2022 Final Report

from the

East Central Research Foundation

Project Title: Barley MAX Experiment 1 & 2
SFP #20190403

Principal Investigators:

Mitchell Japp[1], Shannon Chant[2], Mike Hall[3], Heather Sorestad[3] Robin Lokken[4], Brianne McInnes[5], Jessica Enns[6], Kayla Slind[6] Bryan Nybo[7] and Amber Wall[7]

[1]Saskatchewan Barley Development Commission
[2]Saskatchewan Ministry of Agriculture, Swift Current, SK.
[3]East Central Research Foundation, Yorkton, SK.
[4]Conservation Learning Centre, Prince Albert, SK
[5]Northeast Agriculture Research Foundation, Melfort, SK
[6]Western Applied Research Corporation, Scott, SK

[7]Wheatland Conservation Area Inc., Swift Current, SK

Project Identification

1. **Project Number:** SFP #20190403
2. **Producer Group Sponsoring the Project:** Saskatchewan Barley Development Commission
3. **Project Location(s):** Yorkton, Melfort, Prince Albert, Scott, and Swift Current, SK
4. **Project start and end dates (month & year):** April 2020 to February 2023
5. **Project contact person & contact details:**

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:**

New barley varieties offer higher yields, improved disease resistance and increased straw strength to prevent lodging compared to older varieties. Standard management practices for older varieties may not be suitable to maximize the opportunity for increased production with these varieties. In addition, new barley varieties have improved agronomics that will allow producers to increase nitrogen rates to achieve higher yields, while maintaining malt quality protein levels. The study consists of two separate experiments. Experiment 1 will determine the optimum agronomic package for new varieties in comparison to a recent industry standard variety. Experiment 2 will determine optimum nitrogen fertilizer recommendations for production of new malt barley varieties in comparison to a recent industry standard variety.

7. **Project Rationale:**

Western Canadian barley acres have shrunk by more than 50 per cent in the past 20 years. With the lowest rate of gain among major crops and competition with other low-cost feed options, fewer producers are choosing to grow barley. Yet, there remains optimism that barley can be competitive with other cropping options.

Compared to other crop types, the acceptance of new varieties with improved disease resistance and higher yields is limited. As a result, the majority of barley production is with 20-year-old technology. There are strong indications that the industry is shifting to newer varieties with improved agronomics, but the optimum agronomic input packages are not known for these newer varieties.

Barley is generally either malt or feed, with a significant price difference sometimes in place. As a result, producers are incentivized to manage for malt and sacrifice yield in order to do so. Research is needed to help producers increase their yields, while maintaining malt quality.

Significant advancements in barley agronomy were made under one of the recent barley clusters, but the inputs investigated have not been looked at in a comprehensive package in Saskatchewan, with the most up-to-date varieties.

8. Methodology:

Trials were established from 2020-2022. Both experiments were conducted at Melfort, Prince Albert, Swift Current and Yorkton. The Scott location only participated in experiment 1. Experiment 1 was a 2-order factorial with 4 replicates. The first factor compared the malt varieties AC Metcalfe, AAC Synergy and CDC Bow. The second factor evaluated 7 levels of increasing management. Seeding rates, fertilizer applications, PGR and fungicide varied between management levels as described in Table 1a. Nitrogen applications were adjusted to meet target rates of soil (0-24”) + applied N. This means rates of applied N varied between locations as residual soil N varied between locations.

Each trial was setup as a 2-order factorial with 4 replicates. The malt barley varieties AC Metcalfe, AAC Synergy and CDC Bow were each tested at 60, 120, 180 and 240 lb/ac of soil + fertilizer N (Table 1b). Originally, the N values were supposed to be in kg/ha but a mistake in the protocol sent to sites used lb/ac and we have maintained these units between site-years for consistency. The background level of soil N in the top 12 inches varied between location and these levels were taken into consideration when determining rates of applied fertilizer N. Each location also applied 26.8 lb P_2O_5/ac and 13.4 lb K_2O/ac with every treatment.

For both experiments, plot size and row spacing varied between locations depending on available equipment. Where possible, only the middle section of plots were harvested with a small plot combine to avoid edge effects. Herbicides and insecticides were applied at the discretion of the site manager to ensure adequate control of pests. Dates of key operations for 2020-2022 at each site are listed in Tables 2a-4a for experiment 1 and Tables 2b-4b for experiment 2.   Note that PGR application was missed at Prince Albert in 2021 for experiment 1.

Table 1a. Treatment List for the "Barley MAX Experiment 1" Trial									
Trt #	**Variety**	**Seeding Rate**	**Seed Trt**	**N (soil + fert)**	**P**	**K**	**PGR**	**Flag Leaf fung.**	**FHB fung.**
1	AC Metcalfe	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
2	AC Metcalfe	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
3	AC Metcalfe	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
4	AC Metcalfe	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
5	AC Metcalfe	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
6	AC Metcalfe	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
7	AC Metcalfe	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes
8	AAC Synergy	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
9	AAC Synergy	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
10	AAC Synergy	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
11	AAC Synergy	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
12	AAC Synergy	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
13	AAC Synergy	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
14	AAC Synergy	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes
15	CDC Bow	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
16	CDC Bow	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
17	CDC Bow	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
18	CDC Bow	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
19	CDC Bow	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
20	CDC Bow	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
21	CDC Bow	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 1b. Treatment List for "Barley MAX Experiment 2" Trial		
Treatmen t #	**Variety**	**N (Soil + fert)**
1	AC Metcalfe	Background N
2	AC Metcalfe	60 lb N/ac
3	AC Metcalfe	120 lb N/ac
4	AC Metcalfe	180 lb N/ac
5	AC Metcalfe	240 lb N/ac
6	AAC Synergy	Background N
7	AAC Synergy	60 lb N/ac
8	AAC Synergy	120 lb N/ac
9	AAC Synergy	180 lb N/ac
10	AAC Synergy	240 lb N/ac
11	CDC Bow	Background N
12	CDC Bow	60 lb N/ac
13	CDC Bow	120 lb N/ac
14	CDC Bow	180 lb N/ac
15	CDC Bow	240 lb N/ac

Table 2. Dates of operations for the 2020 "Barley MAX Experiment 1" trial.

Operations in 2020	**Melfort**	**Prince Albert**	**Scott**	**Swift Current**	**Yorkton**
Pre-seed Herbicide Application	**May 24** (Heat LQ + Glyphosate)	N/A	**May 15** (Glyphosate + AIM)	**May 4** (Glyphosate + AIM + Merge)	N/A
Seeding Date + Seed Treatment	**May 22** (Raxil Pro)	**May 23** (Raxil Pro)	**May 18** (Raxil Pro)	**May 16** (Raxil Pro)	**May 8** (Raxil Pro)
Emergence Counts	**June 11**	**June 9**	**June 10**	**May 28**	**May 28**
In-crop Herbicide	**June 23** (Prestige XC) & July 3 (Axial)	**June 10** (Infinity)	**June 15** (Axial Ipak)	**May 29** (Liquid Achieve + Buctril M + Turbocharge)	**June 2** (Prestige) & June 8 (Axial)
Plant Growth Regulator Application	**July 3** (Moddus)	**June 22** (Moddus)	**June 19** (Moddus)	**June 16** (Moddus)	**June 16** (Moddus)
Flag Leaf Fungicide Application	**July 11** (Trivapro)	**July 3** (Trivapro)	**July 6** (Trivapro)	**June 24** (Trivapro)	July **1** (Trivapro)
Heading Date	**July 22**	**July 13-24**	**July 14-20**	**July 21**	**July 6**
Fusarium Head Blight Fungicide Application	**July 24** (Caramba)	**July 22** (Caramba)	**July 20** (Caramba)	**July 21** (Caramba)	**July 13** Caramba
Days to Maturity	**Aug 17**	**Aug 13-22**	**Aug 10-18**	**Aug 6**	**July 30**
Heads Counts	**Aug 4**	**N/A**	**N/A**	**Aug 10**	**N/A**
Kernel/Head Counts	**Aug 12**	**N/A**	**N/A**	**Aug 25**	**N/A**
Lodging Rating	**Sept 1**	**Sept 2**	**Aug 14**	**N/A**	**N/A**
Harvest	**Sept 1**	**Sept 4 & 9**	**Aug 25**	**Aug 17**	**Aug 24**

Table 3. Dates of operations for the 2021 "Barley MAX Experiment 1" trial.					
Operations in 2021	**Melfort**	**Prince Albert**	**Scott**	**Swift Current**	**Yorkton**
Pre-seed Herbicide Application	**May 14** (Glyphosate + Heat LQ)	**N/A**	**May 16** (Glyphosate +AIM)	**May 3** (Glyphosate + AIM + Merge)	**N/A**
Seeding Date + Seed Treatment	**May 10** (Raxil PRO)	**May 22** (Raxil PRO)	**May 17** (Raxil PRO)	**May 11** (Raxil PRO)	**May 10** + (Raxil PRO)
Emergence Counts	**June 1**	**June 14**	**June 9**	**June 9**	**June 4**
In-crop Herbicide	**June 8** (Prestige) **June 22** (Axial)	**June 15** (Dyvel)	**June 13** (Axial Ipak) **June 24** (Buctril M)	**June 7** (Liquid Achieve + Buctril M + Turbocharge)	**June 7** (Prestige) **June 16** (Axial)
Plant Growth Regulator Application	**June 18** (Moddus)	**N/A***	**June 24** (Moddus)	**June 22** (Moddus)	**June 16** (Moddus)
Flag Leaf Fungicide Application	**July 5** (Trivapro)	**July 5** (Trivapro)	**July 5** (Trivapro)	**June 29** (Trivapro)	**June 28** (Trivapro)
Heading Date	July 12	July 19	July 29 – Aug 3	July 19	July 16
Fusarium Head Blight Fungicide Application	**July 13** (Caramba)	**July 16** (Caramba)	**July 22** (Caramba)	**July 20** (Caramba)	**July 14** (Caramba)
Days to Maturity	**Aug 4**	**Aug 25**	**Aug 9 -11**	**Aug 7**	**July 26**
Heads Counts	**July 23**	**N/A**	**N/A**	**July 23**	**N/A**
Kernel/Head Counts	**July 23**	**N/A**	**N/A**	**Aug 30**	**N/A**
Lodging Rating	**Aug 13**	**Sept 8**	**Aug 9**	**N/A**	**N/A**
Harvest	**Aug 13**	**Sept 8**	**Aug 16**	**Aug 30**	**Aug 27**

* The PGR application was missed at Prince Albert in 2021

Table 4. Dates of operations for the 2022 "Barley MAX Experiment 1" trial.					
Operations in 2022	**Melfort**	**Prince Albert**	**Scott**	**Swift Current**	**Yorkton**
Pre-seed Herbicide Application	**May 12** (Liquid Avadex) **May 21** (RoundUp Transorb HC 0.67L/ac)	**May 21** (Roundup Transorb @ 1L/ac)	**May 9** (Glyphosate +AIM)	**May 12** (Glyphosate + Aim)	**None**
Seeding Date + Seed Treatment	**May 23** (Raxil Pro)	**June 2** (Raxil Pro)	**May 13** (Raxil Pro)	**May 17** (Raxil Pro)	**May 23** (Raxil Pro)
Emergence Counts	**June 13**	**June 23**	**June 3**	**June 15**	**June 6 & 7**
In-crop Herbicide	**June 23** (Axial + Prestige XC)	**June 28** (Infinity + Puma Advance)	**June 16** (Axial Ipak) **June 22** (Buctril M)	**June 8** (Liquid Achieve + Buctril M)	**June 8** (Akito & Axial separate passes)
Plant Growth Regulator Application	**June 28** (Moddus)	**July 6** (Moddus)	**June 16** (Moddus)	**June 28** (Moddus)	**June 20** (Moddus)
Flag Leaf Fungicide Application	**July 8** (Trivapro)	**July 14** (Trivapro)	**July 4** (Trivapro)	**July 6** (Trivapro)	**July 6** (Trivapro)
Heading Date	**July 25-27**	*	**July 14**	**July 15**	*
Fusarium Head Blight Fungicide Application	**July 22** (Caramba)	**July 27** (Caramba)	**July 14** (Caramba)	**July 27** (Caramba)	**July 20** (Caramba)
Days to Maturity	**Aug 22-Sept 1**	**Various**	**Aug 5-10**	**Aug 5**	**August 12**
Heads Counts	**Aug 5**	**NA**	**NA**	**Aug 8**	**NA**
Kernel/Head Counts	**Aug 5**	**NA**	**NA**	**Sept**	**NA**
Lodging Rating	**Sept 15**	**Aug 22**	**Aug 18**	**Aug 15**	**Sept 6**
Harvest	**Sept 15**	**Sept 6**	**Aug 18**	**Aug 17**	**Sept 6**

* Heading date was missed at two locations in 2022

Table 2a. Dates of operations for 2020 "Barley MAX Experiment 2" trial.				
Operations in 2020	**Melfort**	**Prince Albert**	**Swift Current**	**Yorkton**
Pre-seed Herbicide Application	**May 24** (Heat LQ + Glyphosate 540)	**N/A**	**May 4** (Glyphosate + AIM + Merge)	**N/A**
Seeding Date	**May 22**	**May 23**	**May 16**	**May 8**
Emergence Counts	**June 12**	**June 9**	**May 28**	**May 27**
In-crop Herbicide	**June 23** (Prestige XC) **July 3** (Axial)	**June 10** (Infinity)	**May 29** (Liquid Achieve + Buctril M & Turbocharge)	**June 2** (Prestige) & June 8 (Axial)
Fungicide	**July 24** (Prosaro)	**July 21** (Twinline)	**N/A**	**July 1** (Trivapro A &B)
Heading Date	**July 22**	**July 17-20**	**July 21**	**July 6**
Days to Maturity	**Aug 17-21**	**Aug 13-20**	**Aug 6**	**July 30**
Lodging Rating	**Aug 31**	**Sept 2**	**N/A**	**N/A**
Harvest	**Sept 15**	**Sept 9**	**Aug 18**	**Aug 20**

Table 3a. Dates of operations for 2021 "Barley MAX Experiment 2" trial.				
Operations in 2021	**Melfort**	**Prince Albert**	**Swift Current**	**Yorkton**
Pre-seed Herbicide Application	**May 14** (Glyphosate 540 + Heat)	**N/A**	**May 3** (Glyphosate + AIM +Merge)	**N/A**
Seeding Date	**May 10**	**May 22**	**May 11**	**May 11**
Emergence Counts	**June 2**	**June 8**	**June 9**	**June 4**
In-crop Herbicide	**June 8** (Prestige) **June 22** (Axial)	**June 15** (Dyvel)	**June 7** (Liquid Achieve + Buctril M + Turbocharge)	**June 7** (Prestige) **June 16** (Axial)
Fungicide	**N/A**	**N/A**	**N/A**	**June 28** (Trivapro A +B)
Heading Date	**July 12**	**July 19**	**July (various)**	**July 16**
Days to Maturity	**Aug 3**	**Aug 25**	**Aug (various)**	**July 26**
Lodging Rating	**N/A**	**Aug 17 & Sept 8**	**N/A**	**N/A**
Harvest	**Aug 11**	**Sept 8**	**Aug 30**	**Aug 27**

Table 4a. Dates of operations for 2022 "Barley MAX Experiment 2" trial.				
Operations in 2022	**Melfort**	**Prince Albert**	**Swift Current**	**Yorkton**
Pre-seed Herbicide Application	**May 12** (Liquid Avadex 1.2L/ac) **May 21** (Roundup Transorb HC 540 g)	**May 21** (Roundup Transorb @ 1L/ac)	**May 12** (Glyphosate + Aim + Merge)	**None**
Seeding Date	**May 16**	**June 2**	**May 17**	**May 23**
Emergence Counts	**June 7**	**June 22-23**	**June 15**	**June 6**
In-crop Herbicide	**June 22** (Axial) **June 28** (Prestige XC)	**June 28** (Infinity + Puma Advance)	**June 8** (Liquid Achieve + Buctril M)	**June 8** (Akito and Axial separate passes)
Fungicide	**July 18** (Caramba)	**None**	**none**	**July 6** (Trivapro AB)
Heading Date	**July 20**	**Various**	**Various**	**n/a**
Days to Maturity	**Aug 16 -22**	**Various**	**Various**	**Aug 12**
Lodging Rating	**Aug 24**	**Aug 22**	**NA**	**Sept 6**
Harvest	**Sept 8**	**Sept 2**	**Aug 17**	**Sept 6**

9. Results:

Growing Season Weather

Mean monthly temperatures and precipitation amounts with long-term (1981-2010) averages for 5 sites are listed in Table 5 and 6. In 2020, seasons were warmer than the long-term average at Yorkton and Swift Current and cooler at Prince Albert. Melfort and Scott experienced near normal temperatures. Precipitation was near normal at most locations except Yorkton, which experienced drought withonly 66% of average long-term precipitation received. In 2021, temperatures were well above the long-term average at all locations and drought was widespread. Melfort, Prince Albert, Scott, Swift Current and Yorkton only received 61%, 72%, 66%, 74% and 54% of long-term average precipitation, respectively. In 2022, temperatures were near normal in Melfort and Prince Albert. Yorkton experienced above average temperature and temperatures were well above average at Scott and Swift Current where drought was experienced. Precipitation was well below average at

Scott and Swift Current but the remaining sites received adequate to excellent levels of precipitation. The Yorkton site experienced hail in 2022, but the crop recovered.

Table 5. Mean monthly temperatures and long-term (1981-2010) normals for the 2020, 2021 and 2022 growing seasons at 5 sites in Saskatchewan.

Location	**Year**	**May**	**June**	**July**	**August**	**Avg. / Total**
		-------------------*Mean Temperature (°C)* ----------------				
Melfort	2020	10.1	14.3	18.8	17.6	15.2
	2021	9.6	18.2	20.1	16.9	16.2
	2022	9.9	15.2	18.2	18.7	15.5
	Long-term	***10.7***	***15.9***	***17.5***	***16.8***	***15.2***
Prince Albert	2020	9.2	13.4	17.6	16.1	14.1
	2021	10.1	18.3	20.3	17.0	16.4
	2022	10.5	15.5	18.3	18.5	15.7
	Long-term	***11.4***	***15.9***	***18.5***	***17.1***	***15.7***
Scott	2020	10.2	14.6	17.1	16.0	14.5
	2021	8.9	17.3	19.6	17.2	15.8
	2022	10	15	18.3	18.9	15.6
	Long-term	***10.8***	***14.8***	***17.3***	***16.3***	***14.8***
Swift Current	2020	*10.9*	*16.6*	*18.2*	*19.5*	*16.3*
	2021	9.5	18.4	21.7	18.0	16.9
	2022	10.9	15.9	19.8	20.9	16.9
	Long-term	***10.9***	***15.3***	***18.2***	***17.6***	***15.5***
Yorkton	2020	10.5	16.4	19.9	18.3	16.3
	2021	8.9	19.1	21.0	17.3	16.5
	2022	10.6	15.7	18.6	18.9	16
	Long-term	***10.4***	***15.5***	***17.9***	***17.1***	***15.2***

Table 6. Precipitation amounts along with long-term (1981-2010) normals for the 2020, 2021 and 2022 growing seasons at 5 sites in Saskatchewan.

		--------------------- *Precipitation (mm)* -------------------				
Melfort	2020	26.7	103.7	52.4	18.5	201.3
	2021	31.4	37.6	0.2	69.3	138.5
	2022	90.8	78.1	34.9	36.5	240.3
	Long-term	***42.9***	***54.3***	***76.7***	***52.4***	***226.3***
Prince Albert	2020	68.4	91.4	32.2	33.2	225.2
	2021	30.1	80.3	8.6	59.9	178.9
	2022	17.9	75.7	63.7	37.8	195.1
	Long-term	***40.4***	***79.6***	***84.6***	***42.9***	***247.5***
Scott	2020	48.3	70.2	129.4	25.8	273.7
	2021	43.9	43.8	10.4	51.3	150.1
	2022	11	57.1	86.5	32.1	186.7
	Long-term	***38.9***	***69.7***	***69.4***	***48.7***	***226.7***
Swift Current	2020	36.3	80.0	62.5	6.5	185.3
	2021	35.0	29.6	38.9	55.8	159.3
	2022	51.2	37.7	90.4	7.5	187
	Long-term	***44.1***	***74.5***	***51.9***	***43.2***	***213.7***
Yorkton	2020	16.7	33.6	80.1	49.3	179.7
	2021	24.6	18.1	35.2	69.7	147.6
	2022	137.9	57.9	38.4	90.8	325
	Long-term	***51***	***80***	***78***	***62***	***272***

Soil test results for all sites from 2020 to 2022 are presented in Table 7a for experiment 1 and 7b for experiment 2. For experiment 1, levels of soil N were moderate at Scott (2020-2022) and Swift Current (2020-2021). High levels of soil N were present at Yorkton (2020), Melfort (2020-2021), and Prince Albert (2020-2021). Yorkton had a drought in 2020, so soil N was very high the following year in 2021. In 2021 drought was widespread across the prairies and all sites except Scott had very high levels of soil N in 2022.

For experiment 2, background soil N for Melfort (2020-2022), Prince Albert (2020-2021), and Yorkton (2020-2021) exceeded the 60 lb N/ac treatment. Thus, no additional N was added to this treatment for these locations and it had the same N fertility level as background N treatment. At Prince Albert and Swift Current in 2022, soil N exceed 120 lb/ac so no additional N would have been added to the 60 and 120 lb N/ac treatments. In other words, the background N, 60 lb N/ac and 120 lb N/ac treatments were all at the same level of fertility for these treatments. Rate of soil + fertilizer N were consistent for 180 and 240 lb/ac levels between all locations.

Table 7a. Soil Test Nitrate, Phosphorus and Potassium Levels for each location in 2020, 2021 and 2022.

Nitrate Levels (lbs NO_3-N/ac)	Melfort	Prince Albert	Scott	Swift Current	Yorkton
2020					
0-15cm (0-6in)	21	18	14	20	27
15-30cm (6-12in)	24	28		11	23
15-60cm (6-24in)			21		
30-60cm (12-24in)					10
Total N 0-30cm (0-12in)	45	46		31	
Total N 0-60cm (0-24in)	68 est.	69 est.	35	47est.	60
Phosphorus (Olsen) ppm	12	8	8	20	10
Potassium ppm	469	197	295	482	266
2021					
0-15cm (0-6in)	34	18	13	14	
15-30cm (6-12in)	28	28			
15-60cm (6-24in)			18	44	
30-60cm (12-24in)					18
Total N 0-30cm (0-12in)	62	46			74
Total N 0-60cm (0-24in)	93	69 est.	31	44	92
Phosphorus (Olsen) ppm	10	8	6	13	6
Potassium ppm	511	197	293	292	213
2022					
0-15cm (0-6in)	52	52	16	9	23
15-30cm (6-12in)	46	42	8		
15-60cm (6-24in)				150	81
30-60cm (12-24in)			8		
Total N 0-30cm (0-12in)		94			
Total N 0-60cm (0-24in)	147 est.	141 est.	32	159	104
Phosphorus (Olsen) ppm	13	5	6	7	10
Potassium ppm	453	242	289	274	238

Table 7b. Soil Test Nitrate Levels for each location (lb/ac) in 2020, 2021 and 2022.				
Nitrate Levels (lbs NO_3-N/ac)	**Melfort**	**Prince Albert**	**Swift Current**	**Yorkton**
2020				
0-15cm (0-6in)	21	18	20	15
15-30cm (6-12in)	24	28	11	10
15-60cm (6-24in)				
30-60cm (12-24in)				
Total 0-60cm (0-24in)	67 est.	69 est.	47 est.	38 est.
2021				
0-15cm (0-6in)	34	21	14	22
15-30cm (6-12in)	28			
15-60cm (6-24in)		33	30	29
30-60cm (12-24in)				
Total 0-60cm (0-24in)	93 est.	54	44	77 est.
2022				
0-15cm (0-6in)	21	50	9	23
15-30cm (6-12in)	23	42		
15-60cm (6-24in)			150	81
30-60cm (12-24in)				
Total 0-60cm (0-24in)	66 est.	138 est.	159	104

Experiment 1 Discussion of Results

The following guidelines may be of service when trying to interpret the effects of management.

- Management "A" vs "B"- a lower "A" suggests a positive response to either increasing seeding rate, increasing N, increasing P, added K or some combination of these inputs.
- Management "B" vs "C" – a lower "B" suggests a positive response to seed treatment
- Management "D" vs "E" – a lower "D" suggests a positive response to increasing N
- Management "C" vs "E" – a lower "C" suggests a positive response to FHB fungicide
- Management "E" vs "F" – a lower "E" suggests a positive response to PGR
- Management "F" vs "G" – a lower "F" suggests a positive response to fungicide at flag leaf

For statistical analysis, trials were grouped into high and low yielding site-years. The high yielding group consisted of Scott (2020), Swift Current (2020), Prince Albert (2020-2022), Melfort (2020-2022) and Yorkton (2022). The low yielding group consisted of Yorkton (2020-2021), Swift Current (2021-2022) and Scott (2021-2022). The low yielding group averaged 2078 kg/ha (39 bu/ac) at 15.7% protein and the high yielding group averaged 4637 kg/ha (86.2 bu/ac) at 11.3% protein. The site-years were separated into groups to highlight how environment affects the response of barley to management intensity. The impact of variety and management on barley emergence, maturity, lodging and yield are summarized in Tables 8 and 9 in the appendix for the high and low yielding sites, respectively. Seed quality parameters in the tables include grain protein, thins, plumps, 1000 kernel weight, 4 ml and 8 ml germination tests. Mean separations for the seed quality parameters are not presented as each value is based on a single sample bulked over 4 replications. Individual site-year analyses are found in the appendix (Tables 10-27). At Melfort and Swift Current, additional measurements of kernels/head and heads/m^2 were recorded from 2020-2022 (Tables 25-27)

<u>Emergence</u>

Crop emergence varied between sites. For the low yielding group, average emergence varied from a low of 147 plants/m^2 at Swift Current (2021) to a high of 261 plants/m^2 at Yorkton (2020). For the high yielding group, average emergence varied from 160 plants/m^2 at Scott (2020) to 278 plants/m^2 at Yorkton 2022. On average, increasing seeding rate from 200 to 300 seeds/m^2 increased plant populations from 164 to 215 plants/m^2 for the high yielding group and from 150 to 200 plants/m^2 for the low yielding group. Emergence rates between varieties did not differ greatly for most site-years, however, there were a few exceptions. Emergence for AAC Synergy was significantly lower than the other varieties by about 50 plants/m^2 at Prince Albert in 2021 (Table 14). This likely reduced the yield potential of AAC Synergy as it was the lowest yielding variety and typically it would be the highest. At Prince Albert (2022) emergence rates varied greatly between varieties, from a low of 138 plants/m^2 for CDC Bow to a high of 306 plants/m^2 for AC Metcalfe (Table 15). But, there was a significant variety by management interaction for the emergence and yield data. For CDC Bow, seed treatment greatly reduced emergence from 262 to 105 plants/m^2 which in turn was associated with a yield decline of 609 kg/ha (11.3 bu/ac). Seed treatment did not adversely affect the yield of the other varieties (data not shown). Having only CDC Bow affected by seed treatment is an unusual result and an explanation for this is unclear. It is possible human error with calibration may be at fault. Emergence rates were a bit variable between varieties at Swift Current in 2021 (Table 20) and Yorkton in 2022 (Table 24) and may have had modest effects on yield potential and the relative yield between varieties.

For the vast majority of site-years, emergence was unaffected by seed treatment (B vs C management). However, there were a few exceptions. At Melfort (2020) and Prince Albert

(2022), seed treatment significantly reduced crop emergence (Tables 10 and 15). This is not an uncommon observation when seedling disease levels are low. There may have been some phytotoxic effects of seed treatment, particularly if the product was not applied evenly on seed. While every effort is made to apply seed treatment evenly to small batches of seed, the uniformity of coverage may have been inferior to what commercial seed treaters can accomplish.

Maturity

For the high yielding group, maturity of CDC Bow was significantly longer than the other two varieties (Table 8). For the low yielding group, the maturity of CDC Bow was again significantly longer than the other two varieties and the maturity of AAC Synergy was significantly longer than AC Metcalfe (Table 9). While significant differences in maturity were detected between varieties, the differences were not large enough to be of agronomic concern.

For the low and high yielding groups, increasing seeding rate from 200 to 300 seeds/m^2 significantly hastened maturity by 1-2 days (A vs B management, Tables 8 & 9). While there were also fertility differences between management A and B, the increase in N would have delayed maturity. Thus increasing seeding rate was likely the cause of hasten maturity, which is a well known phenomenon. Application of PGR significantly delayed maturity by a day (E vs F management, Tables 8 & 9) for both low and high yielding groups. This too was anticipated. For the low yielding group, seed treatment (B vs C management) and increasing N (D vs E management) significantly delayed maturity by less than a day (Table 9). Increasing N (D vs E management) also significantly delayed maturity by less than a day for the high yielding group (Table 8).

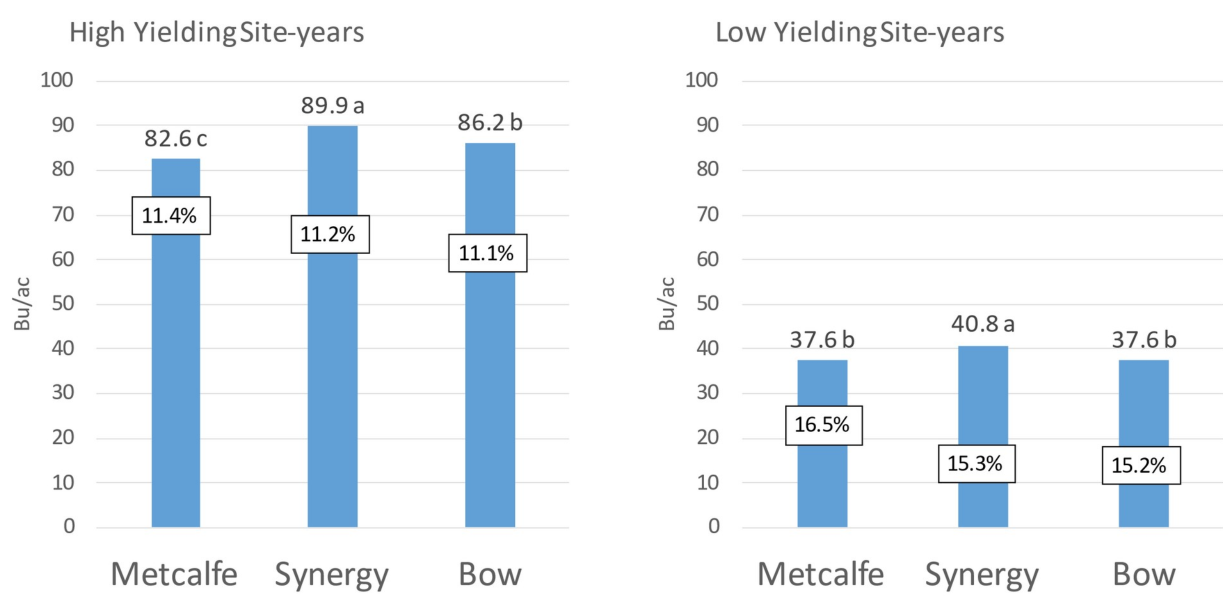
Lodging

For the low yielding group, levels of lodging were extremely low and significant differences between varieties or levels of management were not detected (Table 9). For the high yielding group, lodging was greater but still very low. Lodging was significantly greater for Metcalfe compared to CDC Bow (Table 8). While the differences in lodging were small and inconsequential between varieties, their relative standing is supported by regional information that rates Metcalfe and CDC Bow as having “Fair” and Very Good” resistance to lodging, respectively. The use of PGR significantly reduced lodging, but only for the high yielding group (E vs F management, Table 8).

Yield and Grain Protein

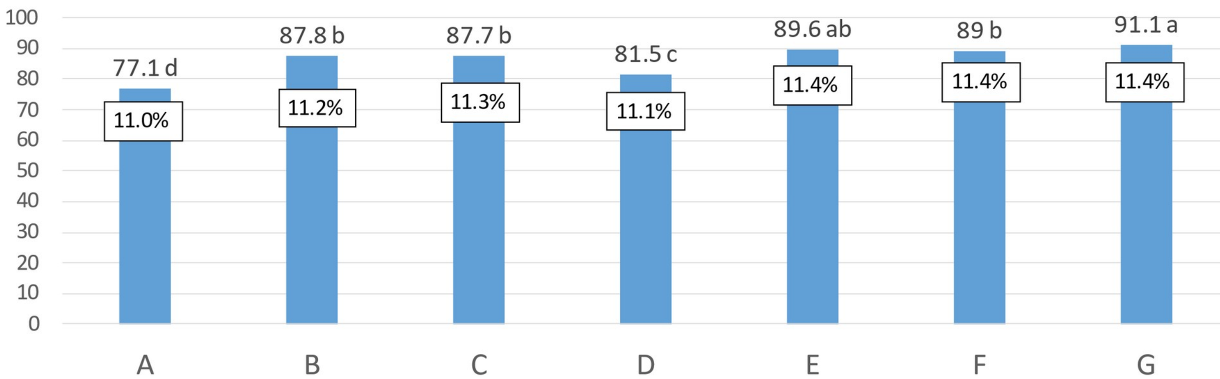
For the high yielding group, AAC Synergy was significantly higher yielding than CDC Bow which was significantly higher yielding than AC Metcalfe (Figure 1; Table 8). AAC Synergy was 8.8% higher yielding than AC Metcalfe which was less than expected based on provincial seed guide information. For the low yielding group, AAC Synergy was higher yielding than the other varieties, which did not statistically differ from each other (Figure 1; Table 9). AC Metcalfe had the highest grain protein for both low and high yielding groups and this is largely due to its lower yield potential.

Figure 1. Main Effect of Variety on Barley Yield and % Grain Protein



The effect of management on yield and grain protein differed somewhat between the low and high yielding groups. Focusing first on the high yielding group, there was no yield response to seed treatment (B vs C management, Figure 2; Table 8) as root disease pressure was not high over the course of this study. Increasing soil + fertilizer N from 90 kg/ha to 120 kg/ha significantly increased yield by 435 kg/ha (8.1 bu/ac) and grain protein was increased by 0.3% (D vs E management). While not statistically significant, the application of fungicide at the fusarium head blight timing numerically increased yield by 102 kg/ha (1.9 bu/ac) (C vs E management). However, the addition of fungicide at the flag leaf timing to treatments receiving PGR and FHB fungicide significantly increase yield by 114 kg/ha (2.1 bu/ac) (F vs G management). There was no significant yield response to PGR (E vs F management) as lodging was only minor and not enough to affect yield.

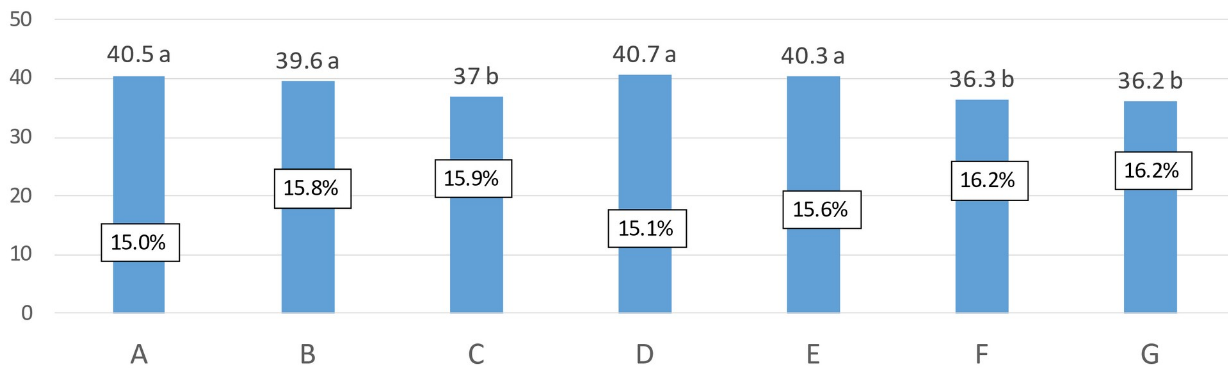
Figure 2. Main Effectsof Management on BarleyYield and % Grain Protein for High YieldingSite-years



Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m^2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m^2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m^2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m^2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m^2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m^2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m^2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Focusing on the low yielding group, a comparison between management B and C would suggest seed treatment significantly reduced yield (Figure 3; Table 9). However, the author suspects this affect is not real as management D also has seed treatment but a higher yield which is not likely the result of applying fungicide for FHB during a drought. For some reason the yield for management C was unexpectedly low. An unusually low yield value for management C when compared with E also gives the impression that there was a significant yield response to fungicide at FHB timing. Again, not a likely outcome for droughted locations. A comparison between management F and G finds the additional application of fungicide at flag leaf timing to treatments receiving fungicide at FHB timing did not further increase yield as was observed with the high yielding group. A comparison between management E and F suggests there was a significant yield decrease in response to PGR. Anecdotally, PGR during drought has been associated with yield loss and the label for the PGR used in the study indicates that it should not be applied during stressful conditions. There is no reason to reduce crop growth with PGR during a drought, as the risk of lodging is very low. In contrast to the high yielding group, increasing the rate of soil + fertilizer N for the low yielding group from 90 to 120 kg/ha did not affect yield (D vs E management). Numerically, management A with the lowest levels of inputs produced the second highest yield and none of the higher levels of management produced a significantly greater yield. To be fair, the lower seeding rate may have actually been a benefit to yield under drought conditions. However, none of the management inputs beyond increasing seed rate had a significantly positive affect on yield (management B vs C-G). The least amount of inputs was most economical for the low yielding group. As a whole, the low yielding group would not have made malt due to excessive grain protein.

Figure 3. Main Effects of Management on Barley Yield and % Grain Protein for Low Yielding Site-years



Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m^2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m^2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m^2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m^2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m^2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m^2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m^2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

<u>Other seed quality factors</u>

Other seed quality factors measured included thins, plumps, 1000 kwt, 4 ml energy germination and 8 ml water sensitive germination. Overall, thins and plumps were acceptable for the low and high yielding groups (Tables 8 and 9). High levels of plumps are desirable because plump kernel contain more starch. However, there appeared to be fewer plumps and more thins when PGR was used for the low yielding group during drought. This trend was not observed for the high yield group. High 4 ml germination rates above 95% are desirable to maximize the fermentation process. Eight ml germination rates which are considerable lower than the 4 ml indicate water sensitivity and adjustments to the brewing process would need to be made. Germination rates (4 ml) were almost 10% higher on average for the high yield group compared to the low yield group. However, most site-years had germination rates which were acceptable for malt (>95%), apart from the following exceptions. Germinations (4 ml) at Prince Albert (2020) were only 70.6%, 58.4% and 22.9% for AC Metcalfe, AAC Synergy and CDC Bow, respectively (Table 13). At Swift Current (2020-21) and Yorkton (2022), CDC Bow was the only variety which had a germination below the 95% level acceptable for malt. In 2021, 4 ml germinations were in the low 80s percentile for all varieties (Table 14). At Yorkton (2021), 4 ml germinations were below 15% for all varieties (Table 23). Site-years with poor germ were not always associated with low yields. However, CDC Bow often had a lower germination than the other varieties. Germination was a little lower for CDC Bow compared to the other varieties for both high and low yielding groups (Table 8 and 9). However, management did not appear to have a substantial impact on 4 ml germination. Eight ml germination rates were lower for both groups but the decline was not excessive, indicating water sensitivity was not an issue for either group.

The malt quality factors presented in tables 27 and 28 can not be statistically analyzed because values are based on a single composite sample for each treatment. However, the discussion will focus mostly on observed trends between the high and low yielding sites. Malt quality factors are important to brewers, but are not a selection criteria for malt barley. Friability, fine vs coarse extract, Kolbach index, beta-glucan, and visocity which are measures of the overall modification of the grain. Friability of over 75% is desirable to ensure the kernel sufficiently break apart. However, if kernels crush too easily fine powder can become an issue in the milling process. Friability was well over 75% for all varieties and management levels for the high yielding site-years (Table 27). Levels were much lower for the low yielding site-years and were particularly low and problematic for AC Metcalfe (Table 28). Perhaps lower friability is related to higher protein content associated with low yielding sites and AC Metcalfe. Fine extract is a determination of how much sugar is within the malt. The target is to have more than 80%. Fine extract was a little over 80% for all varieties and levels of management for the high yielding site-years and below 80% for the low yielding site-years. Coarse extract represents how much sugar a brewer can actually get as malt is typically only coarse ground. Having a value as close as possible to fine extract is desirable. It means the malt has been modified enough to access most of the sugars. In other words, it is desirable to have the difference between fine and coarse extracts to be as close to zero as possible. Target is between 0 and 1.5%. This was achieved for all treatments for both the low and high yielding groups. It should be noted that only data from high and low yielding sites from 2021 and 2022 are represented in the means for fine and coarse ground extracts as coarse ground extracts were not performed in 2020. The Kolbach index is a measure of how much of the total protein was solubilized. Ideally 44% of the protein becomes solubilized and this was achieved for both groups. However, percentages were about 9% higher for the higher yielding group. Beta-glucan is undesirable as this gummy substance from cell wall components must be broken down to avoid filtration issues. The target is to have less than 150 ppm. This was easily achieved for low and high yielding site-years on average. However, levels appeared to increase with the use of fungicide for both groups. Beta-glucan levels were very high at Swift Current in 2022 and levels appeared to be increased from the 200 level to over 250 by fungicide (data not shown). Under modified malt will be more viscous. Thus a viscosity rating between 1.4 and 1.55 is desirable. This was achieved for all varieties and levels of management at every site-year (data not shown). Measures of proteolysis include soluble protein and FAN. Soluble protein is a measure of how much protein will end up in the wort. While yeast require protein to grow, too much protein will result in cloudy beer. The target is to have 4 to 6% in the wort. Levels were between 5.3 and 5.7 for the high yielding group on average depending on treatment. However, soluble protein was very high on average for the low yielding group, varying between 6.7 and 7.2 depending on treatment. This is likely due to the higher rate of total protein resulting from drought at the low yielding site-years. FAN stands for free amino nitrogen which are derived from protein and consumed by yeast. A high FAN greater than 150 is desirable which was accomplished for all treatments for the low and high-yielding site-years. Like the soluble protein FAN levels were higher for the lower yielding group. Enzyme levels are also important to brewers and the measures are diastatic power and alpha-Amylase. Diastatic power is a measure of total saccharifying activity. The more activity the more sugar conversion. The target is to have more than 125ºL. Alpha-Amylase is the most important enzyme and levels should be greater than 50 D.U. These levels were easily exceeded by all treatments for both groups with levels being higher for the low yielding group. Other miscellaneous measures include colour, and moisture. Color requirement depends on the goals of the brewer but for pale malts the target is approximately 2ºLovibond. This was achieved by all treatments for the high yielding group. However, color was much darker for the low yielding group, particularly for AC Metcalfe and CDC Bow. Moisture after kilning is targeting between 3-5%. If moisture is too low the malt will crumble too easily and if it is too high mold may develop. This was achieved for all treatments and site-years (data not shown). Overall, it was difficult to make firm conclusions about treatment effects since treatment means are based on single composite samples. However, the quality of the malt was better from the high yielding group compared to the low yielding group on average. The high yielding group had better friability, lower soluble protein, a higher Kolbach ratio, better colour for pale ale, higher fine extract and a better FAN level.

Other yield parameters

At Melfort and Swift Current, the number of heads/m^2 and kernels/head were determined for each treatment. It is difficult to make any meaningful comparisons between varieties for any site-year as heads/m^2 will be influenced by variations in emergence rates between varieties. While more meaningful comparisons can be made between the different levels of management, statistical differences between levels of management were not detected for either heads/m^2 or kernels/head at Swift Current (2021) and Melfort (2021-2022) (Tables 26 and 27). Drought was severe at Swift Current (2021) and the site only produced 17 bu/ac. Compared to the other site-years the number of kernels/head was extremely low (Table 25-27). Drought likely caused floral abortions. Increasing rate of N (D vs E management) significantly increased the number of heads/m^2 at Swift Current (2020) and Melfort (2020). Though not statistically significant, numeric increases were also observed at all other site-years. It is well established that added N increases tillering and this was certainly observed in this study. Not surprisingly, increasing the seeding rate and added fertility tended to increase the number of heads/m^2 and decrease the number of kernels per head. Effect of other levels of management on parameters were not significant or consistent.

Experiment 2 Discussion of Results

For statistical analysis, trials were grouped into high and low yielding site-years. The high yielding group consisted of Melfort (2020 & 2022), Prince Albert (2020-2022), Swift Current (2020) and Yorkton (2022). The low yielding group consisted of Melfort (2021), Yorkton (2020-2021) and Swift Current (2021-2022). On average, the high yielding group produced 4980 kg/ha (92.6 bu/ac) of grain at 12% protein and the low yielding group produced 2176 kg/ha (40.5 bu/ac) of grain at 15% protein. Drought was responsible for the low yields. The site-years were separated into groups to highlight how environment affects the response of each malt barley variety to increasing nitrogen. The impact of variety and level of soil + fertilizer N on barley emergence, maturity, lodging and yield are summarized in Tables 30 and 9 in the appendix for the high and low yielding sites, respectively. Seed quality parameters in the tables include grain protein, thins, plumps, 1000 kernel weight, 4 ml and 8 ml germination tests. Mean separations for the seed quality parameters are not presented as each value is based on a single sample bulked over 4 replications. Individual site-year analyses are found in the appendix (Tables 32-43).

Emergence

Crop emergence varied between site-years. For the low yielding group, emergence varied from 175 plants/m^2 at Swift Current (2021) to 278 plants/m^2 at Yorkton (2020). For the high yielding group, emergence varied from 164 plants/m^2 at Prince Albert (2021) to 321 plants/m^2 at Yorkton (2022). Increasing rate of N significantly reduced emergence for both the low and high yielding groups (Tables 30 & 31). However, the reduction was not large enough to greatly affect yield.

Maturity

AAC Synergy was later maturing than AC Metcalfe for both low and high yielding groups (Tables 30 & 31). However, maturity differences between varieties were not large and rankings were not consistent between site-years. Added N delayed maturity for both low and high yielding groups which is a well-recognized response to increased N fertilizer.

Lodging

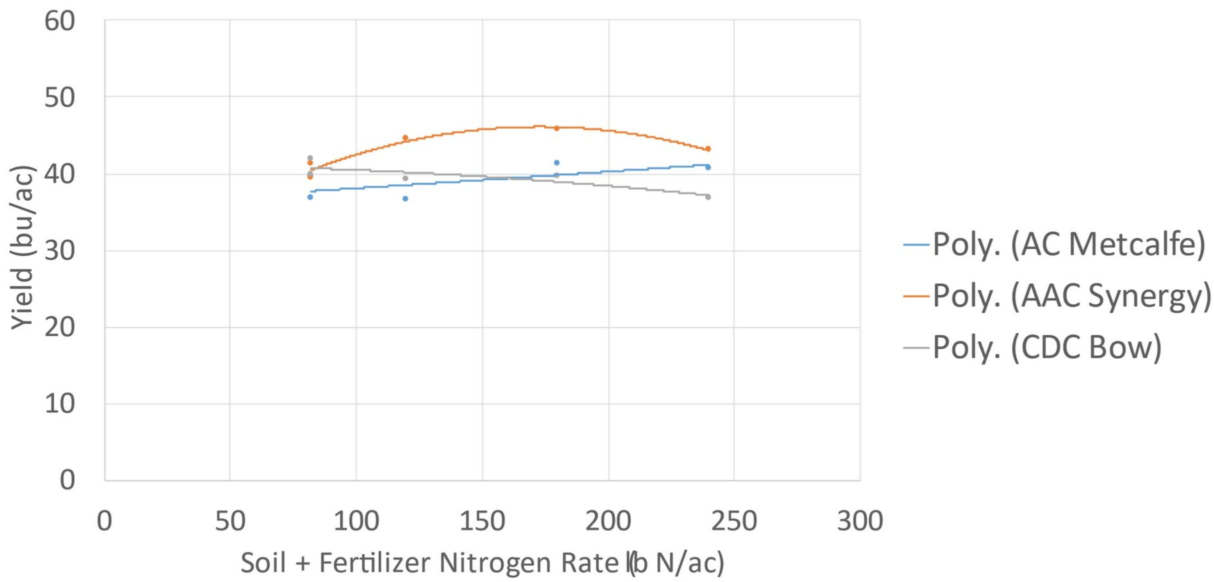
While lodging was higher for Metcalfe compared to the other varieties for the high yielding group, differences were usually small. However, there were some significant interactions. At Prince Albert (2020), CDC Bow and AAC Synergy were substantially more resistant to lodging at the highest rate of N than AC Metcalfe (data not shown). At Melfort (2022) and Yorkton (2022), CDC Bow was substantially more resistant to lodging than the other two varieties at the highest rate of N (data not shown). This is in keeping with regional information which rates lodging resistance for CDC Bow as “Very Good” compared to “Fair” for the other varieties.

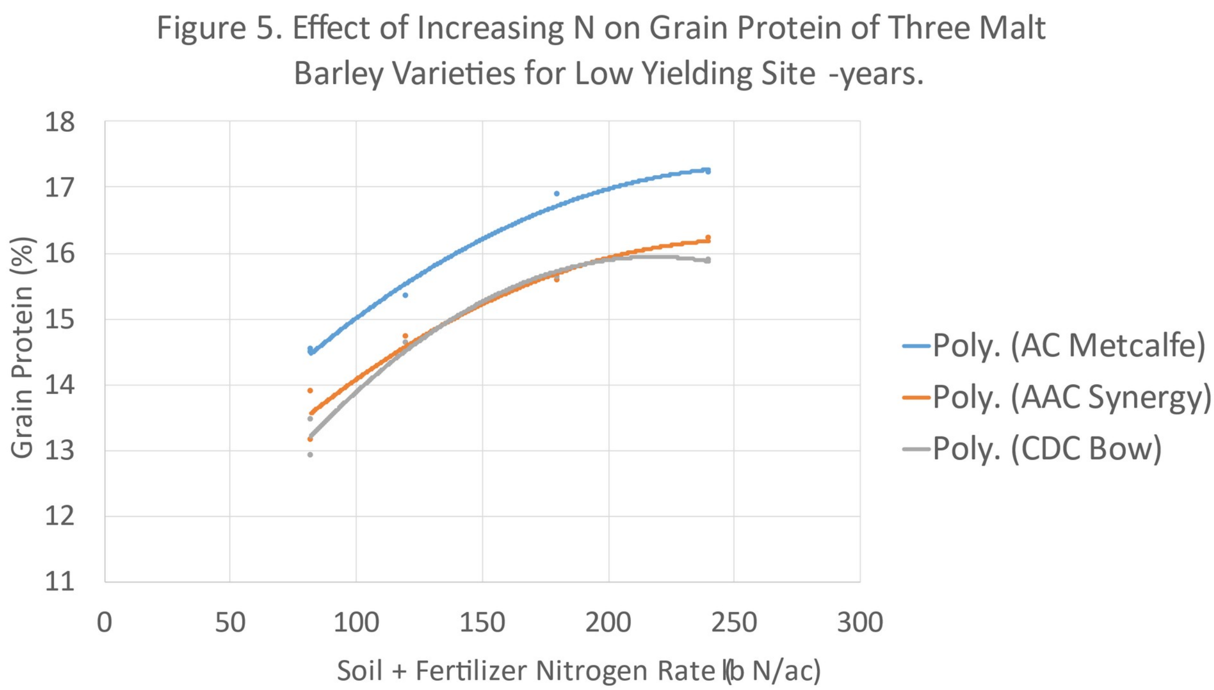
Yield, Protein and Economics

For the high yielding group, AAC Synergy was significantly higher yielding than CDC Bow which was significantly higher yielding than AC Metcalfe (Table 30). The trend was similar for the low yielding group, except only AAC Synergy was significantly higher yielding (Table 31). For both groups, AC Metcalfe had higher grain protein than AAC Synergy which is likely related to its lower yield potential.

For both the low and high yielding groups there was a significant variety by N interaction. For the low yielding group the yield of AC Metcalfe was less responsive to added N than AAC Synergy. However, the response to added N was modest for all varieties in the low yielding group and was not always positive (Figure 4). In contrast, grain protein was highly responsive to increasing N (Figure 5). While levels of grain protein were higher for AC Metcalfe compared to the other varieties, the protein levels were too high for malt, regardless of the level of N or variety. However, the higher level of grain protein for AC Metcalfe implies it requires less N than the newer varieties.

Figure 4. Effect of Increasing N on Yield of Three Malt Barley Varieties for Low Yielding Site -years.





In contrast, yields were much more responsive to added N for the high yielding group and grain protein was at lower levels (Figure 6 & 7). The yields of AAC Synergy and CDC Bow were responsive to higher rates of N than AC Metcalfe. In addition, grain protein for AAC Synergy and CDC Bow was considerably lower compared to AC Metcalfe. These differences mean the optimum rate of N to achieve malt is lower for AC Metcalfe compared to the other varieties. To illustrate this difference, an economic comparison using only AAC Synergy and AC Metcalfe will be made as the economics for AAC Synergy and CDC Bow would be very similar based on their comparable yield and grain protein responses to added N.

Figure 6. Effect of Increasing N on Yield of Three Malt Barley Varieties for High Yielding Site -years.

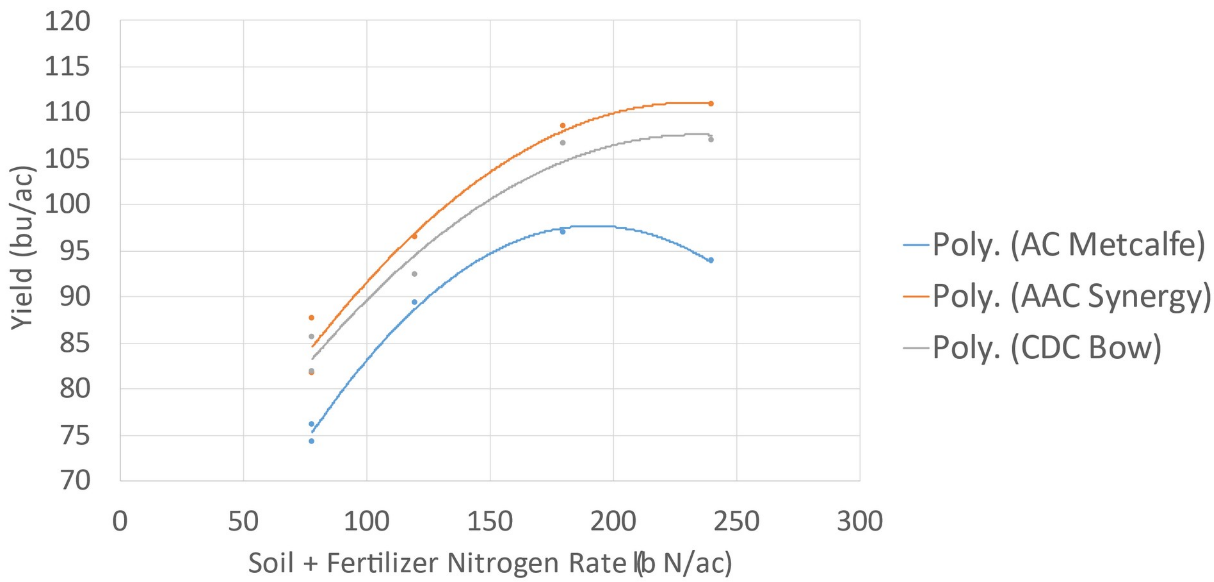
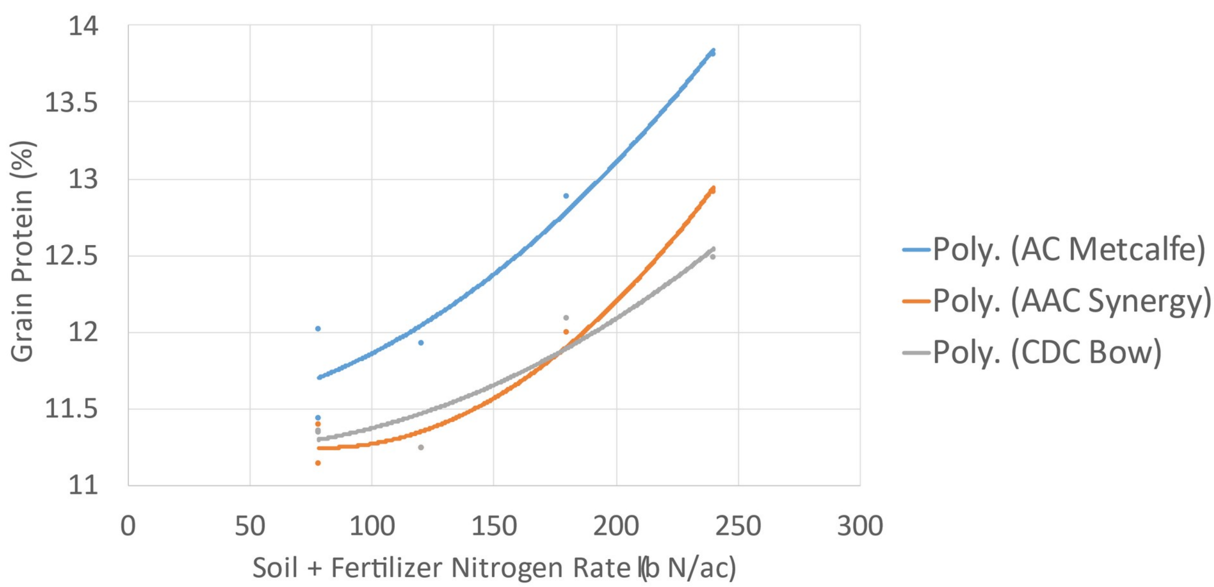
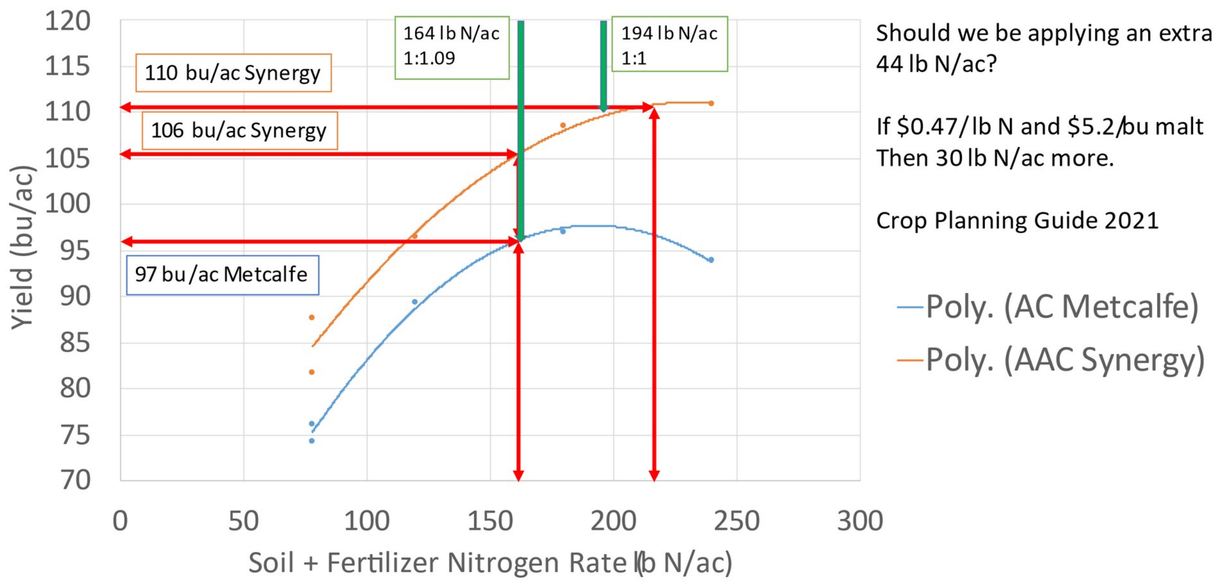


Figure 7. Effect of Increasing N on Grain Protein of Three Malt Barley Varieties for High Yielding Site -years.

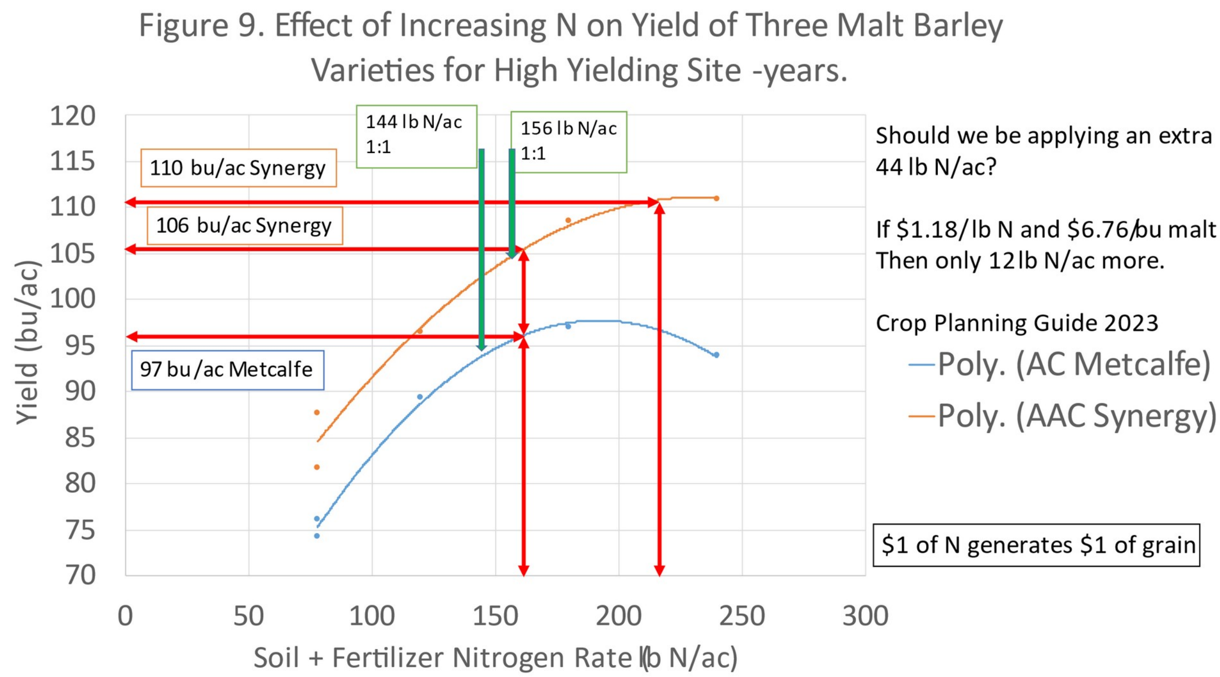


Let us assume barley grain with a protein greater than 12.5% will not be accepted for malt. For Metcalfe, 12.5% grain protein is not reached until soil + fertilizer N has reached 164 lb N/ac (Figure 7). In contrast, levels of soil + fertilizer N can be increased until 208 lb N/ac before 12.5% protein is reached with AAC Synergy. In other words, another 44 lb N/ac can be added to AAC Synergy relative to AC Metcalfe before grain protein is too high for malt quality. However, this does not mean an extra 44 lb N/ac should be applied as the economics need to be considered. At the rate of N that results in 12.5% grain protein for Metcalfe, Metcalfe yielded 97 bu/ac and Synergy yielded 106 bu/ac, a difference of 9 bu/ac (Figure 8). But the N rate for AAC Synergy can still be pushed another 44 lb N/ac before 12.5% protein is exceeded. This raises the yield of AAC Synergy another 4 bu/ac to 110 bu/ac. Potentially an additional 13 bu/ac of malt can be produced by growing AAC Synergy instead of AC Metcalfe. If an N price of $0.47/lb and $5.20/ bu of malt are used based on Saskatchewan Crop Planning Guide 2021 assumptions, then the most economic rates of soil + fertilizer N was 164 lb/ac for Metcalfe and 194 lb/ac for AAC Synergy. This difference is 30 lb N/ac which may not be a perfectly fair comparison. At 194 lb/ac level of N fertility, the last dollar spent on added N is returning a dollar worth of malt grain for AAC Synergy. However, the last dollar spent of N for AC Metcalfe is providing $1.09 in malt grain. More N cannot be added in the AC Metcalfe scenario to be at a 1:1 marginal return because grain protein of 12.5% would be exceeded. If we reduce the N rate for AAC Synergy so the marginal returns of added N are equal between the varieties at 1:1.09, then AAC Synergy should only be receiving an additional 22 lb N/ac more than AC Metcalfe (Figure 9).

Figure 8. Effect of Increasing N on Yield of Three Malt Barley Varieties for High Yielding Site -years.



If a poorer economic scenario based on 2023 Saskatchewan Crop Planning Guide assumptions of $1.18/ lb N and $6.67/bu of malt is used, then only 12 lb N/ac more is required for AAC Synergy to maximum returns. This assumes 1:1 marginal return on N for both varieties.



Other seed quality factors

Other seed quality factors measured included thins, plumps, 1000 kwt, 4 ml energy germination and 8 ml water sensitive germination. For the high yielding group, increasing N rate tended to decrease % plumps. On average, plumps were below 95% for AC Metcalfe which is low for malt quality (Table 30). In contrast, % plumps were unaffected by increasing N for the low yielding sites and were within acceptable levels for malt for all varieties (Table 31). Percent plumps were very low for all varieties at Swift Current 2020 (Table 34), and for AC Metcalfe at Prince Albert 2022 (Table 41). The reason for this is not clear. Both of these site-years were high yielding. On average, 4 ml germination was quite poor for the high yielding group and even poorer for the low yielding group. Increasing N did not appear to affect germination rates for either group. However, germination varied greatly between sites. Germination rates were acceptable for malt at multiple locations which tended to be from the high yielding group but not always. These included Melfort 2020, Swift Current 2020, Melfort 2021, Melfort 2022, Prince Albert 2022, Swift Current 2022 (Tables 32, 34, 36, 40-42). Eight ml germination rates were lower for both groups but the decline was not excessive, indicating water sensitivity was not an issue for either group.

Extension

- ECRF presented the results from this trial at WARC's Crop Opportunity webinar on March 2, 2021 and on March 2, 2023. This information has been made available through ECRF Youtube channel. https://www.youtube.com/watch?v=ZCHeXanpqRo

- Some information is being used in presentations by SaskBarley, including Top Notch Farming online in 2021 and at five locations in 2023.

- The Ministry presented on Barley MAX at the Conservation Learning Centre's virtual field day in 2020, available on their YouTube channel. https://www.youtube.com/watch?v=8p9dxywysnU

- SaskBarley has posted videos on their YouTube channel, which includes a presentation made for Top Notch Farming Webinar last winter. Barley MAX information was also included in a AgriVisions meeting (approx. Feb 7, 2022). https://www.youtube.com/channel/UCKVWV8OUR_ocevE-al5LFEg/playlists

  https://www.lloydex.com/_files/ugd/2ab3f7_90040d7445c04d2c96e75c1254320b11.pdf

- SaskBarley wrote about the Barley MAX trial in their Spring 2021 Newsletter https://barleybin.ca/wp-content/uploads/2021/08/Spring2021-SB-Newsletter.pdf

- ECRF has created the following videos which are posted on line and were used at conference webinars:
  - https://www.youtube.com/watch?v=IQyE2RqjrQ8 (56 views + viewed at the Agronomy Research Update on November 29, 2021 by 750 attendees)
  - https://www.youtube.com/watch?v=Q2PqdHCbDwk&t=8s (164 views + viewed at ECRF/Parkland College webinar on March 5, 2021 by 70 attendees)
  - https://www.youtube.com/watch?v=nz2hYCxsBjg (87 views)

10. Conclusions and Recommendations

Based on the trial results from experiment 1 the following conclusions can be made. AAC Synergy was usually the highest yielding variety and AC Metcalfe the lowest for both the high and low yielding groups. No difference in required input levels between varieties could be detected for either the high or low yielding site-years. Though Metcalfe was a little less responsive to N compared to the other varieties within the high yielding group. PGR significantly reduced lodging for the high yielding group. But lodging levels were extremely low. PGR did not affect yield, but it did delay maturity by a day. The yield for high yielding site-years did not increase in response to seed treatment as disease pressure was low. The yield for high yielding site-years only increased in response to increasing N, fungicide, and some combination of increasing seeding rate, P, or K. Increasing seeding rate hastened maturity by 2 days for high yielding group. Low yielding site-years did not positively respond to any additional input. The lowest level of inputs would have been most economical. For the low yielding sites, PGR increased thins, decreased plumps, decreased yield and delayed maturity by a day. PGR applied during drought had detrimental effects, consistent with recommended practices for the use of PGRs. It was difficult to determine treatment effects on malt barley. However, the malt quality from high yielding sites had many superior characteristics compared to malt made from the low yielding sites due to drought.

Conclusions from experiment 2 are as follows. Under low yielding environmental conditions, varietal yields were unresponsive to added N and grain protein levels were excessive for malt quality. However, grain protein was still lower for the newer varieties AAC Synergy and CDC Bow compared to AC Metcalfe. This implies that AC Metcalfe would require less N compared to the newer varieties. Under high yielding environmental conditions, AAC Synergy could be fertilized with 44 lb N/ac more than AC Metcalfe before exceeding 12.5% protein and being rejected for malt. However, doing so would be risky and uneconomical. Under a good economic scenario with $0.47/ lb N and $5.20/bu malt barley price, AAC Synergy could be receive 22 to 30 lb N/ac more than AC Metcalfe, depending on risk tolerance. Under poorer economic conditions, assuming $1.18/ lb N and $6.67/bu malt barley price, AAC Synergy would require only 12 lb N/ac more than AC Metcalfe. AAC Synergy will require more N than AC Metcalfe assuming both malt varieties are valued the same. However, exactly how much more will depend on environmental and economic conditions. In contrast, optimum rates of N would not vary much between the newer malt barley varieties AAC Synergy and CDC Bow, as their yield and protein responses to added N were essentially the same.

Overall, this study has determined the N requirements for the old malt barley AC Metcalfe are lower compared to the newer varieties AAC Synergy and CDC Bow under high yielding conditions. While malt barley was also found to respond to fungicide and some combination of increasing seeding rate, P or K under high yielding conditions, differences in response between varieties were not detected.

Supporting Information

11. Acknowledgements:

This project was funded through the Strategic Field Program (SFP) and Saskatchewan Barley Development Commission.

Abstract

12. Abstract/Summary:

Two experiments were conducted from 2020-2022. The objective of experiment 1 was to determine if the optimum agronomic package for AAC Synergy and CDC Bow differ from the old industry standard AC Metcalfe. The objective of experiment 2 was to determine if the most economic rate of N differed between new and old varieties of malt barley. Experiment 1 & 2 were conducted at Melfort, Prince Albert, Swift Current and Yorkton. Scott also conducted experiment 1 but did not participate in experiment 2. Experiment 1 evaluated AAC Synergy, CDC Bow and AC Metcalfe under 7 levels of increasing management. While not every input level was evaluated in isolation, the study examined increasing seeding and fertility rates, the application of seed treatment, PGR, and fungicide at flag and fusarium head blight timings. The trial site-years were separated into high and low yielding groups and analyzed separately. The response of these groups to added inputs differed as drought was the main limiting factor for the low yielding group. AAC Synergy was the highest yielding variety for both the low and high yielding groups and AC Metcalfe was the lowest. However, the difference in yield was not as great between these varieties as expected. Responses to added inputs did not differ between varieties for the high or low yielding groups. The yield of the low yielding group did not respond positively to added inputs. In fact, yield was significantly reduced by PGR indicating that PGR should not be applied during drought. The yield of the high yielding group responded positively to increasing N, fungicide and some combination of increasing seeding rate, P, or K. The high yielding group did not respond to seed treatment or PGR. Disease levels were low and lodging was minor. It was difficult to determine treatment effects on malt barley. However, the malt quality from high yielding sites had many superior characteristics compared to malt made from the low yielding sites due to drought. Experiment 2 evaluated the same varieties used in experiment 1 at multiple levels of increasing N. Like experiment 1, site-years were divided into high and low yielding groups and analyzed separately. Varieties within the low yielding group did not respond to added N and protein levels for all varieties were too high for malt. However, the protein level for AC Metcalfe was significantly higher compared to the newer varieties implying AC Metcalfe requires less N. For the high yielding group, the yield of AAC Synergy and CDC Bow were more responsive to added N than AC Metcalfe. Grain protein for AC Metcalfe reached 12.5% protein when soil + fertilizer N reached 164 lb/ac. In contrast, 208 lb N/ac were required for AAC Synergy to reach 12.5% protein. Assuming protein levels in excess of 12.5% are not acceptable for malt, 44 lb/ac more N could be applied to AAC Synergy compared to AC Metcalfe. However, depending on the value of N and malt, AAC Synergy may only require 12-30 lb N/ac more than AC Metcalfe to maximize economic returns. This study has determined the N requirements for the old malt barley AC Metcalfe are lower compared to

the newer varieties AAC Synergy and CDC Bow. While malt barley was also found to respond to fungicide and some combination of increasing seeding rate, P or K under high yielding conditions, differences in response between varieties were not detected.

13. Appendices

Table 8. Main effects of variety and management on crop quality measures averaged over all high yielding site-years (Scott 2020, Swift Current 2020, Prince Albert 2020-2022, Melfort 2020-2022 and Yorkton 2022.)

	Emergence (plants/m^2)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64",%)	Plumps (>6/64", %)	Thousand kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	216.9 a	229.4 b	0.75 a	4443 c	11.4	4.3	94.5	46.6	92.8	75.6
AAC Synergy	201.8 b	229.3 b	0.62 ab	4834 a	11.2	3.2	95.8	48.1	91.8	77.5
CDC Bow	203.6 b	230.5 a	0.49 b	4634 b	11.1	2.9	96.0	48.6	86.2	70.1
LSD	4.6	0.3	0.13	70	Na	Na	Na	Na	Na	Na
Management (M)[1]										
A	163.4 b	231.1 a	0.61 abcd	4146 d	11.0	2.7	96.3	48.2	91.1	75.9
B	221.2 a	229.2 cd	0.66 abc	4719 b	11.2	3.6	95.3	47.7	91.0	75.0
C	210.9 a	229.2 cd	0.67 ab	4716 b	11.3	3.7	95.2	47.8	89.5	74.2
D	217.7 a	229.6 bc	0.60 bcd	4383 c	11.1	2.9	95.9	48.5	90.5	74.3
E	215.7 a	229.0 d	0.69 a	4818 ab	11.4	3.2	95.8	48.1	89.4	74.2
F	213.8 a	230.0 b	0.58 cd	4783 b	11.4	4.1	94.7	47.0	90.5	74.2
G	209.2 a	230.1 b	0.54 d	4897 a	11.4	3.9	94.8	47.4	89.9	72.8
LSD	7.0	0.5	0.08	108	Na	Na	Na	Na	Na	Na
V by M interaction	<0.0001	0.03	NS	NS	Na	Na	Na	Na	Na	Na

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 9. Main effects of variety and management on crop quality measures averaged over all low yielding site-years (Scott 2021-2022, Swift Current 2021-2022, Yorkton 2020-2021)

	Emergence (plants/m^2)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64",%)	Plumps (>6/64", %)	Thousand kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	190.9 b	213.8 c	0.44 a	2021 b	16.5	3.3	95.9	43.0	81.2	67.5
AAC Synergy	185.9 c	214.1 b	0.47 a	2194 a	15.3	3.8	95.3	44.3	83.3	76.3
CDC Bow	203.8 a	214.4 a	0.47 a	2020 b	15.2	2.5	96.9	44.4	79.4	65.8
LSD	4.6	0.2	NS	81	Na	Na	Na	Na	Na	Na
Management (M)[1]										
A	150.0 a	214.3 b	0.49 a	2180 a	15.0	1.9	97.4	45.2	80.1	69.1
B	198.8 b	213.7 c	0.46 a	2128 a	15.8	2.6	96.7	44.4	80.8	70.8
C	201.0 b	214.1 b	0.46 a	1989 b	15.9	2.6	96.6	44.2	81.5	70.9
D	201.3 b	213.3 d	0.46 a	2186 a	15.1	2.6	96.7	44.1	80.4	67.8
E	203.4 b	213.6 c	0.51 a	2167 a	15.6	2.5	96.8	43.1	81.3	69.8
F	199.6 b	214.7 a	0.43 a	1951 b	16.2	5.0	93.9	42.5	83.1	70.9
G	200.7 b	214.9 a	0.42 a	1947 b	16.2	4.9	94.1	42.5	82.0	69.9
LSD	7.0	0.3	NS	123	Na	Na	Na	Na	Na	Na
V by M interaction	NS	NS	NS	0.04	Na	Na	Na	Na	Na	Na

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 10. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Melfort in 2020.

	Emergence (plants/m^2)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64",%)	Plumps (>6/64", %)	Thousand kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	201.1 c	234 a	1 a	4077 a	10.1	1.7	98.1	49.4	98.3	93.4
AAC Synergy	205.1 bc	232 b	1 a	3634 b	10.8	3.9	95.6	46.4	98.4	92.4
CDC Bow	219.3 a	234 a	1 a	3803 b	10.3	2.1	97.5	49.0	97.6	84.9
LSD	14.5	1.1	NS	247	N/A	N/A	N/A	N/A	N/A	N/A
Management (M)[1]										
A	157.5 d	237 a	1 a	2913 b	10.7	2.9	96.7	47.9	96.5	87.8
B	235.7 a	232 cd	1 a	4207 a	10.2	2.7	97.0	48.1	99.0	92.2
C	206.3 c	232 cd	1 a	4257 a	10.3	2.2	97.5	48.5	98.3	93.3
D	212.0 bc	235 ab	1 a	2970 b	10.5	2.2	97.5	48.1	98.0	86.5
E	229.1 ab	231 d	1 a	4169 a	10.2	2.0	97.7	48.2	98.8	91.8
F	217.5 abc	234 bc	1 a	4087 a	10.5	3.3	96.2	48.1	98.8	90.2
G	201.1 c	234 bc	1 a	4262 a	10.5	2.7	97.0	49.0	97.3	89.8
LSD	22.1	1.7	NS	377	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	NS	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes

F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 11. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Melfort in 2021.

	Emergence (plants/m^2)	**Maturity (Julian days)**	**Lodging (0-9)**	**Yield (kg/ha @13.5%)**	**Protein (%)**	**Thins (>5/64”,%)**	**Plumps (>6/64”, %)**	**Thousand kernel Weight (g)**	**4ml Energy Germination (%)**	**8ml Water Sensitive Germination (%)**
Variety (V)										
AC Metcalfe	202.3 a	215 a	1 a	3234 b	11.7	1.5	98.2	47.4 b	95	92
AAC Synergy	210.5 a	214 a	1 a	3642 a	12.9	1.4	98.2	47.5 b	96	87
CDC Bow	205.5 a	215 a	1 a	3191 b	12.8	1.1	98.5	48.3 b	96	87
LSD	NS	NS	NS	185	N/A	N/A	N/A	0.6	N/A	N/A
Management (M)[1]										
A	153.3 c	215 a	1 a	3232 a	12.2	1.2	98.2	48.3 a	95	90
B	222.4 a	215 a	1 a	3477 a	12.3	1.2	98.4	47.6 bc	95	87
C	215.0 ab	214 a	1 a	3365 a	12.8	1.1	98.5	48.0 ab	95	86
D	212.5 ab	214 a	1 a	3235 a	12.2	1.3	97.5	47.3 ab	97	88
E	226.9 a	215 a	1 a	3373 a	12.6	1.2	98.4	47.5 abc	96	89
F	202.3 b	214 a	1 a	3500 a	12.7	1.7	97.7	46.5 cd	96	91
G	210.1 ab	215 a	1 a	3311 a	12.5	1.4	98.3	46.7 d	95	89
LSD	17.6	NS	NS	NS	N/A	N/A	N/A	0.9	N/A	N/A
V by M interaction	NS	NS	NS	NS	N/A	N/A	N/A	NS	N/A	N/A

Management[1]	**Seeding Rate**	**Seed Trt**	**N (soil + fert)**	**P**	**K**	**PGR**	**Flag Leaf fung.**	**FHB fung.**
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes

E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 12. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Melfort in 2022.

	Emergence (plants/m²)	**Maturity (Julian days)**	**Lodging (0-9)**	**Yield (kg/ha @13.5%)**	**Protein (%)**	**Thins (>5/64",%)**	**Plumps (>6/64", %)**	**Thousand kernel Weight (g)**	**4ml Energy Germination (%)**	**8ml Water Sensitive Germination (%)**
Variety (V)										
AC Metcalfe	236.4 a	234.9 b	1.1 a	5255 c	11.6	3.7	95.6	47.2	98.5	71.7
AAC Synergy	242.2 a	235.7 b	1.0 a	6123 a	10.9	2.5	96.9	48.3	99.0	88.4
CDC Bow	229.9 a	237.8 a	1.0 a	5590 b	11.2	2.8	96.6	49.9	98.2	83.4
LSD	NS	1.56	NS	301	N/A	N/A	N/A	N/A	N/A	N/A
Management (M)[1]										
A	179.8 c	239.7 a	1.0 a	4938 b	10.8	2.4	97.0	46.6	98.3	82.0
B	240.3 ab	234.6 c	1.0 a	5800 a	11.2	2.4	97.0	49.3	98.8	77.3
C	243.6 ab	235.3 bc	1.0 a	5702 a	11.4	2.7	96.7	49.4	98.0	76.0
D	266.3 a	235.1 bc	1.0 a	5094 b	10.6	2.5	96.9	50.1	99.3	86.3
E	236.1 b	234.1 c	1.2 a	6109 a	11.4	2.5	96.9	50.6	97.5	81.0
F	252.2 ab	237.1 b	1.0 a	5797 a	11.5	4.3	94.9	46.3	99.0	81.8
G	234.8 b	237.2 b	1.0 a	6151 a	11.7	4.1	95.0	47.0	99.0	83.8
LSD	29.3	2.39	NS	460	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	0.026	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management[1]	**Seeding Rate**	**Seed Trt**	**N (soil + fert)**	**P**	**K**	**PGR**	**Flag Leaf fung.**	**FHB fung.**
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			

D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 13. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Prince Albert in 2020.

	Emergence (plants/m^2)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64" ,%)	Plumps (>6/64", %)	Thousand Kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	200.7 a	230 a	0.3 a	3784 b	11.7	2.7	96.6	51.7	70.6	41.9
AAC Synergy	204.9 a	230 a	0.0 b	4176 a	11.2	1.4	98.0	53.2	58.4	34.7
CDC Bow	215.6 a	230 a	0.0 b	3883 ab	11.0	1.3	98.1	52.2	22.9	11.1
LSD	NS	NS	0.18	298	N/A	N/A	N/A	N/A	N/A	N/A
Management (M)[1]										
A	150.5 b	232 a	0.1 a	3055 b	11.4	1.8	97.4	52.9	59.2	33.3
B	221.2 a	229 b	0.0 a	3870 a	11.3	2.0	97.3	52.1	55.3	27.2
C	224.5 a	229 b	0.2 a	4157 a	11.0	1.9	97.6	52.9	50.7	32.3
D	214.5 a	229 b	0.3 a	3961 a	11.3	1.7	97.7	52.9	46.8	26.8
E	207.5 a	229 b	0.0 a	4069 a	11.3	1.7	97.7	52.5	41.8	27.2
F	218.2 a	230 b	0.1 a	4255 a	11.3	1.9	97.5	51.5	51.7	29.5
G	213.0 a	230 b	0.0 a	4265 a	11.5	1.8	97.6	51.8	49.0	28.3
LSD	19.7	1.3	NS	455	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	NS	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				

B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 14. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Prince Albert in 2021.

	Emergence (plants/m^2)	**Maturity (Julian days)**	**Lodging (0-9)**	**Yield (kg/ha @13.5%)**	**Protein (%)**	**Thins (>5/64" ,%)**	**Plumps (>6/64", %)**	**Thousand Kernel Weight (g)**	**4ml Energy Germination (%)**	**8ml Water Sensitive Germination (%)**
Variety (V)										
AC Metcalfe	184.6 a	237 a	0.7 a	4698.0 a	11.0	1.9	96.7	46.6	83.6	53.3
AAC Synergy	132.1 b	237 a	0.8 a	4447.9 a	10.9	2.2	96.5	46.5	85.5	49.1
CDC Bow	187.9 a	237 a	0.2 b	4573.8 a	10.8	1.9	96.9	46.2	82.4	45.4
LSD	14.2	NS	0.39	NS	N/A	N/A	N/A	N/A	N/A	N/A
Management (M)[1]										
A	144.2 b	237 a	0.5 a	4819.8 a	11.0	2.0	96.9	47.9	84.7	58.7
B	176.3 a	237 a	0.6 a	4652.9 ab	10.8	1.9	96.9	46.9	87.8	59.5
C	165.3 a	237 a	0.4 a	4573.2 ab	10.6	2.0	96.7	46.7	78.5	44.0
D	178.0 a	237 a	0.6 a	4757.0 ab	11.1	2.0	96.4	47.2	84.3	49.3
E	166.5 a	237 a	0.6 a	4573.1 ab	11.3	2.1	96.7	44.8	85.5	48.3
F	179.2 a	237 a	0.6 a	4181.4 c	10.9	2.0	96.8	45.8	82.8	47.0
G	168.0 a	237 a	0.7 a	4455.3 bc	10.6	2.0	96.5	45.8	83.2	38.0
LSD	21.7	NS	NS	321.6	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	NS	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 15. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Prince Albert in 2022.

	Emergence (plants/m²)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64" ,%)	Plumps (>6/64", %)	Thousand Kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	305.8 a	234.5 b	1.5 a	4770 c	12.4	6.5	91.1	45.6	97.3	79.6
AAC Synergy	233.9 b	235.3 b	1.4 a	5928 a	11.4	3.3	95.1	52.2	97.6	85.4
CDC Bow	138.4 c	238.9 a	1.1 a	5704 b	12.0	1.6	97.0	55.3	97.2	85.0
LSD	15.7	2.2	NS	208	N/A	N/A	N/A	N/A	N/A	N/A
Management (M)[1]										
A	214.0 b	236.3 a	1.7 a	4980 d	11.5	3.3	94.7	49.6	98.2	82.2
B	280.7 a	235.8 a	1.4 a	5544 bc	12.1	4.6	93.2	49.7	95.3	80.0
C	222.7 b	235.9 a	1.6 a	5506 bc	12.1	4.5	93.6	49.9	96.0	84.8
D	216.2 b	236.7 a	1.3 a	5254 c	11.3	2.7	95.8	52.9	98.3	87.7
E	217.7 b	235.8 a	1.4 a	5374 bc	12.0	3.1	95.2	50.8	97.2	82.7
F	215.7 b	236.5 a	1.2 a	5673 ab	12.1	4.4	93.7	51.4	98.3	83.2
G	215.3 b	236.7 a	1.0 a	5939 a	12.5	3.8	94.6	52.6	98.2	83.0
LSD	24.0	NS	NS	318	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	<0.00001	NS	NS	0.0007	N/A	N/A	N/A	N/A	N/A	N/A

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 16. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Scott in 2020.

	Emergence (plants/m^2)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64" ,%)	Plumps (>6/64", %)	Thousand Kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	152.9 b	227 a	0.1 a	5172 b	10.6	5.6	93.9	45.2	98.6	85.9
AAC Synergy	157.5 b	227 a	0 a	5665 a	10.0	2.5	97.0	46.7	97.7	80.4
CDC Bow	168.6 a	228 a	0 a	5344 b	9.5	3.0	96.9	46.3	97.7	80.6
LSD	10.1	NS	NS	197	N/A	N/A	N/A	N/A	N/A	N/A
Management (M)[1]										
A	132.9 b	229 a	0 a	4437 c	10.0	3.2	96.3	45.5	98.0	80.3
B	165.0 a	227 a	0.1 a	5536 a	10.1	4.1	95.6	46.1	97.7	84.2
C	159.7 a	227 a	0.1 a	5582 a	10.1	4.3	95.5	46.1	98.5	84.8
D	169.8 a	227 a	0 a	4991 b	9.8	3.6	96.4	46.2	98.3	78.2
E	168.8 a	227 a	0 a	5793 a	10.0	3.7	96.1	46.7	98.0	85.5
F	156.0 a	228 a	0 a	5660 a	10.2	4.2	95.5	45.7	98.8	79.7
G	165.4 a	228 a	0 a	5757 a	9.9	2.9	96.2	46.3	96.7	83.2
LSD	15.4	NS	NS	300	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	NS	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 17. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Scott in 2021.

	Emergence (plants/m^2)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64" ,%)	Plumps (>6/64", %)	Thousand Kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	165.3 a	209.4 a	1 a	2397 a	15.5	2.0	97.6	44.0	94.9	90.4
AAC Synergy	168.3 a	209.6 a	1 a	2262 a	14.2	3.1	96.5	43.7	99.1	98.7
CDC Bow	173.4 a	209.1 a	1 a	1299 b	15.4	2.2	97.5	43.6	98.1	94.9
LSD	NS	NS	NS	311	N/A	N/A	N/A	N/A	N/A	N/A
Management (M)[1]										
A	126.5 b	209.1 bc	1 a	2070 a	14.4	1.7	97.8	44.4	90.7	82.8
B	175.9 a	208.8 bc	1 a	2076 a	15.2	2.1	97.6	44.5	98.0	97.7
C	170.7 a	209.7 ab	1 a	1743 a	15.3	2.5	96.9	43.6	99.0	97.8
D	173.8 a	208.6 c	1 a	2172 a	14.1	2.1	97.5	44.1	98.8	96.7
E	182.0 a	208.2 c	1 a	2085 a	15.1	1.9	97.7	44.7	98.7	96.3
F	182.1 a	210.6 a	1 a	1895 a	15.6	3.6	95.9	42.5	98.8	95.8
G	172.0 a	210.6 a	1 a	1863 a	15.5	2.9	96.3	42.6	97.5	95.3
LSD	14.7	0.89	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

V by M interaction	NS	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 18. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Scott in 2022.

	Emergence (plants/m^2)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64" ,%)	Plumps (>6/64", %)	Thousand Kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	170.1 b	218.4 c	1.0 a	2880 b	15.7	4.1	95.6	43.3	98.8	78.1
AAC Synergy	163.4 c	218.8 b	1.0 a	3181 a	14.5	2.6	97.1	45.6	99.4	85.2
CDC Bow	180.6 a	220.5 a	1.0 a	3134 a	14.0	1.6	98.1	47.0	99.1	78.1
LSD	5.3	0.40	NS	132	N/A	N/A	N/A	N/A	N/A	N/A
Management (M)[1]										
A	126.4 c	220.0 a	1.0 a	2917 c	14.2	1.5	98.3	46.7	99.3	83.5
B	172.8 b	218.4 c	1.0 a	2981 bc	14.9	3.4	96.2	44.5	99.7	81.0
C	174.5 b	219.3 b	1.0 a	2903 c	15.3	2.9	96.9	45.3	96.7	82.2
D	187.2 a	218.3 c	1.0 a	3128 ab	14.2	3.3	96.4	44.9	99.3	79.3
E	178.8 b	219.4 ab	1.0 a	3153 ab	14.8	2.6	97.1	45.8	99.8	82.0
F	179.1 ab	219.7 ab	1.0 a	3225 a	14.8	2.7	97.0	44.9	99.3	80.7
G	180.8 ab	219.7 ab	1.0 a	3150 ab	15.0	3.0	96.8	44.9	99.3	74.8

LSD	8.1	0.61	NS	201	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	0.0003	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 19. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Swift Current in 2020.

	Emergence (plants/m2)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64" ,%)	Plumps (>6/64", %)	Thousand Kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	177.4 a	218.0 b	0 a	4101 ab	11.6	9.8	87.4	42.4	95.7	95.0
AAC Synergy	174.9 a	218.1 b	0 a	4253 a	10.4	6.6	91.2	44.8	96.4	97.0
CDC Bow	179.3 a	218.9 a	0 a	4047 b	10.9	8.8	88.2	43.7	86.4	95.8
LSD	NS	0.4	NS	158	N/A	N/A	N/A	N/A	N/A	N/A
Management (M)[1]										
A	139.1 b	218.9 a	0 a	3723 d	9.8	5.0	93.3	44.8	96.5	95.7
B	176.3 a	217.9 c	0 a	4253 abc	10.7	8.2	89.4	43.3	91.0	96.3
C	179.8 a	218.1 bc	0 a	4128 bc	11.2	10.1	86.8	43.1	93.2	96.0
D	188.9 a	218.1 bc	0 a	4036 c	11.0	7.6	89.9	44.3	88.8	96.8

E	191.6 a	218.2 abc	0 a	4380 a	11.4	8.0	89.5	44.2	92.2	94.3
F	183.3 a	218.8 ab	0 a	4283 ab	11.3	8.8	88.5	43.2	95.7	96.8
G	181.3 a	218.6 abc	0 a	4133 bc	11.2	11.1	85.3	42.6	92.3	95.5
LSD	22.7	0.7	NS	242	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	NS	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management [1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 20. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Swift Current in 2021.

	Emergence (plants/m2)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64”,%)	Plumps (>6/64”, %)	Thousand Kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	150.1 b	219.9 a	1	749.8 c	17.7	3.3	94.8	36.3 b	92.3	65.5
AAC Synergy	123.7 c	219.1 b	1	1107.2 a	16.4	3.5	94.8	41.6 a	94.9	80.3
CDC Bow	167.4 a	219.0 b	1	943.7 b	16.0	2.2	96.4	41.7 a	86.6	61.1
LSD	14.2	0.51	NS	127.5	N/A	N/A	N/A	2.0	N/A	N/A
Management (M)[1]										
A	107.3 b	218.8 cd	1	1010.2 a	15.8	2.2	96.4	43.0 ab	90.5	70.3
B	141.3 a	219.2 bcd	1	980.8 a	16.7	2.0	96.5	41.7 ab	90.7	70.7

C	154.4 a	219.6 ab	1	959.8 a	17.1	2.3	96.1	42.0 a	94.2	71.0
D	158.7 a	218.5 d	1	1000.5 a	15.5	2.2	96.0	41.3 b	89.8	63.8
E	158.4 a	219.3 bc	1	980.8 a	16.5	2.2	96.3	41.5 ab	89.7	71.0
F	154.0 a	219.9 ab	1	791.2 a	17.7	5.1	92.5	38.9 c	92.7	68.3
G	155.6 a	220.0 a	1	811.7 a	17.7	5.1	92.5	38.7 c	91.3	67.5
LSD	21.7	0.77	NS	NS	N/A	N/A	N/A	3.0	N/A	N/A
V by M interaction	NS	NS	NS	NS	N/A	N/A	N/A	NS	N/A	N/A

Management [1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 21. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Swift Current in 2022.

	Emergence (plants/m2)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64" ,%)	Plumps (>6/64", %)	Thousand Kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	202.1 a	215.4 b	1.0 a	2699 a	16.2	6.0	93.1	43.6	98.5	95.8
AAC Synergy	192.2 a	217.1 a	1.0 a	2759 a	15.4	8.2	90.6	44.2	96.9	98.0
CDC Bow	189.9 a	217.3 a	1.0 a	2782 a	15.1	4.7	94.2	45.2	98.4	97.4
LSD	NS	0.47	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A
Management (M)[1]										
A	171.2 b	218.0 a	1.0 a	2709 ab	15.2	4.0	94.9	45.3	97.3	98.2

B	193.7 a	216.3 cd	1.0 a	2848 a	15.5	4.9	94.2	45.4	98.7	95.7
C	200.0 a	216.1 cd	1.0 a	2839 a	15.6	4.9	94.2	45.3	98.2	98.3
D	195.1 a	215.7 d	1.0 a	2885 a	14.9	4.2	94.8	44.8	99.0	97.2
E	201.2 a	216.0 d	1.0 a	2920 a	15.5	4.9	94.1	42.4	97.0	96.8
F	201.0 a	216.8 bc	1.0 a	2561 bc	16.1	10.9	87.7	43.6	98.5	96.8
G	201.0 a	217.4 ab	1.0 a	2465 c	16.0	10.2	88.6	43.6	97.0	96.5
LSD	16.4	0.72	NS	237	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	NS	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management [1]	**Seeding Rate**	**Seed Trt**	**N (soil + fert)**	**P**	**K**	**PGR**	**Flag Leaf fung.**	**FHB fung.**
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 22. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Yorkton in 2020.

	Emergence (plants/m2)	**Maturity (Julian days)**	**Lodging (0-9)**	**Yield (kg/ha @13.5%)**	**Protein (%)**	**Thins (>5/64",%)**	**Plumps (>6/64", %)**	**Thousand Kernel Weight (g)**	**4ml Energy Germination (%)**	**8ml Water Sensitive Germination (%)**
Variety (V)										
AC Metcalfe	242.5 a	210 b	0.4 a	2015 b	16.3	1.6	98.0	46.9	99.1	68.2
AAC Synergy	249.1 a	210 b	0.6 a	2511 a	14.5	1.3	98.3	48.7	98.7	87.2
CDC Bow	290.9 a	211 a	0.6 a	2472 a	14.4	1.2	98.4	48.7	98.9	54.9
LSD	NS	0.6	NS	232	N/A	N/A	N/A	N/A	N/A	N/A
Management (M)[1]										

A	199.7 b	211 a	0.8 a	2551 a	13.9	0.9	98.8	49.2	97.8	73.3
B	277.7 a	211 a	0.5 a	2361 a	15.5	1.0	98.6	48.8	99.3	71.2
C	277.9 a	210 a	0.5 a	2210 a	15.5	1.2	98.4	48.4	99.3	68.3
D	280.2 a	210 a	0.6 a	2215 a	14.8	1.1	98.5	48.6	98.2	62.3
E	271.7 a	211 a	0.8 a	2568 a	14.6	1.0	98.8	48.7	99.3	65.3
F	257.3 ab	211 a	0.4 a	2211 a	15.5	2.2	97.3	46.8	99.3	74.5
G	261.3 ab	211 a	0.3 a	2214 a	15.6	2.2	97.3	46.2	98.8	75.7
LSD	65.3	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	NS	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 23. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Yorkton in 2021.

	Emergence (plants/m2)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64",%)	Plumps (>6/64", %)	Thousand Kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	215 a	209.4 a	0 a	1386 a	17.8	2.8	96.6	40.4	7.3	7.0
AAC Synergy	219 a	209.6 a	0 a	1343 a	17.0	3.9	94.8	40.4	13.0	8.6
CDC Bow	221 a	209.1 a	0 a	1490 a	16.4	2.5	96.8	41.1	7.9	8.5
LSD	NS	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management (M)[1]										
A	169 b	209.1 bc	0 a	1824.3 a	16.8	1.2	98.2	42.7	6.3	6.5
B	231 a	208.8 bcd	0 a	1521.3 ab	17.0	2.2	97.2	41.5	6.7	8.5
C	229 a	209.7 b	0 a	1282.6 bc	16.9	2.3	97.3	40.8	8.0	7.5
D	213 a	208.6 cd	0 a	1717.5 a	17.0	2.4	96.9	40.9	6.5	7.5
E	228 a	208.2 d	0 a	1297.6 bc	17.2	2.5	97.0	41.1	10.5	7.5
F	224 a	210.6 a	0 a	1024.2 c	17.3	5.1	93.1	38.3	13.5	9.0
G	233 a	210.6 a	0 a	1180.1 c	17.6	5.7	92.8	39.1	14.3	9.8
LSD	21.8	0.88	NS	329.5	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	0.51	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 24. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Yorkton in 2022.

	Emergence (plants/m2)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64",%)	Plumps (>6/64", %)	Thousand Kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	290.8 a	234.1 b	1.14 a	4901 b	12.3	5.3	93.1	44.2	94.7	67.9
AAC Synergy	255.0 b	234.5 b	0.29 b	5632 a	12.1	4.6	94.0	47.5	95.9	83.1
CDC Bow	288.0 a	235.2 a	0.04 b	5578 a	11.9	3.7	94.6	47.3	84.5	57.5
LSD	16.1	0.62	0.31	276	N/A	N/A	N/A	N/A	N/A	N/A

Management (M)[1]										
A	199.6 c	235.6	0.25 cd	5214 ab	12.1	2.5	96.5	49.9	92.5	73.2
B	273.3 b	234.3	0.83 a	5128 b	12.1	5.1	93.2	45.9	90.2	71.7
C	280.8 ab	234.1	0.75 ab	5174 b	12.1	4.7	93.8	45.4	91.7	70.0
D	300.8 a	234.8	0.33 bcd	5149 b	12.3	2.9	95.4	47.4	94.7	69.0
E	296.9 ab	234.7	0.66 abc	5518 ab	12.3	4.5	94.1	46.2	91.2	68.2
F	300.1 a	234.5	0.41 abcd	5610 a	12.0	6.6	91.4	44.3	90.2	69.3
G	294.1 ab	234.4	0.16 d	5796 a	11.8	5.5	92.9	45.1	91.5	65.2
LSD	24.5	NS	0.48	422	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	NS	0.005	0.035	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management[1]	**Seeding Rate**	**Seed Trt**	**N (soil + fert)**	**P**	**K**	**PGR**	**Flag Leaf fung.**	**FHB fung.**
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 25. Main effects of variety and management on kernels/head/m^2, and heads/m^2 of barley at Melfort and Swift Current in 2020.

	Melfort		Swift Current	
	Kernels/head	**Heads/m^2**	**Kernels/head**	**Heads/m^2**
Variety (V)				
AC Metcalfe	22.8 a	421.6 a	18.3 b	558.1 a
AAC Synergy	22.0 b	445.9 a	19.4 a	521.4 b
CDC Bow	21.5 b	423.4 a	18.8 ab	555.6 a
LSD	0.5	NS	0.9	31.2
Management (M)[1]				
A	22.4 ab	300.2 c	19.5 a	458.9 d
B	22.3 ab	471.5 a	18.6 a	542.8 bc
C	22.4 ab	463.8 a	18.4 a	568.1 abc
D	21.9 abc	353.8 b	18.5 a	527.8 c
E	22.7 a	476.6 a	18.8 a	590.8 a
F	21.4 c	484.9 a	19.1 a	548.8 abc
G	21.8 bc	461.5 a	19.0 a	578.2 ab
LSD	0.8	34.4	NS	47.7
V by M interaction	NS	NS	NS	NS

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 26. Main effects of variety and management on kernels/head, and heads/m2 of barley at Melfort and Swift Current in 2021.

	Melfort		Swift Current	
	Kernels/head	**Heads/m^2**	**Kernels/head**	**Heads/m^2**
Variety (V)				
AC Metcalfe	19.7 b	394.1 a	6.9 b	242.9 a
AAC Synergy	21.5 a	360.0 a	8.3 a	241.2 a
CDC Bow	18.1 c	368.7 a	7.0 b	257.3 a
LSD	1.1	NS	1.2	NS
Management (M)[1]				
A	20.3 a	345.4 a	8.6 a	218.3 a
B	19.4 a	386.0 a	6.8 a	251.2 a
C	20.4 a	381.6 a	7.8 a	253.8 a
D	19.2 a	344.0 a	8.4 a	241.3 a
E	19.3 a	374.9 a	7.3 a	258.8 a
F	19.5 a	388.7 a	6.2 a	248.1 a
G	20.2 a	399.3 a	6.6 a	258.3 a
LSD	NS	NS	NS	NS
V by M interaction	NS	NS	NS	NS

Management[1]	**Seeding Rate**	**Seed Trt**	**N (soil + fert)**	**P**	**K**	**PGR**	**Flag Leaf fung.**	**FHB fung.**
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 27. Main effects of variety and management on kernels/head, and heads/m2 of barley at Melfort and Swift Current in 2022.

	Melfort		Swift Current	
	Kernels/head	**Heads/m^2**	**Kernels/head**	**Heads/m^2**
Variety (V)				
AC Metcalfe	23.7 a	482.0 a	19.9 a	380.3 a
AAC Synergy	24.3 a	474.0 a	20.1 a	399.4 a
CDC Bow	24.1 a	467.1 a	19.9 a	389.9 a
LSD	NS	NS	NS	NS
Management (M)[1]				
A	25.0 a	414.5 a	20.5 ab	372.4 cd
B	24.0 a	483.7 a	20.9 ab	395.9 abc
C	24.1 a	464.8 a	21.6 a	360.3 d
D	23.7 a	467.2 a	19.9 ab	381.2 bcd
E	23.8 a	488.0 a	20.5 ab	388.5 abcd
F	23.5 a	484.7 a	19.2 bc	412.0 ab
G	24.2 a	517.6 a	17.4 c	418.8 a
LSD	NS	NS 0.053	2.1	32.4
V by M interaction	NS	NS	NS	NS

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 28. Main effects of variety and management on malt quality factors averaged over all high yielding site-years (Scott 2020, Swift Current 2020, Prince Albert 2020-2022, Melfort 2020-2022 and Yorkton 2022.)

	Friability (%)	Fine Extract %, db[2]	Coarse Extract %, db[2]	Diastatic Power°, db	Apha-Amylase DU, db	Soluble Protein %, db	Kolbach S/T Ratio (%)	FAN mg/L	Colour°	Beta-Glucan mg/L
Variety (V)										
AC Metcalfe	87.5	81.9	81.3	152.4	87.4	5.3	48.0	216.1	2.6	87.5
AAC Synergy	90.0	82.1	81.6	143.3	82.1	5.4	49.7	217.0	2.6	91.4
CDC Bow	91.0	82.1	81.6	141.1	79.3	5.7	53.1	238.1	3.2	83.5
Management (M)[1]										
A	90.9	82.3	81.7	143.3	82.9	5.5	51.8	227.7	3.0	82.6
B	89.5	82.3	81.8	144.1	81.8	5.6	51.2	227.6	3.0	81.9
C	89.3	82.1	81.6	146.8	81.6	5.6	50.5	227.3	2.9	84.6
D	90.1	82.4	81.7	142.6	80.8	5.4	50.5	222.3	2.8	87.7
E	88.9	82.2	81.6	144.9	83.6	5.4	49.3	220.3	2.7	91.4
F	89.2	81.5	81.0	148.9	84.5	5.4	49.3	220.6	2.6	93.1
G	88.8	81.6	80.9	148.7	84.8	5.4	49.3	220.3	2.6	91.1

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes

F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

[2]Values do not include data from 2020 as coarse extract was not performed.

Table 29. Main effects of variety and management on malt quality factors averaged over all low yielding site-years (Scott 2021-2022, Swift Current 2021-2022, Yorkton 2020-2021)

	Friability (%)	**Fine Extract %, db[2]**	**Coarse Extract %, db[2]**	**Diastatic Power°, db**	**Apha-Amylase DU, db**	**Soluble Protein %, db**	**Kolbach S/T Ratio (%)**	**FAN mg/L**	**Colour°**	**Beta-Glucan mg/L**
Variety (V)										
AC Metcalfe	67.8	76.8	75.9	217.3	94.9	7.0	40.2	291.2	6.0	100.1
AAC Synergy	73.8	77.3	76.8	182.7	84.1	6.7	41.3	262.1	3.8	86.4
CDC Bow	80.6	77.4	76.6	179.7	77.6	7.1	44.4	295.2	7.0	94.6
Management (M)[1]										
A	78.4	77.8	77.1	185.9	83.8	6.7	42.7	273.3	5.0	84.2
B	74.2	77.1	76.5	196.0	83.9	6.9	41.7	283.6	5.5	84.3
C	73.3	77.1	76.4	195.8	83.3	7.1	41.9	292.4	6.1	89.2
D	78.5	77.9	77.2	178.8	80.8	6.7	42.6	274.1	5.9	98.4
E	74.0	77.3	76.2	187.5	82.7	6.8	41.3	276.4	5.5	101.0
F	70.5	76.5	75.8	206.4	91.9	7.2	41.9	291.7	5.6	97.4
G	69.9	76.5	75.8	202.4	89.9	7.1	41.6	288.5	5.7	101.1

Management[1]	**Seeding Rate**	**Seed Trt**	**N (soil + fert)**	**P**	**K**	**PGR**	**Flag Leaf fung.**	**FHB fung.**
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			

C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

[2]Values do not include data from 2020 as coarse extract was not performed.

Table 30. Main effects of variety and nitrogen rate on various parameters of barley averaged over all high yielding sites (Melfort 2020&2022, Prince Albert 2020-2022, Swift Current 2020 and Yorkton 2022.

	Emergence (plants/m^2)	**Maturity (Julian days)**	**Lodging (0-9)**	**Yield (kg/ha @13.5%)**	**Protein (%)**	**Thins (>5/64",%)**	**Plumps (>6/64", %)**	**Thousand kernel Weight (g)**	**4ml Energy Germination (%)**	**8ml Water Sensitive Germination (%)**
Variety (V)										
AC Metcalfe	242 a	229.8 b	1.23 a	4630 c	12.4	6.4	91.5	45.9	87.6	68.3
AAC Synergy	209 c	230.5 a	0.83 b	5218 a	11.7	3.6	95.0	49.0	86.9	72.1
CDC Bow	225 b	230.1 b	0.72 b	5091 b	11.7	4.0	94.5	49.0	82.2	62.8
LSD	6	0.33	0.17 b	114	NA	NA	NA	NA	NA	NA
Nitrogen Rate (Soil + fertilizer) (lb N/ac)										
Background N[1]	223 bc	230.4 ab	0.61 c	4328 c	11.3	3.6	95.0	48.3	85.6	67.3
Background N[1]	229 b	230.1 bc	0.75 c	4402 c	11.6	4.1	94.3	47.7	85.0	65.6
120	233 a	229.6 d	0.69 c	4986 b	11.5	4.1	94.3	48.0	86.7	68.4
180	226 b	229.9 cd	1.02 b	5593 a	12.3	5.2	93.0	47.8	84.9	68.2
240	216 c	230.5 a	1.57 a	5588 a	13.1	6.3	91.2	48.0	85.6	69.2
LSD	8	0.43	0.22	148	NA	NA	NA	NA	NA	NA
V by M interaction	NS	0.036	<0.0001	0.008	NA	NA	NA	NA	NA	NA

[1]Background level of N averaged over the high yielding site-years was 82 lb N/ac.

Table 31. Main effects of variety and nitrogen rate on various parameters of barley averaged over all low yielding sites (Melfort 2021, Yorkton 2020-2021 and Swift Current 2021-2022.

	Emergence (plants/m^2)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64",%)	Plumps (>6/64", %)	Thousand kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	217 a	213.7 b	0.91 a	2097 b	15.7	2.5	96.4	43.7	76.7	59.1
AAC Synergy	208 b	214.1 a	0.95 a	2305 a	14.7	2.6	96.3	45.3	77.8	67.6
CDC Bow	219 a	214.0 ab	0.98 a	2127 b	14.5	1.9	97.1	45.1	68.3	53.8
LSD	6	0.3	NS	88	NA	NA	NA	NA	NA	NA
Nitrogen Rate (Soil + fertilizer) (lb N/ac)										
Background N[1]	216 ab	213.4 c	0.97 a	2084 c	13.5	2.4	96.5	44.4	73.2	57.9
Background N[1]	220 a	213.4 c	0.93 a	2201 ab	14.0	2.1	96.7	44.7	73.3	58.5
120	220 a	213.8 c	0.88 a	2157 bc	14.9	2.4	96.7	44.5	74.2	61.4
180	210 bc	214.3 b	0.98 a	2275 a	16.0	2.4	96.5	44.8	75.4	61.9
240	207 c	214.8 a	0.97 a	2165 abc	16.4	2.4	96.6	45.0	75.3	61.2
LSD	7	0.4	NS	114	NA	NA	NA	NA	NA	NA
V by M interaction	NS	NS	NS	0.008	NA	NA	NA	NA	NA	NA

[1]Background level of N averaged over the high yielding site-years was 78 lb N/ac.

Table 32. Main effects of variety and nitrogen rate on various parameters of barley at Melfort 2020.

	Emergence (plants/m²)	**Maturity (Julian days)**	**Lodging (0-9)**	**Yield (kg/ha @13.5%)**	**Protein (%)**	**Thins (>5/64",%)**	**Plumps (>6/64", %)**	**Thousand kernel Weight (g)**	**4ml Energy Germination (%)**	**8ml Water Sensitive Germination (%)**
Variety (V)										
AC Metcalfe	209.4 b	231.2 b	0	3649.9 c	11.2	4.8	94.6	46.1	99.1	88.4
AAC Synergy	208.3 b	232.6 a	0	4443.1 a	10.5	1.8	97.7	49.8	98.2	90.6
CDC Bow	221.0 a	232.2 a	0	4195.5 b	10.7	2.1	97.5	49.4	97.6	79.2
LSD	10.8	0.8	NS	217	NA	NA	NA	NA	NA	NA
Nitrogen Rate (Soil + fertilizer) (lb N/ac)										
Background N[1]	228.4 ab	231.3 bc	0	2795.6 d	10.6	3.1	96.2	46.7	98.7	81.3
Background N[1]	220.2 b	231.8 bc	0	2525.8 d	10.3	3.0	96.4	46.9	97.3	77.5
120	237.6 a	230.8 c	0	3817.9 c	10.1	2.7	97.0	47.7	97.8	87.8
180	205.3 c	232.2 b	0	5509.5 b	10.8	2.8	96.9	49.5	98.3	91.5
240	172.9 d	233.8 a	0	5832.0 a	12.2	3.0	96.5	51.3	99.3	92.2
LSD	13.9	1.0	NS	281	NA	NA	NA	NA	NA	NA
V by M	NS	NS	NS	0.037	NA	NA	NA	NA	NA	NA

interaction										
[1]Background level of N was 67 lb N/ac.										

Table 33. Main effects of variety and nitrogen rate on various parameters of barley at Prince Albert 2020.

	Emergence (plants/m²)	**Maturity (Julian days)**	**Lodging (0-9)**	**Yield (kg/ha @13.5%)**	**Protein (%)**	**Thins (>5/64",%)**	**Plumps (>6/64", %)**	**Thousand kernel Weight (g)**	**4ml Energy Germination (%)**	**8ml Water Sensitive Germination (%)**
Variety (V)										
AC Metcalfe	228.3 a	228.2 b	2.02 a	4323.0 b	12.4	2.5	96.9	51.2	52.3	25.3
AAC Synergy	233.4 a	229.4 a	0.50 b	4761.9 a	12.0	1.3	98.0	53.8	40.4	20.3
CDC Bow	239.4 a	227.5 b	0.25 b	5021.6 a	11.7	0.8	98.5	53.4	14.6	7.1
LSD	NS	1.0	0.59	294	NA	NA	NA	NA	NA	NA
Nitrogen Rate (Soil + fertilizer) (lb N/ac)										
Background N[1]	232.3 a	228.8 a	0.25 c	3576.6 d	11.4	1.4	98.1	53.5	35.3	17.3
Background N[1]	238.2 a	228.2 a	0.32 c	4297.3 c	11.3	1.1	98.2	53.0	34.2	17.5
120	228.2 a	228.3 a	0.40 bc	4874.8 b	11.7	1.3	98.1	53.3	36.0	15.8
180	230.0 a	228.3 a	1.15 b	5280.3 a	12.1	1.6	97.7	52.6	36.3	20.0
240	239.8 a	228.1 a	2.50 a	5481.8 a	13.4	2.5	96.9	51.7	37.0	17.2

LSD	NS	NS	0.76	380	NA	NA	NA	NA	NA	NA
V by M interaction	0.03	NS	<0.0001	NS	NA	NA	NA	NA	NA	NA
[1]Background level of N was 69 lb N/ac.										

Table 34. Main effects of variety and nitrogen rate on various parameters of barley at Swift Current 2020.

	Emergence (plants/m^2)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64",%)	Plumps (>6/64", %)	Thousand kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	168.8 b	218.3 ab	1	4387.1 b	13.4	17.7	76.9	41.3	100.0	97.8
AAC Synergy	174.8 b	218.0 b	1	4867.0 a	13.1	12.9	82.7	43.7	99.5	98.8
CDC Bow	192.8 a	218.8 a	1	4474.5 b	13.2	15.8	78.4	41.9	99.7	98.2
LSD	15.9	0.5	NS	237	NA	NA	NA	NA	NA	NA
Nitrogen Rate (Soil + fertilizer) (lb N/ac)										
Background N[1]	193.3 a	218.1 a	1	4392.7 b	11.5	10.3	86.1	43.6	99.7	97.9
60	191.3 ab	218.3 a	1	4371.0 b	12.5	13.0	82.1	43.0	99.7	97.5
120	185.3 ab	218.8 a	1	4798.0 a	12.8	13.5	82.0	42.3	99.8	98.5

180	171.5 bc	218.1 a	1	4855.1 a	14.2	18.2	76.2	41.7	99.7	99.0
240	152.6 c	218.5 a	1	4464.2 b	15.4	22.4	70.0	40.9	99.8	98.5
LSD	20.5	NS	NS	305	NA	NA	NA	NA	NA	NA
V by M interaction	NS	NS	NS	NS	NA	NA	NA	NA	NA	NA

[1]Background level of N was 47 lb N/ac.

Table 35. Main effects of variety and nitrogen rate on various parameters of barley at Yorkton 2020.

	Emergence (plants/m^2)	**Maturity (Julian days)**	**Lodging (0-9)**	**Yield (kg/ha @13.5%)**	**Protein (%)**	**Thins (>5/64",%)**	**Plumps (>6/64", %)**	**Thousand kernel Weight (g)**	**4ml Energy Germination (%)**	**8ml Water Sensitive Germination (%)**
Variety (V)										
AC Metcalfe	280.6 a	210.5 a	0	2473.2 a	14.3	1.2	98.4	48.0	91.3	51.9
AAC Synergy	274.0 a	210.7 a	0	2718.6 a	13.7	0.9	98.7	50.3	85.8	72.9
CDC Bow	280.6 a	211.0 a	0	2564.3 a	13.4	0.9	98.7	50.1	52.3	42.1
LSD		NS	NS	NS	NA	NA	NA	NA	NA	NA
Nitrogen Rate (Soil + fertilizer) (lb N/ac)										
Background N[1]	280.7 a	210.3 a	0	2229.8 a	11.6	0.7	99.1	49.7	73.0	48.7

60	284.2 a	210.4 a	0	2550.4 ab	12.5	0.7	98.9	49.7	73.0	51.5
120	281.8 a	210.6 a	0	2613.9 bc	14.8	1.2	98.3	49.6	78.3	59.2
180	268.2 a	211.1 a	0	2913.0 c	14.8	1.2	98.5	49.5	80.2	61.5
240	277.1 a	211.1 a	0	2619.5 bc	15.3	1.3	98.3	48.9	77.8	57.3
LSD	NS	NS	NS	344	NA	NA	NA	NA	NA	NA
V by M interaction	NS	NS	NS	NS	NA	NA	NA	NA	NA	NA
[1]Background level of N was 38 lb N/ac.										

Table 36. Main effects of variety and nitrogen rate on various parameters of barley at Melfort 2021.

	Emergence (plants/m²)	**Maturity (Julian days)**	**Lodging (0-9)**	**Yield (kg/ha @13.5%)**	**Protein (%)**	**Thins (>5/64”,%)**	**Plumps (>6/64”, %)**	**Thousand kernel Weight (g)**	**4ml Energy Germination (%)**	**8ml Water Sensitive Germination (%)**
Variety (V)										
AC Metcalfe	204.4 a	215.3 a	1 a	3146.9 b	13.5	1.4	98.2	45.9	97.1	89.7
AAC Synergy	215.8 a	215.2 a	1 a	3448.1 a	12.1	1.8	97.8	46.4	96.6	90.2
CDC Bow	212.2 a	215.2 a	1 a	2925.6 b	12.7	1.3	98.4	47.7	97.1	84.2
LSD	NS	NS	NS	251	NA	NA	NA	NA	NA	NA
Nitrogen Rate (Soil + fertilizer) (lb N/ac)										

Background N[1]	228.2 a	215.0 b	1 a	3003.3 a	11.3	1.5	98.0	46.2	97.5	90.3
Background N[1]	219.2 ab	215.0 b	1 a	3281.2 a	11.9	1.5	98.1	46.4	97.5	86.7
120	215.3 ab	215.0 b	1 a	3036.6 a	11.2	1.6	98.0	46.3	94.7	88.5
180	207.3 b	215.2 b	1 a	3397.9 a	14.1	1.4	98.3	46.7	99.2	88.8
240	183.7 c	215.9 a	1 a	3148.6 a	15.2	1.6	98.0	47.9	95.8	85.8
LSD	14.3	0.2	NS	NS	NA	NA	NA	NA	NA	NA
V by M interaction	0.02	NS	NS	0.004	NA	NA	NA	NA	NA	NA

[1]Background level of N was 93 lb N/ac.

Table 37. Main effects of variety and nitrogen rate on various parameters of barley at Prince Albert 2021.

	Emergence (plants/m^2)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64",%)	Plumps (>6/64", %)	Thousand kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	222.1 a	237 a	0.80 a	5639.1 a	13.5	2.7	96.3	47.2	71.2	33.3
AAC Synergy	131.7 b	237 a	0.95 a	5128.2 a	13.0	2.6	96.4	46.7	76.9	32.2
CDC Bow	137.4 b	237 a	1.60 a	4912.6 a	12.6	3.3	95.8	46.0	79.8	32.7
LSD	18.0	NS	NS	NS	NA	NA	NA	NA	NA	NA
Nitrogen										

Rate (Soil + fertilizer) (lb N/ac)										
Background N[1]	175.5 a	237 a	0.5 a	5122.3 a	12.8	2.8	96.1	47.4	75.8	33.0
60	161.2 a	237 a	1.33 a	4874.9 a	13.8	3.3	95.8	45.8	76.2	29.0
120	169.0 a	237 a	1.00 a	5449.2 a	12.9	2.9	96.1	46.8	83.8	36.3
180	158.0 a	237 a	1.33 a	5825.3 a	13.6	2.8	96.4	46.8	70.2	30.5
240	155.0 a	237 a	1.42 a	4861.3 a	12.0	2.7	96.5	46.3	73.8	34.8
LSD	NS	NS	NS	NS	NA	NA	NA	NA	NA	NA
V by M interaction	NS	NS	NS	NS	NA	NA	NA	NA	NA	NA

[1]Background level of N was 54 lb N/ac.

Table 38. Main effects of variety and nitrogen rate on various parameters of barley at Swift Current 2021.

	Emergence (plants/m^2)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64",%)	Plumps (>6/64", %)	Thousand kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	184.8 a	219.4 a	1 a	881.3 c	16.8	3.1	94.5	40.0	84.7	48.7
AAC Synergy	151.4 b	219.0 a	1 a	1243.8 a	15.5	2.9	94.9	42.4	93.2	69.7
CDC Bow	187.8 a	218.6 a	1 a	1059.8 b	14.9	2.5	95.6	40.6	84.7	37.6
LSD	12.4	NS	NS	92.1	NA	NA	NA	NA	NA	NA

Nitrogen Rate (Soil + fertilizer) (lb N/ac)										
Background N[1]	172.6 a	218.6 a	1 a	875.6 2	13.5	3.3	94.3	40.2	83.5	45.7
60	185.0 a	218.5 a	1 a	900.5 b	14	3.1	94.3	40.2	86.5	47.8
120	180.0 a	218.8 a	1 a	1163.0 a	16.3	2.4	96.1	41.2	85.2	55.0
180	168.7 a	219.3 a	1 a	1173.3 a	17.4	2.6	95.0	41.8	89.8	54.8
240	166.1 a	219.8 a	1 a	1195.7 a	17.4	2.8	95.2	41.5	92.7	56.7
LSD	NS	NS	NS	119.0	NA	NA	NA	NA	NA	NA
V by M interaction	0.003	NS	NS	NS	NA	NA	NA	NA	NA	NA

[1]Background level of N was 44 lb N/ac.

Table 39. Main effects of variety and nitrogen rate on various parameters of barley at Yorkton 2021.

	Emergence (plants/m²)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64",%)	Plumps (>6/64", %)	Thousand kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	319.1 a	207.2 a	1.55 a	1472.1 a	17.6	1.9	97.4	42.0	11.2	7.4
AAC Synergy	321.3 a	206.7 a	1.75 a	1473.7 a	17.0	2.3	97.0	42.2	14.2	6.2
CDC Bow	323.6 a	206.7 a	1.90 a	1435.4 a	16.5	1.6	97.8	41.8	8.3	6.8

LSD	NS	NS	NS	NS	NA	NA	NA	NA	NA	NA
Nitrogen Rate (Soil + fertilizer) (lb N/ac)										
Background N[1]	297.3 c	206.3 c	1.83 a	1667.5 a	16.8	2.0	97.2	41.8	12.7	6.3
Background N[1]	305.4 bc	206.4 bc	1.67 a	1566.1 a	17.2	1.9	97.4	42.3	11.2	8.2
120	342.2 a	206.8 abc	1.42 a	1350.7 a	16.3	1.9	97.5	41.7	13.2	5.7
180	327.7 ab	207.2 ab	1.92 a	1274.1 a	17.4	1.9	97.6	41.9	8.7	6.0
240	334.1 a	207.5 a	1.83 a	1443.7 a	17.6	2.0	97.5	42.4	10.5	7.8
LSD	24.8	0.8	NS	NS	NA	NA	NA	NA	NA	NA
V by M interaction	NS	NS	NS	NS	NA	NA	NA	NA	NA	NA

[1]Background level of N was 77 lb N/ac.

Table 40. Main effects of variety and nitrogen rate on various parameters of barley at Melfort 2022.

	Emergence (plants/m^2)	**Maturity (Julian days)**	**Lodging (0-9)**	**Yield (kg/ha @13.5%)**	**Protein (%)**	**Thins (>5/64”,%)**	**Plumps (>6/64”, %)**	**Thousand kernel Weight (g)**	**4ml Energy Germination (%)**	**8ml Water Sensitive Germination (%)**
Variety (V)										

AC Metcalfe	222.9 a	232.4 a	1.6 a	4699.7 b	11.5	4.0	95.0	45.3	99.2	94.0
AAC Synergy	226.7 a	232.6 a	1.5 a	5460.8 a	10.3	1.8	97.3	46.8	99.5	94.4
CDC Bow	223.5 a	233.6 a	1.0 b	5330.4 a	10.6	1.7	98.0	50.4	96.5	89.9
LSD	NS	NS	0.4	357.3	NA	NA	NA	NA	NA	NA
Nitrogen Rate (Soil + fertilizer) (lb N/ac)										
Background N[1]	221.6 a	233.3 ab	1.0 b	3870.1 d	9.9	1.6	97.3	47.7	99.2	93.3
Background N[1]	220.5 a	234.0 a	1.0 b	4204.6 d	10.2	2.1	97.4	46.2	98.5	91.8
120	222.1 a	230.5 c	1.0 b	5050.3 c	10.0	2.4	96.6	48.1	99.0	93.5
180	240.0 a	232.4 b	1.3 b	5981.4 b	11.4	2.7	96.9	46.7	99.5	93.7
240	217.6 a	234.0 a	2.3 a	6711.7 a	12.5	3.7	95.7	48.7	95.8	91.5
LSD	NS	1.42	0.5	461.3	NA	NA	NA	NA	NA	NA
V by M interaction	NS	NS	0.014	NS	NA	NA	NA	NA	NA	NA
[1]Background level of N was 66 lb N/ac.										

Table 41. Main effects of variety and nitrogen rate on various parameters of barley at Prince Albert 2022.

	Emergence (plants/m^2)	**Maturity (Julian**	**Lodging (0-9)**	**Yield (kg/ha**	**Protein (%)**	**Thins (>5/64",%)**	**Plumps (>6/64", %)**	**Thousand kernel**	**4ml Energy Germination**	**8ml Water Sensitive**

		days)		@13.5%)				Weight (g)	(%)	Germination (%)
Variety (V)										
AC Metcalfe	322.5 a	234.5 a	2.15 a	4769.3 b	13.1	9.0	86.3	45.8	96.2	79.3
AAC Synergy	170.3 c	235.6 a	1.20 b	6344.3 a	12.1	2.9	95.5	53.4	96.0	87.5
CDC Bow	236.3 b	235.5 a	1.00 b	6192.8 a	11.7	1.9	96.6	53.7	96.9	76.8
LSD	18.4	NS	0.42	270.0	NA	NA	NA	NA	NA	NA
Nitrogen Rate (Soil + fertilizer) (lb N/ac)										
Background N[1]	215.8 b	236.2 a	1.33 a	5812.4 a	11.8	3.6	94.7	51.6	96.0	82.3
Background N[1]	263.5 a	234.8 a	1.33 a	5719.7 a	11.9	4.1	93.3	51.2	95.5	83.5
Background N[1]	247.5 a	234.6 a	1.25 a	5710.9 a	11.6	3.4	94.3	51.4	96.8	80.5
180	247.8 a	234.8 a	1.58 a	5819.8 a	12.7	5.6	90.7	50.4	96.7	78.0
240	240.5 a	235.7 a	1.75 a	5781.3 a	13.4	6.2	91.0	50.3	96.8	81.7
LSD	23.8	NS	NS	NS	NA	NA	NA	NA	NA	NA
V by M interaction	NS	NS	NS	0.011	NA	NA	NA	NA	NA	NA

[1]Background level of N was 138 lb N/ac.

Table 42. Main effects of variety and nitrogen rate on various parameters of barley at Swift Current 2022.

	Emergence (plants/m²)	**Maturity (Julian days)**	**Lodging (0-9)**	**Yield (kg/ha @13.5%)**	**Protein (%)**	**Thins (>5/64",%)**	**Plumps (>6/64", %)**	**Thousand kernel Weight (g)**	**4ml Energy Germination (%)**	**8ml Water Sensitive Germination (%)**
Variety (V)										
AC Metcalfe	191.6 a	216.3 b	1 a	2513.1 a	16.4	4.9	93.3	42.5	99.2	98.0
AAC Synergy	177.4 a	219.0 a	1 a	2638.8 a	15.3	5.1	93.3	45.3	99.2	98.8
CDC Bow	189.0 a	218.4 a	1 a	2649.2 a	15.0	3.3	94.7	45.0	99.0	98.4
LSD	NS	0.78		NS	NA	NA	NA	NA	NA	NA
Nitrogen Rate (Soil + fertilizer) (lb N/ac)										
Background N[1]	185.1 a	216.9 b	1 a	2644.5 a	14.6	4.4	93.8	44.4	99.2	98.3
Background N[1]	191.7 a	216.8 b	1 a	2706.4 a	14.2	3.6	94.6	44.8	98.3	98.5
Background N[1]	190.7 a	217.5 b	1 a	2619.3 a	15.9	4.8	93.3	44.0	99.7	98.5
180	180.3 a	218.7 a	1 a	2616.2 a	16.5	5.0	93.0	44.0	99.0	98.3
240	182.1 a	219.5 a	1 a	2415.3 b	16.8	4.3	94.0	44.3	99.5	98.3
LSD	NS	1.0	NS	174.1	NA	NA	NA	NA	NA	NA
V by M interaction	NS	NS	NS	NS	NA	NA	NA	NA	NA	NA

[1]Background level of N was 159 lb N/ac.

Table 43. Main effects of variety and nitrogen rate on various parameters of barley at Yorkton 2022.

	Emergence (plants/m²)	Maturity (Julian days)	Lodging (0-9)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64",%)	Plumps (>6/64", %)	Thousand kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	319.1 a	235.7 a	1.1 a	4941.2 b	11.9	3.9	94.7	44.6	95.1	59.9
AAC Synergy	321.3 a	235.8 a	0.7 b	5521.2 a	11.3	2.2	97.0	48.4	97.7	81.1
CDC Bow	323.6 a	235.8 a	0.2 c	5507.1 a	11.5	2.2	96.7	48.4	90.2	55.9
LSD	NS	NS	0.4	317.0	NA	NA	NA	NA	NA	NA
Nitrogen Rate (Soil + fertilizer) (lb N/ac)										
Background N[1]	297.3 c	236.4 a	0.2 c	4729.5 c	11.2	2.5	96.4	47.3	94.5	65.8
Background N[1]	305.4 bc	235.7 b	0.3 c	4822.7 bc	11.1	2.0	97.2	47.7	93.7	62.7
120	342.2 a	235.7 b	0.2 c	5199.4 b	11.2	2.5	96.0	46.5	93.3	66.3
180	327.7 ab	235.3 b	0.8 b	5880.8 a	11.5	2.7	96.2	47.0	93.8	64.8
240	334.1 a	235.7 b	2.0 a	5983.5 a	12.7	4.0	94.9	47.1	96.3	68.5
LSD	24.8	0.64	0.5	409.2	NA	NA	NA	NA	NA	NA
V by M interaction	NS	0.0001	<0.0001	NS	NA	NA	NA	NA	NA	NA

[1]Background level of N was 104 lb N/ac.