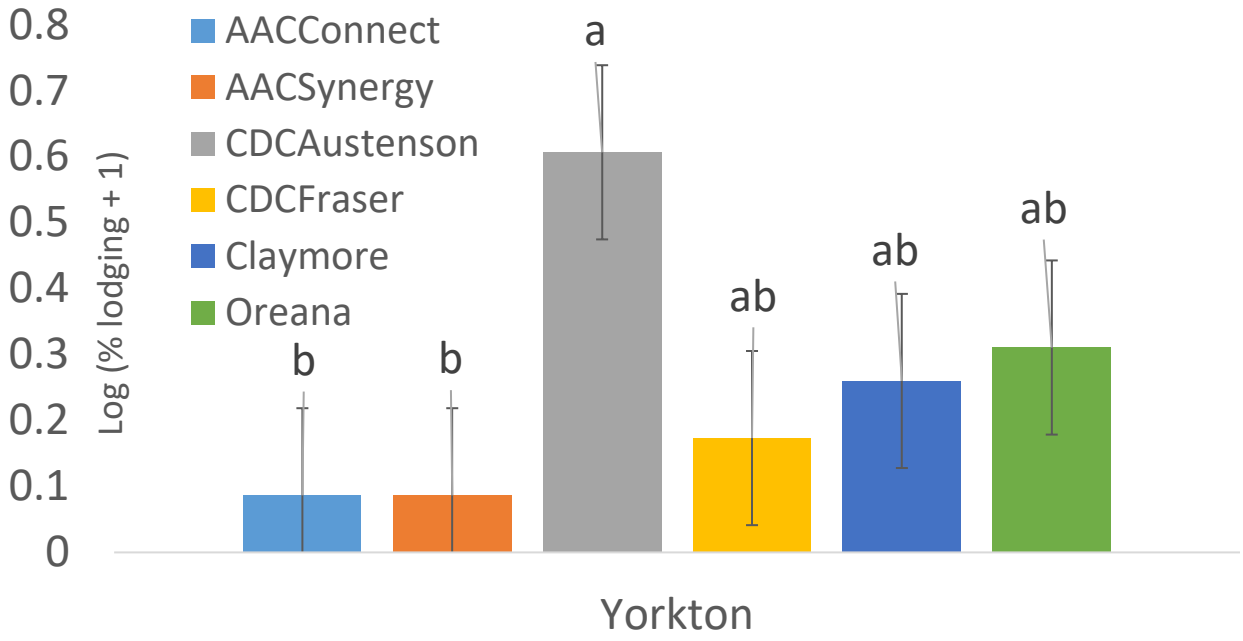

Figure 3. Varietal differences in lodging at Yorkton. Letters indicate the separation of means within individual sites. Error bars indicate the average standard error for all sites.

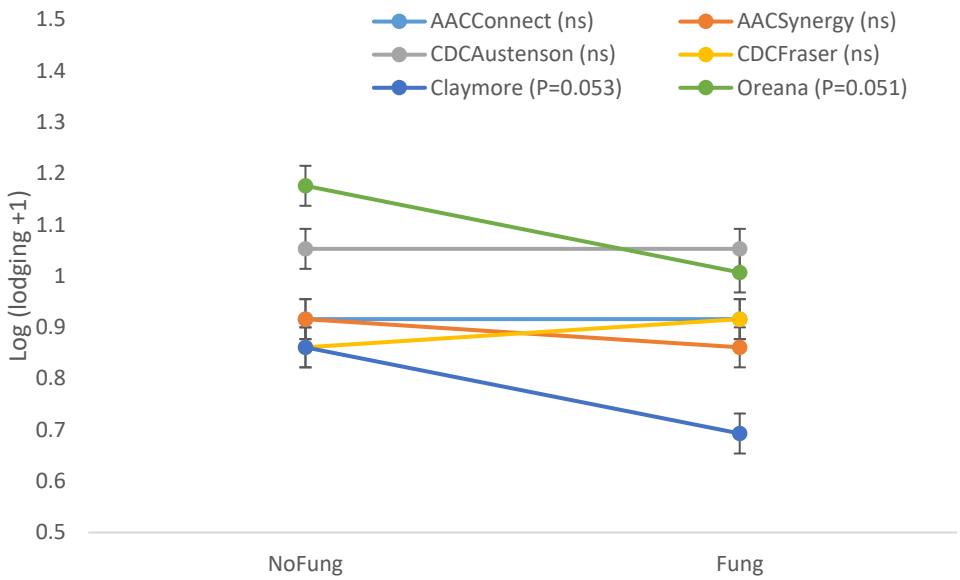

Figure 4. The interactive effect of variety and fungicide application on lodging at Indian Head. P-values are shown for varieties with marginally significant effect of fungicide application. 'NS' indicates that lodging did not differ with fungicide application. Error bars indicate the standard error.

Yield

The three-way interaction of variety and fungicide with sites was significant for yield (Table 6), so the sites were analyzed separately (Table 10). Tabulated estimated marginal means for all fixed effects at all sites and means separation are provided in the appendix (Table A-3).

The main effect of fungicide did not significantly affect barley yield at any location other than Swift Current, where yield was significantly decreased with fungicide. The reason for the yield reduction is not clear but may be related to hot dry conditions (Tables 10, A-3). A lack of yield response, despite reductions in leaf disease, is likely related to low levels of disease. Variety by fungicide interactions were detected at Indian Head and Outlook, suggesting fungicide may have increased the yield of some varieties. While not statistically significant, the yield for Oreana, CDC Fraser, and Claymore numerically increased in response to fungicide at Indian Head (Figure 5). At Outlook, the yield of Oreana significantly increased in response to fungicide, whereas increases for the other varieties were not as great or significant. Greater yield responses for Claymore and Oreana to fungicide may be attributed to their greater susceptibility to leaf disease. For the remaining sites, differences in disease development may have had an influence on varietal rankings by yield. Under dry conditions at Scott and Swift Current, Oreana yielded relatively well compared to the other varieties (Figure 6). Under moister conditions at Prince Albert and Yorkton, Oreana had the highest level of leaf disease and the lowest yield potential (Figures 2 and 6). Claymore also had a high level of leaf disease and low yield at the Yorkton site.

Table 10. The effect of variety and fungicide application on yield at each site individually. F-test results are considered significant at P<0.05.

	Indian Head	Melfort	Outlook	Prince Albert	Scott	Swift Current	Yorkton
Fixed effects	---------- *Pr(>F)* ----------						
Variety (V)	**<0.001**	0.191	0.268	**0.009**	**0.002**	**0.002**	**0.001**
Fungicide (F)	0.075	0.522	0.134	0.740	0.128	**0.034**	0.766
V x F	**0.043**	0.877	**0.002**	0.103	0.450	0.973	0.401

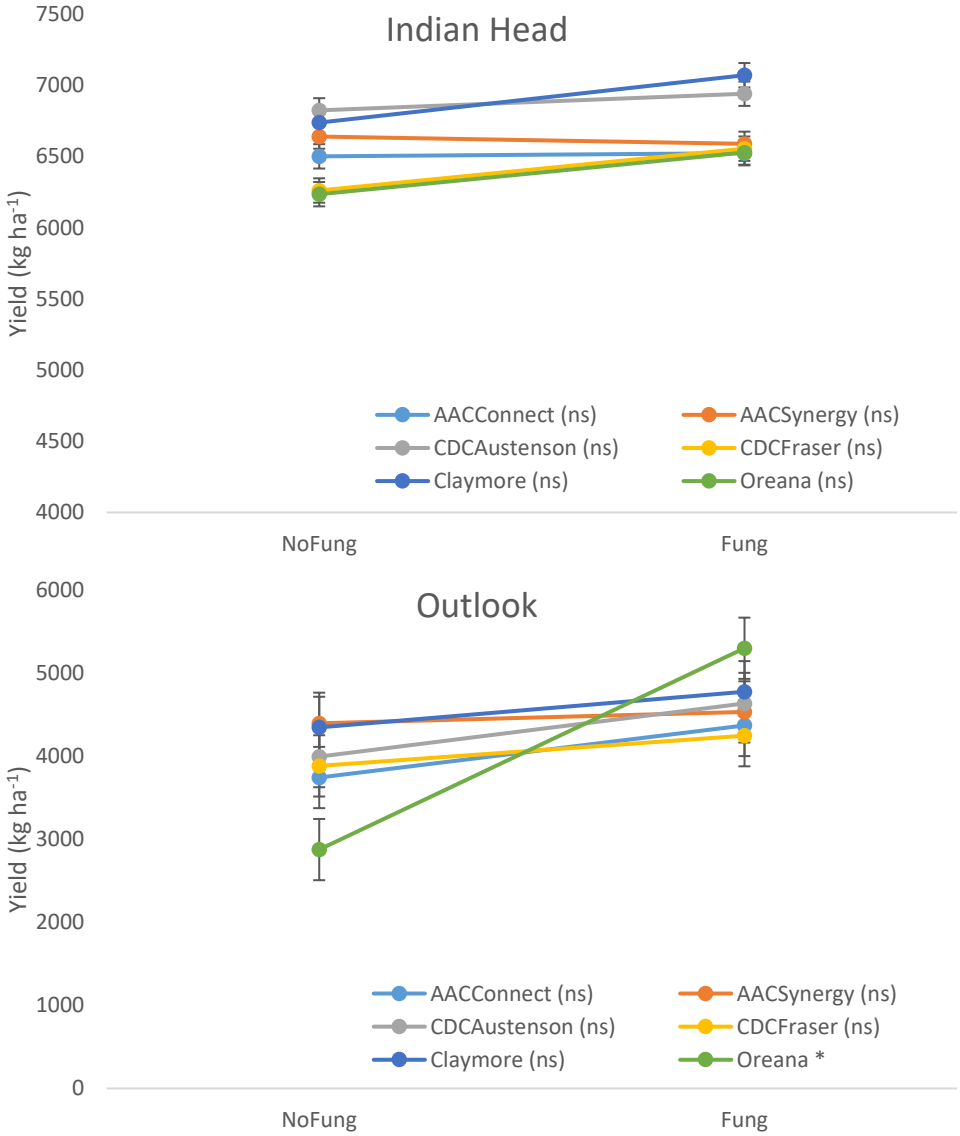

Figure 3. The interactive effect of variety and fungicide application on yield at Indian Head and Outlook. An asterisk shown beside the variety name indicates that yield was significantly different with and without fungicide application. 'NS' indicates that lodging did not differ with fungicide application for that variety. Error bars indicate the standard error within each site.

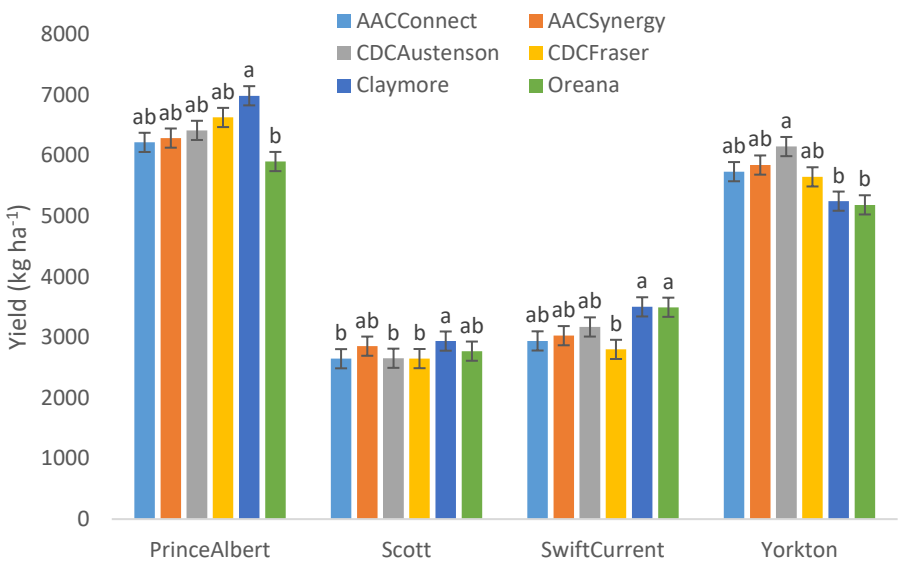

Figure 4. Varietal differences in yield at Prince Albert, Scott, Swift Current, and Yorkton. Letters indicate the separation of means within individual sites. Error bars indicate the average standard error for all sites.

Protein

Protein level was only assessed on the malt varieties. The protein level varied with variety and with site, but there were no site interactions (Table 6), indicating that the varietal difference in protein level was similar across sites. Results of individual site analyses and tabulated estimated marginal means for all fixed effects at all sites and means separation are provided in the appendix (Table A-4). AAC Synergy had significantly lower protein than AAC Connect or CDC Fraser, regardless of environment or fungicide application (Figure 7).

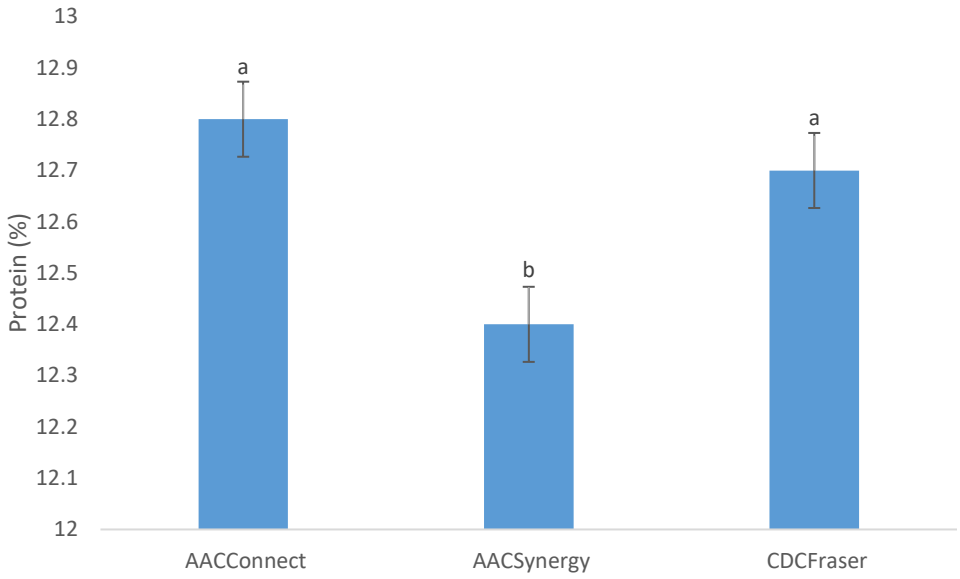

Figure 5. Varietal differences in protein level, across sites and fungicide treatments. Letters indicate the separation of means. Error bars indicate the standard error.

DON

Bulked samples of treated and untreated barley were tested for DON to select sites for further testing. Barley grain DON levels nearing 1 ppm are typically unacceptable for malt. Overall, DON levels for the untreated checks were very low across sites. However, the untreated controls at Indian Head and Prince Alberta contained 0.8 ppm and 0.49 ppm, respectively. As these levels were considered relatively high, a complete analysis was done for each treatment at these locations based on composite samples from reps 1&3 and reps 2&4 (Table A-5). The discussion for Prince Albert will focus on the 2nd testing run where more statistically significant differences were detected. Overall, the application of fungicide significantly reduced DON levels from 0.36 ppm down to 0.26 ppm. However, the reduction in DON varied between varieties as there was a significant Variety by Fungicide interaction. Fungicide significantly reduced DON levels for AAC Synergy and CDC Fraser as these varieties had higher levels of DON when untreated. Oreana also had a high level of DON when untreated, but the application of fungicide did not reduce DON enough to be statistically significant. However, higher levels of DON for AAC Synergy, CDC Fraser and Oreana would not be unexpected based on their respective FHB resistance ratings of Intermediate, Intermediate and Susceptible. Claymore and AAC Connect are rated as Moderately Resistant and these varieties had relatively low levels of DON when untreated. CDC Austenson also had a low level of DON despite only having an Intermediate rating.

Levels of DON were higher at Indian Head and treatment separations were very similar between the runs. However, the discussion will focus on the 2nd run where DON levels were a little higher. Untreated Claymore and AAC Connect had the lowest level of DON which relates well to these varieties having the highest resistance rating to FHB amongst the varieties in this study. Since the levels of DON for these varieties was low when untreated, the application of fungicide did not significantly reduce DON. Fungicide did significantly reduce DON for CDC Fraser, CDC Austenson and Oreana which had relatively high levels of DON when untreated. The highest level of DON at 1.05 ppm was detected for untreated CDC Fraser and CDC Austenson. This is above levels acceptable for malt. However, the application of Fungicide brought DON levels down below 0.3 which would be acceptable for malt.

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10. Conclusions and Recommendations

While levels of leaf disease were relatively low, application of fungicide tended to reduce the incidence of leaf disease at all locations. Leaf disease was reduced the most by fungicide for Oreana at Indian Head. Despite reducing leaf disease, the application of fungicide rarely increased yield. However, fungicide did numerically increase yield for Claymore, Oreana and CDC Fraser at Indian Head and yield of Oreana was significantly increased at Outlook. Grain protein was not affected by fungicide since yield was rarely affected. If yield is not increased, then an effect on protein would not be anticipated. Overall, fungicide did not affect lodging in this study, but lodging levels were low. However, fungicide reduced lodging for Oreana and Claymore at Indian Head. Claymore and particularly Oreana were frequently associated with higher levels of leaf disease. This would be anticipated as these varieties have a poor leaf disease package compared to the other varieties. The use of fungicide was more often beneficial for Claymore and Oreana in terms of leaf disease control, yield and lodging. This may be related to their greater susceptibility to leaf disease. However, if FHB was present, fungicide reduced DON for varieties with an Intermediate or lower level of resistance to FHB. At Indian Head, the application of fungicide was able to bring the DON levels for CDC Fraser and CDC Austenson, with Intermediate resistance to FHB, down from 1.05 ppm to less than 0.3 ppm making them acceptable for malt. The poorer the leaf disease package and level of resistance to FHB, the more likely the variety would benefit from fungicide. Oreana was a variety that frequently benefited from the use of fungicide, whereas AAC Connect was not.

Supporting Information

11. Acknowledgements:

This project was funded through the Agricultural Demonstration of Practices and Technologies (ADOPT)

12. Appendices

Table A-1. Estimated marginal means of percent leaf disease (log transformed values) for all fixed effects at all sites. Means separation is indicated by letters where effects were significant at P<0.05.

	Indian Head	Melfort	Outlook	Prince Albert	Scott	Swift Current	Yorkton
Variety	---------- *log (% leaf disease +1)* ----------						
AAC Synergy	0.800 b	0.584 c	0.629	0.876 b	3.09 a	1.74	1.39 b
AAC Connect	0.843 b	0.875 b	0.567	0.969 b	3.13 a	2.03	1.58 b
CDC Fraser	0.702 b	0.608 c	0.655	0.863 b	2.92 ab	1.94	1.29 b
CDC Austenson	0.600 b	0.825 bc	0.837	1.035 b	2.78 b	1.79	1.33 b
Claymore	0.840 b	1.251 a	1.155	1.210 b	3.07 ab	1.77	2.75 a
Oreana	1.573 a	1.288 a	0.823	2.949 a	3.08 ab	1.95	2.79 a
S.E.	*0.121*	*0.097*	*0.199*	*0.096*	*0.11*	*0.29*	*0.12*
Fungicide							
None	1.255 a	1.003 a	1.133 a	1.420 a	3.41 a	2.18	2.05 a
Yes	0.531 b	0.807 b	0.423 b	1.220 b	2.61 b	1.56	1.66 b
S.E.	*0.104*	*0.085*	*0.115*	*0.055*	*0.12*	*0.30*	*0.07*
V x F							
AAC Synergy – None	1.267 b	0.662	0.794	0.922	3.66	2.15	1.64
AAC Connect – None	1.260 b	0.968	0.918	1.147	3.49	2.50	1.68
CDC Fraser – None	0.936 bcd	0.692	0.925	0.922	3.30	2.06	1.44
CDC Austenson – None	0.864 bcd	0.862	1.073	1.189	3.19	2.26	1.50
Claymore – None	1.103 b	1.322	1.727	1.168	3.35	1.89	3.04
Oreana – None	2.103 a	1.514	1.361	3.144	3.45	2.24	2.98
AAC Synergy – Fung	0.333 e	0.506	0.463	0.830	2.51	1.32	1.14
AAC Connect – Fung	0.427 de	0.782	0.217	0.792	2.78	1.55	1.48
CDC Fraser – Fung	0.467 de	0.523	0.386	0.803	2.53	1.83	1.15
CDC Austenson – Fung	0.337 e	0.788	0.601	0.881	2.36	1.32	1.17
Claymore – Fung	0.577 cde	1.179	0.583	1.251	2.79	1.66	2.46
Oreana – Fung	1.044 bc	1.062	0.286	2.754	2.70	1.66	2.60
S.E.	*0.142*	*0.113*	*0.282*	*0.135*	*0.16*	*0.37*	*0.17*

Table A-2. Estimated marginal means of lodging (log transformed values) for all fixed effects at sites with lodging effects. Means separation is indicated by letters where effects were significant at P<0.05.

	Indian Head	Outlook	Yorkton
Variety	---------- *log (lodging +1)* ----------		
AAC Synergy	0.89 b	1.47	0.087 b
AAC Connect	0.92 b	1.26	0.087 b
CDC Fraser	0.89 b	1.48	0.173 ab
CDC Austenson	1.05 a	1.25	0.607 a
Claymore	0.78 c	1.27	0.260 ab
Oreana	1.09 a	1.26	0.311 ab
S.E.	*0.03*	*0.14*	*0.115*
Fungicide			
None	0.96	1.41	0.318
Yes	0.91	1.25	0.190
S.E.	*0.02*	*0.08*	*0.066*
V x F			
AAC Synergy – None	0.92 bc	1.43	0.173
AAC Connect – None	0.92 bc	1.40	0.173
CDC Fraser – None	0.86 cd	1.51	0.347
CDC Austenson – None	1.05 ab	1.35	0.693
Claymore – None	0.86 cd	1.13	0.173
Oreana – None	1.18 a	1.62	0.347
AAC Synergy – Fung	0.86 cd	1.51	0.000
AAC Connect – Fung	0.92 bc	1.13	0.000
CDC Fraser – Fung	0.92 bc	1.44	0.000
CDC Austenson – Fung	1.05 ab	1.14	0.520
Claymore – Fung	0.69 d	1.42	0.347
Oreana – Fung	1.01 abc	0.90	0.275
S.E.	*0.04*	*0.19*	*0.162*

Table A-3. Estimated marginal means of yield for all fixed effects at all sites. Means separation is indicated by letters where effects were significant at P<0.05.

	Indian Head	Melfort	Outlook	Prince Albert	Scott	Swift Current	Yorkton
Variety	---------- *Yield (kg ha^{-1})* ----------						
AAC Synergy	6615 b	5194	4467	6288 ab	2854 ab	3027 ab	5843 ab
AAC Connect	6513 bc	4868	4563	6217 ab	2647 b	2941 ab	5734 ab
CDC Fraser	6409 bc	4920	4090	6628 ab	2649 b	2801 b	5648 ab
CDC Austenson	6884 a	5315	4317	6415 ab	2655 b	3171 ab	6148 a
Claymore	6906 a	4852	4067	6986 a	2938 a	3503 a	5247 b
Oreana	6383 c	5033	4059	5901 b	2772 ab	3496 a	5186 b
S.E.	*65.4*	*206*	*266*	*196*	*98.7*	*182*	*159*
Fungicide							
None	6534	5135	3875	6379	2609	3277 a	5615
Yes	6702	4925	4646	6432	2896	3037 b	5654
S.E.	*56.6*	*219*	*276*	*116*	*109*	*146*	*91.9*
V x F							
AAC Synergy – None	6641 bc	5404	4398 a	6469	2636	3191	5772
AAC Connect – None	6502 cd	4962	3745 ab	6385	2492	3031	5733
CDC Fraser – None	6262 d	4904	3885 ab	6569	2454	2841	5910
CDC Austenson – None	6825 abc	5511	3997 ab	6177	2543	3304	6161
Claymore – None	6739 abc	4883	4349 a	7225	2846	3604	5014
Oreana – None	6236 d	5148	2877 b	5451	2685	3687	5099
AAC Synergy – Fung	6590 cd	4984	4635 ab	6107	3071	2863	5914
AAC Connect – Fung	6524 cd	4774	4372 ab	6049	2802	2851	5736
CDC Fraser – Fung	6556 cd	4935	4249 ab	6688	2845	2761	5386
CDC Austenson – Fung	6942 ab	5119	4637 ab	6652	2767	3038	6135
Claymore – Fung	7072 a	4820	4778 ab	6747	3031	3402	5480
Oreana – Fung	6529 cd	4914	5302 a	6351	2858	3305	5272
S.E.	*85.6*	*292*	*369*	*275*	*131*	*226*	*225*

Table A-4. Estimated marginal means of protein for all fixed effects at all sites. Means separation is indicated by letters where effects were significant at P<0.05.

	Indian Head	Melfort	Outlook	Prince Albert	Scott	Swift Current	Yorkton
Variety	----------	----------	*Protein (%)*	----------	----------	----------	
AAC Synergy	10.7 b	10.3 b	13.3	10.9	15.8 b	14.2	11.2 b
AAC Connect	11.1 a	10.8 a	13.6	11.6	16.4 a	14.3	11.6 ab
CDC Fraser	10.7 b	10.3 b	13.8	11.2	16.4 a	14.6	11.9 a
Pr(>F)	**0.006**	**0.021**	0.081	0.185	**0.014**	0.060	**0.048**
S.E.	*0.12*	*0.19*	*0.15*	*0.23*	*0.29*	*0.21*	*0.19*
Fungicide							
None	10.8	10.5	13.7	11.2	16.4	14.4	11.7
Yes	10.8	10.4	13.4	11.2	16.0	14.7	11.4
Pr(>F)	0.518	0.812	0.262	0.952	0.308	0.110	0.391
S.E.	*0.11*	*0.18*	*0.17*	*0.19*	*0.31*	*0.23*	*0.20*
V x F							
AAC Synergy – None	10.6	10.3	13.4	10.7	16.1	13.8	11.3
AAC Connect – None	11.0	10.8	13.8	11.9	16.6	14.1	11.6
CDC Fraser – None	10.7	10.4	13.9	11.1	16.5	14.4	12.1
AAC Synergy – Fung	10.8	10.3	13.2	11.2	15.4	14.6	11.1
AAC Connect – Fung	11.1	10.8	13.4	11.2	16.2	14.6	11.6
CDC Fraser – Fung	10.6	10.2	13.6	11.3	16.4	14.8	11.6
Pr(>F)	0.526	0.828	0.833	0.236	0.397	0.360	0.585
S.E.	*0.14*	*0.22*	*0.22*	*0.33*	*0.35*	*0.27*	*0.27*

Table A-5. Estimated marginal means of DON ppm for all fixed effects at Indian Head and Prince Albert for 2 runs of testing. Means separation is indicated by letters where effects were significant at P<0.05.

	Indian Head Run 1	Indian Head Run 2	Prince Albert Run 1	Prince Albert Run 2
Variety				
AAC Synergy	0.40 bcd	0.40 bc	0.23 c	0.30 bc
AAC Connect	0.25 d	0.30 c	0.33 abc	0.25 cd
CDC Fraser	0.55 ab	0.63 ab	0.40 ab	0.35 b
CDC Austenson	0.60 a	0.65 a	0.28 bc	0.33 b
Claymore	0.33 cd	0.38 c	0.20 c	0.20 d
Oreana	0.45 abc	0.48 abc	0.43 a	0.43 a
S.E.				
Fungicide				
None	0.62 a	0.70 a	0.34	0.36 a
Yes	0.24 b	0.24 b	0.28	0.26 b
S.E.				
V x F				
AAC Synergy – None	0.50 cd	0.55 bc	0.25	0.40 ab
AAC Connect – None	0.30 de	0.40 cd	0.35	0.30 bc
CDC Fraser – None	0.85 ab	1.05 a	0.50	0.50 a
CDC Austenson – None	0.95 a	1.05 a	0.20	0.25 bc
Claymore – None	0.40 de	0.40 cd	0.20	0.20 c
Oreana – None	0.70 bc	0.75 ab	0.55	0.50 a
AAC Synergy – Fung	0.30 de	0.25 cd	0.20	0.20 c
AAC Connect – Fung	0.20 e	0.20 d	0.30	0.20 c
CDC Fraser – Fung	0.25 e	0.20 d	0.30	0.20 c
CDC Austenson – Fung	0.25 e	0.25 cd	0.35	0.40 ab
Claymore – Fung	0.25 e	0.35 cd	0.20	0.20 c
Oreana – Fung	0.20 e	0.20 d	0.30	0.35 abc

Abstract

13. Abstract/Summary:

In 2022, a study was conducted at seven AgriARM locations across Saskatchewan with the objective of comparing the responsiveness 3 malt and 3 feed barley varieties to fungicide applied at heading (FHB timing). The malt varieties to be screened include AAC Synergy, AAC Connect, CDC Fraser, and the feed varieties included CDC Austenson, Claymore, and Oreana. Despite low levels of leaf disease, the application of fungicide reduced leaf disease in most cases but did not increase yield or affect grain protein. Levels of lodging were quite low in this study and the application of fungicide did not usually affect lodging. However, Oreana and to a lesser extent Claymore would benefit from the application of fungicide in terms of greater disease control, yield and lodging. These greater benefits are likely related to the poor leaf disease resistance package that these varieties have relative to the other varieties in this study. Varieties with lower levels of resistance to FHB were more likely to have levels of DON reduced by fungicide application. At Indian Head, the application of fungicide was able to bring the DON levels for CDC Fraser and CDC Austenson, with Intermediate resistance to FHB, down from 1.05 ppm to less than 0.3 ppm making them acceptable for malt. The poorer the leaf disease package and level of resistance to FHB, the more likely the variety would benefit from fungicide. Oreana was a variety that frequently benefited from the use of fungicide whereas, CDC Connect was not.