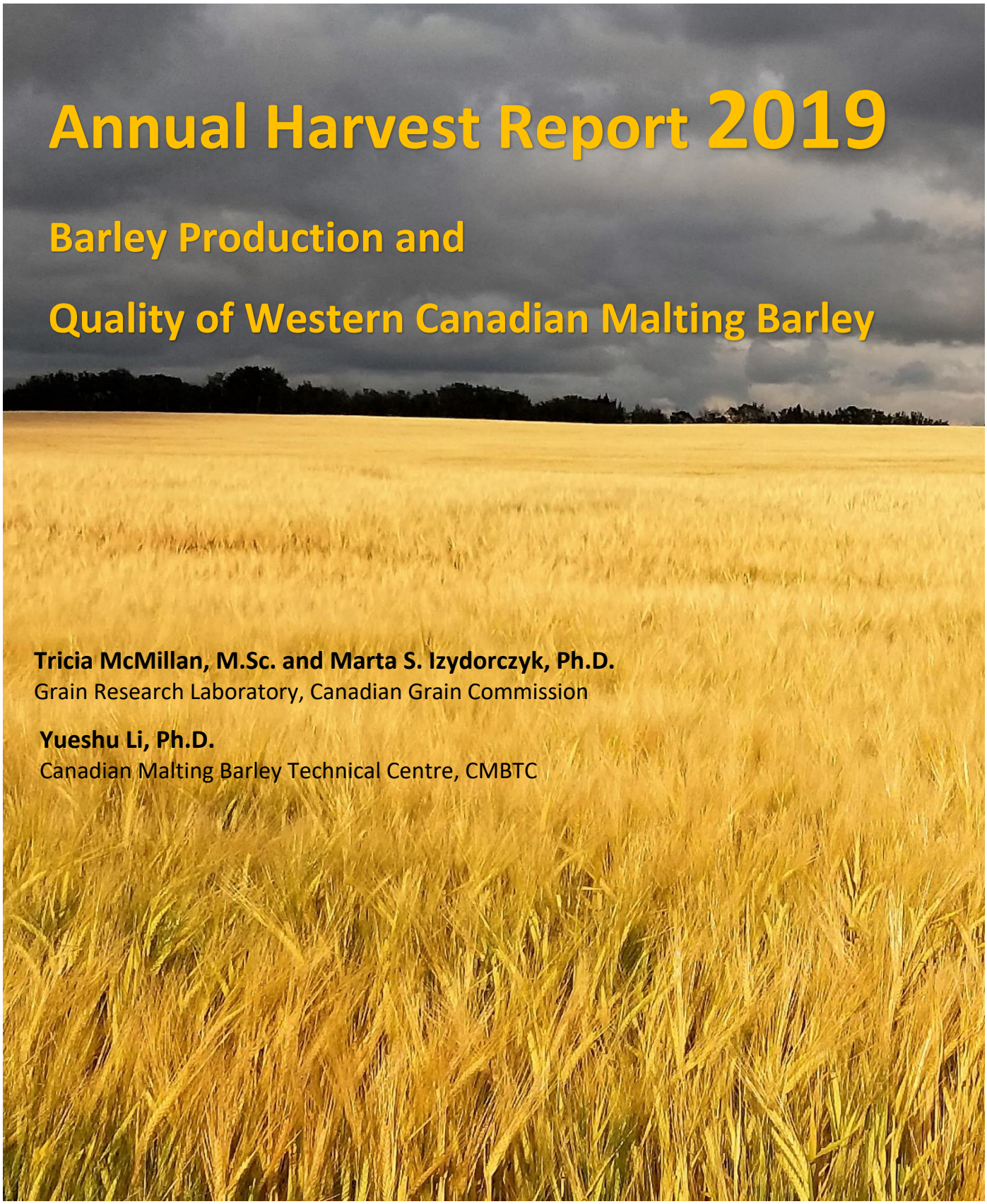
Canadian Grain Commission | Commission canadienne des grains



Annual Harvest Report 2019

Barley Production and Quality of Western Canadian Malting Barley

Tricia McMillan, M.Sc. and Marta S. Izydorczyk, Ph.D.
Grain Research Laboratory, Canadian Grain Commission

Yueshu Li, Ph.D.
Canadian Malting Barley Technical Centre, CMBTC

Version: Final draft

CMBTC™ CANADIAN MALTING BARLEY TECHNICAL CENTRE

Canada

Table of contents

Summary

Total barley production in Western Canada in 2019 is estimated at 9,617,000 tonnes, which represents an increase of 20.3% compared to 2018. The higher barley production in 2019 has been attributed to an increase in barley-seeded area this year. The total area planted with barley in Western Canada in 2019 was 2,878,000 hectares, indicating a 15.1% increase compared to the 2018 acreage. The average yield for barley in Canada is estimated at 68.5 bushels per acre in 2019 compared to 65.0 bushels per acre in 2018.

CDC Copeland (44.03%), AC Metcalfe (23.70%) and AAC Synergy (19.20%) dominated the portfolio of malting barley cultivars being grown in 2019 in Western Canada. In 2019, the area seeded with CDC Copeland and AC Metcalfe decreased by 2.3% and 6.1%, respectively, compared to 2018. On the other hand, the area seeded with AAC Synergy increased by 8% in 2019 compared to 2018. The area seeded with each of the newer barley varieties, such as AAC Connect, CDC Bow, CDC Fraser, Sirish, Lowe, and CDC Copper, slightly increased in 2019.

The relatively dry and cool growing season in 2019 produced barley with lower kernel weight and protein concentration compared to 2018. Overall, protein content in barley grain averaged at 11.5% dry basis (db) in 2019 compared to 11.9% (db) in 2018. The 1000 kernel weight of this year's barley averaged at 45.1 g compared to 46.7 g last year. The average kernel size and kernel weight of the newer Canadian malting barley varieties, such as AAC Synergy, AAC Connect, Bentley, CDC Bow, and CDC Fraser, were noticeably higher than those of CDC Copeland and AC Metcalfe.

The 2019 crop was challenged by wet harvest conditions, resulting in a high incidence of pre-harvest sprouting as indicated by relatively low RVA values (<50 RVU). The average moisture content of barley grain received in this survey was higher than usual. The majority of barley tested in this survey showed adequate germination energy (98%), but water sensitivity was higher than last year.

Generally, good quality malt was obtained from 2019 barley with adequate levels of enzymes (diastatic power and α-amylase), soluble proteins, and free amino nitrogen (FAN). Lower concentration of grain proteins in 2019 barley resulted in higher malt extract levels than the 2018 and 5-year average values.

Good quality malt can be produced from the 2019 barley crop through careful selection, timely malting, and application of appropriate processing conditions.

Part 1: Growing and harvest conditions in 2019

In most areas of Western Canada, 2019 spring planting was completed by the first week of June. Dry conditions in the southern regions created some germination issues, especially for early seeded crops. Dry and cool weather conditions through June and July (Figures 1.1 and 1.2) slowed crop growth, and in some areas, particularly southern Alberta, significantly curtailed yield and quality potential. However, rains in late July and early August boosted crop development as well as yield and quality potential. Normal August harvest occurred mostly in the southern regions, where yields and quality were below average. In the central and northern regions, below-average temperatures during the growing season delayed crop maturity, pushing the harvest into late August and September. The late crop maturity supported larger yields, but harvest was plagued with rain and wet conditions through September (Figure 1.3), and interrupted by snow and frost in some areas. The wet conditions persisted through October, with about 95% of the barley crop harvested as of October 31 across the prairies. The wet conditions forced famers to harvest a high percentage of their barley tough (damp), which resulted in large volumes of barley that needed to be dried on farm. The rains also caused significant quality degradation in the malting barley crop this year, with a larger percentage grading feed compared with the previous two years. On the positive side, there was limited disease present in this year's barley crop.

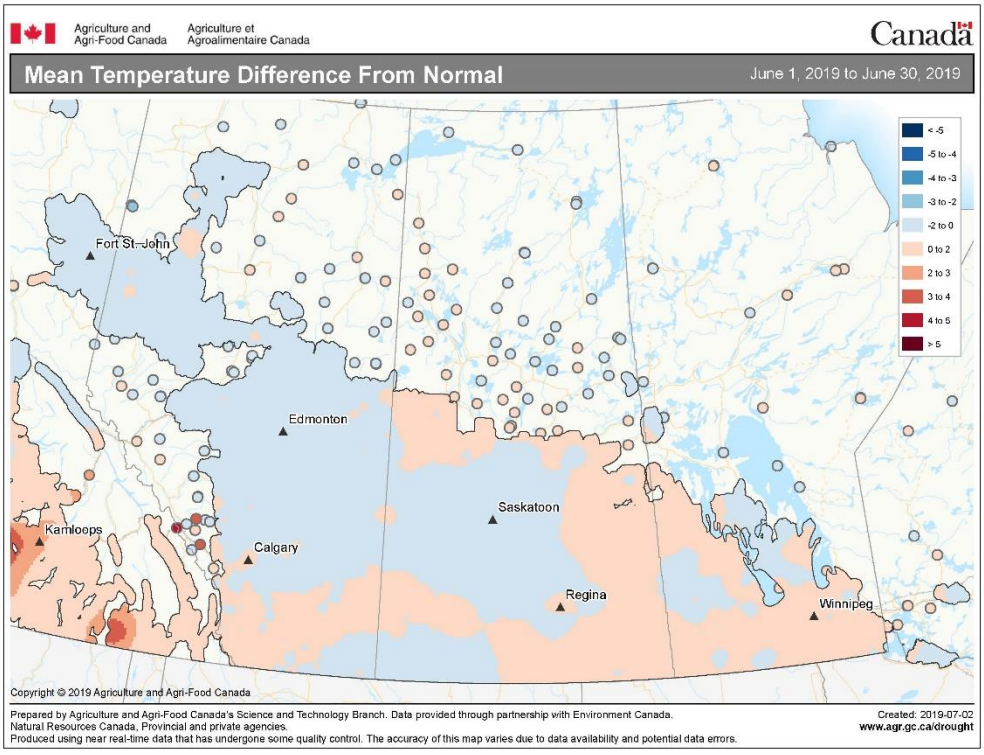


Figure 1.1 Mean temperature differences from normal for June, 2019

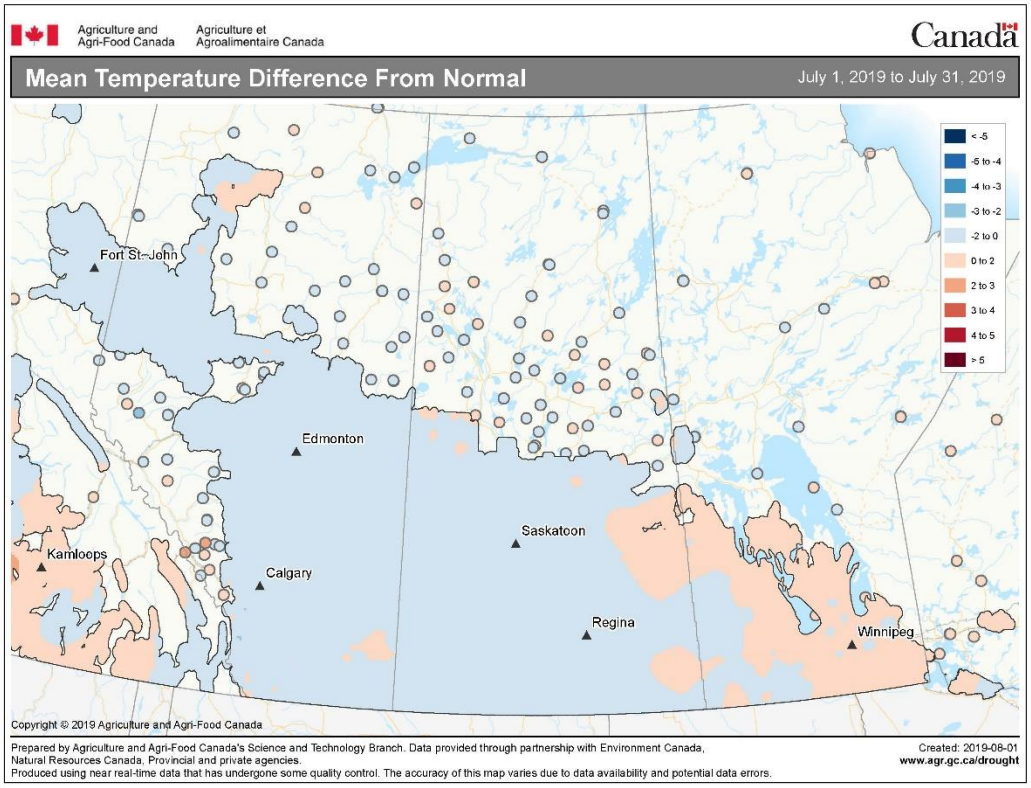


Figure 1.2 Mean temperature differences from normal for July, 2019

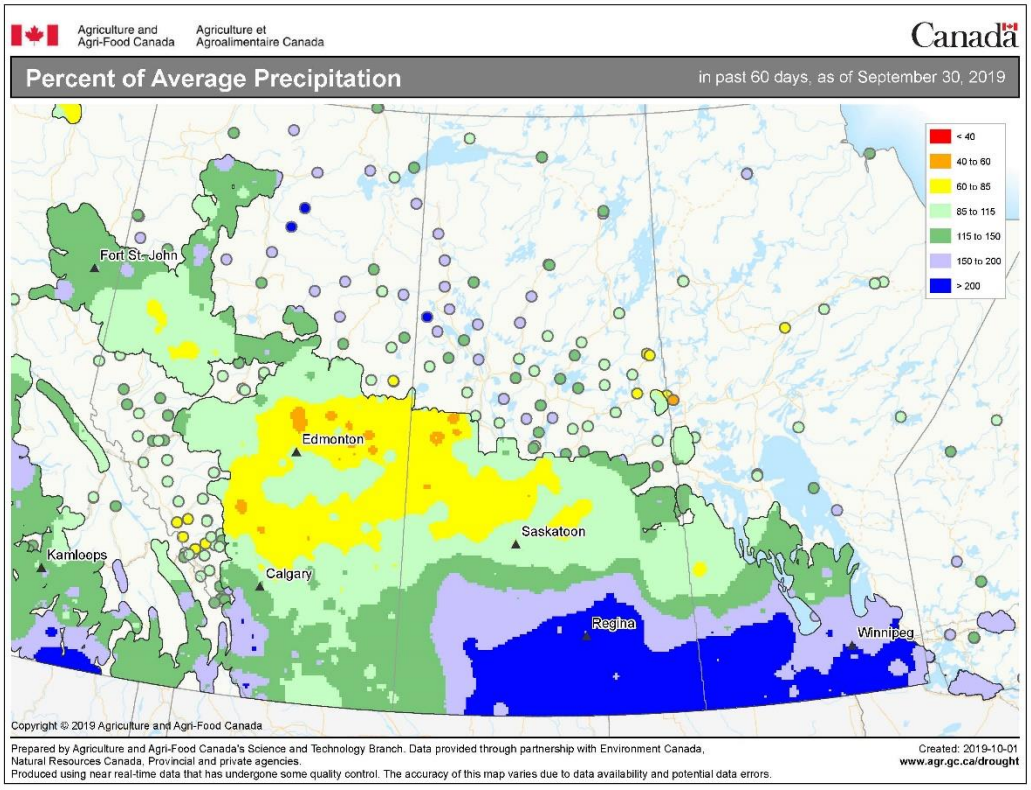


Figure 1.3 Percent of average precipitation from August 1 to September 30, 2019

Part 2: Barley production in 2019

2.1 Annual production statistics

The total area planted with barley in Western Canada in 2019 was 2.878 million hectares, indicating a 15.1% increase compared to the 2018 acreage (Table 2.1). Barley production in Western Canada in 2019, estimated at about 9.617 million tonnes, was about 20.3% higher than in 2018 (Table 2.2). The average yield for barley in Canada (entire country) is estimated at 68.5 bushels per acre in 2019, compared to 65.0 bushels per acre in 2018 (Table 2.3 and Figure 2.3).

Barley seeded area increased in 2019 in Alberta (including the northeastern part of BC), Saskatchewan, and Manitoba by 14.6%, 17.1%, and 3.8%, respectively, compared to last year (Table 2.1 and Figure 2.1). In 2019, barley production in Alberta (including the northeastern part of BC), Saskatchewan, and Manitoba increased by 24%, 18%, and 4.7%, respectively, compared to last year (Table 2.2 and Figure 2.2).

Table 2.1 Total barley seeded area

	Seeded area (million hectares)			
	2017	2018	10-year average*	2019**
Manitoba	0.107	0.131	0.173	0.136
Saskatchewan	0.941	1.089	1.001	1.275
Alberta & BC	1.170	1.280	1.428	1.467
Western Canada	**2.219**	**2.501**	**2.605**	**2.878**
Canada	**2.336**	**2.628**	**2.757**	**2.996**

Source: Statistics Canada
*10-year average from 2009 to 2018
** Estimated as of September 23, 2019

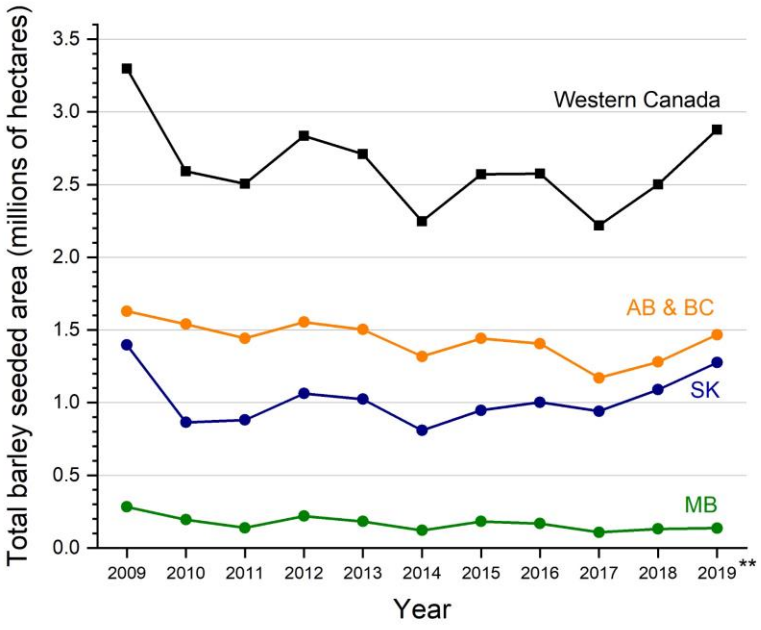


Figure 2.1 Yearly comparison of total barley seeded area in Western Canada

Table 2.2 Total barley production in Canada

	Production (millions of tonnes)			
	2017	2018	10-year average*	2019**
Manitoba	0.438	0.501	0.551	0.525
Saskatchewan	3.135	3.439	2.921	4.061
Alberta & BC	3.944	4.057	4.419	5.030
Western Canada	**7.516**	**7.997**	**7.903**	**9.617**
Canada	**7.891**	**8.380**	**8.375**	**9.987**

Table 2.3 Average barley yield

	Average barley yield (bushels per acre)			
	2017	2018	10-year average*	2019**
Manitoba	80.4	75.3	65.6	80.0
Saskatchewan	66.4	62.7	58.8	64.3
Alberta	71.8	66.8	67.6	72.0
Western Canada	**69.8**	**65.4**	**64.1**	**69.1**
Canada	**69.4**	**65.0**	**63.9**	**68.5**

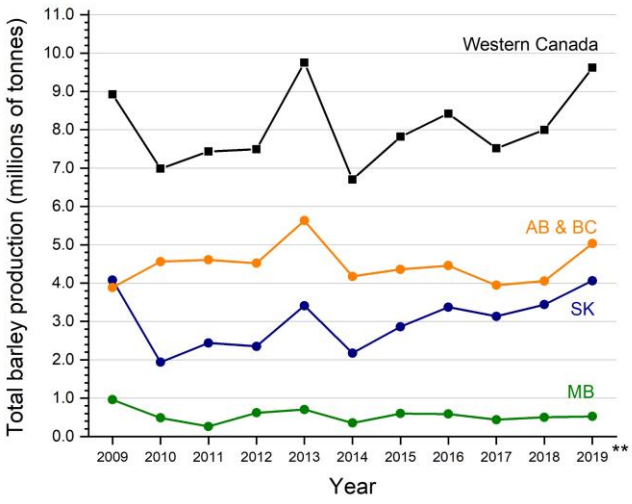


Figure 2.2 Yearly comparison of total barley production in Western Canada

Source: Statistics Canada, Table 32-10-0359-01
*10 year average calculated from 2009 to 2018
**Estimated as of September 23, 2019

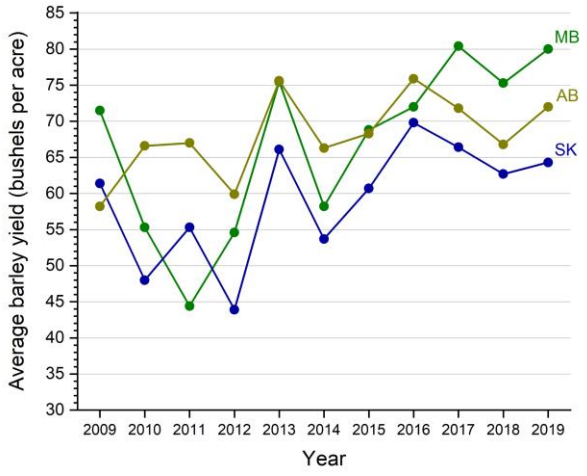


Figure 2.3 Yearly comparison of average barley yield in the Prairie Provinces

2.2 Distribution of barley classes and varieties

Barley is a versatile crop grown for malting, food, and general purposes (feed and forage) across the Canadian Prairies. Based on insured commercial acres, general purpose barley accounted for 50.1% of total barley seeded area this year in Alberta, compared with malting barley at 45.8% (Figure 2.4, left). In Saskatchewan, the majority of seeded area (67.7%) was planted with malting barley varieties (Figure 2.4, left). In Manitoba, about 45.9% of barley seeded area was allocated to malting varieties and 49.4% to general purpose varieties (Figure 2.4, left). Overall in Western Canada 2019, seeded area comprised of 55.1% malting barley, 37.3% general purpose barley, and 2.2% food barley (Figure 2.4, right).

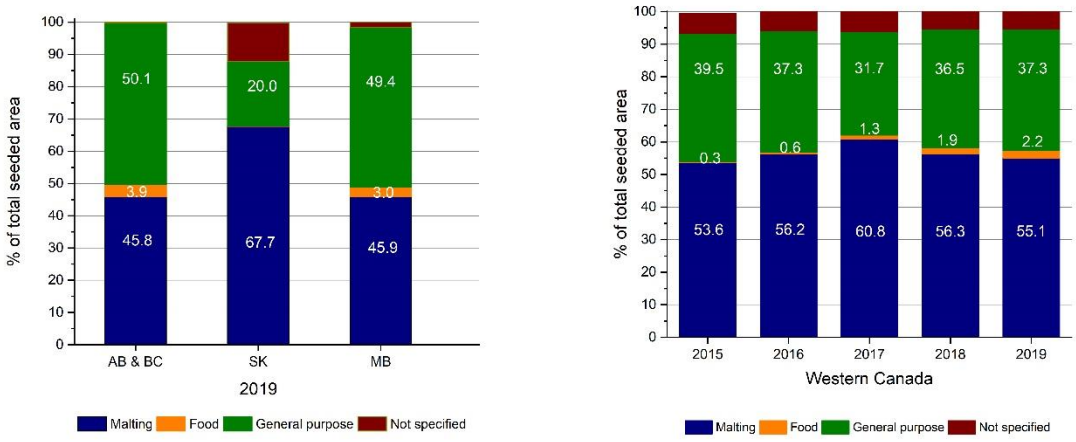


Figure 2.4 Distribution of barley classes as a percentage of total area seeded with barley in each province in 2019 (left) and overall in Western Canada from 2015-2019 (right)

In 2019, CDC Copeland, AC Metcalfe, and AAC Synergy dominated the portfolio of malting barley cultivars being grown in Western Canada (Table 2.4). The area seeded with CDC Copeland (44.03%) was lower than last year (46.31%). The area seeded with AC Metcalfe decreased from 29.79% in 2018 to 23.70% in 2019 (Figure 2.5). The third most popular variety in 2019 was AAC Synergy, whose acreage has been increasing since 2014 (Figure 2.5). The acreage planted with recently registered two-rowed cultivars, including CDC Bow, AAC Connect, CDC Fraser, and CDC Copper (Figure 2.6), continued to grow, together accounting for about 4.63% of total area seeded with malting barley varieties in Western Canada (Table 2.4).

The production of six-rowed malting barley continued to decline. In 2019, the six-rowed cultivars occupied only about 4.01% of the total area seeded with malting barley, compared to 4.67% in 2018. Legacy, Celebration and Tradition remained the top three six-rowed varieties (Table 2.4).

The production of two-rowed cultivars dominated in each province (Table 2.4). In Alberta and British Columbia (BC), CDC Copeland and AAC Synergy were the top two varieties. In Saskatchewan, CDC Copeland and AC Metcalfe dominated the acreage seeded with malting barley. Compared to Alberta and Saskatchewan, the area seeded with malting barley in Manitoba was relatively low. In 2019, the most popular cultivars seeded in Manitoba were AAC Synergy, CDC Copeland, and AC Metcalfe, followed by Celebration (Table 2.4).

Based on the insured acreage in Western Canada, food and general purpose barley varieties accounted for 39.5% of total barley seeded area (Figure 2.4 right). CDC Austenson, followed by Brahma, Champion, and Xena dominated the portfolio of general barley cultivars being grown in Western Canada (Table 2.5 and Figure 2.7). CDC Austenson was the top variety grown in every western province in 2019. Canmore is a new variety that can be used for food and feed purposes; it has experienced steady growth since 2014 (Figure 2.7).

Table 2.4 Distribution of malting barley cultivars as percentage of total area seeded with malting barley in Western Canada in 2019

Malting barley cultivars	% of total area seeded with malting barley in Western Canada in 2019			
	Alberta & BC	Saskatchewan	Manitoba	Western Canada
2-rowed	%	%	%	%
CDC Copeland	20.09	22.79	1.15	44.03
AC Metcalfe	6.92	15.81	0.97	23.70
AAC Synergy	9.91	8.04	1.25	19.20
AAC Connect	0.75	0.77	0.54	2.06
CDC Bow	1.26	0.72	0.02	2.01
Newdale	0.43	0.62	0.50	1.55
Bentley	0.47	0.15	0.11	0.73
CDC PlatinumStar	0.00	0.69	0.00	0.69
CDC Fraser	0.27	0.15	0.11	0.53
Sirish	0.32	0.00	0.01	0.33
CDC Meredith	0.27	0.21	0.01	0.48
CDC Kindersley	0.12	0.02	0.06	0.20
Harrington	0.03	0.06	0.00	0.09
CDC Stratus	0.04	0.02	0.00	0.06
CDC PolarStar	0.01	0.05	0.00	0.06
BC 100	0.05	0.00	0.00	0.05
Cerveza	0.05	0.00	0.00	0.05
CDC Copper	0.03	0.00	0.00	0.03
Major	0.02	0.00	0.00	0.02
AC Oxbow	0.02	0.00	0.00	0.02
Lowe	0.02	0.00	0.00	0.02
Merit 57	0.01	0.00	0.00	0.01
Calder	0.01	0.00	0.00	0.01
Manley	0.00	0.00	0.00	0.01
CDC Goldstar	0.01	0.00	0.00	0.01
AAC Goldman	0.01	0.00	0.00	0.01
Total 2-rowed	**41.14**	**50.10**	**4.75**	**95.99**
6-rowed	%	%	%	%
Legacy	0.60	1.83	0.08	2.51
Celebration	0.00	0.25	0.73	0.98
Tradition	0.00	0.02	0.21	0.23
Total 6-rowed	**0.77**	**2.13**	**1.11**	**4.01**

Source: Sask Crop Insurance, Alberta Ag Financial Services Corp., Manitoba Agricultural Services Corporation, BC Crop Insurance

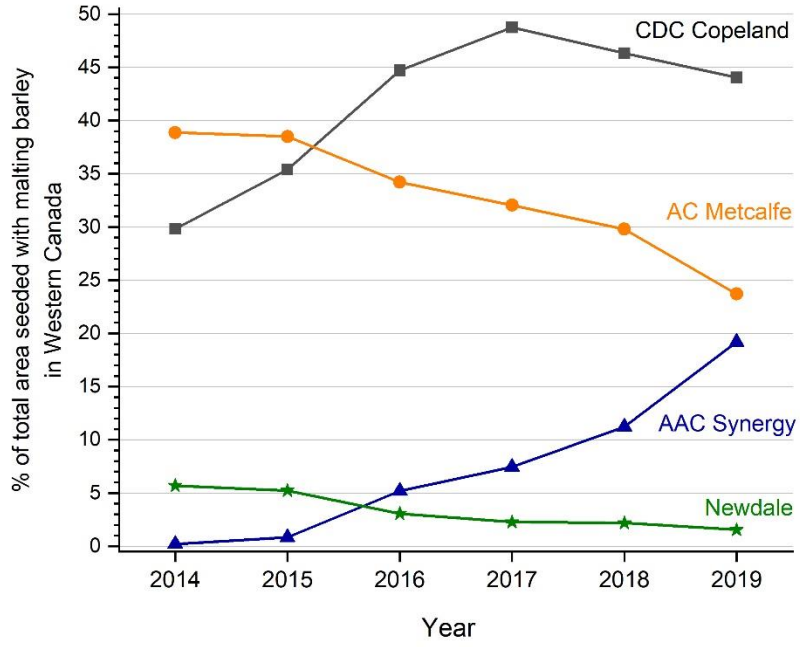


Figure 2.5 Comparison of areas seeded with top four malting barley cultivars in Western Canada from 2014 to 2019. Source: Sask Crop Insurance, Alberta Ag Financial Services Corp., Manitoba Agricultural Services Corporation, BC Crop Insurance

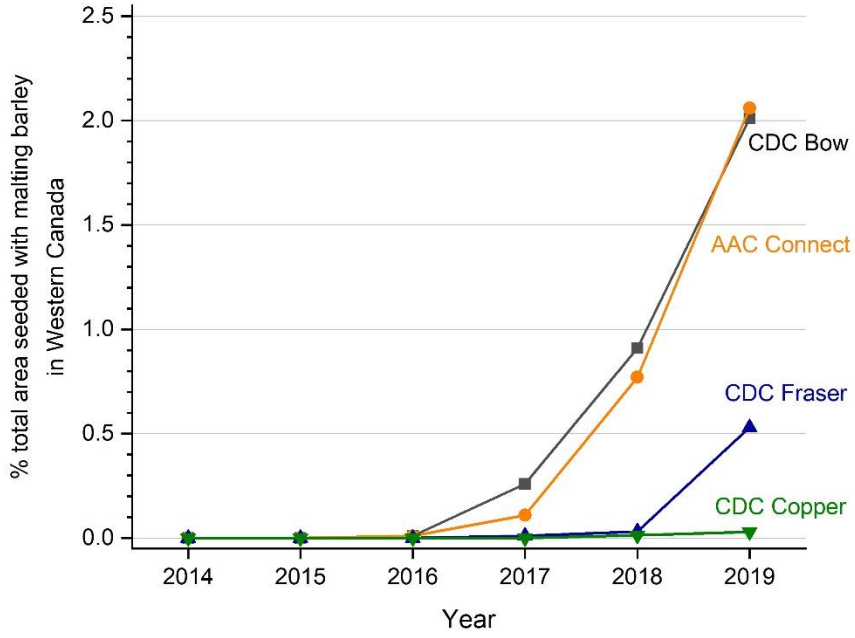


Figure 2.6 Comparison of areas seeded with the recently registered malting barley cultivars: AAC Connect (2016), CDC Bow (2015), CDC Fraser (2016), and CDC Copper (2018) in Western Canada from 2014 to 2019. The number in brackets indicates the year of variety registration. Source: Sask Crop Insurance, Alberta Ag Financial Services Corp., Manitoba Agricultural Services Corporation, BC Crop Insurance.

Table 2.5 Distribution of barley cultivars as percentage of area seeded with general purpose and food (F) barley in Western Canada in 2019

General purpose and food barley cultivars	% of total area seeded with general purpose and food barley in 2019			
	Alberta & BC	Saskatchewan	Manitoba	Western Canada
CDC Austenson	23.30	13.08	4.03	40.42
Brahma	10.80	0.11	--	10.91
Champion	5.77	1.65	0.29	7.72
Xena	6.32	0.32	0.00	6.64
Canmore (F)	5.02	--	0.52	5.54
Conlon	1.05	0.44	3.80	5.29
CDC Coalition	4.80	0.23	--	5.03
CDC Maverick	1.56	1.74	0.26	3.47
CDC Cowboy	1.59	1.05	0.10	2.74
Claymore	1.09	1.41	0.03	2.52
Oreana	2.04	0.36	0.08	2.48
CDC Thompson	0.71	0.00	--	0.71
Seebe	0.74	0.00	--	0.74
AC Ranger	0.15	0.45	0.01	0.62
Amisk	0.44	0.00	--	0.44
Sundre	0.30	0.12	--	0.41
AC Rosser	0.12	0.29	--	0.41
CDC Trey	0.35	0.05	--	0.40
Ponoka	0.37	--	--	0.37
Busby	0.30	--	--	0.30
Gadsby	0.23	--	--	0.23
CDC Bold	0.21	--	--	0.21
Stander	0.19	--	--	0.19
Falcon	0.16	--	--	0.16
AC Albright	0.14	--	--	0.14
CDC McGwire (F)	--	0.11	0.03	0.14
AB Cattlelac	0.13	--	--	0.13
Trochu	0.12	--	--	0.12
Vivar	0.12	--	--	0.12
Chigwell	0.11	--	--	0.11
CDC Helgason	0.11	--	--	0.11
CDC Dolly	0.04	0.07	--	0.10
Other	0.72	0.16	0.19	1.1
Total general purpose and food	**69.00**	**21.66**	**9.34**	**100.00**

Source: Sask Crop Insurance, Alberta Ag Financial Services Corp., Manitoba Agricultural Services Corporation, BC Crop Insurance.
(F): food barley varieties

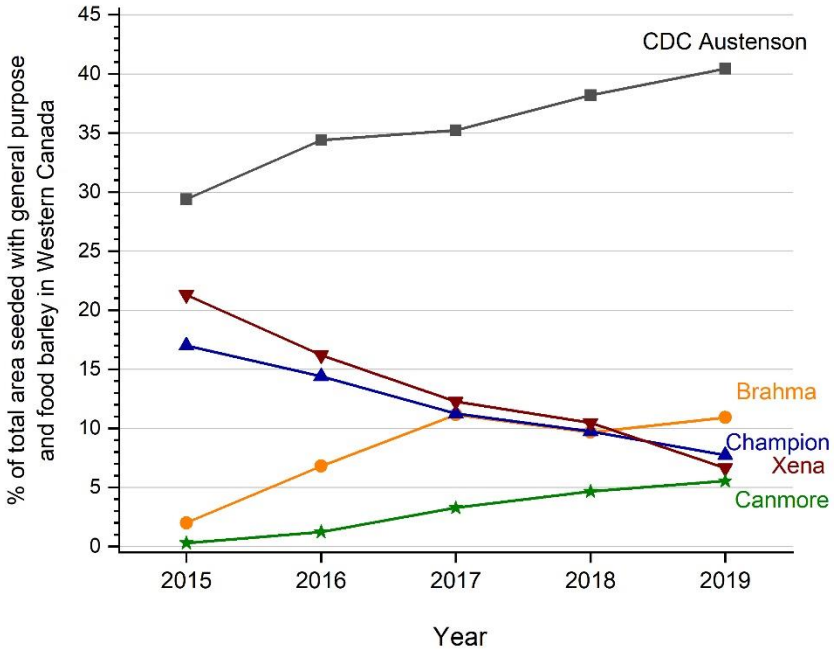


Figure 2.7 Comparison of areas seeded with top five general purpose and food barley cultivars in Western Canada from 2015 to 2019

Part 3: Annual harvest survey

3.1 Sampling and survey methodology

The 2019 malting barley survey was based on 88 varietal composites, representing about 1.5 million tonnes of barley selected for domestic malt processing or for export as malting barley by several grain handling and malting companies: Cargill Ltd., Canada Malting Co. Ltd., Rahr Malting Canada Ltd., Richardson International Ltd., Viterra Inc, and Malteurop Canada Ltd. The tonnage included in this survey represents a portion of the total volume of malting barley selected in Western Canada and does not reflect the actual amounts selected. Samples were received from the beginning of harvest until the end of October 2019. All results (unless otherwise stated) presented in this report represent weighted averages based on tonnage of composite samples received and analyzed.

3.2 Quality of barley selected for malting in 2019: general trends and annual statistics

The average level of barley proteins (11.5%) in 2019 was lower than last year (11.9%) and slightly lower than the 10-year average (11.6%) (Figure 3.1). Barley exhibited adequate germination energy (98%), equal to the 10-year average (Figure 3.2). This year's average 1000 kernel weight (45.1 g) was slightly lower than last year's average value (46.7 g), but higher than the 10-year average value (44.7 g) (Figure 3.3). Kernel plumpness, a measure of kernels remaining on the 6/64" slotted screen, averaged at 92.7%, which was lower than last year (95.6%) and slightly lower than the 10-year average (93.1%) (Figure 3.4).

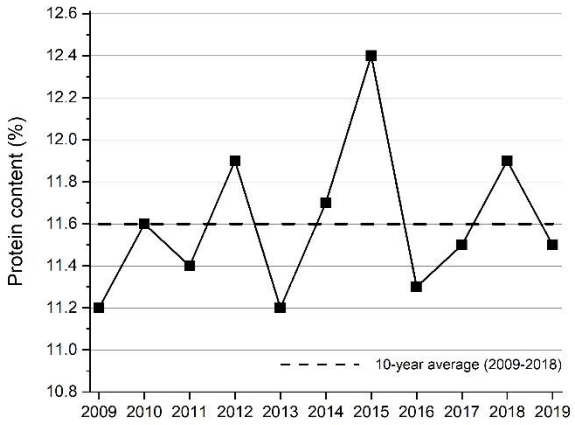


Figure 3.1 Average protein content in barley selected for malting from 2009 to 2019

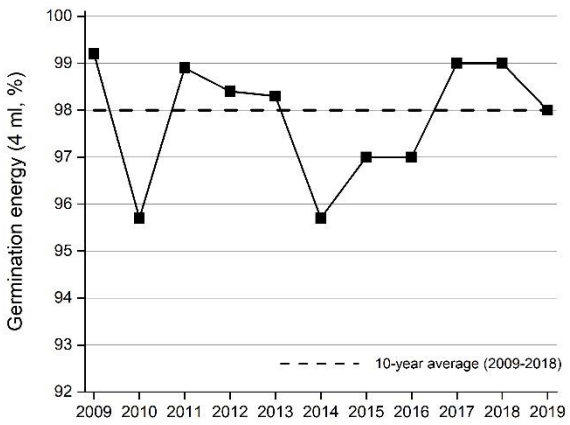


Figure 3.2 Average germination energy of barley selected for malting from 2009 to 2019

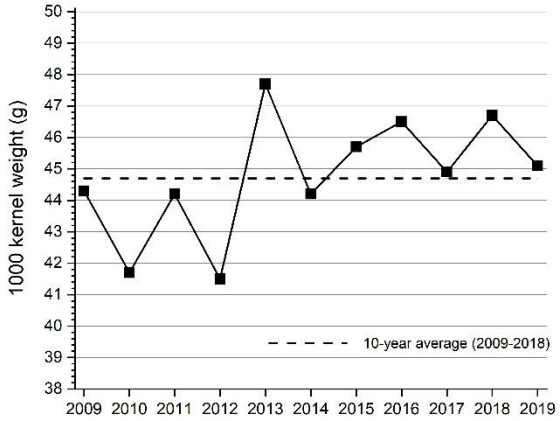


Figure 3.3 Average 1000 kernel weight of barley selected for malting from 2009 to 2019

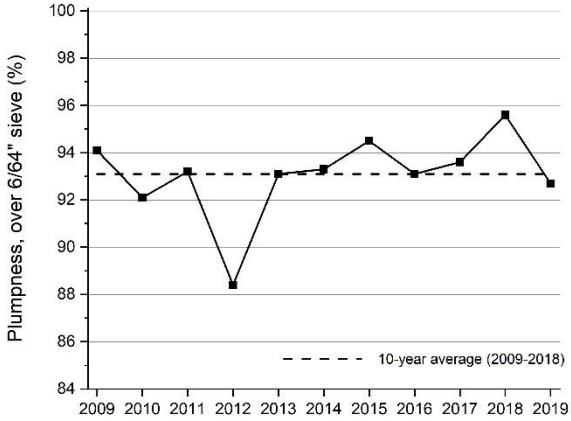


Figure 3.4 Average plumpness of barley selected for malting from 2009 to 2019

The average kernel diameter and kernel weight were determined for individual varieties using the Single Kernel Characterization System. The results indicated differences among barley varieties, with newer varieties, such as AAC Synergy, Bentley, AAC Connect, CDC Fraser, and CDC Bow, having bigger and heavier kernels than CDC Copeland and AC Metcalfe (Figure 3.5). The yearly variations in 1000 kernel weight and grain protein level in several established and new malting barley varieties are presented in Figures 3.6 and 3.7.

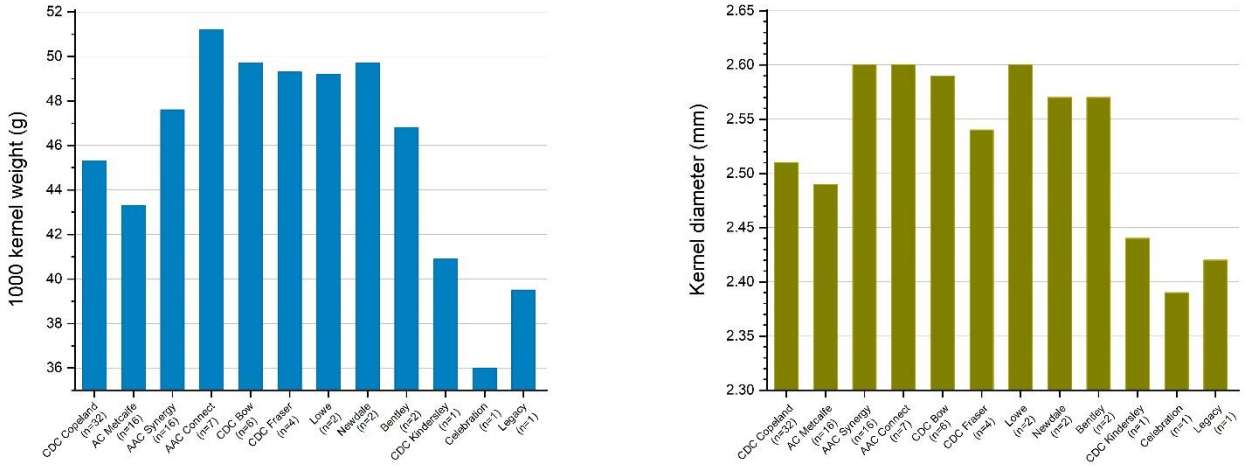


Figure 3.5 Average 1000 kernel weight (left) and average kernel diameter (right) for barley cultivars selected for malting in 2019. Kernel diameters values were determined using the Single Kernel Characterization System.

.

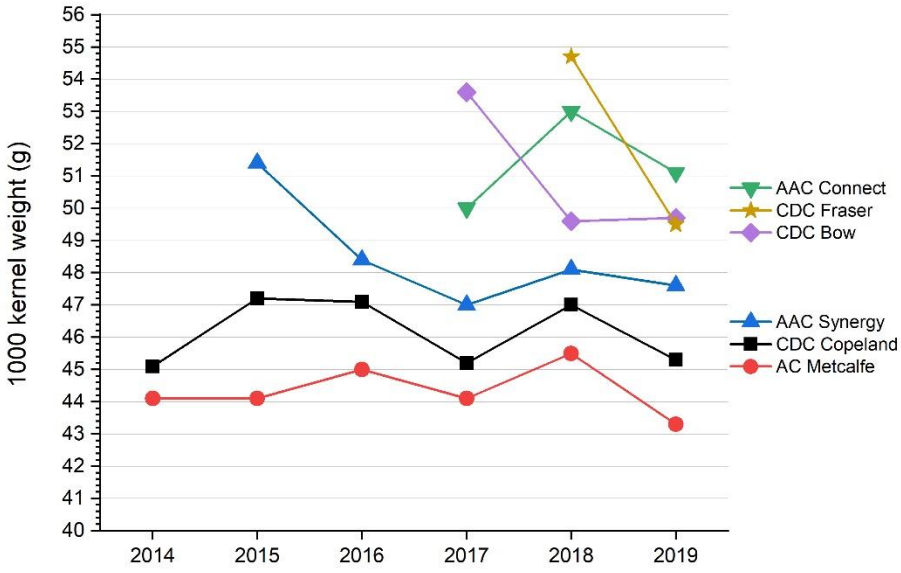


Figure 3.6 Comparison of the average 1000 kernel weight of selected barley varieties from 2014 to 2019

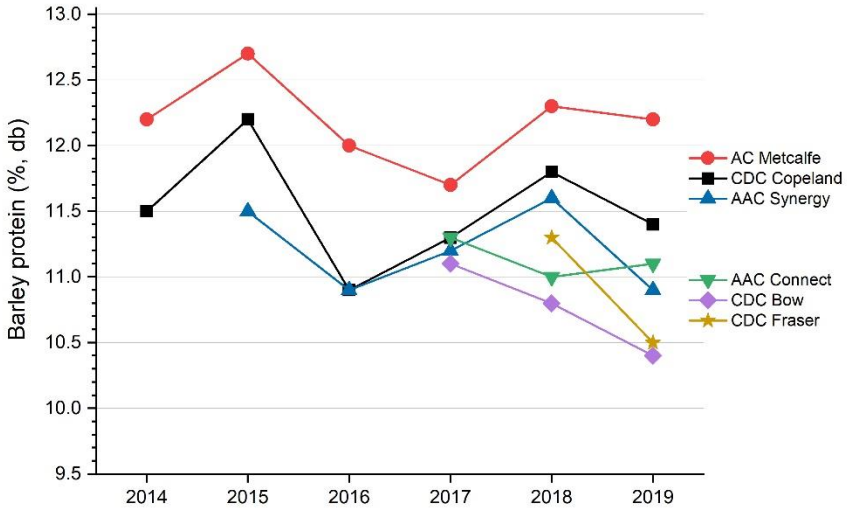
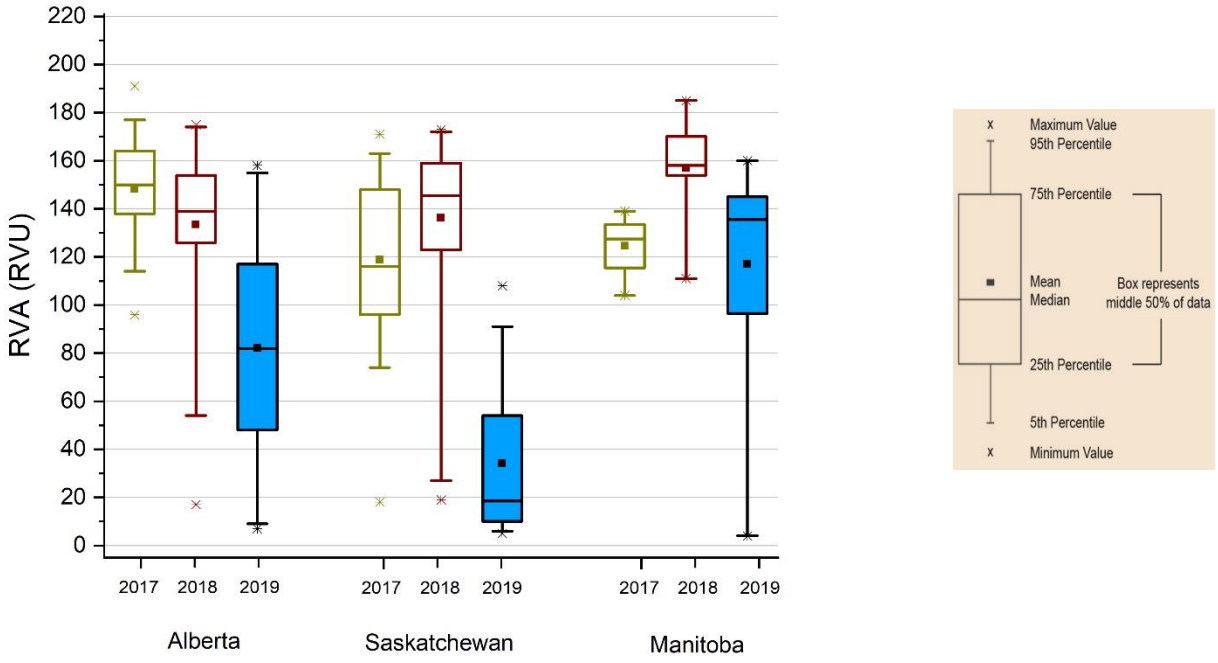


Figure 3.7 Comparison of the average protein content in selected barley varieties from 2014 to 2019

Pre-germination is the premature sprouting of grain while still in the ear as a consequence of prolonged spells of wet weather when mature grain remains uncut in the field or swathed and not yet combined. This event is called pre-harvest sprouting. One of the enzymes produced very early during germination is α-amylase. Since the level of α-amylase in sound grain is very low compared to its level in the germinating grain, the content of α-amylase in grain can be used as a marker of germination. Rapid visco analysis (RVA) indirectly estimates the amount of α-amylase in barley by measuring the viscosity of ground barley in water. The results are expressed as viscosity in Rapid Visco Units (RVU) than can be converted to centipoise (cP) (1 RVU = 12 cP).

Barley selectors use RVA to identify sound, moderately and strongly pre-germinated barley, and to manage their supply accordingly. Samples with final viscosity values > 120 (RVU) are considered sound, and the probability that they will retain germination energy after storage is very high. Samples with RVA values 50-120 (RVU) are moderately pre-germinated, whereas samples with RVA values < 50 (RVU) are substantially pre-germinated and the probability that they will lose germination energy during storage is high. They should be malted as soon as possible. To predict safe storage time more accurately, storage conditions (temperature and relative humidity) and the initial moisture content of the grain have to be taken into account, as well as the RVA values.

This year's crop was challenged by wet harvest conditions. The RVA results showed a high incidence of substantial pre-germination with RVA values < 50 RVU (Figure 3.8). The RVA results stress the need to identify barley with low RVU that should be malted promptly, especially if the moisture content of grain is relatively high. As indicated in the next section of this report, pre-germinated barley malted soon after harvest can produce good quality malt.



Risk of germination loss in storage	RVA viscosity (RVU)
Low	≥120
Intermediate	50-120
High	<50

Figure 3.8 RVA results for barley selected for malting in 2019 in comparison with previous years

3.3 Malting conditions and methodologies

Initial malting trials indicated that this year's barley generally achieved adequate hydration levels with two wet steep cycles at 14°C. However, pre-germinated barley absorbed water faster and to a greater extent than sound barley, and occasionally some barley samples were sprayed with water during germination. The germination and kilning steps were conducted according to the same schedules as last year. All analytical methods used in this survey to assess the barley, malt and wort quality are listed in Appendix I.

Table 3.1 Malting conditions used with GRL Phoenix Micromalting System in 2019

Steeping	10 hours wet steep, 14 hours air rest, 8 hours wet steep, 13 hours air rest @ 14°C
Germination	96 hours @ 15°C
Kilning	12 hours @ 60-65°C, 6 hours @ 65°C, 2 hours @ 75°C, 5 hours @ 83-85°C

3.4 Malting quality in 2019: varietal and yearly comparison

Figures 3.9 to 3.14 compare the average values of malt proteins, fine extract, malt diastatic power, malt α-amylase, wort free amino nitrogen (FAN), and wort β-glucans among six varieties evaluated annually in our survey since 2014.

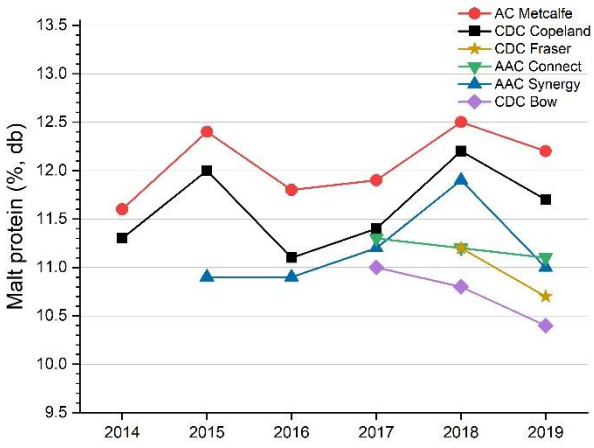


Figure 3.9 Comparison of average concentration of proteins in malt of selected barley varieties from 2014 to 2019

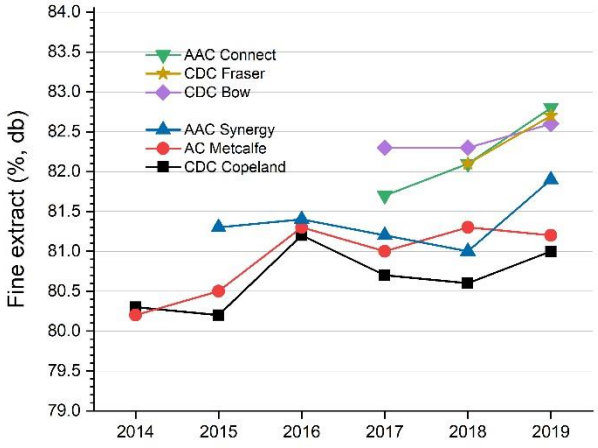


Figure 3.10 Comparison of average fine extract levels from malt of selected barley varieties from 2014 to 2019

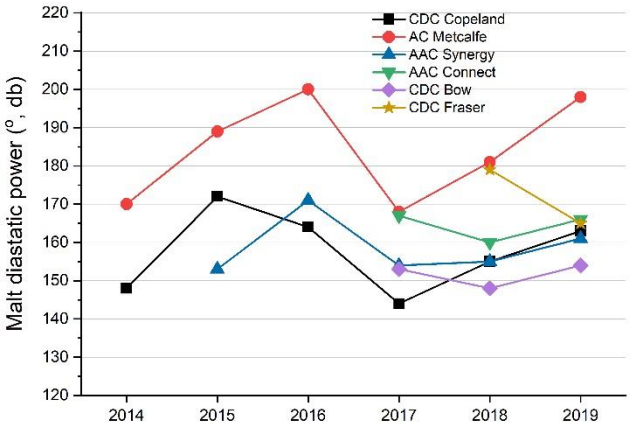


Figure 3.11 Comparison of average diastatic power in malt of selected barley varieties from 2014 to 2019

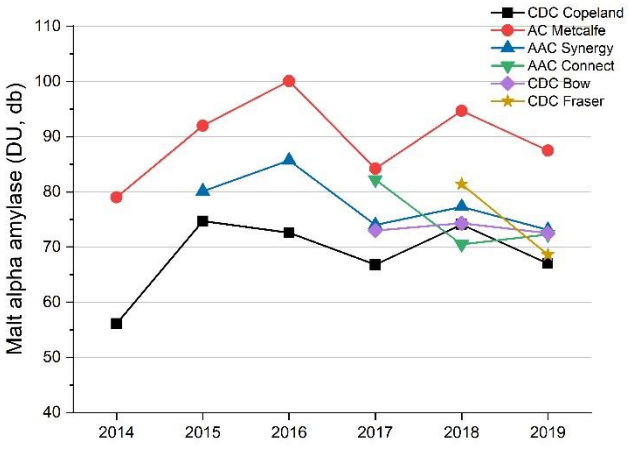


Figure 3.12 Comparison of average activity of α-amylase in malt of selected barley varieties from 2014 to 2019

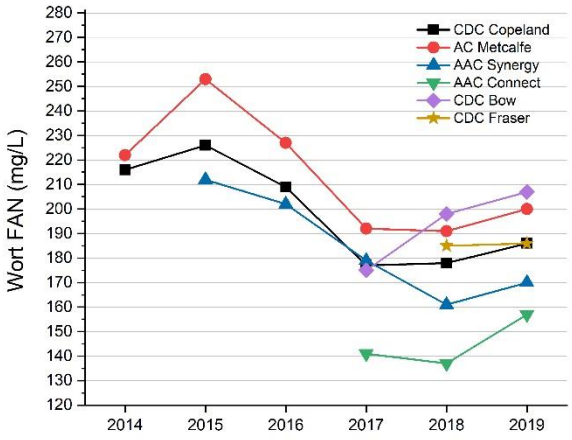


Figure 3.13 Comparison of average FAN level in wort produced from malt of selected barley varieties from 2014 to 2019

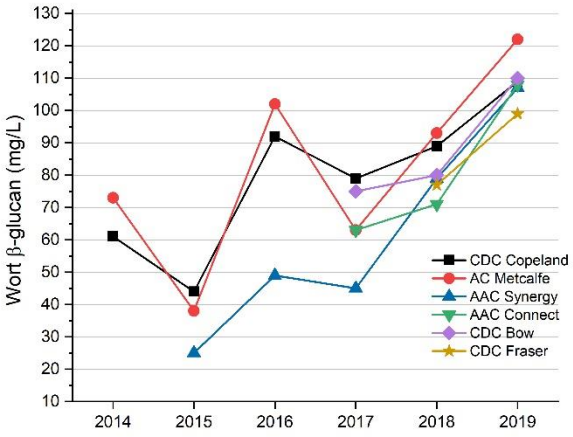


Figure 3.14 Comparison of average β-glucan concentration in wort produced from malt of selected barley varieties from 2014 to 2019

3.5 Quality of malting barley in 2019: highlights

- The relatively dry and cool growing season in 2019 produced barley with lower concentration of proteins and lower kernel weight compared to 2018. Overall, the content of proteins in barley grain averaged at 11.5% (db) in 2019 compared to 11.9% (db) in 2018. The 1000 kernel weight of this year's barley averaged at 45.1 g compared to 46.7 g last year.
- The average kernel size and kernel weight of the newer Canadian malting barley varieties, such as AAC Synergy, AAC Connect, Bentley, CDC Bow, and CDC Fraser, were noticeably higher than those of CDC Copeland and AC Metcalfe.
- The 2019 crop was challenged by wet harvest conditions resulting in a high incidence of pre-harvest sprouting, as indicated by relatively low RVA values (<50 RVU). The average moisture content of barley grain received in this survey was higher than usual.
- The majority of barley tested in this survey showed adequate germination energy (98%), but water sensitivity was higher than last year.
- Well-modified malt was obtained from 2019 barley with adequate levels of enzymes (diastatic power and α-amylase), soluble proteins, and free amino nitrogen (FAN).
- Lower concentration of grain proteins in 2019 barley resulted in higher malt extract levels compared to last year and the 5-year average values.
- Good quality malt can be produced from the 2019 barley crop through careful selection, timely malting, and application of appropriate processing conditions.

Part 4: Quality data for individual varieties

CDC Copeland
CDC Copeland has remained the dominant malting barley variety grown in Western Canada in 2019. Its excellent brewing characteristics, combined with lower protein and enzyme levels than AC Metcalfe, provide an excellent balance within the portfolio of malting barley varieties.

AC Metcalfe
In 2019, the production of AC Metcalfe continued its steady decline. However, with high levels of starch-degrading enzymes, AC Metcalfe exhibits excellent brewing performance and generates strong demand from both domestic and export markets.

AAC Synergy
The popularity of AAC Synergy on the Prairies significantly increased in 2019 with acreage approaching that of AC Metcalfe. AAC Synergy is a newer high-yielding variety registered in Canada in 2012. AAC Synergy is characterized by relatively high kernel weight and plumpness and relatively low grain protein content. AAC Synergy has a desirable malting quality profile with high malt extract, good protein modification, low levels of wort β-glucans, and intermediate levels of starch-degrading enzymes. Overall, AAC Synergy's excellent combination of agronomic traits and malting quality makes it a desirable two-rowed malting barley variety for western Canadian producers and the malting and brewing industry.

AAC Connect
AAC Connect is a recently registered (2016) high-yielding malting barley variety with excellent agronomic traits and disease resistance. Although limited, production of this cultivar is steadily increasing. This variety offers high extract, moderate enzymes and relatively low FAN levels, as well as good brewhouse performance and fermentability.

CDC Bow
CDC Bow is a recently registered (2015) high-yielding malting barley variety with excellent agronomic traits and disease resistance. Production of this cultivar is slowly increasing. CDC Bow offers high extract, moderate enzymes, high FAN levels, high fermentability and good overall brewhouse performance.

CDC Fraser
The harvest quality results for CDC Fraser are reported in 2019 for the second time. CDC Fraser is a recently registered (2016) high yielding variety with excellent lodging resistance. This variety offers high extract, as well as moderate to high enzyme and FAN levels.

Newdale
The area seeded with Newdale continues to occupy relatively small percentage of the total area seeded with malting barley in 2019. Its moderate levels of enzymes, soluble proteins and FAN make this variety well-suited for all-malt brewing.

Bentley
The area seeded with Bentley decreased slightly in 2019 compared to 2018; however, still-significant quantities were grown and selected in 2019. With high yields and good disease resistance, Bentley is an attractive choice for producers. Bentley's consistently large kernels have the potential to deliver high levels of extract.

CDC Copeland

Table 4.1 Quality data for CDC Copeland malting barley[a]

Origin of selected samples	Alberta		Saskatchewan		Manitoba		Prairie Provinces		
Crop year	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	2014-2018 Average
Tonnage[b], thousand of tonnes	**357**	281	**448**	699	**18**	106	**824**	1,087	818
Barley									
Test Weight (kg/hL)	**66.0**	67.7	**66.1**	69.1	**66.4**	68.6	**66.1**	68.7	66.6
1000 kernel weight (g)	**44.1**	46.0	**46.3**	47.2	**44.4**	48.7	**45.3**	47.0	46.3
Plump, over 6/64" sieve (%)	**91.5**	95.3	**93.7**	95.7	**92.4**	96.3	**92.7**	95.7	94.2
Intermediate, over 5/64" sieve (%)	**7.0**	3.8	**5.0**	3.5	**6.4**	3.0	**5.9**	3.5	4.3
Moisture[c] (%)	**12.7**	11.4	**13.3**	10.6	**11.9**	13.0	**13.1**	11.0	12.2
Protein (%, db)	**11.5**	11.8	**11.3**	11.7	**11.3**	12.1	**11.4**	11.8	11.5
Germination, 4 ml (%)	**98**	99	**99**	99	**99**	99	**98**	99	97
Germination, 8 ml (%)	**93**	99	**93**	97	**95**	96	**93**	97	92
Malt									
Yield (%)	**91.6**	91.0	**90.9**	90.9	**91.3**	91.1	**91.2**	91.0	91.1
Steep-out moisture (%)	**45.1**	45.4	**45.6**	45.6	**44.7**	45.9	**45.4**	45.6	44.8
Friability (%)	**72.0**	75.5	**74.8**	77.1	**76.3**	73.0	**73.6**	76.3	77.6
Moisture (%)	**5.2**	4.9	**5.1**	4.6	**5.4**	4.5	**5.1**	4.7	5.2
Protein (%, db)	**11.7**	12.1	**11.7**	12.3	**11.7**	12.6	**11.7**	12.2	11.6
Diastatic power (°, db)	**169**	149	**158**	157	**168**	157	**163**	155	157
α-Amylase (DU, db)	**68.4**	68.1	**65.7**	76.3	**69.9**	76.0	**67.0**	74.1	68.9
Wort									
Fine grind extract (%, db)	**81.0**	80.1	**81.0**	80.8	**81.2**	80.9	**81.0**	80.6	80.6
Coarse grind extract (%, db)	**80.3**	79.4	**80.6**	79.6	**80.7**	79.8	**80.5**	79.6	79.8
F/C difference (%, db)	**0.7**	0.7	**0.4**	1.2	**0.5**	1.0	**0.6**	1.0	0.8
ß-Glucan (mg/L)	**118**	84	**102**	91	**102**	91	**109**	89	73
Viscosity (cP)	**1.44**	1.43	**1.43**	1.44	**1.42**	1.44	**1.44**	1.44	1.43
Soluble protein (%, db)	**4.71**	4.29	**4.81**	4.49	**4.74**	4.82	**4.77**	4.47	4.64
Ratio S/T (%)	**40.3**	35.6	**41.2**	36.6	**40.5**	38.5	**40.8**	36.5	40.0
FAN (mg/L)	**184**	175	**188**	178	**189**	185	**186**	178	201
Colour (º)	**1.68**	1.79	**1.89**	1.95	**1.82**	2.04	**1.79**	1.92	2.10

[a] Values represent weighted averages based on tonnage of composite samples received.
[b] Indicates weight of selected barley represented in this survey; does not represent amounts commercially selected.
[c] Moisture not representative of new crop moisture levels as samples were not collected or stored in moisture-proof containers.
db = dry basis; DU = dextrinizing units; S/T = soluble/total protein

AC Metcalfe

Table 4.2 Quality data for AC Metcalfe malting barley[a]

Origin of selected samples	Alberta		Saskatchewan		Manitoba		Prairie Provinces		
Crop year	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	2014-2018 Average
Tonnage[b], thousand of tonnes	**113**	45	**268**	602	**9.6**	104	**390**	754	601
Barley									
Test Weight (kg/hL)	**66.7**	69.8	**67.1**	71.2	**66.3**	69.2	**66.9**	70.8	68.4
1000 kernel weight (g)	**42.2**	46.0	**43.8**	45.4	**41.7**	45.9	**43.3**	45.5	44.6
Plump, over 6/64" sieve (%)	**90.3**	95.0	**91.2**	95.0	**88.7**	95.6	**90.8**	95.0	93.3
Intermediate, over 5/64" sieve (%)	**8.0**	4.0	**7.2**	3.9	**9.3**	3.5	**7.5**	3.8	5.0
Moisture[c] (%)	**12.9**	10.7	**13.3**	10.4	**12.7**	12.6	**13.2**	10.7	11.9
Protein (%, db)	**12.2**	12.3	**12.1**	12.3	**12.3**	12.5	**12.2**	12.3	12.2
Germination, 4 ml (%)	**98**	98	**97**	100	**100**	100	**97**	100	98
Germination, 8 ml (%)	**87**	91	**89**	97	**95**	93	**89**	96	89
Malt									
Yield (%)	**91.2**	91.4	**91.4**	90.8	**90.9**	90.3	**91.3**	90.7	90.6
Steep-out moisture (%)	**45.7**	45.4	**46.1**	45.1	**45.9**	45.3	**45.9**	45.2	44.9
Friability (%)	**59.1**	62.2	**58.5**	68.6	**58.4**	65.4	**58.7**	67.8	67.1
Moisture (%)	**5.4**	5.2	**5.3**	4.9	**5.5**	4.9	**5.3**	4.9	5.3
Protein (%, db)	**12.3**	12.7	**12.1**	12.4	**12.4**	12.7	**12.2**	12.5	12.0
Diastatic power (°, db)	**202**	186	**197**	182	**200**	176	**198**	181	182
α-Amylase (DU, db)	**90.0**	88.3	**86.3**	95.4	**91.8**	93.9	**87.5**	94.7	90.0
Wort									
Fine grind extract (%, db)	**81.1**	80.6	**81.2**	81.4	**81.0**	81.2	**81.2**	81.3	80.9
Coarse grind extract (%, db)	**80.5**	79.2	**80.6**	80.4	**80.5**	79.8	**80.6**	80.2	80.1
F/C difference (%, db)	**0.6**	1.5	**0.6**	1.0	**0.4**	1.4	**0.6**	1.1	0.7
ß-Glucan (mg/L)	**120**	111	**123**	92	**117**	87	**122**	93	74
Viscosity (cP)	**1.44**	1.44	**1.44**	1.44	**1.43**	1.43	**1.44**	1.44	1.43
Soluble protein (%, db)	**4.94**	4.56	**5.04**	4.63	**5.07**	4.92	**5.02**	4.67	4.85
Ratio S/T (%)	**40.2**	36.0	**41.5**	37.3	**40.7**	38.6	**41.1**	37.4	40.0
FAN (mg/L)	**198**	181	**200**	190	**205**	202	**200**	191	217
Colour (º)	**1.77**	2.06	**1.93**	2.13	**1.85**	2.32	**1.88**	2.16	2.19

[a] Values represent weighted averages based on tonnage of composite samples received.
[b] Indicates weight of selected barley represented in this survey; does not represent amounts commercially selected.
[c] Moisture not representative of new crop moisture levels as samples were not collected or stored in moisture-proof containers.
db = dry basis; DU = dextrinizing units; S/T = soluble/total protein

AAC Synergy

Table 4.3 Quality data for AAC Synergy malting barley[a]

Origin of selected samples	Alberta		Saskatchewan		Manitoba		Prairie Provinces		
Crop year	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	2015-2018 Average
Tonnage[b], thousand of tonnes	**125**	177	**72**	128	**0**	2	**197**	307	121
Barley									
Test Weight (kg/hL)	**66.4**	68.1	**65.7**	70.7		69.1	**66.1**	69.2	67.1
1000 kernel weight (g)	**47.4**	47.9	**47.8**	48.4		49.1	**47.6**	48.1	48.7
Plump, over 6/64" sieve (%)	**95.7**	96.2	**95.2**	96.7		95.9	**95.5**	96.4	96.6
Intermediate, over 5/64" sieve (%)	**3.2**	2.9	**3.6**	2.6		3.0	**3.4**	2.8	2.3
Moisture[c] (%)	**13.4**	11.7	**12.2**	11.0		12.3	**13.0**	11.4	12.2
Protein (%, db)	**10.8**	11.5	**11.2**	11.8		11.4	**10.9**	11.6	11.3
Germination, 4 ml (%)	**98**	99	**99**	99		96	**98**	99	99
Germination, 8 ml (%)	**85**	98	**92**	96		87	**86**	97	93
Malt									
Yield (%)	**91.5**	91.4	**92.0**	80.8		90.0	**91.6**	91.1	90.8
Steep-out moisture (%)	**46.2**	45.5	**46.4**	46.1		46.4	**46.3**	45.8	45.5
Friability (%)	**69.1**	73.3	**67.6**	72.0		77.6	**68.5**	72.8	74.8
Moisture (%)	**5.1**	4.9	**5.2**	5.0		5.2	**5.2**	5.0	5.2
Protein (%, db)	**10.7**	11.8	**11.4**	12.1		11.2	**11.0**	11.9	11.2
Diastatic power (°, db)	**146**	149	**184**	164		152	**161**	155	158
α-Amylase (DU, db)	**68.2**	73.4	**80.3**	82.9		73.6	**73.1**	77.3	79.3
Wort									
Fine grind extract (%, db)	**81.8**	80.6	**82.0**	81.6		82.4	**81.9**	81.0	81.2
Coarse grind extract (%, db)	**81.4**	80.2	**81.9**	80.4		81.4	**81.6**	80.3	80.6
F/C difference (%, db)	**0.4**	0.4	**0.1**	1.2		1.0	**0.3**	0.7	0.6
ß-Glucan (mg/L)	**109**	74	**102**	84		91	**107**	79	50
Viscosity (cP)	**1.43**	1.41	**1.43**	1.42		1.45	**1.43**	1.42	1.41
Soluble protein (%, db)	**4.48**	3.94	**4.73**	4.52		4.44	**4.58**	4.18	4.38
Ratio S/T (%)	**42.0**	33.5	**41.5**	37.5		39.6	**41.8**	35.2	39.3
FAN (mg/L)	**167**	149	**176**	178		178	**170**	161	189
Colour (º)	**1.76**	1.64	**1.79**	1.90		2.34	**1.77**	1.75	1.88

[a] Values represent weighted averages based on tonnage of composite samples received.
[b] Indicates weight of selected barley represented in this survey; does not represent amounts commercially selected.
[c] Moisture not representative of new crop moisture levels as samples were not collected or stored in moisture-proof containers.
db = dry basis; DU = dextrinizing units; S/T = soluble/total protein

AAC Connect

Table 4.4 Quality data for AAC Connect malting barley[a]

Origin of selected samples	Prairie Provinces		
Crop year	**2019**	2018	2017-2018 Average
Tonnage[b], thousand of tonnes	**8.8**	7.7	4.0
Barley			
Test weight (kg/hL)	**67.9**	67.8	67.0
1000 kernel weight (g)	**51.1**	52.2	51.5
Plump, over 6/64" sieve (%)	**97.2**	96.7	95.7
Intermediate, over 5/64" sieve (%)	**2.2**	2.4	3.3
Moisture[c] (%)	**14.0**	12.9	13.5
Protein (%, db)	**11.1**	11.3	11.2
Germination, 4 ml (%)	**99**	99	99
Germination, 8 ml (%)	**89**	97	95
Malt			
Yield (%)	**91.8**	92.2	91.7
Steep-out moisture (%)	**44.4**	45.6	44.8
Friability (%)	**73.3**	83.0	83.6
Moisture (%)	**5.1**	4.7	5.0
Protein (%, db)	**11.1**	11.2	11.3
Diastatic power (°, db)	**166**	160	164
α-Amylase (DU, db)	**72.3**	70.5	76.4
Wort			
Fine grind extract (%, db)	**82.8**	82.1	81.9
Coarse grind extract (%, db)	**82.0**	81.4	81.4
F/C difference (%, db)	**0.8**	0.7	0.6
ß-Glucan (mg/L)	**108**	71	67
Viscosity (cP)	**1.43**	1.43	1.43
Soluble protein (%, db)	**4.36**	3.77	3.83
Ratio S/T (%)	**39.3**	33.9	34.2
FAN (mg/L)	**157**	137	139
Colour (º)	**1.79**	1.64	1.68

[a] Values represent weighted averages based on tonnage of composite samples received.
[b] Indicates weight of selected barley represented in this survey; does not represent amounts commercially selected.
[c] Moisture not representative of new crop moisture levels as samples were not collected or stored in moisture-proof containers.
db = dry basis; DU = dextrinizing units; S/T = soluble/total protein

CDC Bow

Table 4.5 Quality data for CDC Bow malting barley[a]

Origin of selected samples	Prairie Provinces		
Crop year	**2019**	2018	2017-2018 Average
Tonnage[b], thousand of tonnes	**6.0**	2.0	2.0
Barley			
Test weight (kg/hL)	**67.9**	67.8	69.4
1000 kernel weight (g)	**49.7**	49.6	51.6
Plump, over 6/64" sieve (%)	**97.8**	96.4	97.0
Intermediate, over 5/64" sieve (%)	**1.6**	2.6	2.1
Moisture[c] (%)	**13.8**	12.0	12.5
Protein (%, db)	**10.4**	10.8	11.0
Germination, 4 ml (%)	**98**	100	100
Germination, 8 ml (%)	**89**	98	98
Malt			
Yield (%)	**91.1**	90.6	91.1
Steep-out moisture (%)	**46.1**	46.1	44.7
Friability (%)	**76.8**	83.7	79.3
Moisture (%)	**5.0**	4.5	4.7
Protein (%, db)	**10.4**	10.8	10.9
Diastatic power (°, db)	**154**	155	154
α-Amylase (DU, db)	**72.5**	74.3	73.7
Wort			
Fine grind extract (%, db)	**82.6**	82.3	82.3
Coarse grind extract (%, db)	**82.2**	82.2	82.1
F/C difference (%, db)	**0.4**	0.1	0.2
ß-Glucan (mg/L)	**110**	80	78
Viscosity (cP)	**1.45**	1.42	1.44
Soluble protein (%, db)	**4.90**	4.82	4.52
Ratio S/T (%)	**46.0**	44.8	41.7
FAN (mg/L)	**207**	198	187
Colour (º)	**2.00**	1.99	1.86

[a] Values represent weighted averages based on tonnage of composite samples received.
[b] Indicates weight of selected barley represented in this survey; does not represent amounts commercially selected.
[c] Moisture not representative of new crop moisture levels as samples were not collected or stored in moisture-proof containers.
db = dry basis; DU = dextrinizing units; S/T = soluble/total protein

CDC Fraser

Table 4.6 Quality data for CDC Fraser malting barley[a]

Origin of selected samples	Prairie Provinces	
Crop year	**2019**	2018
Tonnage[b], thousand of tonnes	**2.2**	0.9
Barley		
Test weight (kg/hL)	**66.5**	69.2
1000 kernel weight (g)	**49.5**	54.7
Plump, over 6/64" sieve (%)	**97.0**	99.5
Intermediate, over 5/64" sieve (%)	**1.8**	0.1
Moisture[c] (%)	**14.3**	12.2
Protein (%, db)	**10.5**	11.3
Germination, 4 ml (%)	**99**	99
Germination, 8 ml (%)	**89**	99
Malt		
Yield (%)	**90.2**	91.1
Steep-out moisture (%)	**46.2**	45.5
Friability (%)	**83.6**	77.2
Moisture (%)	**5.4**	5.5
Protein (%, db)	**10.7**	11.2
Diastatic power (°, db)	**165**	179
α-Amylase (DU, db)	**68.6**	81.4
Wort		
Fine grind extract (%, db)	**82.7**	82.1
Coarse grind extract (%, db)	**82.4**	82.1
F/C difference (%, db)	**0.3**	0.0
ß-Glucan (mg/L)	**99**	77
Viscosity (cP)	**1.42**	1.42
Soluble protein (%, db)	**4.61**	4.27
Ratio S/T (%)	**43.3**	38.1
FAN (mg/L)	**186**	185
Colour (º)	**2.02**	1.84

[a] Values represent weighted averages based on tonnage of composite samples received.
[b] Indicates weight of selected barley represented in this survey; does not represent amounts commercially selected.
[c] Moisture not representative of new crop moisture levels as samples were not collected or stored in moisture-proof containers.
db = dry basis; DU = dextrinizing units; S/T = soluble/total protein

Newdale

Table 4.7 Quality data for Newdale malting barley[a]

Origin of selected samples	Prairie Provinces		
Crop year[b]	**2019**	2018	2012-2018 Average
Tonnage[c], thousand of tonnes	**4.8**	9.3	19
Barley			
Test weight (kg/hL)	**67.9**	68.5	66.5
1000 kernel weight (g)	**50.4**	48.6	45.9
Plump, over 6/64" sieve (%)	**96.0**	96.0	93.2
Intermediate, over 5/64" sieve (%)	**3.0**	3.2	5.1
Moisture[d] (%)	**13.7**	13.2	12.9
Protein (%, db)	**10.5**	11.9	12.2
Germination, 4 ml (%)	**99**	99	98
Germination, 8 ml (%)	**65**	92	90
Malt			
Yield (%)	**91.6**	90.7	90.9
Steep-out moisture (%)	**43.9**	45.6	45.2
Friability (%)	**77.8**	70.6	73.3
Moisture (%)	**4.9**	4.8	5.2
Protein (%, db)	**10.6**	12.1	12.0
Diastatic power (°, db)	**144**	153	152
α-Amylase (DU, db)	**67.0**	76.0	69.3
Wort			
Fine grind extract (%, db)	**81.9**	80.7	79.9
Coarse grind extract (%, db)	**81.3**	79.6	79.2
F/C difference (%, db)	**0.6**	1.2	0.7
ß-Glucan (mg/L)	**174**	67	61
Viscosity (cP)	**1.47**	1.42	1.42
Soluble protein (%, db)	**4.29**	3.97	4.38
Ratio S/T (%)	**40.6**	33.0	36.2
FAN (mg/L)	**145**	156	173
Colour (º)	**1.70**	1.80	1.83

[a] Values represent weighted averages based on tonnage of composite samples received.
[b] Newdale was not included in the 2014 and 2016 Harvest Survey due to lack of sufficient number of samples.
[c] Indicates weight of selected barley represented in this survey; does not represent amounts commercially selected.
[d] Moisture not representative of new crop moisture levels as samples were not collected or stored in moisture-proof containers.
db = dry basis; DU = dextrinizing units; S/T = soluble/total protein

Bentley

Table 4.8 Quality data for Bentley malting barley[a]			
Origin of selected samples	Prairie Provinces		
Crop year	**2019**	2018	2013-2018 Average
Tonnage[b], thousand of tonnes	**2.5**	3.0	9.1
Barley			
Test weight (kg/hL)	**66.9**	66.7	66.7
1000 kernel weight (g)	**46.8**	52.4	51.7
Plump, over 6/64" sieve (%)	**95.9**	95.4	96.1
Intermediate, over 5/64" sieve (%)	**3.1**	2.7	2.2
Moisture[c] (%)	**14.4**	13.5	13.3
Protein (%, db)	**10.6**	11.5	11.6
Germination, 4 ml (%)	**98**	97	97
Germination, 8 ml (%)	**74**	87	86
Malt			
Yield (%)	**91.4**	91.2	91.0
Steep-out moisture (%)	**46.1**	45.2	44.9
Friability (%)	**67.8**	65.6	70.1
Moisture (%)	**5.1**	5.0	5.4
Protein (%, db)	**10.5**	11.8	11.3
Diastatic power (°, db)	**147**	163	163
α-Amylase (DU, db)	**62.0**	72.9	68.8
Wort			
Fine grind extract (%, db)	**81.9**	81.4	81.4
Coarse grind extract (%, db)	**81.4**	80.6	80.9
F/C difference (%, db)	**0.5**	0.8	0.5
ß-Glucan (mg/L)	**142**	77	77
Viscosity (cP)	**1.47**	1.42	1.43
Soluble protein (%, db)	**4.54**	4.52	4.66
Ratio S/T (%)	**43.2**	38.3	40.5
FAN (mg/L)	**177**	184	207
Colour (º)	**1.73**	1.91	1.97

[1] Values represent weighted averages based on tonnage of composite samples received.
[2] Indicates weight of selected barley represented in this survey; does not represent amounts commercially selected.
[3] Moisture not representative of new crop moisture levels as samples were not collected or stored in moisture-proof containers.
db = dry basis; DU = dextrinizing units; S/T = soluble/total protein

Part 5: Brewing trials in 2019

The brewing trials were carried out at the Canadian Malting Barley Technical Centre (CMBTC) according to its standard brewing conditions[1]. In the brewing process, malts produced from 2019 crop of AC Metcalfe, CDC Copeland and AAC Synergy barley performed satisfactorily, and no process difficulties were recorded. Therefore, normal brewing performance can be expected from the 2019 crop barley of AC Metcalfe, CDC Copeland and AAC Synergy.

[1]Brewing conditions used for brewing trials conducted at CMBTC

Mashing
100% all-malt brew with 40 kg malt charge. 3.75:1 water to malt ratio in mash tun using temperature profile as follows: mash in at 48˚C, hold for 30 min, raise at 1.5 °C per min to 65˚C, hold for 30 min (measure conversion every minute), raise at 1.5˚C to 77˚C and hold for one min.

Lautering
Transfer mash to lauter tun with 25 L underlet water. Set in lauter tun for 10 min, then vorlauf until wort turbidity is less than 100 FTU. Run lautering tun with rakes lowered and used at slow speed as necessary; sparge using 3.38:1 water to malt ratio.

Kettle and Whirlpool
Boil wort for 90 min at 9% evaporation rate with hop additions of Magnum for 90 min and Mt. Hood for 5 min. Transfer to whirlpool and rest for 15 min.

Fermentation
Ferment for 7 days using Nottingham Ale yeast at 19˚C until final attenuation achieved; force (overnight) fermentation using 100g of Nottingham Ale yeast and 600 ml of wort.

Beer filtration
Crash cool to -1˚C; filter through a 2.5-4 µm pad filter system. Carbonate to 2.6 v/v CO_2. Keg and store at 1˚C.

AC Metcalfe malt of the 2019 crop brewed well in the brewhouse. When comparing to the 2018 AC Metcalfe crop averages, its conversion time was satisfactory but significantly longer; time to clear in lauter tun was quick and slightly slower; brewhouse efficiency was lower and wort colour was slightly higher; and wort attenuation limit was satisfactory, but significantly lower than the 2018 AC Metcalfe crop average (Table 5.1).

CDC Copeland malt of the 2019 crop performed well in the brewing trials. When comparing to the 2018 CDC Copeland crop year averages, its conversion time was satisfactory but longer. Time to clear was quick and comparable; lautering time was quick but longer; brewhouse efficiency was good but lower; wort colour was good but higher; and wort attenuation limit was excellent and slightly higher than the 2018 crop (Table 5.2).

AAC Synergy malt of the 2019 crop performed well in the brewing trials and did not present any difficulties in process. When comparing the 2018 AAC Synergy crop year averages, the 2019 crop AAC Synergy's conversion time was satisfactory and significantly shorter; time to clear in lauter tun and lautering time were good but longer; brewhouse efficiency was satisfactory but significantly lower; final wort colour was significantly higher; and wort attenuation limit was good, though slightly lower than the 2018 crop (Table 5.3)

Table 5.1 Brewhouse observations for AC Metcalfe pilot brewing trials.

Parameter*	2019 AC Metcalfe average (n=2)	2018 AC Metcalfe average (n=2)	2017 AC Metcalfe average (n= 2)	2016 AC Metcalfe average (n= 5)	2015 AC Metcalfe average
Conversion time (min)	20	16.5	12.5	12	12
Time to clear (min)	7	5	5	7	7
Lautering time (min)	52.0	51.5	49	49	45
Brewhouse efficiency (%)	87.3	86.4	87.8	86.5	88.5
Wort pH	5.53	5.55	5.36	5.30	5.37
Wort colour (SRM)	3.45	3.12	3.42	4.42	5.57
Attenuation limit (%)	86.6	88.1	84.8	84.9	85.0

n: number of brewing trials

Table 5.2 Brewhouse observations for CDC Copeland pilot brewing trials.

Parameter*	2018 CDC Copeland average (n=3)	2018 CDC Copeland average (n=2)	2017 CDC Copeland average (n=2)	2016 CDC Copeland average (n=4)	2015 CDC Copeland average
Conversion time (min)	22.0	18.5	22.5	16.0	16.0
Time to clear (min)	6.0	6.5	6	7	5
Lautering time (min)	50	44	49	49	46
Brewhouse efficiency (%)	87.6	89.7	89.1	87.8	88.0
Wort pH	5.57	5.50	5.35	5.34	5.51
Wort colour (SRM)	2.73	2.33	2.81	3.89	4.37
Attenuation limit (%)	89.2	89.0	90.7	88.9	87.6

n: number of brewing trials

.

Table 5.3 Brewhouse observations for AAC Synergy pilot brewing trials.

Parameter*	2019 AAC Synergy average (n=2)	2018 AAC Synergy average (n=2)	2017 AAC Synergy average (n=2)	2016 AAC Synergy average (n=2)	2015 AAC Synergy average
Conversion time (min)	**16**	18.5	16	12	12
Time to clear (min)	**8.5**	5.5	7	9	8
Lautering time (min)	**51.5**	49	52	43	47
Brewhouse efficiency (%)	**85.8**	87.5	89.6	89.6	88.1
Wort pH	**5.53**	5.58	5.35	5.31	5.35
Wort colour (SRM)	**3.78**	2.60	2.58	4.34	5.43
Attenuation limit (%)	**89.3**	90.0	90.7	86.2	91.1

n: number of brewing trials

Appendix I: Methods

This section describes methods used at the Grain Research Laboratory. Unless otherwise specified, analytical results for barley and malt are reported on a dry weight basis.

α-Amylase activity

α-Amylase activity is determined according to American Society of Brewing Chemists (ASBC) method MALT 7B by segmented flow analysis, using ASBC dextrinized starch as the substrate, and calibrated with standards that have been determined by method ASBC Malt 7A.

Assortment

All samples are passed through a Carter Dockage Tester equipped with a No. 6 riddle to remove foreign material and two slotted sieves to sort the barley. Plump barley is the material retained on a 6/64" (2.38 mm) x 3/4" slotted sieve.

Intermediate Grade is barley that passes through the 6/64" x 3/4" sieve but is retained on a 5/64" (1.98 mm) x 3/4" slotted sieve.

β-Glucan content

β-Glucan content is determined in malt extract by segmented flow analysis using Calcofluor staining of soluble, high molecular weight ß-glucan (ASBC Wort-18B).

Diastatic power

Diastatic power is determined by segemented flow analysis, using an automated neocuproin assay for reducing sugars, which is calibrated using malt standards analysed using the official ferricyanide reducing sugar method, (ASBC Malt 6A).

Fine-grind and coarse-grind extracts

Extracts are prepared using an Industrial Equipment Corporation (IEC) mash bath and the Congress mashing procedure from 45°C to 70°C. Specific gravities are determined at 20°C with an Anton Paar DMA 5000M digital density meter (ASBC Malt-4).

Free Amino Nitrogen (FAN)

Free amino nitrogen is determined on the fine extract according to the official ASBC method Wort-12 by segmented flow analysis.

Germination energy

Germination energy is determined by placing 100 kernels of barley on two layers of Whatman #1 filter paper, in a 9.0 cm diameter petri dish, and adding 4.0 ml of purified water. Samples are controlled at 20 degrees Celcius and 90% relative humidity in a germination chamber. Germinated kernels are removed after 24 and 48 hours and a final count is made at 72 hours (ASBC Barley 3C).

Kolbach index (ratio S/T)

Kolbach index is calculated from the formula, (% Soluble protein/% Malt protein) x 100.

Micromalting

Malts are prepared using an Automated Phoenix Micromalting System designed to handle twenty-four 500 g samples of barley or forty-eight 250 g samples of barley per batch.

Malt mills

Fine-grind malt is prepared with a Buhler-Miag disc mill set to fine-grind. Coarse-grind malt is prepared with the same mill set to coarse-grind. The settings for fine- and coarse-grinds are calibrated quarterly, based on the screening of a ground ASBC standard check malt (ASBC Malt-4).

Moisture content of barley

Moisture content of barley is predicted using NIR equipment that has been calibrated by the standard ASBC method (ASBC Barley 5C).

Moisture content of malt

Moisture content of malt is determined on a ground sample by oven drying at 104°C for 3 hours (ASBC Malt-3).

Protein content (N x 6.25)

Barley protein content is predicted on dockage-free barley using NIR equipment that has been calibrated by Combustion Nitrogen Analysis (CNA). Malt protein is measured by CNA. CNA is determined on a LECO Model FP-628 CNA analyzer calibrated by EDTA. Samples are ground on a UDY Cyclone Sample Mill fitted with a 1.0-mm screen. A 200-mg sample is analyzed as received (it is not dried prior to analysis). A moisture analysis is also performed and results are reported on a dry matter basis (ASBC Barley 7C).

Rapid Viscometric Analysis

The degree of pre-germination in barley was determined as described by Izydorczyk (2005); see the CGC website at https://www.grainscanada.gc.ca/en/grain-research/scientific-reports/rva/. Samples were analyzed using the RVA-4 (Newport Scientific) and the Stirring Number Program. Final viscosity values were presented in Rapid Visco Units (RVU).

Viscosity

Viscosity is measured on fine grind Congress wort using an Anton Paar Lovis 2000 automated rolling ball viscometer (ASBC Wort-13B).

Water sensitivity

Water sensitivity is determined exactly as described for germination energy, except that 8.0 ml of purified water is added to each petri dish (ASBC 3C, IOB and EBC procedure). The water sensitivity value is the numerical difference between the 4ml and 8ml tests.

Weight per thousand kernels

A 500 gram sample of dockage-free barley is divided several times in a mechanical divider to obtain one representative 40g sub-sample. All foreign material and broken kernels are removed from one 40 gram portion and the net weight determined. The number of kernels is then counted with a mechanical counter and thousand kernel weight is calculated (as is basis) (Institute of Brewing's Recommended Methods of Analysis, Barley 1.3 (1997)).

Wort-soluble protein

Wort-soluble protein is determined spectrophotometrically using ASBC method Wort-17.

Wort Color

Wort color is determined spectrophotometrically using ASBC method Wort-9 and Beer-10.

Acknowledgements

The Grain Research Laboratory and the Canadian Malting Barley Technical Centre are grateful to the following people and organizations:

• Domestic grain handling and malting companies for providing composite samples of barley varieties selected for malting in 2019: Canada Malting Ltd., Cargill Ltd., Prairie Malt Ltd., Rahr Malting Canada Ltd., Richardson International, Viterra Inc., and Malteurop Canada Ltd.

• Mr. Pat Rowan for providing the analysis of the growing and harvest conditions in 2019

• Agriculture and Agri-Food Canada's National Agroclimate Information Services Unit for the weather and climate data

• Statistics Canada for their publication on seeding and production figures

• Shawn Parsons for barley analysis and micro-malting; Debby Kelly for complete malt analysis; Kim Phan, Anna Chepurna, and Shin Nam for physicochemical analyses