

2022 Final Report

from the

Saskatchewan Barley Development Commission

Project Title: Enhanced Barley Variety Trials-Fertility



Principal Investigators:

Mike Hall¹, Heather Sorestad¹, Chris Holzapfel², Christiane Catellier², Gursahib Singh³, Brianne McInnes⁴,
Bryan Nybo⁵, Amber Wall⁵, Robin Lokken⁶, Jessica Enns⁷

¹East Central Research Foundation, Yorkton, SK

²Indian Head Agricultural Research Foundation, Indian Head, SK

³Irrigation Crop Diversification Corporation, Outlook, SK

⁴Northeast Agriculture Research Foundation, Melfort, SK

⁵Wheatland Conservation Area Inc., Swift Current, SK

⁶Conservation Learning Centre, Prince Albert, SK

⁷Western Applied Research Corporation, Scott, SK

Project Identification

- 1. Project Number:** 20211029
- 2. Producer Group Sponsoring the Project:** Saskatchewan Barley Development Commission
- 3. Project Location(s):** Yorkton, Indian Head, Melfort, Outlook, Prince Albert, Swift Current and Scott, 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 N responsiveness of 3 malt and 3 feed barley varieties, which are gaining popularity based on 2021 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.

[Link to data](#)

More specific to this demonstration, optimum N management between malt barley varieties has been observed to differ based on initial findings from the Barley MAX study, which is a joint funded study through the Ministry's Strategic Field Program and SaskBarley. This study is comparing the yield and grain protein response of AC Metcalfe, AAC Synergy and CDC Bow to increasing N. AC Metcalfe is an older, lower yielding variety which is still popular amongst maltsters but appears to be on the decline based on the latest stats on insured acres provided by the Canadian Grain Commission. AAC Synergy and CDC Bow are newer, higher yielding varieties. AAC Synergy is the

highest yielding variety and is gaining popularity amongst producers. In 2020, the most economic rate of soil + Fertilizer N, when averaged over 4 locations, was a 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.

Historically, the approach has been to apply more N to feed barley than malt because feed is higher yielding and excessive protein is not a concern. While there is more risk with applying too much N with malt, the most economic rate for feed may not be higher than it is for malt when the price differential is considered. This is particularly true if the comparison is with a high yielding malt variety. For example, a recent study supported by the Ministry and SaskBarley, found that while a feed variety like CDC Austenson was higher yielding and more responsive to added N compared to AC Metcalfe it didn't 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.

Comparisons with older varieties such as AC Metcalfe or CDC Copeland, which are declining in popularity, will become irrelevant in the future. Thus, this study will focus on newer varieties, which are increasing in popularity and are more likely to be grown in the future. The malt barley varieties to be compared in this study include AAC Synergy, AAC Connect and CDC Fraser, which constituted 17%, 4% and 2% of total insured barley acres in Saskatchewan, respectively (Canadian Grain Commission 2021). AAC Synergy is the new check and according to the regional trials, CDC Fraser has a comparable yield and AAC Connect is about 7% lower yielding in area 3 & 4 (Varieties of Grain Crops 2021). The feed varieties included in this demonstration are CDC Austenson, Claymore and Oreana, which were grown on 17%, 5% and 3% of Saskatchewan's insured barley acres, respectively. CDC Austenson is a couple percent higher yielding than the check AAC Synergy. Claymore is similar yielding to Synergy and Oreana is 7% lower yielding in area 3 & 4.

Relevance to producers

Past study has revealed that N rates can be pushed higher with newer varieties of malt relative to AC Metcalfe. Moreover, the most economic rate of N for malt is increasing relative to feed as the difference in yield potential between malt and feed varieties narrows. 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. This information will become part of a variety specific approach to crop management recommendations being developed by SaskBarley.

8. Methodology:

The trials were established at each location as a 2-order factorial with 4 replicates. The first factor compared a “Standard” vs “Enhanced” rate of soil available N (0-24”) + fertilizer N. The second factor was variety. 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.

Where soil sampling to 24 inches was not possible, N available in a 12-inch depth was multiplied by 1.5 to approximate N present in a 24 inch depth. The purpose of these N rates was not to precisely determine the most economic rate of N but to determine if response to additional N fertilizer may differ between varieties. Unfortunately, soil N was very high at Melfort, Prince Albert and Swift Current (Table 6). N rate comparisons had to be pushed higher at these locations in order to achieve the desired separations between standard and enhanced rates of N. This resulted in comparisons between standard and enhanced rates of 142 lb N/ac vs 174 lb N/ac at Melfort, 139 lb N/ac vs 169 lb N/ac at Prince Albert and 159 lb N/ac vs 184 lb N/ac at Swift Current. Three malt and 3 feed varieties, which are increasing in popularity were selected based on 2021 crop insurance data compiled by the Canadian Grain Commission. A complete listing of the treatments established are presented in Table 1. Phosphorous and potassium was applied evenly to all treatments in each trial to be non-limiting even at the highest rate of N. All trials were small plot, and plot size varied between locations based on equipment available. Seeding rates for each variety were based on TKW and germination tests to target 300 live seeds/m². Pesticides at each location were applied at the discretion of the research manager to limit yield reduction from pests. A small plot combine was used to harvest plots.

Table 1. Treatment list for project (N fertility by Barley Variety)			
#	Variety	Type	Nitrogen Fertility¹
1	AAC Synergy	Malt	Standard
2	AAC Synergy	Malt	Enhanced
3	AAC Connect	Malt	Standard
4	AAC Connect	Malt	Enhanced
5	CDC Fraser	Malt	Standard
6	CDC Fraser	Malt	Enhanced
7	CDC Austenson	Feed	Standard
8	CDC Austenson	Feed	Enhanced
9	Claymore	Feed	Standard
10	Claymore	Feed	Enhanced
11	Oreana	Feed	Standard
12	Oreana	Feed	Enhanced

¹Standard and Enhanced rates of N Fertility [soil (0-24") + added N] will vary between locations based on historic yield potentials obtained from SCIC data. Sites will fall into the following groupings:

- Group 1 = low yield potential: Swift Current: Intended comparison 100 vs 125 lb N/ac of soil + added N; Actual comparison 159 vs 184 lb N/ac.
- Group 2 = mid range yield potential: Prince Albert, Indian Head, Scott: Intended comparison 120 vs 150 lb N/ac of soil + added N; actual comparison for Prince Albert 139 vs 169 lb N/ac.
- Group 3 = high yield potential: Yorkton, Melfort, Outlook: Intended comparison 130 vs 162 lb N/ac of soil + added N; actual comparison for Melfort 142 vs 174 lb N/ac

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

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

Operations in 2022	Indian Head	Melfort	Outlook	Prince Albert	Swift Current	Yorkton	Scott
Pre-seed/ pre-emergent herbicide application	May 22 (0.67 l/ac Roundup Weathermax Hc)	May 12 (Liquid Avadex) May 21 (0.67 l/ac Roundup Transorb)	May 2 (1 l/ac Glyphosate)	May 21 (1 l/ac Roundup Transorb)	May 4 (0.67 l/ac RT540)	None	May 9 (Glyphosate 540 1 l/ac & Aim)
Seeding Date	May 16	May 16	May 10	June 3	May 17	May 12	May 13
Emergence Counts	June 1	June 7	May 30	June 22	June 17	June 2	May 25
In-crop Herbicide Application	June 11 (Pixxaro A + Pixxaro 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 6 (Prestige) June 8 (Axial)	June 22 (Buctril M)
Fungicide/ Insecticide Application	July 1 (Nexicor) July 9 (Decis for grasshoppers) July 17 (Prosaro XTR)	July 18 (Caramba)	None	None	None	July 6 (Trivapro AB)	July 14 (Caramba)
Lodging Rating	August 29	Sept 2	Aug 3	Aug 22	Aug 15	Sept 2	Aug 16
Harvest	August 31	Sept 12	Aug 17	Sept 6	Aug 17	Sept 2	Aug 18

9. Results:

Growing Season Weather

Mean monthly temperatures and precipitation amounts with long-term (1981-2010) averages for the 7 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, Prince Albert, 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

Levels of soil N in the top 2 feet of soil for each site are listed in table 6.

Table 6. Soil test results from 2022 trials.			
Site	Soil N (lb N/ac)¹	Site	Soil N (lb N/ac)¹
Indian Head	17	Swift Current	159
Melfort	142	Yorkton	104
Outlook	97	Scott	32
Prince Albert	139		

¹Top 24 inches of soil

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 fertility treatment, all two-way interactions, and the three-way interaction as fixed effects, and replicate within site as a random effect. If significant site interactions were identified, then sites were analyzed separately, with variety, fertility, and the variety by fertility interaction as fixed effects, and replicate as a random effect. Lodging was 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 7. 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 emergence	Lodging	Yield	Protein
<i>Fixed effects</i>	----- <i>Pr(>F)</i> -----			
Variety (V)	0.000	0.002	0.021	0.110
Fertility (F)	0.000	0.000	0.801	0.000
Site (S)	0.000	0.000	0.000	0.000
V x F	0.474	0.516	0.428	0.327
V x S	0.000	0.001	0.000	0.011
F x S	0.000	0.000	0.000	0.000
V x F x S	0.251	0.948	0.342	0.008

Tables 8 to 13 are found in the appendices.

Plant emergence

The variety by fertility interaction was not significant across sites, and the three-way interaction was also not significant for the plant emergence data (Table 7). Sites were analyzed individually to examine the significant variety by site, and fertility by site interactions (Table 8).

There was no significant variety by fertility interaction at any of the sites. Plant emergence varied significantly with variety at 6 sites, but the effect was different at each site. However, establishment differences were not large enough to have a substantial influence on yield between varieties. Plant emergence also varied significantly with fertility treatment at 3 sites, but the effect differed between sites. Increasing fertility rate reduced plant stands at Outlook, Scott and Yorkton, indicating seed safety

issues with added nitrogen. Reductions in plant stands were not substantial enough to reduce yield potential at Scott and Yorkton. In contrast, the plant stand reduction was very large at Outlook and this did have a substantial impact on yield which will be discussed further.

Lodging

Lodging was log-transformed prior to analysis and transformed values are shown in the tables. The variety by fertility interaction was not significant across sites, and the three-way interaction was also not significant (Table 7). Sites were analyzed individually to examine the significant variety by site, and fertility by site interactions (Table 9).

Lodging was absent at Scott. There was a significant variety by fertility interaction at Indian Head and Prince Albert. At Indian Head, lodging was significantly higher with enhanced fertility compared to standard fertility with CDC Austenson but did not differ with fertility treatment for any other variety. It is uncertain why increasing fertility only affected the lodging of CDC Austenson. While CDC Austenson is only rated as having “good” resistance to lodging, CDC Fraser and AAC Connect are also rated as “good” and AAC Synergy is rated even poorer as “fair”. Claymore and Oreana would not be expected to lodge more than the other varieties as they are rated as having “very good” resistance to lodging. At Prince Albert, lodging was significantly higher with enhanced fertility for AAC Synergy, which would be anticipated based on its lower rating for lodging resistance compared to the other varieties compared. However, there was little variability in lodging at this site overall. At Melfort and Swift Current, lodging differed between varieties but was not affected by fertility. Oreana had the best resistance to lodging at both Melfort and Swift Current which would be anticipated based on Oreana’s “very good” resistance to lodging. Claymore is also rated as having “very good” resistance to lodging and had the second highest level of lodging resistance at Melfort. However, it did not show superior performance at Swift Current. At Outlook, lodging was significantly higher with enhanced fertility across all varieties, but there was no difference in lodging between varieties. Lodging did not differ between varieties or fertility at Yorkton. Overall, levels of lodging were very low in this study.

Yield

The variety by fertility interaction was not significant across sites, and the three-way interaction was also not significant (Table 7). There were significant variety by site and fertilizer by site interactions, so sites were analyzed individually (Table 10).

There was a significant variety by fertility interaction at Scott only. At this site, yield was significantly lower with enhanced compared to standard fertility for AAC Synergy only, while the yield of all other varieties was not significantly affected by fertility. The reason for this is not clear and maybe due to error. There was a significant difference in yield between varieties at five sites, but the highest to lowest-yielding varieties varied by site. On average, CDC Fraser was a little lower yielding than the other varieties and was statistically the lowest yielding variety at Indian Head, Scott and Swift Current. There was a significant effect of fertility at four sites. At Indian Head, Melfort, and Yorkton, the yield was significantly higher with enhanced fertility compared to standard fertility. In contrast, yield was significantly higher with the standard rate of N at Outlook. This was likely the result of seed safety issues

with increasing N, as emergence was reduced substantially from 194 plants/m² with the standard rate of N to 109 plants/m² with the enhanced rate of N. The lack of a response to increasing N at Scott and Swift Current would be due to drought and the very high N rates used for comparison at Swift Current. N comparisons also had to be increased at Prince Albert and this too will have decreased the chance of detecting a yield difference between the N rates.

Protein

Protein level was only assessed on the malt varieties. The three-way interaction of variety and fertility with site was significant for protein (Table 7). There was a significant variety by fertility interaction at Scott. Protein was significantly lower with standard fertility than enhanced fertility for Synergy, but the other varieties did not vary significantly with fertility treatment (Table 11). There was a significant difference in protein between varieties at two sites, Indian Head and Melfort. CDC Fraser had lower protein than other varieties at these sites. Protein was also significantly higher with enhanced fertility compared to standard fertility at four sites and was not affected by fertility at the other three sites. Protein levels were acceptable for malt at all locations except Scott and Swift Current where drought greatly reduced yield potential.

Economics

With only one exception, there were no interactions between variety and fertility for the protein and yield data. The one interaction occurred at Scott, where the yield of AAC Synergy was significantly and substantially reduced by the enhanced rate of fertility. This does not make much sense and may be the result of an error. Barring this exception, the varietal yield response to increasing N from standard to enhanced rates of N was the same. However, it is very difficult to make N rate response comparisons between varieties when only two rates of N are being compared. For example, Swift Current, Scott and Prince Albert were not responsive to added N and there were no interactions between variety and nitrogen. Drought reduced yield potential at Swift Current and Scott and background soil N was high at Prince Albert and Swift Current making N rate comparisons between standard and enhanced higher than intended. So there is no evidence to suggest varieties do or do not differ in their response to N, since rates were too high to detect a response for all varieties. If the N rates for standard and enhanced had been lower at these locations it may have been possible to detect a variety by N interaction. At Outlook, there was a significant decrease in yield as N rate was increased. Again, this makes it impossible to determine if the optimum rate of N differed between varieties.

At Yorkton, Indian Head and Melfort there was a significant yield response to increasing N from standard to enhanced rates, despite N rate comparisons being higher than desired at Melfort. Since there were no interactions between variety and N rate, the optimum N rate would not differ within malt varieties or within feed varieties. The price differential between malt and feed makes it impossible for optimum N rates to differ between malt and feed varieties. However, both feed and malt varieties benefitted from the enhanced rate of N at Indian Head, Melfort and Yorkton based on the economic scenario obtained from the 2021 Saskatchewan Crop Planning Guide (Table 12). Under less favorable economics taken from the 2023 guide, only Indian Head and Melfort found net revenues for malt and feed were higher

with the enhanced rate of N (Table 13). Economic returns were always higher when considering malt because of its higher value and this suggests the optimum rate of N is higher for malt than feed, particularly since protein levels acceptable for malt were not exceeded.

References

Bates D, Maechler M, Bolker B, and Walker S. (2015). Fitting Linear Mixed-Effects Models Using *lme4*. *Journal of Statistical Software*, 67(1), 1-48. doi:10.18637/jss.v067.i01.

Kuznetsova A, Brockhoff PB, and Christensen RHB (2017). *lmerTest* Package: Tests in Linear Mixed Effects Models. *Journal of Statistical Software*, 82(13), 1-26. doi:10.18637/jss.v082.i13

Lenth R. (2023). *emmeans*: Estimated Marginal Means, aka Least-Squares Means. R package version 1.8.4-1. <https://CRAN.R-project.org/package=emmeans>

R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>.

10. Conclusions and Recommendations

No evidence was found to suggest the optimum rate of N differed within varieties of malt or within varieties of feed. However, it should be noted that it is difficult to detect differences in N response between varieties when only two rates of N are used for comparison. Moreover, N rate comparisons were higher than desired at Melfort, Prince Albert and Swift Current due to high residual soil N at these locations. The placement of the N rates along the yield response curves for a particular site-year has to be just right to detect differences. If they are placed too high or low differences in response between varieties cannot be detected. For sites where there was a significant response to the enhanced rate of N, there still was no evidence to suggest the yield response between varieties differed (ie: no interactions). However, the optimum N rate at these locations would be higher for malt than feed because of the greater price paid for malt.

Supporting Information

11. Acknowledgements:

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

12. Appendices

Table 8. Estimated marginal means for the main effects and interaction of variety and fertility on plant emergence at individual sites. Means separation is indicated by letters where F-test results were significant at $P < 0.05$. S.E. indicates the standard error.

	Indian Head	Melfort	Outlook	Prince Albert	Scott	Swift Current	Yorkton
<i>Variety</i>		----- plants m ² -----					
AAC Synergy	219	207 a	142 ab	276 a	214 a	161 ab	196 a
AAC Connect	233	171 b	147 ab	239 ab	203 ab	157 b	153 b
CDC Fraser	222	179 ab	169 a	236 b	192 b	179 a	167 ab
CDC Austenson	225	191 ab	165 a	262 ab	198 ab	179 a	166 ab
Claymore	229	178 ab	156 ab	254 ab	205 ab	161 ab	151 b
Oreana	231	182 ab	120 b	247 ab	191 b	163 ab	148 b
<i>Pr(>F)</i>	<i>0.497</i>	0.015	0.018	0.048	0.003	0.015	0.003
<i>S.E.</i>	6.12	10.4	8.47	9.81	4.57	6.00	14.9
<i>Fertility</i>							
Standard	221 b	189	194 a	253	207 a	168	174
Enhanced	232 a	180	109 b	252	194 b	166	153
<i>Pr(>F)</i>	0.036	<i>0.124</i>	<0.001	<i>0.939</i>	<0.001	<i>0.682</i>	0.004
<i>S.E.</i>	3.88	8.68	5.03	6.24	3.16	4.16	13.2
<i>V x F</i>							
AAC Synergy – Standard	211	205	174	271	213	174	214
AAC Connect – Standard	228	178	207	226	203	156	164
CDC Fraser – Standard	211	188	215	227	199	177	181
CDC Austenson – Standard	224	197	199	276	208	172	178
Claymore – Standard	221	177	189	261	213	162	153
Oreana – Standard	233	190	179	254	206	165	155
AAC Synergy – Enhanced	226	210	111	280	214	149	179
AAC Connect – Enhanced	238	164	87.2	252	203	159	142
CDC Fraser – Enhanced	233	170	123	246	184	182	153
CDC Austenson – Enhanced	226	184	132	247	188	185	155
Claymore – Enhanced	237	178	123	248	197	160	149
Oreana – Enhanced	228	174	78.8	240	177	161	140
<i>Pr(>F)</i>	<i>0.641</i>	<i>0.774</i>	<i>0.113</i>	<i>0.276</i>	<i>0.096</i>	<i>0.212</i>	<i>0.831</i>
<i>S.E.</i>	8.43	12.6	11.9	13.5	6.09	8.01	17.1

Table 9. Estimated marginal means for the main effects and interaction of variety and fertility on lodging (log-transformed values) at individual sites where lodging was observed. Means separation is indicated by letters where F-test results were significant at P<0.05. 'S.E.' indicates the standard error.

	Indian Head	Melfort	Outlook	Prince Albert	Swift Current	Yorkton
<i>Variety</i>	----- <i>log (lodging +10)</i> -----					
AAC Synergy	2.47 ab	2.41 b	2.58	2.33 a	2.40 b	2.31
AAC Connect	2.48 ab	2.42 b	2.50	2.30 b	2.40 b	2.30
CDC Fraser	2.45 b	2.40 b	2.59	2.30 b	2.40 b	2.30
CDC Austenson	2.49 a	2.40 b	2.57	2.30 b	2.41 ab	2.30
Claymore	2.40 c	2.44 ab	2.53	2.30 b	2.40 b	2.33
Oreana	2.45 b	2.50 a	2.61	2.30 b	2.43 a	2.34
<i>Pr(>F)</i>	<0.001	0.003	0.590	0.024	0.039	0.085
<i>S.E.</i>	0.012	0.019	0.062	0.006	0.008	0.011
<i>Fertility</i>						
Standard	2.44 b	2.42	2.49 b	2.30	2.41	2.31
Enhanced	2.48 a	2.44	2.64 a	2.31	2.40	2.32
<i>Pr(>F)</i>	<0.001	0.119	<0.001	0.092	0.281	0.068
<i>S.E.</i>	0.009	0.011	0.049	0.003	0.005	0.007
<i>V x F</i>						
AAC Synergy – Standard	2.44 bc	2.40	2.51	2.30 b	2.40	2.30
AAC Connect – Standard	2.46 bc	2.40	2.46	2.30 b	2.40	2.30
CDC Fraser – Standard	2.43 c	2.40	2.52	2.30 b	2.40	2.30
CDC Austenson – Standard	2.45 bc	2.40	2.46	2.30 b	2.42	2.30
Claymore – Standard	2.41 c	2.40	2.44	2.30 b	2.40	2.30
Oreana – Standard	2.44 bc	2.50	2.54	2.30 b	2.44	2.33
AAC Synergy – Enhanced	2.50 ab	2.42	2.66	2.35 a	2.40	2.33
AAC Connect – Enhanced	2.50 ab	2.44	2.54	2.30 b	2.40	2.30
CDC Fraser – Enhanced	2.46 bc	2.40	2.67	2.30 b	2.40	2.30
CDC Austenson – Enhanced	2.53 a	2.40	2.67	2.30 b	2.40	2.30
Claymore – Enhanced	2.40 c	2.48	2.63	2.30 b	2.40	2.35
Oreana – Enhanced	2.45 bc	2.50	2.68	2.30 b	2.42	2.35
<i>Pr(>F)</i>	0.024	0.580	0.952	0.024	0.789	0.498
<i>S.E.</i>	0.015	0.027	0.078	0.008	0.012	0.015

Table 10. Estimated marginal means for the main effects and interaction of variety and fertility on yield at individual sites. Means separation is indicated by letters where F-test results were significant at $P < 0.05$. 'S.E.' indicates the standard error.

	Indian Head	Melfort	Outlook	Prince Albert	Scott	Swift Current	Yorkton
<i>Variety</i>	----- $kg\ ha^{-1}$ -----						
AAC Synergy	7337 bc	5935	5082	6476 ab	3493 a	3037 bc	6853 ab
AAC Connect	7185 c	6123	5299	6975 a	3668 a	3196 ab	7191 a
CDC Fraser	6943 d	5977	4772	7183 a	2930 b	2708 c	6726 abc
CDC Austenson	7553 b	6195	5371	7112 a	3440 ab	3354 ab	6875 ab
Claymore	7909 a	5562	5356	6797 a	3729 a	3353 ab	6194 c
Oreana	7390 bc	5789	6213	5844 b	3892 a	3606 a	6257 bc
<i>Pr(>F)</i>	<0.001	<i>0.437</i>	<i>0.338</i>	0.001	<0.001	<0.001	<0.001
<i>S.E.</i>	<i>81.4</i>	<i>285</i>	<i>514</i>	<i>297</i>	<i>170</i>	<i>120</i>	<i>190</i>
<i>Fertility</i>							
Standard	7092 b	5588 b	5895 a	6813	3571	3252	6542 b
Enhanced	7681 a	6273 a	4803 b	6649	3479	3166	6824 a
<i>Pr(>F)</i>	<0.001	<0.001	0.005	<i>0.367</i>	<i>0.358</i>	<i>0.342</i>	0.026
<i>S.E.</i>	<i>68.7</i>	<i>213</i>	<i>366</i>	<i>237</i>	<i>138</i>	<i>78.7</i>	<i>146</i>
<i>V x F</i>							
AAC Synergy – Standard	6962	5699	5704	6606	4157 a	3101	6724
AAC Connect – Standard	6918	5771	5466	7092	3770 abc	3161	6954
CDC Fraser – Standard	6634	5975	5247	7618	2961 cde	2691	6394
CDC Austenson – Standard	7324	5785	5912	6803	3191 bcde	3414	6547
Claymore – Standard	7655	4752	6388	6753	3471 abcde	3500	6388
Oreana – Standard	7056	5545	6653	6006	3878 ab	3648	6242
AAC Synergy – Enhanced	7711	6171	4460	6346	2829 e	2974	6982
AAC Connect – Enhanced	7452	6475	5132	6859	3565 abcde	3231	7428
CDC Fraser – Enhanced	7252	5980	4298	6747	2898 de	2724	7058
CDC Austenson – Enhanced	7781	6604	4830	7421	3688 abcd	3294	7202
Claymore – Enhanced	8164	6372	4324	6840	3987 ab	3205	6000
Oreana – Enhanced	7724	6034	5773	5683	3907 ab	3564	6272
<i>Pr(>F)</i>	<i>0.412</i>	<i>0.269</i>	<i>0.836</i>	<i>0.305</i>	<0.001	<i>0.879</i>	<i>0.121</i>
<i>S.E.</i>	<i>97.4</i>	<i>366</i>	<i>677</i>	<i>369</i>	<i>209</i>	<i>163</i>	<i>241</i>

Table 11. Estimated marginal means for the main effects and interaction of variety and fertility on protein of malt varieties at individual sites. Means separation is indicated by letters where F-test results were significant at $P < 0.05$. 'S.E.' indicates the standard error.

	Indian Head	Melfort	Outlook	Prince Albert	Scott	Swift Current	Yorkton
<i>Variety</i>	----- Protein (%) -----						
AAC Synergy	11.1 a	10.8 ab	12.6	11.2	13.7	14.9	11.8
AAC Connect	11.1 a	11.2 a	12.8	11.4	14.1	14.6	12.0
CDC Fraser	10.7 b	10.7 b	12.5	11.4	14.6	14.8	11.9
<i>Pr(>F)</i>	0.007	0.049	0.442	0.470	0.078	0.383	0.379
<i>S.E.</i>	0.09	0.21	0.37	0.50	0.44	0.31	0.18
<i>Fertility</i>							
Standard	10.8 b	10.8	11.9 b	11.2	13.6 b	14.4 b	12.0
Enhanced	11.1 a	11.0	13.4 a	11.5	14.7 a	15.2 a	11.8
<i>Pr(>F)</i>	0.013	0.074	<0.001	0.088	0.003	<0.001	0.184
<i>S.E.</i>	0.08	0.20	0.35	0.49	0.41	0.30	0.17
<i>V x F</i>							
AAC Synergy – Standard	10.9	10.8	11.8	11.1	12.4 b	14.6	11.8
AAC Connect – Standard	11.2	10.9	12.1	11.3	13.8 ab	14.3	12.2
CDC Fraser – Standard	10.5	10.6	11.8	11.1	14.4 a	14.3	12.1
AAC Synergy – Enhanced	11.3	10.8	13.5	11.2	14.9 a	15.1	11.8
AAC Connect – Enhanced	11.1	11.5	13.6	11.6	14.4 a	15.0	11.9
CDC Fraser – Enhanced	11.0	10.9	13.2	11.8	14.8 a	15.3	11.8
<i>Pr(>F)</i>	0.091	0.255	0.761	0.536	0.041	0.263	0.450
<i>S.E.</i>	0.13	0.25	0.40	0.53	0.52	0.33	0.20

Table 12. Net increase in Revenue for Malt and Feed Barley from increasing N rates from Standard to Enhanced. ¹				
Site	N increase (lb/ac)	Yield increase (bu/ac)	Net Malt Revenue	Net Feed Revenue
Indian Head	30	11.0	43	34
Melfort	32	12.7	51	41
Yorkton	32	5.2	12	8

¹Values based on \$0.47/lb N, \$5.20/bu Malt and \$4.37/bu Feed from 2021 Saskatchewan Crop Planning Guide.

Table 13. Net increase in Revenue for Malt and Feed Barley from increasing N rates from Standard to Enhanced. ¹				
Site	N increase (lb/ac)	Yield increase (bu/ac)	Net Malt Revenue	Net Feed Revenue
Indian Head	30	11.0	38	32
Melfort	32	12.7	47	41
Yorkton	32	5.2	-3	-5
¹ Values based on \$1.18/lb N, \$6.67/bu Malt and \$6.16/bu Feed from 2023 Saskatchewan Crop Planning Guide.				

Abstract

13. Abstract/Summary:

Trials were conducted in 2022 at Yorkton, Indian head, Outlook, Melfort, Swift Current, Prince Albert and Scott to determine the responsiveness of 3 malt and 3 feed barley varieties to “standard” and “enhanced” rates of N. Depending on the yield potential of the location, standard rates varied from 100 to 130 lb/ac of soil + fertilizer N and enhanced rates varied from 125 to 162 lb/ac of soil + fertilizer N. However, N rate comparisons were higher than desired at Melfort, Prince Albert and Swift Current due to high levels of residual soil N. Levels of lodging were very low in this study, however, there were a few instances where lodging was increased with the enhanced rate of N. CDC Fraser was the lowest yielding variety at Indian, Scott and Swift Current. However, the ranking of varieties did vary between sites. Yield did not respond to the enhanced rate of N at Swift Current, Scott and Prince Albert. This was due to drought at Swift Current and Scott and likely higher than desired N rate comparisons at Swift Current and Prince Albert. At Outlook, yield was reduced when the N rate was increased due to seed safety issues that substantially reduced crop emergence. Since there was not a positive yield response to increased N or interactions between variety and N rate, no conclusions regarding the relative yield response between varieties could be made. At Indian Head, Melfort and Yorkton, yield significantly responded to the enhanced rate of N. The enhanced rate of N proved to be economical at all locations based on economic assumptions from the 2021 Saskatchewan Crop Planning Guide. However, the enhanced rate of N did not prove economical at Yorkton under the poorer economic assumptions provided in the 2023 Guide. Again, there were no N by variety interactions detected so there was no evidence to suggest most economic rate of N would differ within feed varieties or within malt varieties. However, the most economic rate of N would be higher for the malt varieties due to the greater value of malt.