Agriculture Demonstration of Practices and Technologies (ADOPT)

Project Final Report

The final project report should be made available electronically (MS Word). Additional data tables and or graphs may be submitted in spreadsheet format. Due to formatting, printing and distribution requirements, final reports will not be accepted as PDF documents. Completed reports must be returned by email to Evaluation.Coordinator@gov.sk.ca.

Project Title:	Do Barley Varieties Differ in Response to N Fertility, PGR, and Fungicide?
Project Number:	20220522
Producer Group Sponsoring the Project:	Saskatchewan Barley Development Commission
Project Location(s): *Provide the name or number of the rural municipality, nearest town or legal land location if possible. Provide the name of any cooperating landowner(s).*	Indian Head, R.M. #156 (Indian Head Agricultural Research Foundation); Melfort, R.M. #428 (Northeast Agriculture Research Foundation); Outlook, R.M. #284 (Irrigation Crop Diversification Corporation); Prince Albert, R.M. #481 (Conservation Learning Centre); Scott, R.M. #380 (Western Applied Research Corporation); Swift Current, R.M. #137 (Wheatland Conservation Area Inc.); Yorkton, R.M. #244 (East Central Research Foundation)
Project start date *(month & year):*	4/1/2023
Project end date *(month & year):*	2/1/2024

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Abstract *(maximum 200 words)*

Detail key elements from the project objectives, methodology, results and conclusions to provide a short concise summary of the project. List extension activities such as field days or workshops and include the number of people who visited the project.

Project Objectives

Provide a short statement outlining the project objectives. Identify the key concept this project was designed to demonstrate. For example, you might use a statement such as *"This project was intended to demonstrate and compare the benefits of……" or "The objective of this project was to demonstrate the impact of…."*

The broad objective is to determine if 3 malt and 3 feed barley varieties differ in response to N fertility, PGR, and fungicide. The malt varieties to be screened include AAC Synergy, AAC Connect, CDC Fraser, and the feed varieties include CDC Austenson, Claymore, and Oreana.

Project Rationale

Briefly describe why this project is of interest to local producers. Why is it important to have this project? What are the potential beneficial outcomes? What is the perceived need?

This project is a resubmission of the enhanced barley trials which were supported by ADOPT and SaskBarley last year, with modifications to reduce costs and increase efficiency. This proposal combines the N fertility, PGR, and Fungicide proposals from last year into one study. Efficiencies are gained by not having to replicate the no fungicide no PGR checks for 3 separate trials. This trial design also allows for a comparison between the additive effects of PGR and Fungicide that was not possible with last year's study. SaskBarley believes it is important to have more than one year of study on this topic to provide producers with better information that covers a range of environmental conditions.

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

There is also evidence that the optimum management of barley with N fertility, and applications of PGRs or fungicide can vary between barley varieties.

The most economic rate of applied N differed between malt varieties in the Barley MAX study, which was jointly funded through the Ministry's Strategic Field Program and SaskBarley. In 2020, the most economic rate of soil + Fertilizer N, when averaged over 4 locations, was 40 lb N/ac higher for AAC Synergy compared to AC Metcalfe. AAC Synergy was higher yielding, more responsive to increasing N and had lower grain protein for a given rate of N compared to AC Metcalfe. This means N rates could be pushed higher with AAC Synergy before the maximum allowable grain protein level of 12.5% was exceeded.

A similar study supported by the Ministry and SaskBarley found the most economic rate of N for feed did not exceed that for malt barley. This contrasts with conventional wisdom. While the feed variety CDC Austenson was higher yielding and more responsive to added N compared to the malt variety AC Metcalfe, it did not require more N to maximize returns once the price premium received for malt was considered. When the comparison was with the higher yielding malt variety AAC Synergy, CDC Austenson required relatively less N to maximize economic returns compared to the malt variety. Producers also need to be aware that the most economic rate of N for malt relative to feed is increasing as the yield gap narrows. However, the greater consequences of applying too much N to malt compared to feed barley also needs to be considered when choosing rates of N, due to the risk of failing to meet malt specifications for grain protein.

Researchers have also found the efficacy of PGRs can differ between barley varieties. For example, lodging in CDC Copeland could not be consistently managed with PGRs[3]. This study proposes to use trinexapac-ethyl which was found to be more effective than either chlormequat chloride or ethephon (Ethrel), with the largest number of height reductions and scale of reductions. In addition, Chlormequat has not been well received by end users[2] and recent

research shows the product to be inconsistent at preventing lodging in barley[3].

Barley yield response to applied fungicide is also known to differ between varieties. 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[4]. 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 [5].

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.

This project is relevant because producers may benefit from adjusting their management based on variety selection, which is being driven by a rare period of transition to new malt varieties, as well as the introduction of some new feed varieties. The need to manage old and new varieties differently has been somewhat determined. However, as older varieties such as AC Metcalfe and CDC Copeland are becoming less popular, this study will focus on varieties whose popularity is continuing to increase. Thus, producers will have management information which is relevant to barley varieties in use for years to come. 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] https://keepitclean.ca/product-advisory#cereals

[3] B.D. Tidemann, J.T. O'Donovan, M. Izydorczyk, T.K. Turkington, L. Oatway, B. Beres, R. Mohr,W.E. May, K.N. Harker, E.N. Johnson, and H. de Gooijer. 2020. Effects of plant growth regulator applications on malting barley in western Canada. Canadian Journal of Plant Science. 100: 653-665.

[4] 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

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

Methodology

Fully describe how the project was set up and run. You should provide enough information so that any reader can understand what you did, and where and when you did it. From that they can determine if your report has any relevance to their own operation. For example, your description should include all relevant items such as 1) the number and size of any field plots, 2) what was seeded, 3) what treatments were applied to the plots, 4) the schedule or timing of any relevant activities such as seeding, treatment application or harvest, and 5) what was measured to evaluate the success of any treatment. If your project dealt with animals, you should be sure to include 1) the number of animals in each trial group, 2) the treatment or procedure applied to each group, and 3) what was measured to evaluate the success of each treatment.

Table 1 lists the treatments established at each location in a split-plot design with 4 replications. The main-plot factor is "Barley Management" and the sub-plot factor is "Barley Variety". Management A acts as a check for managements B, C and D which helped to keep the trial size to a manageable level. Management A has been compared to management B to determine the varietal response to standard vs enhanced N fertility when all varieties have received fungicide at flag but no PGR. Standard and Enhanced rates of N varied by location group based on historic yield potential (SCIC data). The groupings were as follows:

-Group 1 = low yield potential: Swift Current: 100 vs 125 lb N/ac of soil + added N

- Group 2 = mid range yield potential: Prince Albert, Indian Head, Scott: 120 vs 150 lb N/ac of soil + added N

- Group 3 = high yield potential: Yorkton, Melfort, Outlook: 130 vs 162 lb N/ac of soil + added N

When soil sampling to 24 inches was not possible, N available in a 12 inch depth was multiplied by 1.5 for an approximation of N present in a 24 inch depth. Phosphorous and potassium were applied evenly to all treatments in each trial to be non-limiting to yield even at the highest rate of N.

Management A was compared to management C to determine the varietal response to PGR, at a standard rate of N and with fungicide at flag leaf timing. The PGR applied was Moddus (trinexapac-ethyl) at GS30-32 (stem elongation). Management A was compared to management D to determine the varietal response to fungicide applied at flag leaf. For this comparison, all varieties were compared at the standard rate of N and with no PGR. The fungicide Trivapro© was applied at flag leaf timing. A 4th comparison was also made between Management C and D to determine the varietal response to a combination of PGR and fungicide for varieties fertilized at a standard rate of N.

Herbicide and insecticide selection were at the discretion of the site manager to ensure pests were non-limiting to yield. All trials were "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 operations and measurement taken at each site are listed in Table 2.

Table 1. Treatment list for project (Barley Management by Barley Variety)

#	Barley Management (A-D)	Barley Variety
1	A. Standard[1] N Fertility – No PGR – Fungicide[3]	AAC Synergy
2	A. Standard[1] N Fertility – No PGR – Fungicide[3]	AAC Connect
3	A. Standard[1] N Fertility – No PGR – Fungicide[3]	CDC Fraser
4	A. Standard[1] N Fertility – No PGR – Fungicide[3]	CDC Austenson
5	A. Standard[1] N Fertility – No PGR – Fungicide[3]	Claymore
6	A. Standard[1] N Fertility – No PGR – Fungicide[3]	Oreana
7	B. Enhanced[1] N Fertility – No PGR – Fungicide[3]	AAC Synergy
8	B. Enhanced[1] N Fertility – No PGR – Fungicide[3]	AAC Connect
9	B. Enhanced[1] N Fertility – No PGR – Fungicide[3]	CDC Fraser
10	B. Enhanced[1] N Fertility – No PGR – Fungicide[3]	CDC Austenson
11	B. Enhanced[1] N Fertility – No PGR – Fungicide[3]	Claymore
12	B. Enhanced[1] N Fertility – No PGR – Fungicide[3]	Oreana
13	C. Standard[1] N Fertility – PGR[2] - Fungicide	AAC Synergy
14	C. Standard[1] N Fertility – PGR[2] - Fungicide	AAC Connect
15	C. Standard[1] N Fertility – PGR[2] - Fungicide	CDC Fraser
16	C. Standard[1] N Fertility – PGR[2] - Fungicide	CDC Austenson
17	C. Standard[1] N Fertility – PGR[2] - Fungicide	Claymore
18	C. Standard[1] N Fertility – PGR[2] - Fungicide	Oreana
19	D. Standard[1] N Fertility – No PGR – No Fungicide	AAC Synergy
20	D. Standard[1] N Fertility – No PGR – No Fungicide	AAC Connect
21	D. Standard[1] N Fertility – No PGR – No Fungicide	CDC Fraser
22	D. Standard[1] N Fertility – No PGR – No Fungicide	CDC Austenson
23	D. Standard[1] N Fertility – No PGR – No Fungicide	Claymore
24	D. Standard[1] N Fertility – No PGR – No Fungicide	Oreana

[1]All sites were fertilized at P and K levels to be not limiting, even for the high N rate based on soil test recommendations.

[2]PGR applied will be Moddus (trinexapac-ethyl) at GS30-32 (stem elongation).

[3]Fungicide applied will either be Trivapro or Nexicor applied at flag leaf.

Dates of operations are listed in Table 2.

Table 2. Dates of operations for locations in 2023

Operation in 2023	Yorkton	Swift Current	Melfort	Outlook	Indian Head	Prince Albert	Scott
Seed	May 16	May 18	May 16	May 10	May 9	June 5	May 15
Pre-seed herbicide (if needed)	None	RT540 – May 1	Startup - May 16	None	Weathermax – May 11	Prepass – May 26	Glyphosate + Aim – May 14
Emergence counts	May 30 & 31	May 30	June 1	May 31	May 29	June 23	June 14
In-crop Herbicide	Prestige XL - June 5 Axial - June 6	Liquid Achieve + Buctril M + Carrier – June 8	Prestige XL - June 7 Axial - June 20	Buctril M +Tralkoxydim – June 5	Axial + Prestige – June 7	None due to low weed pressure.	Axial + Infinity – June 2 Buctril M – June 13
In-crop Insecticide	None	None	Decis - June 23 for grasshoppers	None	Coragen Max -June 22 for grasshoppers	None	Decis - July 7 for grasshoppers
Apply Moddus (trinexpac-ethyl) at GS30-32 (stem elongation)	June 14	June 16	June 13	June 7	June 12	June 28	June 16
Trivapro applied at flag leaf	June 27	June 20	June 29	June 20	June 24	July 7	June 29
Height (cm)	July 24	August 2	July 31	July 27	July 26	Was missed	August 3
Lodging (0-9)	August 15	August 2	August 21	July 27	August 4	September 8	August 16
Percent leaf disease coverage of penultimate leaf. Rate 10 leaves per plot for treatments 1-6 and 19-24 at least 10 days after fungicide application.	Rep 1 to 3 July 10 Rep 4 July 11	June 30	July 10	July 4	July 10	July 18	July 10
Seed Yield: corrected to 13.5% moisture	August 15	September 25	August 21	August 14	August 15	September 12	August 17

Results *(you must provide the following information)*

Present and discuss any project results, including any data or measurements taken to evaluate the demonstration. Include things that didn't appear to work. These results are just as important to share. List extension activities such as field days or workshops. List the activity, the date it occurred, and the number of people who attended.

Mean monthly temperatures and precipitation for each location are presented along with the long-term (1981-2010) averages in Tables 3 and 4, respectively. All locations were considerably warmer than average, with May and June being particularly hot. All locations but one were much drier than their historical average. Swift Current was the wettest relative to its average annual precipitation. Unfortunately, some of its precipitation came in the form of hail resulting in an estimated yield loss of 50%. Outlook was the driest of the sites with only 95 mm of precipitation (46% of average); however, this location was irrigated. The remaining locations received 49-70% of the long-term average precipitation amounts with Indian Head, Melfort, and Yorkton being the driest in absolute terms and as a percentage of their long-term averages.

Table 3. Mean monthly temperatures amounts along with long-term (1981-2010) normals for the 2023 growing season at 7 sites in Saskatchewan.

Location	Year	May	June	July	August	Avg. / Total
		----------*Mean Temperature (°C)* ----------				
Indian Head	2023	14.0	19.4	16.7	17.7	17.0
	Long-term	***10.8***	***15.8***	***18.2***	***17.4***	***15.6***
Melfort	2023	14.1	19.2	16.9	17.3	16.9
	Long-term	***10.7***	***15.9***	***17.5***	***16.8***	***15.2***
Outlook	2023	15.2	19.5	18.5	18.7	18.0
	Long-term	***11.5***	***16.1***	***18.9***	***18.0***	***16.1***
Prince Albert	2023	14.4	18.8	16.6	17.1	16.7
	Long-term	***10.4***	***15.3***	***18.0***	***16.7***	***15.1***
Scott	2023	14.9	17.2	17.1	17.4	16.7
	Long-term	***10.8***	***14.8***	***17.3***	***16.3***	***14.8***
Swift Current	2023	14.8	17.7	18.4	18.8	17.4
	Long-term	***11.0***	***15.7***	***18.4***	***17.9***	***15.8***
Yorkton	2023	13.8	19.7	16.7	17.8	17.0
	Long-term	***10.4***	***15.5***	***17.9***	***17.1***	***15.2***

Table 4. Precipitation amounts along with long-term (1981-2010) normals for the 2023 growing season at 7 sites in Saskatchewan.

Location	Year	May	June	July	August	Avg. / Total
		---------- *Precipitation (mm)* ----------				
Indian Head	2023	12.9	49.6	15.9	40.8	119
	Long-term	***51.8***	***77.4***	***63.8***	***51.2***	***244***
Melfort	2023	17.9	26.4	16.4	50.0	111
	Long-term	***42.9***	***54.3***	***76.7***	***52.4***	***226***
Outlook	2023	17.2	15.3	15.5	46.6	95
	Long-term	***42.6***	***63.9***	***56.1***	***42.8***	***205***
Prince Albert	2023	22.8	52.8	40.8	51.2	168
	Long-term	***44.7***	***68.6***	***76.6***	***61.6***	***252***
Scott	2023	16.6	81.8	29.7	31.7	159
	Long-term	***38.9***	***69.7***	***69.4***	***48.7***	***227***
Swift Current	2023	41.0	32.9	63.3	42.1	179
	Long-term	***42.1***	**66.1**	**44.0**	**35.4**	***188***
Yorkton	2023	16.8	67.9	18.0	33.3	136
	Long-term	***51.3***	***80.1***	***78.2***	***62.2***	***272***

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 (plant density, disease, height, lodging, yield, and protein) with fixed effects being Site, Variety and Management, all two-way interactions, and the three-way interaction. Random effects were Replicate within Site, and Management within Replicate within Site (Management was blocked in the split-plot design). If a significant three-way interaction was identified, then sites were analyzed separately, with Variety, Management, and the interaction as fixed effects, and Replicate and Management within Replicate (split-plot design) as random effects. Estimated marginal means were determined and if significant treatment effects were identified, 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 $P<0.05$.

Study Results

Table 1. F-test results of mixed-effects model analysis of crop response variables assessing the presence of site interactions with Variety and Management. Effects are considered significant if P<0.05 and significant effects are bolded for emphasis. S.E. is the standard error of the model.

	Plant density	Disease	Height	Lodging	Yield	Protein
Fixed effects			*Pr(>F)*			
Variety (V)	**<0.001**	**<0.001**	**<0.001**	0.771	**<0.001**	**<0.001**
Management (M)	0.399	**0.017**	**<0.001**	0.113	0.312	**<0.001**
Site (S)	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
V x M	0.265	**<0.001**	**<0.001**	0.185	**0.014**	0.195
V x S	**<0.001**	**<0.001**	**<0.001**	0.662	**<0.001**	**<0.001**
M x S	0.743	0.081	0.995	0.111	0.385	0.076
V x M x S	0.140	**<0.001**	0.061	0.116	0.174	0.442
S.E.	*16.6*	*0.71*	*2.24*	*0.83*	*284*	*0.31*

Plant density

There was a significant Variety by Site interaction on plant density, but no difference in plant density between Management treatments (Table 1). Pairwise comparisons were completed to examine the Variety by Site interaction and showed that there was no significant difference in plant density between varieties at all sites except Prince Albert (Table 2). However, plant density varied by less than 10% at Prince Albert and would not be expected to differentially influence crop response between varieties at this site. Individual site analyses for plant density can be found in Table 1a of the Appendix.

Table 2. Estimated marginal means for the effect of variety on plant density at each site. Letters indicate the separation of estimated marginal means within individual sites using multiple pairwise comparisons across all varieties and sites. Letters are not shown for sites with no significant difference between varieties.

	Melfort	Yorkton	Prince Albert	Outlook	Scott	Swift Current	Indian Head
Variety			*plants m^{-2}*				
AAC Synergy	234	303	246 b	270	237	198	270
AAC Connect	224	320	266 a	259	243	193	292
CDC Fraser	238	314	270 a	274	254	202	310
CDC Austenson	225	287	272 a	247	231	193	284
Claymore	230	284	262 ab	260	236	210	306
Oreana	229	307	261 ab	255	254	202	302
S.E. (V x S)			*13.1*				

Disease

There was a significant three-way interaction for disease (Table 1), so the sites were analyzed individually. There was a significant Variety by Management interaction at four sites (Table 3). At all four sites, means separation indicated that disease was significantly reduced with a fungicide application with Oreana, but did not differ with fungicide application on any other varieties (Figure 1). At Outlook, leaf disease levels were also relatively high for Claymore. While not significant when using Tukey's test, leaf disease was significantly reduced by fungicide when lsd was used to separate means (data not shown). Both Claymore and Oreana are rated as "Susceptible" to Netted net blotch and all other varieties are more resistant. There were also other significant differences in disease level between varieties, with and without fungicide, at these four sites. At Melfort, there was a significant difference in disease level between varieties, but no effect of management (Table 2a in Appendix), and there was no difference in disease levels between varieties or management at either Prince Albert or Swift Current. Individual site analyses for leaf disease can be found in Table 2a of the Appendix.

Table 3. F-test results of mixed-effects models of disease levels assessing the presence of Variety and Management interactions at each site individually. Effects are considered significant if P<0.05 and significant effects are bolded for emphasis. S.E. is the standard error of the model.

	Melfort	Yorkton	Prince Albert	Outlook	Scott	Swift Current	Indian Head
Fixed effects				*Pr(>F)*			
Variety (V)	**0.047**	**<0.001**	0.153	**0.049**	**<0.001**	0.474	**<0.001**
Management (M)	0.470	**<0.001**	0.408	**0.001**	0.208	0.520	**0.011**
V x M	0.985	**<0.001**	0.660	**0.033**	**0.022**	0.338	**<0.001**
S.E.	*0.11*	*0.48*	*0.26*	*0.05*	*1.77*	*0.11*	*0.31*

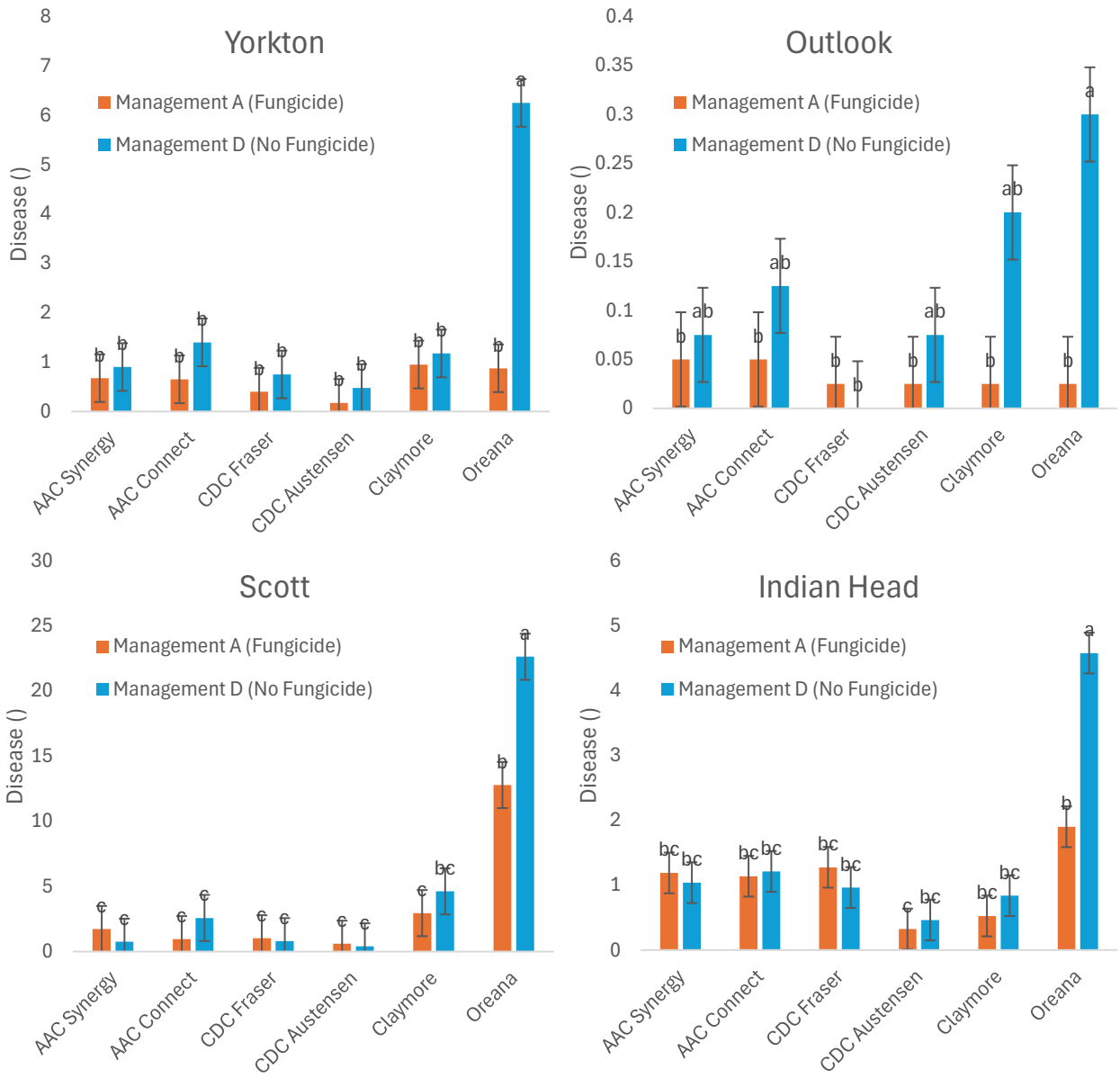

Figure 1. The interaction of variety and management at four sites. Error bars indicate the standard error within sites. Letters indicate the separation of estimated marginal means by pairwise comparisons using the Tukey method.

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Height

There were significant Variety by Management and Variety by Site interactions for height, and the 3-way interaction between variety, management and site was nearly considered significant with a p value of 0.061 (Table 1). The Variety by Management interaction showed that height varied with management across all sites in all varieties except Oreana (Figure 2). For all varieties other than Oreana, plants were significantly shorter with Management C (PGR application with standard fertility) than with Management B (no PGR application with enhanced fertility). AAC Synergy and CDC Fraser also showed a significant decrease in height with PGR application even without added fertility (Management A vs Management C). The Variety by Site interaction showed that there were significant differences in height between varieties at all six sites (height was not assessed at Prince Albert), but the sites differed in regards to the shortest and tallest varieties (Figure 3). AAC Synergy and Claymore were often but not always significantly taller than other varieties, while AAC Connect, CDC Austensen, and Oreana were often but not always significantly shorter than other varieties, depending on site. When sites were analyzed separately, significant interactions between management and variety were detected at Melfort, Yorkton and Indian Head (Table 4). At Yorkton and Indian head only the heights of the malt barley varieties were significantly reduced by PGR (Figure 4). At Melfort, height for each variety was not statistically reduced by PGR when using the Tukey's test for mean separation. However, when the less conservative lsd test was used, only the height of malt varieties were significantly reduced by PGR (data not shown). Individual site analyses for crop height can be found in Table 3a of the Appendix.

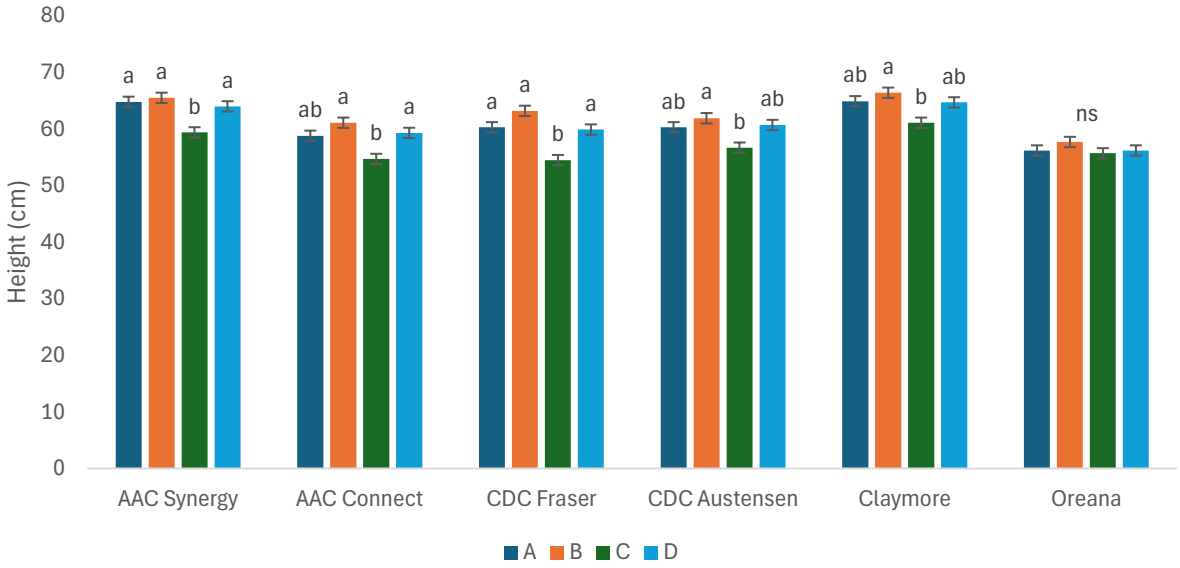

Figure 2. The interactive effect of management (Treatments A, B, C and D) and variety on height across all sites. Letters indicate the separation of estimated marginal means by pairwise comparison within variety. Error bars indicate the standard error across all sites.

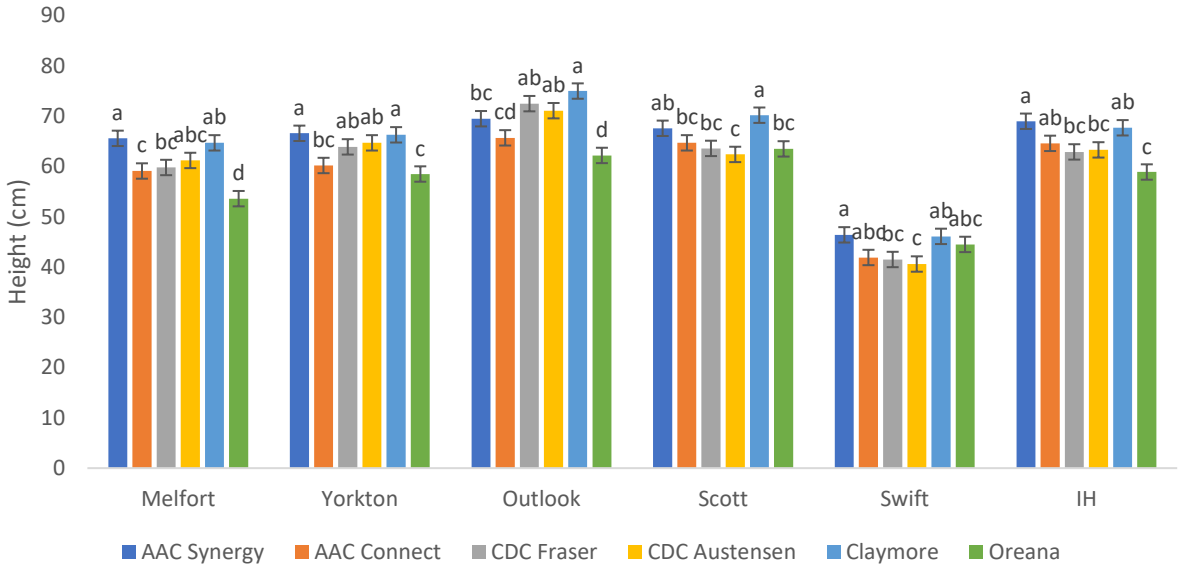

Figure 3. The interactive effect of variety and site on height across all management treatments. Letters indicate the separation of estimated marginal means by pairwise comparison within site. Error bars indicate the standard error across all sites.

Table 4. F-test results of mixed-effects models of height levels assessing the presence of Variety and Management interactions at each site individually. Effects are considered significant if P<0.05 and significant effects are bolded for emphasis. S.E. is the standard error of the model.

	Melfort	Yorkton	Prince Albert	Outlook	Scott	Swift Current	Indian Head
Fixed effects			---------- *Pr(>F)* ----------				
Variety (V)	**0.001**	**0.003**	Na	0.262	0.732	**<0.001**	**0.001**
Management (M)	**<0.001**	**<0.001**	Na	**<0.001**	**<0.001**	**<0.001**	**<0.001**
V x M	**0.009**	**0.053**	Na	0.11	0.661	0.482	**<0.001**
S.E.	*1.44*	*1.94*		*3.21*	*3.23*	*1.56*	*1.03*

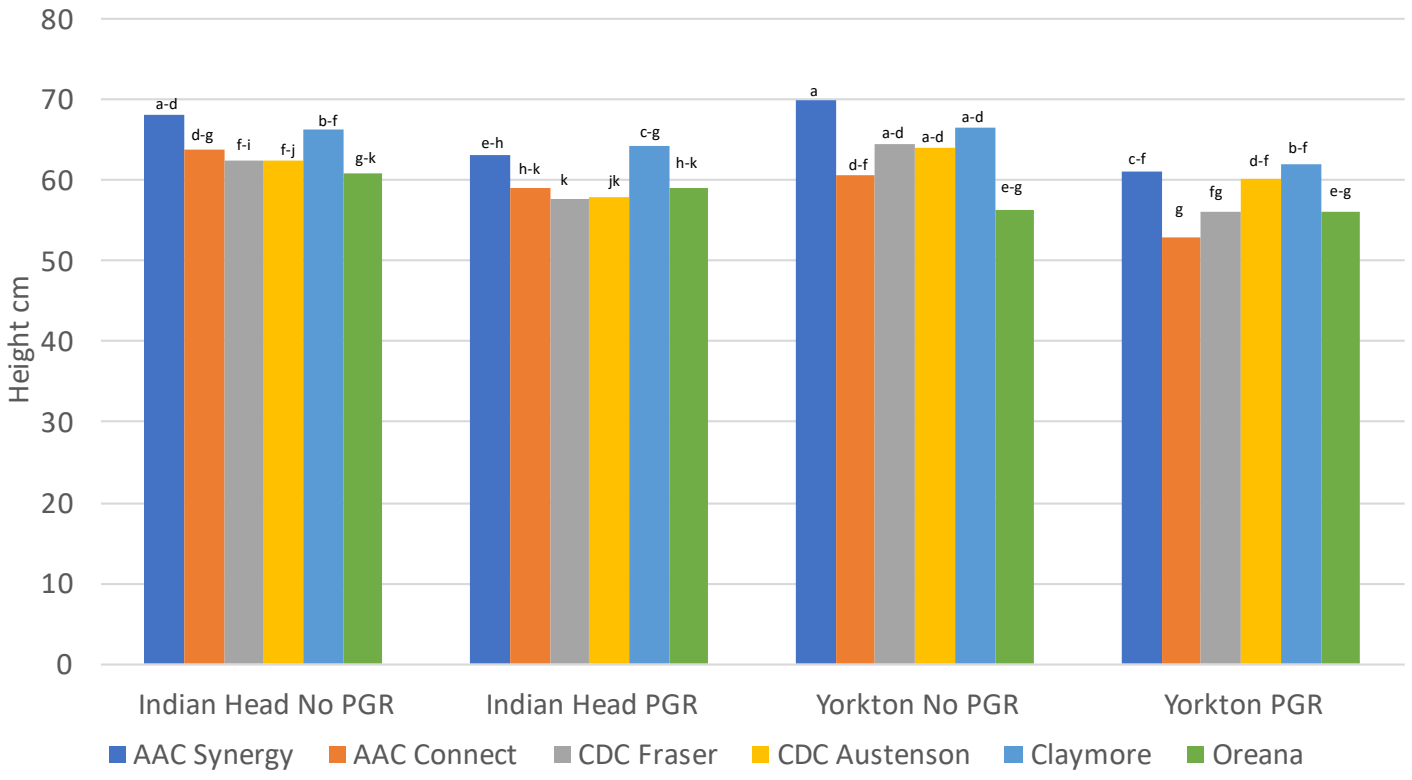

Figure 4. The interactive effect of variety and PGR on crop height. Means followed by the same letter are not significantly different within a location (Tukey test).

Lodging

Lodging differed between sites but there was no effect of management or difference between varieties (Table 1). Levels of lodging were very low in this study. Individual site analyses for lodging can be found in Table 4a of the Appendix.

Yield

Similar to height, there were significant Variety by Management and Variety by Site interactions for yield, but the three-way interaction was not significant (Table 1). The Variety by Management interaction showed that across sites, yield did not differ significantly with management in all varieties except Oreana (Figure 5). Yield of Oreana was significantly higher with Management B (enhanced fertility + fungicide) than with management D (standard fertility, no fungicide). The Variety by Site interaction showed that there was no significant difference in yield between varieties at any site except Outlook (Figure 6). At Outlook, the feed varieties tended to be higher yielding than the malt varieties. Individual site analyses for Yield can be found in Table 5a of the Appendix. Although the three-way interaction was insignificant (p=0.174), individual site analysis found PGR significantly increased yield at Swift Current which had low yield potentials due to hail. The reason for the increase is unclear as improvements in lodging were not detected as this location. PGR also significantly reduced yield potential of AAC Synergy at Indian Head and a trend was observed for all other varieties except Claymore. PGR applied during drought has often been observed to reduce yield potential. Enhancing N increased yield of AAC Connect and Claymore at Indian Head.

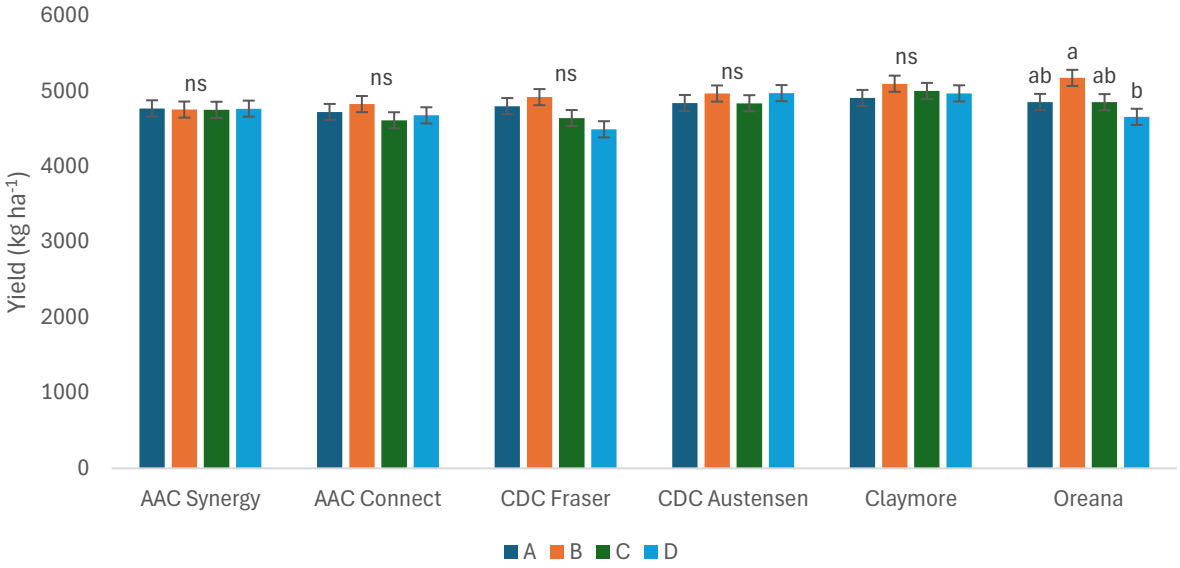

Figure 5. The interactive effect of management and variety on yield across all sites. Letters indicate the separation of estimated marginal means by pairwise comparison within variety. Error bars indicate the standard error across all sites.

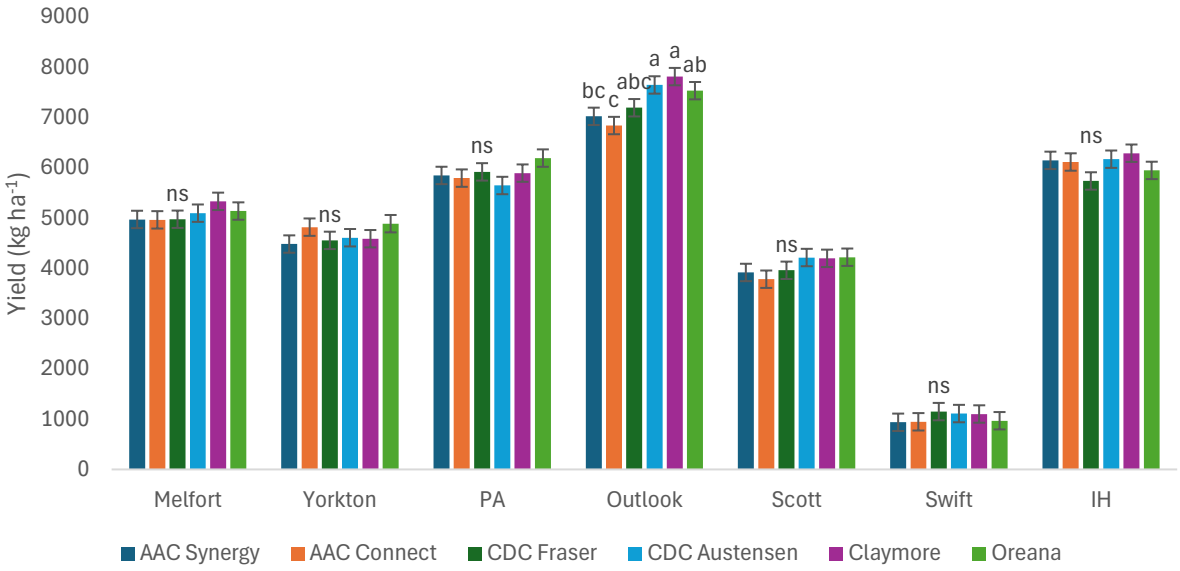

Figure 6. The interactive effect of variety and site on yield across all management treatments. Letters indicate the separation of estimated marginal means by pairwise comparison within site. Error bars indicate the standard error across all sites.

Protein

There was a significant effect of management on protein overall, and the Variety by Site interaction was significant (Table 1). The effect of management on protein was consistent across varieties and sites and was such that protein was significantly higher with Management B (Enhanced fertility) than with A, C, or D (standard fertility) (Figure 7). The Variety by Site interaction was such that there was a significant difference in protein between varieties at all sites except Scott, but varieties with higher and lower protein levels differed from site to site (Figure 8). Individual site analyses for protein can be found in Table 6a of the Appendix.

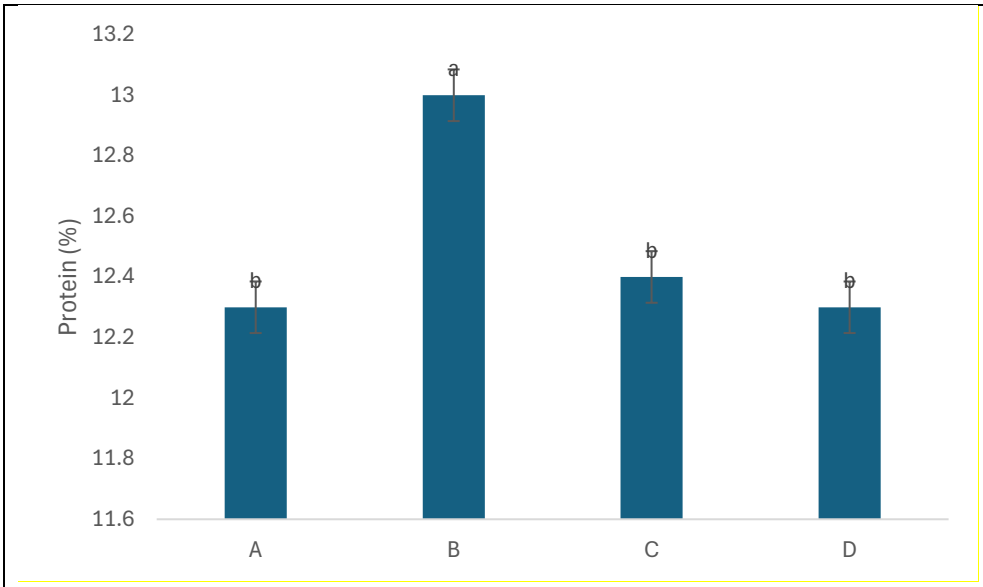

Figure 7. The effect of management on protein across varieties and sites. Letters indicate the separation of estimated marginal means by pairwise comparison. Error bars indicate the standard error.

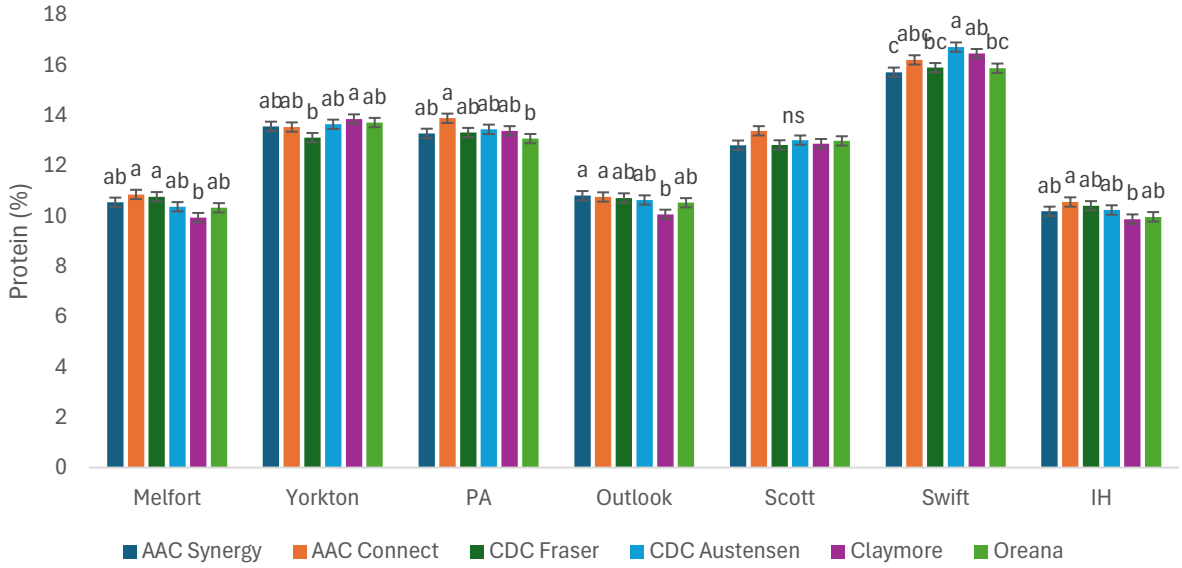

Figure 8. The interactive effect of variety and site on protein across all management treatments. Letters indicate the separation of estimated marginal means by pairwise comparison within site. Error bars indicate the standard error across all sites.

Conclusions and Recommendations

Describe what was learned from the demonstration. Highlight any significant conclusions and provide recommendations for the application and adoption of the project results. Be sure that you have presented the relevant data to support your conclusions. Identify any further research, development and communication needs, if applicable.

Weather conditions were dry at all locations, except Outlook under irrigation. As a result, leaf disease levels were low, lodging was minimal, and yields were average. At several sites, application of fungicide only significantly reduced leaf disease for Oreana, which when untreated had significantly more leaf disease compared to all other varieties. However, levels of leaf disease would still be considered minimal for untreated Oreana regardless of location. As a result, applying fungicide did not increase yield and only served to reduce net returns. Assuming a feed barley value of $5.03/bu, a malt value of $6.45/bu and a cost of applying fungicide of $25/ac, net return was only positive for CDC Fraser ($12/ac) when considering all sites together. For the rest of the varieties net returns were reduced between $6 to $38/ac. There were many instances where crop height was reduced by PGR. However, height reduction from PGR was more apparent for malt versus feed varieties. Regardless of management, lodging was not an issue for any treatment within this study. Application of PGR only served to reduce economic returns when considering all sites together. Assuming a cost of applying PGR of $23/ac, net returns were reduced between $14 to $42/ac depending on variety. At Swift Current, barley yield averaged across varieties was increased by 5.8 bu/ac, a large increase for a low yielding hailed crop. Using a crop price averaged between malt and feed ($5.88/bu), the applications of PGR would have increased net returns by $11/ac. The reason for this is unclear as lodging was not reported as an issue at this site despite the hail. Enhancing N by 30 lb/ac also reduced net returns. Assuming $1.20/lb N, enhancing N resulted in reduced net returns varying between $22/ac to $38/ac for malt varieties and from $5/ac to $23/ac for feed varieties. However, an argument could be made that enhancing N increased net returns for AAC Connect ($27/ac) and Claymore ($7/ac) at Indian Head. In summary, there was not a lot of evidence to suggest varieties should be managed differently under the dry conditions of this study. Oreana may be more likely to benefit from fungicide than other varieties in this study due to its greater susceptibility to leaf disease. Feed varieties in this study may be less likely to benefit from PGR application since their heights were less affected by PGR and they generally have higher ratings for lodging resistance. However, yield benefits from applying of fungicide to Oreana or PGR to malt varieties vs feed were not observed in this study.

Sustainable Canadian Agricultural Partnership (Sustainable CAP) Performance Indicators

a) List of performance indicators

Sustainable CAP Indicator	Total Number
Scientific publications from this project (List the publications under section b)	
• Published	0
• Accepted for publication	0
HQPs trained during this project	
• Master's students	0
• PhD students	0
• Post docs	0

Knowledge transfer products developed based on this project (presentations, brochures, factsheets, flyers, guides, extension articles, podcasts, videos). List the knowledge transfer products under section (c)	10

[1] Please only include the number of unique knowledge transfer products.

b) List of scientific journal articles published/accepted for publication from this project.

Title	Author(s)	Journal	Date Published or Accepted for Publication	Link (if available)
n/a	n/a	n/a	n/a	n/a

c) List of knowledge transfer products/activities developed from this project.

Knowledge Transfer Product or Activity	Event/Location Where Knowledge Transfer Was Conducted	Estimated Number of Producers Participated In Knowledge Transfer	Link (if available)
M. Hall (ECRF) Plot tour	ECRF Annual Field Day, Yorkton (July 20, 2023)	80	
M. Hall (ECRF) Presentation Webinar	Home Grown Research: Cereal Update (video posted)	(296 registered; 113 attendees. Recording posted for registrants.)	
M. Hall (ECRF) Presentation	Youtube Video	97 views-April 7 (10 days)	https://www.youtube.com/watch?v=uQIUqxmXwuo
A. Wall (WCA) Radio	"Walk The Plots" CKSW (570)		https://wheatlandconservation.ca/news-events/
Shannon Chant (MOA) Plot tour	WCA Annual Field Day, Swift Current (July 18, 2023)	80	
C. Holzapfel (IHARF) Plot tour	IHARF Annual Field Day, Indian Head (July 18, 2023)	160	
M. Japp (SaskBarley)	Top Notch Farming meetings covering 2022 results: Spiritwood, St Walburg, Unity, Melfort and Saskatoon	175 Top Notch 20 Producer Malt Academy	

Acknowledgements

Include actions taken to acknowledge support by the Ministry of Agriculture, the Canadian Agriculture Partnership (for projects approved between 2017 and 2023) and the Sustainable Canadian Agriculture Partnership (for projects approved between 2023 and 2028).

Sustainable Canadian Agricultural Partnership
Saskatchewan
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Appendices

Identify any changes expected to industry contributions, in-kind support, collaborations or other resources.

Table 1a. Means, P-values, and Tukey's separations for the main and interaction effects of Management and Variety on Emergence in Barley

Management (M)	Indian Head	Melfort	Outlook	Prince Albert	Scott	Swift Current	Yorkton
A. Standard[1] N Fertility – No PGR – Fungicide[3]	300.8	231.8	253.8	512.5	243.9	201.7	306.9
B. Enhanced[1] N Fertility – No PGR – Fungicide[3]	295.6	219.0	272.4	522.8	235.0	191.1	295.1
C. Standard[1] N Fertility – PGR[2] - Fungicide[3]	280.9	238.8	255.8	533.8	242.3	202.7	299.9
D. Standard[1] N Fertility – No PGR – No Fungicide	298.3	230.8	260.3	535.8	248.5	286.8	311.4
P-value	0.363	0.147	0.595	0.860	0.752	0.157	0.589
Variety (V)							
AAC Synergy	269.8^{c}	233.8	269.8	491.3	237.3^{b}	197.6	302.7^{ab}
AAC Connect	291.6^{abc}	223.7	258.8	533.3	242.8^{ab}	193.1	319.7^{a}
CDC Fraser	309.8^{a}	239.1	273.5	540.0	254.1^{a}	202.6	313.9^{ab}
CDC Austenson	284.1^{bc}	225.4	246.6	545.5	230.7^{b}	193.4	286.6^{b}
Claymore	305.8^{ab}	230.2	259.6	525.3	235.6^{b}	210.1	283.8^{b}
Oreana	302.3^{ab}	228.4	255.1	522.3	254.0^{a}	326.6	313.1^{ab}
P-value	<0.001	0.461	0.317	0.103	<0.001	0.031	0.008
M x V							
Management A - AAC Synergy	298.3	247.5	263.0	471.0	241.0	201.8	306.3
Management A - AAC Connect	287.3	230.3	238.5	510.0	249.0	193.0	314.5
Management A - CDC Fraser	315.5	233.8	254.0	541.0	243.5	201.8	310.0
Management A - CDC Austenson	297.8	216.8	234.5	536.0	237.3	196.8	273.9
Management A - Claymore	296.5	228.5	272.0	508.0	248.8	214.0	305.9
Management A - Oreana	309.3	234.0	260.5	509.0	244.0	202.8	330.5
Management B - AAC Synergy	248.5	223.5	269.5	480.0	233.3	181.5	319.4
Management B - AAC Connect	296.8	212.3	279.0	534.0	238.3	189.3	299.8
Management B - CDC Fraser	337.8	234.5	268.0	538.0	241.0	197.0	320.7
Management B - CDC Austenson	271.0	209.3	279.5	561.0	221.5	181.3	264.5
Management B - Claymore	316.3	214.8	260.0	526.0	224.5	202.0	292.4
Management B - Oreana	303.3	220.0	278.5	498.0	251.5	195.8	273.9
Management C - AAC Synergy	236.8	227.3	263.0	494.0	227.0	203.8	264.9
Management C - AAC Connect	296.5	234.0	251.5	554.0	236.0	197.3	331.3
Management C - CDC Fraser	293.0	243.3	314.5	506.0	262.0	204.3	310.8
Management C - CDC Austenson	286.0	240.0	225.0	568.0	232.8	198.0	296.1
Management C - Claymore	295.3	244.0	242.5	553.0	229.8	210.5	262.8
Management C - Oreana	277.8	244.3	238.0	528.0	266.0	202.3	333.4
Management D - AAC Synergy	295.8	236.8	283.5	520.0	247.8	203.3	320.3
Management D - AAC Connect	286.0	218.3	266.0	535.0	248.0	193.0	333.4
Management D - CDC Fraser	292.8	245.0	257.5	575.0	270.0	207.3	314.1
Management D - CDC Austenson	281.8	235.8	247.5	517.0	231.3	197.8	312.1
Management D - Claymore	315.0	233.5	264.0	514.0	239.3	214.0	273.9
Management D - Oreana	318.8	215.3	243.5	554.0	254.5	705.8	314.5
M x V interaction P-value	0.020	0.854	0.341	0.794	0.327	0.999	0.102

Table 2a. Means, P-values, and Tukey's separations for the main and interaction effects of Management and Variety on leaf disease in Barley

Management (M)	Indian Head	Melfort	Outlook	Prince Albert	Scott	Swift Current	Yorkton
A. Standard[1] N Fertility – No PGR – Fungicide[3]	1.058[b]	0.075[a]	0.033[b]	0.313	3.338	0.063	0.621[b]
D. Standard[1] N Fertility – No PGR – No Fungicide	1.515[a]	0.133[a]	0.129[a]	0.188	5.296	0.021	1.825[a]
P-value	0.011	0.470	0.001	0.408	0.208	0.520	<0.001
Variety (V)							
AAC Synergy	1.113[b]	0.063[ab]	0.063[ab]	0.25	1.238[b]	0.188	0.788[b]
AAC Connect	1.175[b]	0.325[a]	0.088[ab]	0.625	1.763[b]	0	1.025[b]
CDC Fraser	1.119[b]	0.05[ab]	0.013[b]	0.063	0.913[b]	0	0.575[b]
CDC Austenson	0.394[b]	0[b]	0.05[ab]	0.438	0.5[b]	0	0.325[b]
Claymore	0.681[b]	0.05[ab]	0.113[ab]	0	3.788[b]	0.063	1.063[b]
Oreana	3.238[a]	0.138[ab]	0.163[a]	0.125	17.7[a]	0	3.563[a]
P-value	<0.001	0.047	0.049	0.153	<0.001	0.474	<0.001
M x V							
Management A - AAC Synergy	1.188[bc]	0.025[a]	0.05[b]	0.125	1.725[c]	0.375	0.675[b]
Management A - AAC Connect	1.138[bc]	0.275[a]	0.05[b]	0.75	0.95[c]	0	0.65[b]
Management A - CDC Fraser	1.275[bc]	0.025[a]	0.025[b]	0.125	1.025[c]	0	0.4[b]
Management A - CDC Austenson	0.325[c]	0[a]	0.025[b]	0.75	0.6[c]	0	0.175[b]
Management A - Claymore	0.525[bc]	0.05[a]	0.025[b]	0	2.95[c]	0	0.95[b]
Management A - Oreana	1.9[b]	0.075[a]	0.025[b]	0.125	12.775[b]	0	0.875[b]
Management D - AAC Synergy	1.038[bc]	0.1[a]	0.075[ab]	0.375	0.75[c]	0	0.65[b]
Management D - AAC Connect	1.213[bc]	0.375[a]	0.125[ab]	0.5	2.575[c]	0	1.4[b]
Management D - CDC Fraser	0.963[bc]	0.075[a]	0[b]	0	0.8[c]	0	0.75[b]
Management D - CDC Austenson	0.463[bc]	0[a]	0.075[ab]	0.125	0.4[c]	0	0.475[b]
Management D - Claymore	0.838[bc]	0.05[a]	0.2[ab]	0	4.625[c]	0.125	1.175[b]
Management D - Oreana	4.575[a]	0.2[a]	0.3[a]	0.125	22.625[a]	0	6.25[a]
M x V interaction P-value	<0.001	0.985	0.033	0.660	0.022	0.338	<0.001

Table 3a. Means, P-values, and Tukey's separations for the main and interaction effects of Management and Variety on Height in Barley

Management (M)	Indian Head	Melfort	Outlook	Prince Albert	Scott	Swift Current	Yorkton
A. Standard[1] N Fertility – No PGR – Fungicide[3]	64^{a}	59.5^{ab}	68.3^{a}	na	65.7^{a}	44.2^{a}	63.7^{ab}
B. Enhanced[1] N Fertility – No PGR – Fungicide[3]	66^{a}	62.4^{a}	71.5^{a}	na	66.1^{a}	44.2^{a}	65.6^{a}
C. Standard[1] N Fertility – PGR[2] - Fungicide[3]	60.2^{b}	56.7^{b}	64.4^{a}	na	62.5^{a}	40.2^{b}	58.1^{c}
D. Standard[1] N Fertility – No PGR – No Fungicide	64.2^{a}	60.6^{a}	68.9^{a}	na	65.4^{a}	44^{a}	61.7^{b}
P-value	<0.001	0.005	0.262	na	0.731	<0.001	0.003
Variety (V)							
AAC Synergy	67.9^{a}	64.3^{a}	69.5^{a}	na	67.5^{a}	45.6^{a}	65.7^{a}
AAC Connect	63.4^{b}	57.5^{c}	64.9^{b}	na	64^{b}	41.7^{bc}	59.3^{c}
CDC Fraser	62^{b}	58.4^{bc}	70.5^{a}	na	62.7^{b}	40.9^{c}	62.4^{b}
CDC Austenson	62.2^{b}	60.6^{b}	70.6^{a}	na	62.3^{b}	40^{c}	63.6^{ab}
Claymore	67^{a}	64.4^{a}	73.2^{a}	na	69.8^{a}	46^{a}	65.3^{a}
Oreana	59.1^{c}	53.6^{d}	61.1^{b}	na	63.2^{b}	44.5^{ab}	57.4^{c}
P-value	<0.001	<0.001	<0.001	na	<0.001	<0.001	<0.001
M x V							
Management A - AAC Synergy	68.1^{a-d}	64.2^{a-e}	69.4^{a-d}	na	69.5^{abc}	47.8^{a}	69.9^{a}
Management A - AAC Connect	63.7^{d-g}	55.9^{f-k}	65.8^{b-e}	na	63.3^{a-e}	43.3^{a-d}	60.7^{def}
Management A - CDC Fraser	62.6^{f-i}	59.1^{c-j}	69^{a-d}	na	64.4^{a-e}	42.3^{a-d}	64.5^{a-d}
Management A - CDC Austenson	62.4^{f-j}	60.6^{b-g}	69.9^{a-d}	na	64^{a-e}	40.6^{a-d}	64.1^{a-d}
Management A - Claymore	66.3^{b-f}	63.9^{a-e}	76.5^{ab}	na	69.7^{abc}	46.5^{abc}	66.6^{a-d}
Management A - Oreana	60.8^{g-k}	53.1^{jk}	59.1^{de}	na	63.3^{a-e}	44.6^{a-d}	56.4^{efg}
Management B - AAC Synergy	71.3^{a}	68^{a}	69.4^{a-d}	na	67.7^{a-d}	48^{a}	68.5^{ab}
Management B - AAC Connect	67.1^{a-e}	62.4^{a-f}	67.1^{b-e}	na	65.9^{a-e}	42.1^{a-d}	62.1^{b-f}
Management B - CDC Fraser	64.7^{b-g}	62.7b^{a-e}	76.6^{ab}	na	65.4^{a-e}	42.5^{a-d}	67^{a-d}
Management B - CDC Austenson	65.4^{b-f}	62.5^{a-f}	72.3^{abc}	na	62.6^{b-e}	41.8^{a-d}	66.9^{a-d}
Management B - Claymore	69^{ab}	65.3^{abc}	78.8^{a}	na	70.9^{ab}	46.3^{abc}	68.2^{abc}
Management B - Oreana	58.4^{ijk}	53.7^{h-k}	64.6^{cde}	na	64.2^{a-e}	44.6^{a-d}	60.8^{def}
Management C - AAC Synergy	63.2^{e-h}	60.2^{b-h}	67.8^{a-d}	na	64.5^{a-e}	39.5^{bcd}	61.2^{c-f}
Management C - AAC Connect	59.1^{h-k}	51.8^{k}	63.4^{cde}	na	62.2^{b-e}	38.9^{cd}	53^{g}
Management C - CDC Fraser	57.6^{k}	53.7^{h-k}	63.6^{cde}	na	59.2^{de}	37^{d}	56^{fg}
Management C - CDC Austenson	57.9^{jk}	58^{e-k}	67.8^{a-d}	na	58.8^{e}	37.4^{d}	60.3^{def}
Management C - Claymore	64.4^{c-g}	62.3^{a-f}	67.6^{bcd}	na	66.8^{a-e}	43.4^{a-d}	62.1^{b-f}
Management C - Oreana	59.1^{h-k}	54.5^{g-k}	56.3^{e}	na	63.5^{a-e}	44.9^{a-d}	56.2^{efg}
Management D - AAC Synergy	68.7^{abc}	65^{a-d}	71.5^{abc}	na	68.4^{abc}	47.3^{ab}	63.3^{a-e}
Management D - AAC Connect	63.8^{d-g}	59.9^{b-i}	63.5^{cde}	na	64.7^{a-e}	42.6^{a-d}	61.3^{c-f}
Management D - CDC Fraser	63^{e-h}	58.3^{d-k}	72.6^{abc}	na	61.9^{cde}	42^{a-d}	62^{b-f}
Management D - CDC Austenson	63^{e-h}	61.3^{b-f}	72.4^{abc}	na	63.8^{a-e}	40.4^{a-d}	63.2^{a-e}
Management D - Claymore	68.3^{abc}	66.2^{ab}	69.8^{a-d}	na	71.9^{a}	47.8^{a}	64.5^{a-d}
Management D - Oreana	58.3^{ijk}	53.3^{ijk}	64.3^{cde}	na	61.7^{cde}	43.9^{a-d}	56.2^{efg}
M x V interaction P-value	<0.001	0.009	0.110	na	0.660	0.482	0.053

Table 4a. Means, P-values, and Tukey's separations for the main and interaction effects of Management and Variety on Lodging in Barley

Management (M)	Indian Head	Melfort	Outlook	Prince Albert	Scott	Swift Current	Yorkton
A. Standard[1] N Fertility – No PGR – Fungicide[3]	1.00[b]	1	1	3.66	1	1	0.5
B. Enhanced[1] N Fertility – No PGR – Fungicide[3]	1.15[a]	1	1	2.46	1	1	0.5
C. Standard[1] N Fertility – PGR[2] - Fungicide[3]	1.00[b]	1	1	1.14	1	1	0.5
D. Standard[1] N Fertility – No PGR – No	1.04[ab]	1	1	4.42	1	1	0.5
P-value	0.006	0.436	0.436	0.203	0.436	0.436	0.436
Variety (V)							
AAC Synergy	1.09	1	1	3.00	1	1	0.5
AAC Connect	1.09	1	1	2.62	1	1	0.5
CDC Fraser	1	1	1	3.44	1	1	0.5
CDC Austenson	1	1	1	3.00	1	1	0.5
Claymore	1.09	1	1	2.94	1	1	0.5
Oreana	1	1	1	2.69	1	1	0.5
P-value	0.126	0.426	0.426	0.733	0.426	0.426	0.426
M x V							
Management A - AAC Synergy	1.0	1	1	3.25[abc]	1	1	0.5
Management A - AAC Connect	1.0	1	1	4.75[abc]	1	1	0.5
Management A - CDC Fraser	1.0	1	1	5.00[ab]	1	1	0.5
Management A - CDC Austenson	1.0	1	1	2.00[abc]	1	1	0.5
Management A - Claymore	1.0	1	1	4.25[abc]	1	1	0.5
Management A - Oreana	1.0	1	1	2.75[abc]	1	1	0.5
Management B - AAC Synergy	1.37	1	1	2.50[abc]	1	1	0.5
Management B - AAC Connect	1.25	1	1	1.50[abc]	1	1	0.5
Management B - CDC Fraser	1.0	1	1	2.50[abc]	1	1	0.5
Management B - CDC Austenson	1.0	1	1	3.00[abc]	1	1	0.5
Management B - Claymore	1.25	1	1	2.00[abc]	1	1	0.5
Management B - Oreana	1.0	1	1	3.25[abc]	1	1	0.5
Management C - AAC Synergy	1.0	1	1	1.00[bc]	1	1	0.5
Management C - AAC Connect	1.0	1	1	1.00[bc]	1	1	0.5
Management C - CDC Fraser	1.0	1	1	1.25[abc]	1	1	0.5
Management C - CDC Austenson	1.0	1	1	1.66[abc]	1	1	0.5
Management C - Claymore	1.0	1	1	0.750[c]	1	1	0.5
Management C - Oreana	1.0	1	1	1.50[abc]	1	1	0.5
Management D - AAC Synergy	1.0	1	1	5.25[a]	1	1	0.5
Management D - AAC Connect	1.25	1	1	3.25[abc]	1	1	0.5
Management D - CDC Fraser	1.0	1	1	5.00[ab]	1	1	0.5
Management D - CDC Austenson	1.0	1	1	5.00[ab]	1	1	0.5
Management D - Claymore	1.125	1	1	4.75[abc]	1	1	0.5
Management D - Oreana	1.0	1	1	3.25[abc]	1	1	0.5
P-value	0.291	0.467	0.467	0.171	0.467	0.467	0.467

Table 5a. Means, P-values, and Tukey's separations for the main and interaction effects of Management and Variety on Yield in Barley

Management (M)	Indian Head	Melfort	Outlook	Prince Albert	Scott	Swift Current	Yorkton
A. Standard[1] N Fertility – No PGR – Fungicide[3]	5947.3^{ab}	4995.5	7235.5	6118.9	4023.1	942.1^{b}	4457.1
B. Enhanced[1] N Fertility – No PGR – Fungicide[3]	6219.4^{a}	5228.6	7501.9	5657.9	4130.9	1037.3^{b}	4912.1
C. Standard[1] N Fertility – PGR[2] - Fungicide[3]	5801.5^{b}	4885.7	7417.9	5768.9	3943.3	1254.4^{a}	4408.8
D. Standard[1] N Fertility – No PGR – No Fungicide	5945.1^{ab}	4901.4	6874	6414.5	3928.1	905.8^{b}	4330.2
P-value	0.009	0.210	0.476	0.373	0.881	<0.001	0.476
Variety (V)							
AAC Synergy	6044.4^{b}	4924.8^{b}	7149.8^{abc}	5971.8	3899.8^{abc}	963.1^{bc}	4376.3
AAC Connect	5988.4^{bc}	4853.3^{b}	6773.3^{c}	5995.4	3783.6^{c}	928.2^{c}	4653.2
CDC Fraser	5673^{d}	4901.7^{b}	7008.1^{bc}	5971	3842.1^{bc}	1167.3^{a}	4416.9
CDC Austenson	6086.9^{ab}	5017.1^{ab}	7548.6^{ab}	5809.4	4194.1^{a}	1091.7^{abc}	4584.8
Claymore	6203.8^{a}	5239.6^{a}	7676.4^{a}	6097.4	4167.4^{ab}	1116.1^{ab}	4462.1
Oreana	5873.4^{c}	5080.3^{ab}	7387.8^{ab}	6095.5	4151^{ab}	943^{c}	4669.2
P-value	<0.001	0.0019	<0.001	0.718	<0.001	<0.001	0.235
M x V							
Management A - AAC Synergy	6100.5^{a-h}	4997.3^{ab}	7293.5^{abc}	5703.8^{ab}	4036^{ab}	878e^{bc}	4387.8^{ab}
Management A - AAC Connect	5832^{e-j}	4751.5^{b}	6919.5^{abc}	6417.5^{ab}	3819^{ab}	778.8^{c}	4544.5^{ab}
Management A - CDC Fraser	5736^{f-j}	4988^{ab}	7084^{abc}	6317^{ab}	3853^{ab}	1098^{abc}	4527.8^{ab}
Management A - CDC Austenson	6131.8^{a-f}	5080.5^{ab}	7196.8^{abc}	5865.5^{ab}	4072^{ab}	974^{bc}	4576.5^{ab}
Management A - Claymore	6019.5^{b-i}	5090.8^{ab}	7471.3^{abc}	6118.8^{ab}	4109.3^{ab}	1134^{abc}	4419.5^{ab}
Management A - Oreana	5864^{e-j}	5064.8^{ab}	7448.3^{abc}	6290.8^{ab}	4249.3^{ab}	790^{c}	4286.5^{ab}
Management B - AAC Synergy	6347^{abc}	5062^{ab}	6759.8^{abc}	5592.8^{ab}	3949.5^{ab}	883.5^{bc}	4691.3^{ab}
Management B - AAC Connect	6359.5^{ab}	5179^{ab}	6965.3^{abc}	5387.3^{b}	3778.3^{ab}	984.5^{bc}	5144.3^{ab}
Management B - CDC Fraser	5738.5^{f-j}	5119.3^{ab}	7558.3^{ab}	5805.8^{ab}	4193.3^{ab}	1115.8^{abc}	4829.3^{ab}
Management B - CDC Austenson	6330.5^{a-d}	5250^{ab}	7835.3^{ab}	5304.8^{b}	4251.3^{ab}	1151^{abc}	4652.3^{ab}
Management B - Claymore	6452.8^{a}	5510.5^{a}	8078.8^{a}	5477.3^{ab}	4257.8^{ab}	1072.3^{abc}	4835.5^{ab}
Management B - Oreana	6088.3^{a-h}	5251^{ab}	7814^{ab}	6379.8^{ab}	4355.3^{ab}	1017^{bc}	5320.3^{a}
Management C - AAC Synergy	5722^{g-j}	4720^{b}	7574.5^{ab}	5918.5^{ab}	3781.3^{ab}	1221.5^{ab}	4328^{ab}
Management C - AAC Connect	5776.8^{f-j}	4712.5^{b}	6802.8^{abc}	5812.8^{ab}	3927.8^{ab}	1160.5^{abc}	4097^{b}
Management C - CDC Fraser	5547.3^{j}	4718.5^{b}	7406^{abc}	5580.8^{ab}	3646.5^{ab}	1448.5^{a}	4148.3^{b}
Management C - CDC Austenson	5950.3^{c-j}	4843.3^{ab}	7532^{ab}	5682.8^{ab}	3945.5^{ab}	1267.3^{ab}	4627.8^{ab}
Management C - Claymore	6114.8^{a-g}	5249^{ab}	7747.3^{ab}	5887.3^{ab}	4220.3^{ab}	1243.3^{ab}	4551.3^{ab}
Management C - Oreana	5698^{hij}	5070.8^{ab}	7444.8^{abc}	5731.5^{ab}	4138.3^{ab}	1185.3^{abc}	4700.8^{ab}
Management D - AAC Synergy	6008^{b-i}	4919.8^{ab}	6971.3^{abc}	6672^{ab}	3832.3^{ab}	869.5^{bc}	4098^{b}
Management D - AAC Connect	5985.5^{b-i}	4770^{b}	6405.5^{bc}	6364^{ab}	3609.5^{b}	789^{c}	4827^{ab}
Management D - CDC Fraser	5670.3^{ij}	4781^{ab}	5984.3^{c}	6180.5^{ab}	3675.8^{ab}	1006.8^{bc}	4162.3^{b}
Management D - CDC Austenson	5935^{d-j}	4894.5^{ab}	7630.3^{ab}	6384.5^{ab}	4507.8^{a}	974.5^{bc}	4482.5^{ab}
Management D - Claymore	6228.3^{a-e}	5108.3^{ab}	7408.5^{abc}	6906.3^{a}	4082.3^{ab}	1015^{bc}	4042.3^{b}
Management D - Oreana	5843.5^{e-j}	4934.8^{ab}	6844^{abc}	5980^{ab}	3861.3^{ab}	779.8^{c}	4369.3^{ab}
M x V interaction	0.096	0.950	0.172	0.163	0.350	0.797	0.242

Table 6a. Means, P-values, and Tukey's separations for the main and interaction effects of Management and Variety on Protein content (%) in Barley

Management (M)	Indian Head	Melfort	Outlook	Prince Albert	Scott	Swift Current	Yorkton
A. Standard[1] N Fertility – No PGR – Fungicide[3]	9.9[b]	10.06[b]	10.57[b]	13.35	12.55	16.06	13.31
B. Enhanced[1] N Fertility – No PGR – Fungicide[3]	10.83[a]	11.36[a]	11.11[a]	13.95	13.5	16.29	13.7
C. Standard[1] N Fertility – PGR[2] - Fungicide[3]	10.07[b]	10.36[b]	10.2[c]	13.43	12.96	16.22	13.49
D. Standard[1] N Fertility – No PGR – No	10.07[b]	10.09[b]	10.48[bc]	12.87	12.95	16.03	13.82
P-value	<0.001	<0.001	<0.001	0.097	0.323	0.643	0.142
Variety (V)							
AAC Synergy	10.19[bc]	10.55[bc]	10.81[a]	13.29	12.82[b]	15.73[d]	13.57[a]
AAC Connect	10.56[a]	10.86[a]	10.76[a]	13.89	13.39[a]	16.21[bc]	13.54[a]
CDC Fraser	10.41[ab]	10.77[ab]	10.73[a]	13.32	12.83[b]	15.9[cd]	13.13[b]
CDC Austenson	10.21[abc]	10.37[c]	10.64[a]	13.45	13.02[ab]	16.72[a]	13.65[a]
Claymore	9.88[c]	9.94[d]	10.08[b]	13.39	12.88[ab]	16.46[ab]	13.86[a]
Oreana	9.99[c]	10.33[c]	10.53[a]	13.08	12.99[ab]	15.88[d]	13.73[a]
P-value	<0.001	<0.001	<0.001	0.109	0.029	<0.001	<0.001
M x V							
Management A - AAC Synergy	9.7[e]	10.28[e-i]	10.7[a-d]	13.35[ab]	12.2[c]	15.8[gh]	12.95[de]
Management A - AAC Connect	10.1[b-e]	10.45[d-h]	10.7[a-d]	13.73 [ab]	13.1[abc]	15.9[e-h]	13.53[b-e]
Management A - CDC Fraser	10.2[b-e]	10.23[e-i]	10.8[a-d]	13.43 [ab]	12.2[c]	15.9[fgh]	12.83[e]
Management A - CDC Austenson	10[de]	10.1[e-j]	10.8[a-d]	13.4 [ab]	12.6[abc]	16.6[a-e]	13.3[b-e]
Management A - Claymore	9.8[de]	9.43[j]	10.1[cd]	13.35 [ab]	12.5[bc]	16.1[d-h]	13.5[b-e]
Management A - Oreana	9.6[e]	9.9[g-j]	10.4[a-d]	12.88 [ab]	12.7[abc]	16.2[c-g]	13.78[a-d]
Management B - AAC Synergy	10.7[a-d]	11.4[ab]	11.6[a]	13.8 [ab]	13.7[ab]	15.8[gh]	13.93[abc]
Management B - AAC Connect	11.3[a]	11.8[a]	11.4[ab]	14.4[a]	13.9[a]	16.2[c-g]	13.55[a-e]
Management B - CDC Fraser	10.9[abc]	11.7[a]	11.1[abc]	13.28[ab]	13.2[abc]	15.9[fgh]	13.15[cde]
Management B - CDC Austenson	11[ab]	11.3[abc]	11.2[abc]	13.93[a]	13.7[ab]	16.8[abc]	13.93[abc]
Management B - Claymore	10.3[b-e]	10.8[b-e]	10.4[a-d]	14.48[a]	13.5[abc]	17[a]	14.05[ab]
Management B - Oreana	10.8[a-d]	11.2[a-d]	11[abc]	13.88[a]	13.1[abc]	16.1[c-g]	13.58[a-e]
Management C - AAC Synergy	10[de]	10.3[e-h]	10.5[a-d]	13.15[ab]	12.6[abc]	16[e-h]	13.68[a-e]
Management C - AAC Connect	10.4[a-e]	10.7[b-f]	10.3[bcd]	14.1[a]	13.3[abc]	16.4[a-g]	13.43[b-e]
Management C - CDC Fraser	10.5[a-e]	10.5[d-h]	10.3[bcd]	13.15 [ab]	13[abc]	16[e-h]	13.15[cde]
Management C - CDC Austenson	10[de]	10.3[e-i]	10.2[cd]	13.17 [ab]	13.1[abc]	16.9[ab]	13.48[b-e]
Management C - Claymore	9.7[e]	10[f-j]	9.7[d]	13.1 [ab]	12.6[abc]	16.3[b-g]	13.5[b-e]
Management C - Oreana	9.9[de]	10.3[e-h]	10.1[cd]	13.85[a]	13.2[abc]	15.8[gh]	13.7[a-d]
Management D - AAC Synergy	10.4[a-e]	10.2[e-j]	10.5[a-d]	12.88 [ab]	12.7[abc]	15.4[h]	13.73[a-d]
Management D - AAC Connect	10.4[a-e]	10.5[d-h]	10.6[a-d]	13.33 [ab]	13.3[abc]	16.4[a-g]	13.65[a-e]
Management D - CDC Fraser	10.1[b-e]	10.6[c-g]	10.7[a-d]	13.43 [ab]	13[abc]	15.9[fgh]	13.38[b-e]
Management D - CDC Austenson	10[cde]	9.8[hij]	10.4[a-d]	13.25 [ab]	12.8[abc]	16.7[a-d]	13.9[abc]
Management D - Claymore	9.7[e]	9.5[ij]	10.1[cd]	12.63 [ab]	12.9[abc]	16.5[a-f]	14.4[a]
Management D - Oreana	9.7[e]	10[f-j]	10.6[a-d]	11.73[b]	13[abc]	15.5[h]	13.85[abc]
M x V interaction	0.459	0.669	0.968	0.275	0.663	0.358	0.033

Expenditure Statement

Sustainable Canadian Agricultural Partnership
Saskatchewan
Canada

You must provide an expenditure statement showing how ADOPT funds were used. Expenditures must be reported using the budget categories shown in Appendix B of your contract. We recommend that you report your expenditures using the Excel spreadsheet we have developed for this purpose (ADOPT Expenditure Statement.xls). That spreadsheet is available from the research branch project manager or the evaluation coordinator.

Note that the ADOPT contract requires you to retain all receipts and financial records relating to the project for at least six years after the project is completed.