Canadian Grain Commission
Commission canadienne des grains

Barley Production and Quality of Western Canadian Malting Barley

2021

Annual Barley Harvest Report

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Canada

Photos courtesy of Dr. Ana Badea, Brandon Research and Development Centre, Agriculture and Agri-Food Canada (AAFC)

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La présente publication est offerte français.

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Summary

The total area planted with barley in western Canada in 2021 was 3.257 million hectares. This is 10% higher than last year and 25% higher than the 10-year average. The total barley production in western Canada in 2021, however, is estimated at only 6,602,000 tonnes. This is approximately 37% lower than last year. The 2021 crop year was plagued by a severe drought and the lack of moisture contributed to extremely low yields, with an average yield of 42.2 bushels per acre (BPA) compared to 71.8 BPA in 2020.

CDC Copeland (34.7%) and AAC Synergy (28.1%) predominated the malting barley cultivars planted in western Canada in 2021. The area seeded with AC Metcalfe in 2021 was only 11.1%. The area planted with AAC Connect increased to 8.6% in 2021 from 5.2% in 2020. The area planted with other recently registered two-rowed cultivars, Sirish (4.8%), CDC Fraser (3.3%), CDC Bow (2.7%), and CDC Copper (0.9%), accounted for approximately 11.7% of total area seeded with malting barley varieties in western Canada.

Dry and hot growing conditions in 2021 contributed to much higher levels of protein in barley grain than normally observed. The average level of barley proteins (13.2%) in 2021 was considerably higher than last year (11.8%). This year's barley exhibited an excellent average germination energy (98%), however, equal to the 10-year average. It also showed very little water sensitivity. This year's average 1000 kernel weight (45.3 g) was only slightly lower than last year's (45.5 g) and was higher than the 10-year average (45.2 g). The newer varieties with kernels larger than AC Metcalfe and CDC Copeland, contributed to the overall high average kernel weight. The average plumpness of this year's barley (96.1%) was higher than last year's (92.4%) and higher than the 10-year average (93.0%). The test weight, however, was lower (64.8 kg/hL) than the 10-year average (67 kg/hL).

Pre-harvest sprouting in 2021 barley was highly variable due to the incidence of rain in certain parts of the prairies in mid and late August. Processing of barley in a Phoenix Micromalting System indicated that this year's barley easily absorbed water during steeping. High water uptake during steeping resulted in adequate cell wall modification and a low concentration of β-glucans in wort as well as low wort viscosity. A higher concentration of grain protein in 2021 barley contributed to about 2% lower malt extract levels than in previous years but also contributed to high levels of malt enzymes (especially diastatic power) and free amino nitrogen (FAN) making this year's barley suitable for adjunct brewing.

Part 1: Growing and harvest conditions in 2021

The 2021 crop year was negatively affected by a severe drought, comparable to the devastating drought of 1988. Initially, there was much enthusiasm for the seeding of barley as Canadian barley exports have increased substantially in recent years. Farmers in southern Alberta began seeding in early April. Seeding in southern Saskatchewan and the Red River valley began in late April.

Southern Alberta was excessively dry with average rainfall during the growing season ranging from 50 mm to 80 mm (Figure 1.1). This lack of moisture contributed to extremely low yields, ranging from 0 BPA to 35 BPA. Most fields from this region produced 100 BPA in 2020.

Temperatures were well above normal (Figure 1.2) and many regions broke records for the number of days over 30° Celsius. The excessive heat and lack of rain contributed to most areas producing significantly lower yields.

The excessive heat and dry conditions promoted quick crop growth and resulted in a harvest earlier than normal, with most barley being harvested in August. Rain in August (Figure 1.3) resulted in pre-harvest sprouting in some regions.

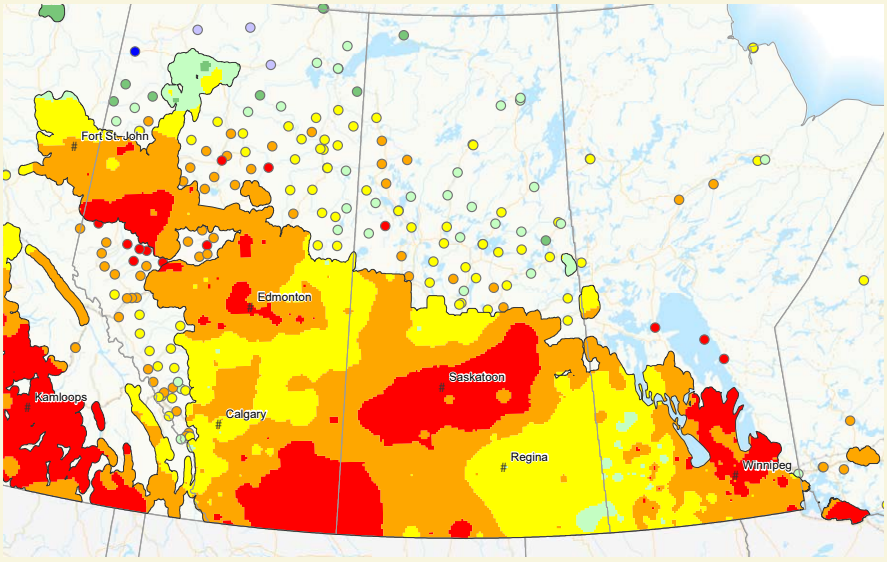


Figure 1.1 Percent of average precipitation in June and July 2021.

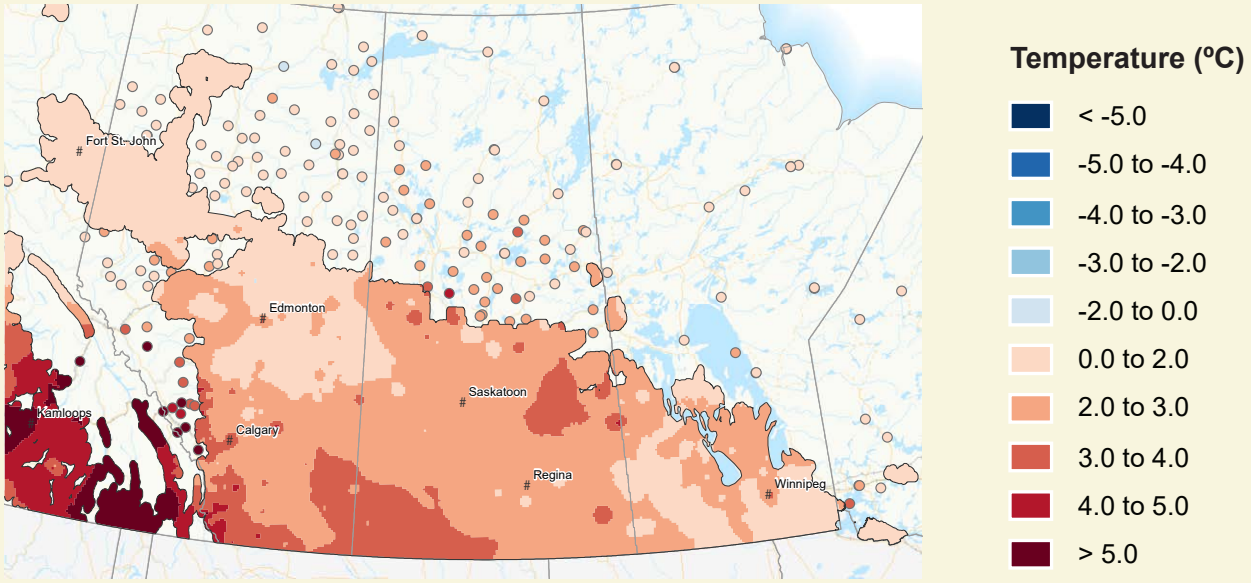


Figure 1.2 Mean temperature differences from normal for July 2021.

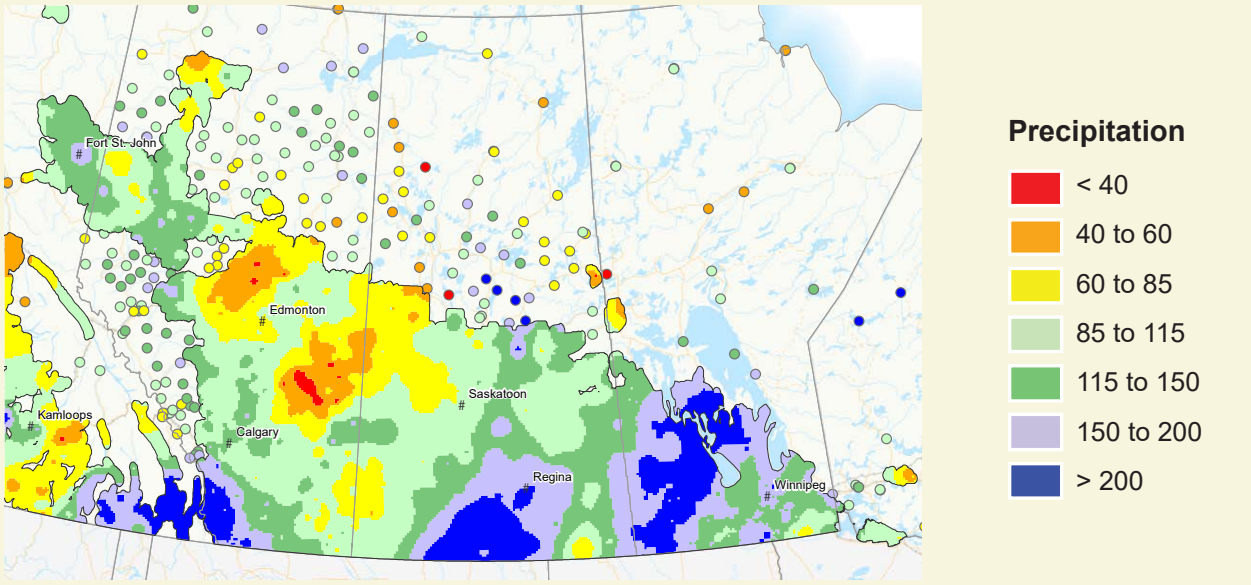


Figure 1.3 Percent of average precipitation in August 2021.

Part 2: Barley production in 2021

2.1 Annual production statistics

The total area planted with barley in western Canada in 2021 was 3.257 million hectares. This is 10% higher than last year and 25% higher than the 10-year average (Table 2.1). Compared to last year, the 2021 barley seeded area in Alberta and British Columbia, and Saskatchewan increased by 5% and 18%, respectively but remained similar in Manitoba (Table 2.1 and Figure 2.1).

Barley production in western Canada in 2021 was estimated at only 6.602 million tonnes. This is approximately 37% lower than last year and 21% lower than the 10-year average (Table 2.2).

This year the severe drought resulted in an estimated barley yield of 42.2 BPA in western Canada. This is exceptionally low compared to the 2020 yield of 71.8 BPA (Table 2.3 and Figure 2.3). The particularly low average barley yield in Saskatchewan is likely due to the abandonment of some fields that had been seeded.

Table 2.1 Total barley seeded area in Canada

Seeded area (million hectares)				
	2019	2020	10-year average*	2021**
Manitoba	0.136	0.168	0.155	0.167
Saskatchewan	1.275	1.264	1.029	1.500
Alberta & British Columbia	1.467	1.512	1.409	1.590
Western Canada	**2.878**	**2.944**	**2.598**	**3.257**
Canada	**2.996**	**3.060**	**2.733**	**3.357**

Source: Statistics Canada
*10-year average from 2011 to 2020
** Estimated as of December 2021

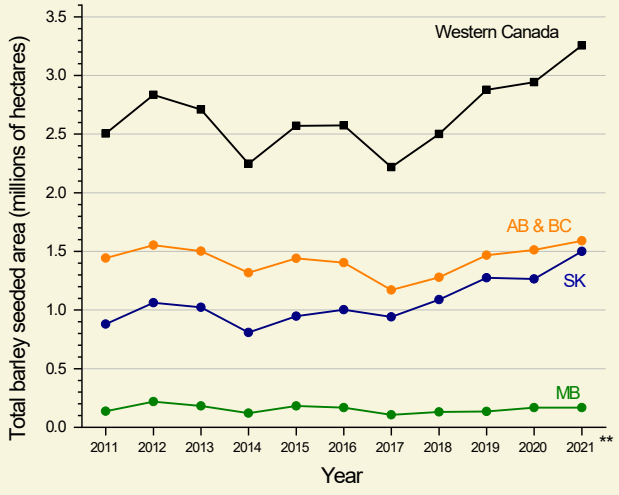


Figure 2.1 Yearly comparison of total barley seeded area in western Canada.

Source: Statistics Canada
** Estimated as of December 2021

Table 2.2 Total barley production in Canada

	Production (millions of tonnes)			
	2019	2020	10-year average*	2021**
Manitoba	0.529	0.686	0.528	0.432
Saskatchewan	4.449	4.385	3.202	2.547
Alberta & British Columbia	5.018	5.345	4.611	3.624
Western Canada	**9.996**	**10.416**	**8.353**	**6.602**
Canada	**10.383**	**10.741**	**8.772**	**6.948**

Table 2.3 Average barley yield

	Average barley yield (bushels per acre)			
	2019	2020	10-year average*	2021**
Manitoba	76.9	79.9	68.6	54.8
Saskatchewan	69.3	68.7	61.7	35.5
Alberta	72.4	74.0	69.8	47.4
Western Canada	**71.1**	**71.8**	**66.6**	**42.2**
Canada	**70.8**	**71.1**	**66.1**	**43.0**

Source: Statistics Canada
*10-year average from 2011 to 2020
** Estimated as of December 2021

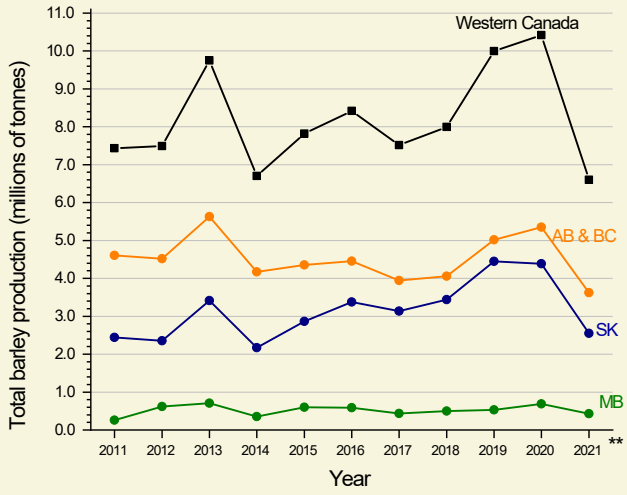


Figure 2.2 Yearly comparison of total barley production in western Canada.

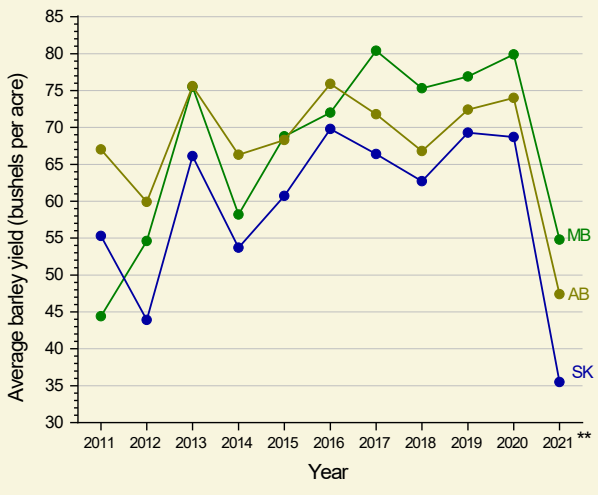


Figure 2.3 Yearly comparison of average barley yield in the prairie provinces.

Source: Statistics Canada
** Estimated as of December 2021

2.2 Distribution of barley classes

Barley is grown across the Canadian prairies and is used for malting, food, and general purposes (feed and forage). Based on insured commercial acres in 2021, general purpose barley accounted for 51.7% of the barley seeded area in Alberta and British Columbia while malting barley accounted for 43.9% (Figure 2.4, left). In Saskatchewan the majority of barley seeded area (29.8%) was planted with malting barley varieties (Figure 2.4, left). In Manitoba approximately 38.9% of barley seeded area was planted with malting varieties and 55.5% with general purpose varieties (Figure 2.4, left). For all of western Canada in 2021, barley seeded area consisted of 50.4% malting barley, 42.3% general purpose barley, and 2.3% food barley (Figure 2.4, right).

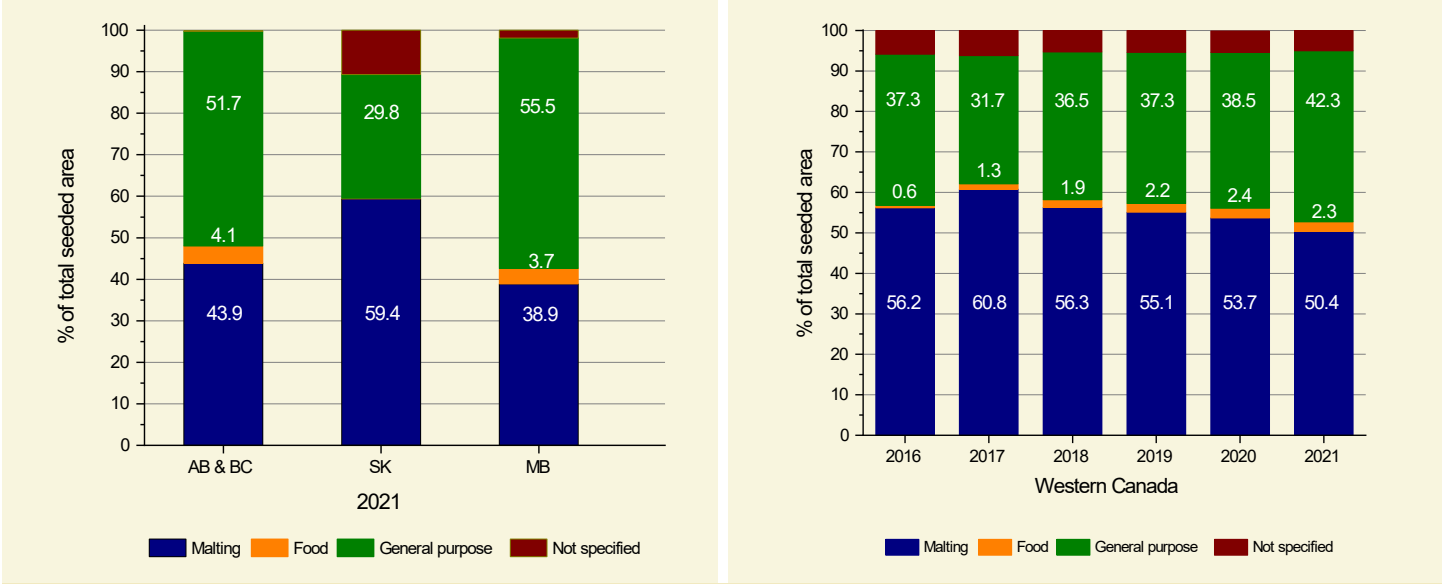


Figure 2.4 Distribution of barley classes as a percentage of total area seeded with barley in each province in 2021 (left) and in all of western Canada from 2016-2021 (right).

2.3 Distribution of malting varieties

CDC Copeland and AAC Synergy were the most common malting barley cultivars grown in western Canada in 2021 (Table 2.4). The area seeded with CDC Copeland was 34.79% in 2021, a decrease from 42.44% in 2020 (Table 2.4 and Figure 2.5). The area seeded with AAC Synergy has been steadily growing and in 2021 it increased to 28.16% from 22.54% in 2020. The area seeded with AC Metcalfe in 2021 was only 11.18%, the lowest seen in the last decade (Figure 2.5). AAC Connect is becoming a popular variety whose acreage shows a steady growth and in 2021 it increased to 8.65% from 5.19% in 2020. The area planted with recently registered two-rowed cultivars, especially CDC Fraser, CDC Copper and Sirish, continued to grow. The area planted with CDC Bow remained stable at about 2.7% (Figure 2.6). Together they accounted for approximately 11.73% of the total area seeded with malting barley varieties in western Canada (Table 2.4).

The production of six-rowed malting barley continued to decline. In 2021, six-rowed cultivars accounted for only about 2.80% of the total area seeded with malting barley, down from 3.32 % in 2020 and 4.01% in 2019. Legacy, Celebration and Tradition remained the top three six-rowed varieties (Table 2.4).

The production of two-rowed cultivars predominated in each province (Table 2.4). In 2021, CDC Copeland and AAC Synergy predominated in Alberta and Saskatchewan. The area seeded with malting barley in Manitoba was relatively low compared to other western provinces. In 2021, the most popular cultivars seeded in Manitoba were AAC Connect, AAC Synergy, CDC Copeland, AC Metcalfe and Celebration (Table 2.4).

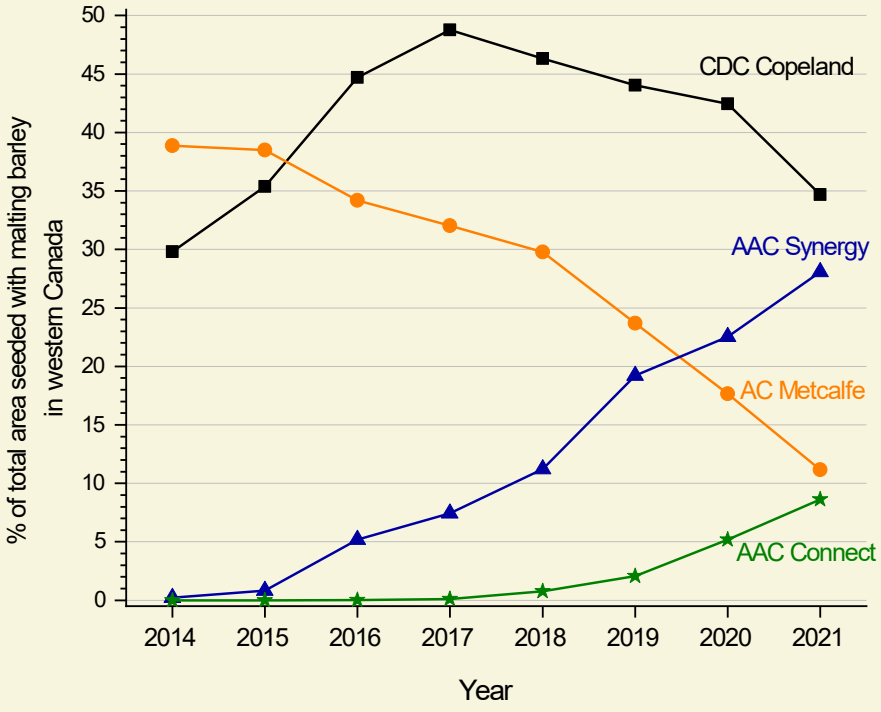


Figure 2.5 Comparison of areas seeded with top malting barley cultivars in western Canada from 2014 to 2021. (Source: Sask Crop Insurance, Alberta Ag Financial Services Corp., Manitoba Agricultural Services Corporation, BC Crop Insurance).

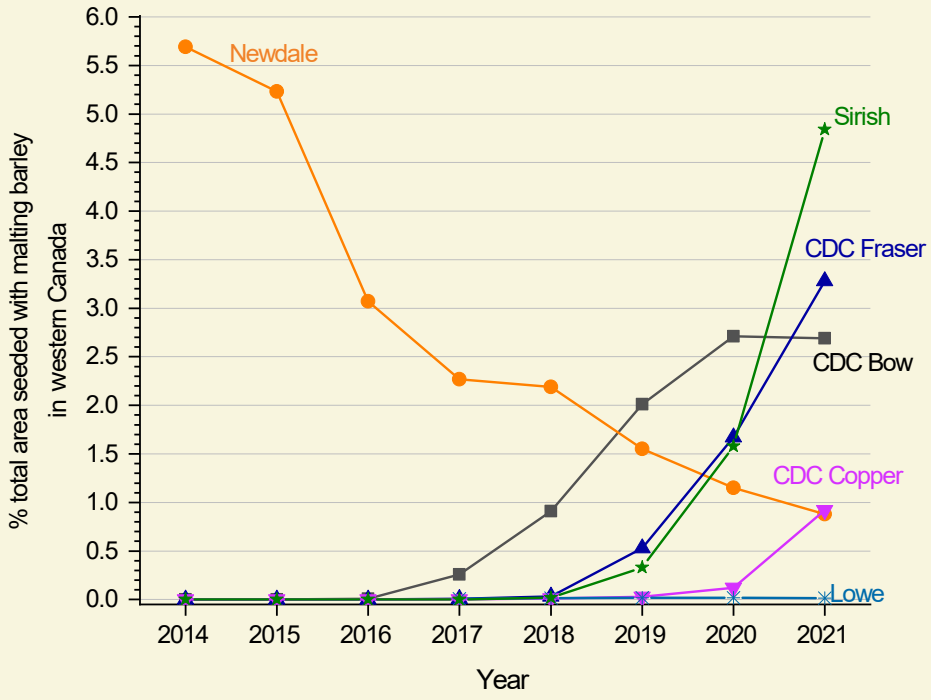


Figure 2.6 Comparison of areas seeded with recently registered malting barley cultivars: CDC Bow (2015), CDC Fraser (2016), Lowe (2016), Sirish (2017), and CDC Copper (2018) in Western Canada from 2014 to 2021. Numbers in brackets indicate the year of variety registration. (Source: Sask Crop Insurance, Alberta Ag Financial Services Corp., Manitoba Agricultural Services Corporation, BC Crop Insurance).

Table 2.4 Distribution of malting barley cultivars expressed as a percentage of the total area seeded with malting barley in 2021

Area seeded with malting barley (% of total) in 2021				
Malting barley cultivars	**Alberta & British Columbia**	**Saskatchewan**	**Manitoba**	**Total western Canada**
2-rowed	%	%	%	%
CDC Copeland	13.76	20.26	0.76	34.79
AAC Synergy	10.75	16.26	1.15	28.16
AC Metcalfe	4.50	6.09	0.59	11.18
AAC Connect	3.63	3.75	1.27	8.65
Sirish	4.78	0.04	0.03	4.85
CDC Fraser	0.93	1.98	0.37	3.29
CDC Bow	1.29	1.27	0.13	2.69
CDC Copper	0.69	0.12	0.12	0.93
Newdale	0.09	0.52	0.28	0.89
Cerveza	0.35	0.06	0.05	0.45
Bentley	0.28	0.04	0.03	0.34
CDC Churchill	0.17	0.09	0.00	0.26
Bill Coors 100	0.23	0.02	0.00	0.25
CDC Platinum Star	0.00	0.17	0.00	0.17
CDC Meredith	0.06	0.02	0.00	0.08
CDC Goldstar	0.00	0.07	0.00	0.07
CDC Kindersley	0.04	0.00	0.00	0.04
Manley	0.00	0.03	0.00	0.03
Lowe	0.01	0.00	0.00	0.01
AB Brewnet	0.01	0.00	0.00	0.01
Harrington	0.01	0.00	0.00	0.01
CDC Stratus	0.01	0.00	0.00	0.01
Other	0.03	0.00	0.00	0.03
Total 2-rowed	**41.64**	**50.76**	**4.79**	**97.2**
6-rowed	**%**	**%**	**%**	**%**
Legacy	0.57	1.31	0.03	1.91
Celebration	0.00	0.15	0.50	0.65
Tradition	0.00	0.00	0.08	0.08
Other	0.11	0.03	0.03	0.16
Total 6-rowed	**0.68**	**1.49**	**0.64**	**2.8**

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

2.4 Distribution of general purpose and food barley varieties

Based on the 2021 insured acreage in western Canada, food (F) and general purpose (GP) barley varieties accounted for 44.6% of the total barley seeded area (Figure 2.4, right). CDC Austenson and Brahma predominated the GP barley cultivars (Table 2.5 and Figure 2.7). CDC Austenson was the top variety grown in every western province in 2021. The area seeded with Champion and Xena decreased in 2021. The acreage of Oreana increased from 4.1% in 2020 to 7.1% in 2021.

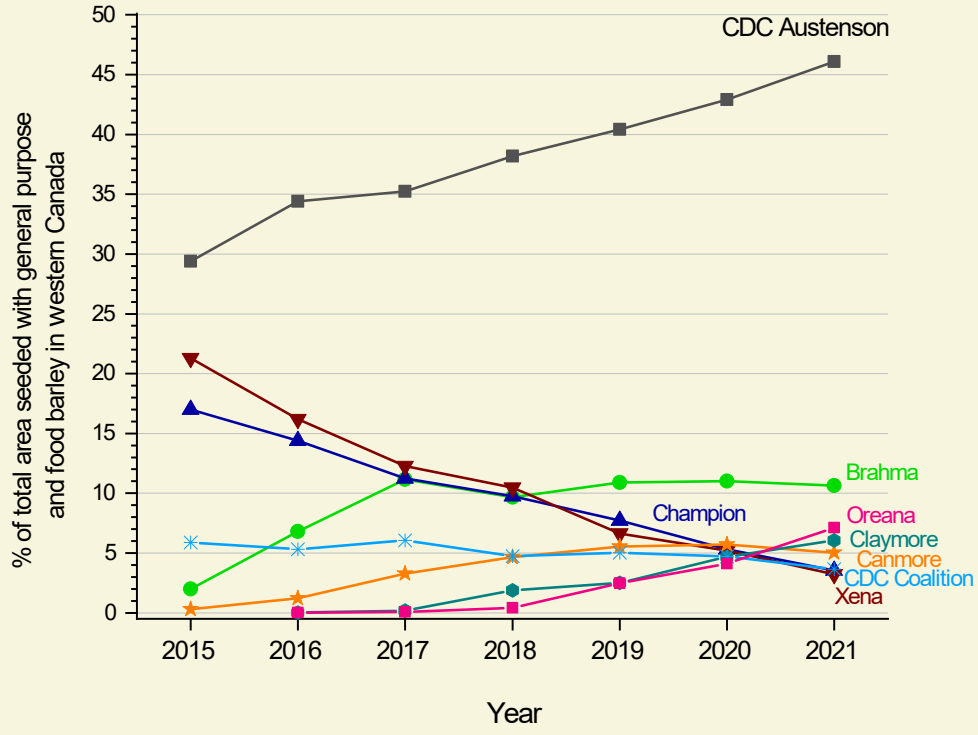
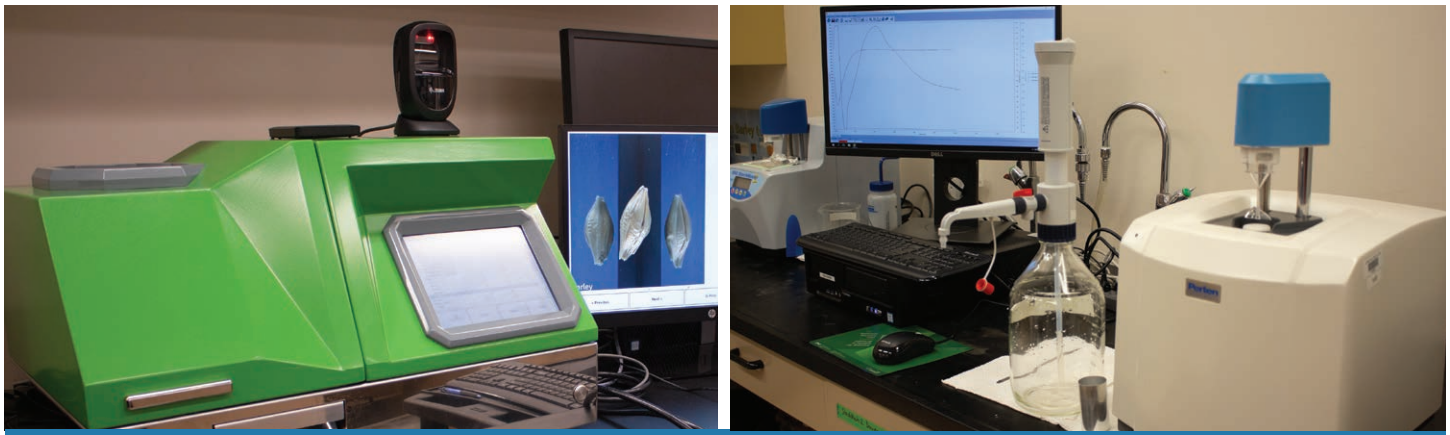


Figure 2.7 Comparison of areas seeded with the top five general purpose and food barley cultivars in western Canada from 2015 to 2021.



Cgrain Value image analyzer (left) and Rapid Visco Analyzer (right) used by the barley program at the Grain Research Laboratory.

Table 2.5 Distribution of barley cultivars expressed as a percentage of the total area seeded with general purpose and food barley in 2021

Area seeded with general purpose and food barley (% of total) in 2021				
General purpose cultivars	**Alberta & BC**	**Saskatchewan**	**Manitoba**	**Total western Canada**
CDC Austenson	20.05	20.06	5.85	45.95
Brahma	10.39	0.21	0.00	10.60
Oreana	5.49	1.55	0.06	7.10
Claymore	3.24	2.39	0.41	6.04
Canmore (F)	4.48	0.00	0.55	5.03
CDC Coalition	3.52	0.14	0.00	3.65
Champion	2.62	0.86	0.05	3.53
CDC Maverick	1.18	2.09	0.21	3.49
Conlon	1.18	0.17	1.95	3.30
Xena	3.10	0.11	0.00	3.21
CDC Cowboy	0.86	0.54	0.05	1.46
Altorado	0.67	0.41	0.03	1.11
AB Cattlelac	0.67	0.17	0.15	1.00
AB Advantage	0.46	0.00	0.00	0.46
Amisk	0.40	0.00	0.00	0.40
CDC Thompson	0.39	0.00	0.00	0.39
AB Advantage	0.00	0.30	0.00	0.30
Esma	0.24	0.00	0.03	0.27
Seebe	0.25	0.00	0.00	0.25
AC Rosser	0.08	0.16	0.00	0.24
Sundre	0.10	0.11	0.00	0.20
AC Ranger	0.13	0.05	0.00	0.18
CDC Bold	0.18	0.00	0.00	0.18
CDC Trey	0.16	0.00	0.00	0.16
Ponoka	0.16	0.00	0.00	0.16
CDC McGwire (F)	0.00	0.10	0.04	0.14
Busby	0.09	0.00	0.00	0.09
AC Albright	0.09	0.00	0.00	0.09
Otal	0.09	0.00	0.00	0.09
Gadsby	0.06	0.03	0.00	0.09
Other	0.69	0.14	0.00	0.83
Total general purpose and food	**61.0**	**29.6**	**9.4**	**100.00**

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

Part 3: Annual harvest survey of malting barley

3.1 Sampling and survey methodology

The 2021 malting barley survey was based on varietal composites that represented about 600,000 tonnes of malting barley selected for domestic processing or for export. The grain handling and malting companies involved in the selection process were 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 only a portion of the total volume of malting barley selected in western Canada. Some samples included in this report came from the Canadian Grain Commission's Harvest Sample Program. Samples were received from the beginning of harvest until November 15, 2021.

3.2 Quality of barley selected for malting in 2021: general trends

The average level of malting barley proteins in 2021 was 13.2%. This is significantly higher than last year (11.8%) and higher than the 10-year average (11.7%) (Figure 3.1). 2021 barley exhibited excellent average germination energy (98%), equal to the 10-year average (Figure 3.2). In 2021, the average germination energy at 8 mL was 91%, which indicates very little water sensitivity. This year's average 1000 kernel weight was 45.3 g, which is close to the 10-year average value of 44.2 g (Figure 3.3). Kernel plumpness, measured by counting the number of kernels remaining on a 6/64" slotted screen, had an average value of 96.1%. This is higher than last year's value of 92.4% and higher than the 10-year average of 93.0% (Figure 3.4). The average test weight of 2021 barley was 64.8 kg/hL, which is lower than last year (67.2 kg/hL), and lower than the 10-year average (67.0 kg/hL) (Figure 3.5). The results presented in Figures 3.1 to 3.5 represent weighted averages based on the tonnage of composite samples received and analyzed.

3.3 Comparison of physicochemical parameters in individual barley varieties

Kernel hardness was determined for individual varieties using a single kernel characterization system. The results indicated some differences among barley varieties (Figure 3.6). Barley grown in 2021 exhibited slightly higher grain hardness than barley grown in 2020. The content of β-glucans in selected malting varieties grown in Canada in the last four years is shown in Figure 3.7. Despite some differences due to the environmental conditions in various years, CDC Copeland exhibited the lowest β-glucan content and AC Metcalfe the highest. Overall, content of β-glucans in grain grown in 2021 is slightly higher than last year. The content of arabinoxylans in selected malting varieties grown in Canada in the last four years is shown in Figure 3.8. The content of arabinoxylans in grain grown in 2021 is slightly higher than in previous years, which is most likely due to the very dry and hot growing conditions. The yearly variations in 1000 kernel weight and grain protein level for several established and new malting barley varieties are presented in Figure 3.9 and Figure 3.10. The 1000 kernel weight of most varieties is lower than last year. However, the newer varieties, such as CDC Bow, CDC Fraser, AAC Synergy, and AAC Connect, show substantially higher kernel weight than CDC Copeland and AC Metcalfe. All varieties show substantially higher protein content in 2021 compared to last year.

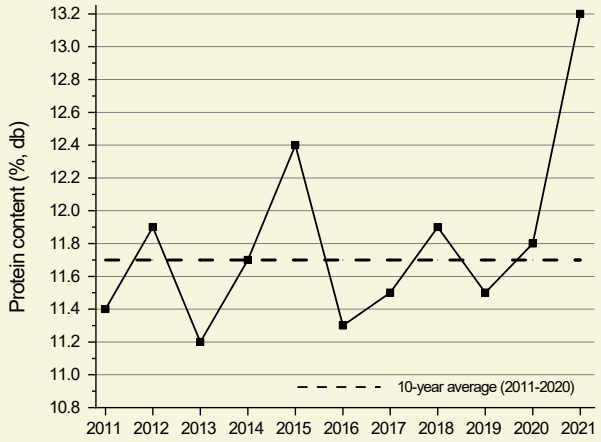


Figure 3.1 Average protein content in barley selected for malting from 2011 to 2021.

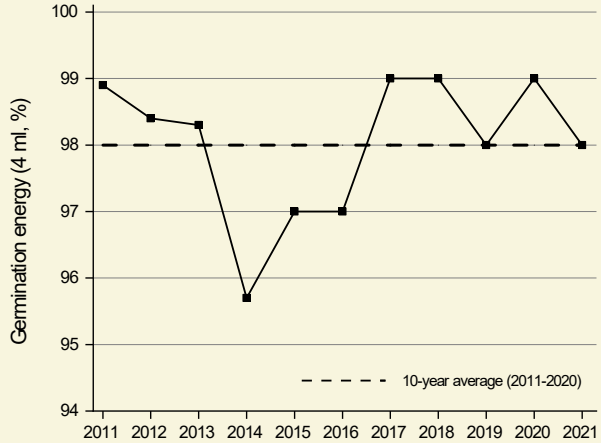


Figure 3.2 Average germination energy of barley selected for malting from 2011 to 2021.

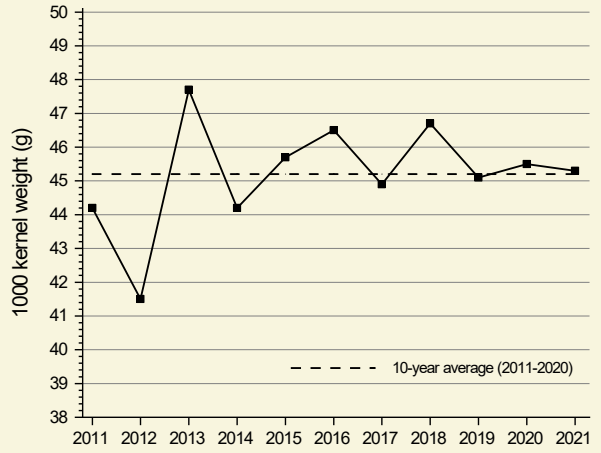


Figure 3.3 Average 1000 kernel weight of barley selected for malting from 2011 to 2021.

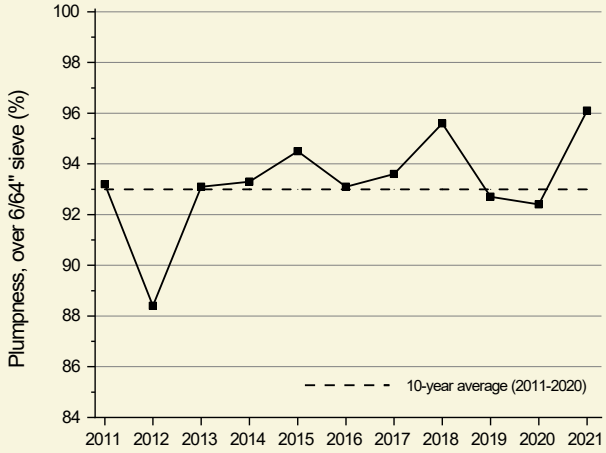


Figure 3.4 Average plumpness of barley selected for malting from 2011 to 2021.

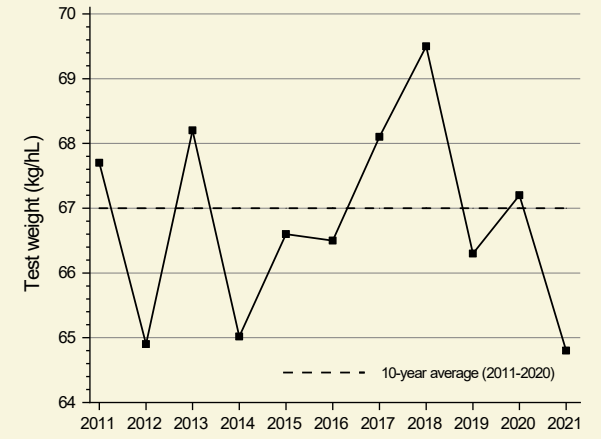


Figure 3.5 Average test weight of barley selected for malting from 2011 to 2021.

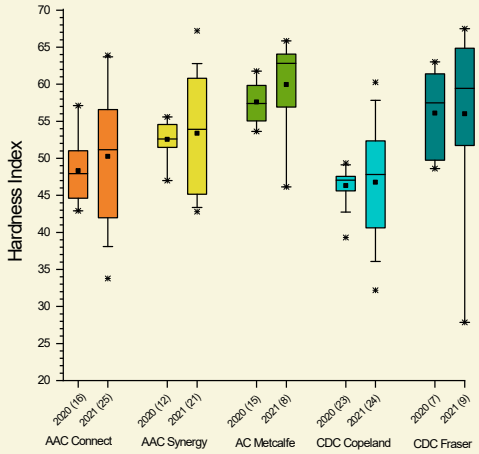


Figure 3.6 Kernel hardness index for barley cultivars selected for malting in 2020 and 2021

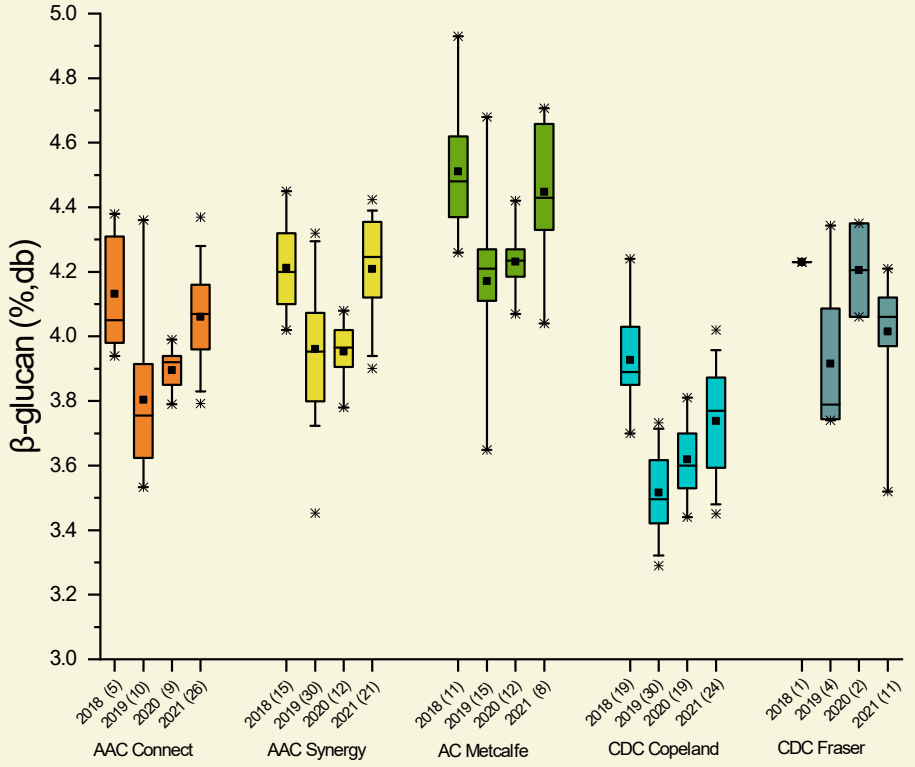


Figure 3.7 Content of β-glucans in selected barley varieties in recent years.

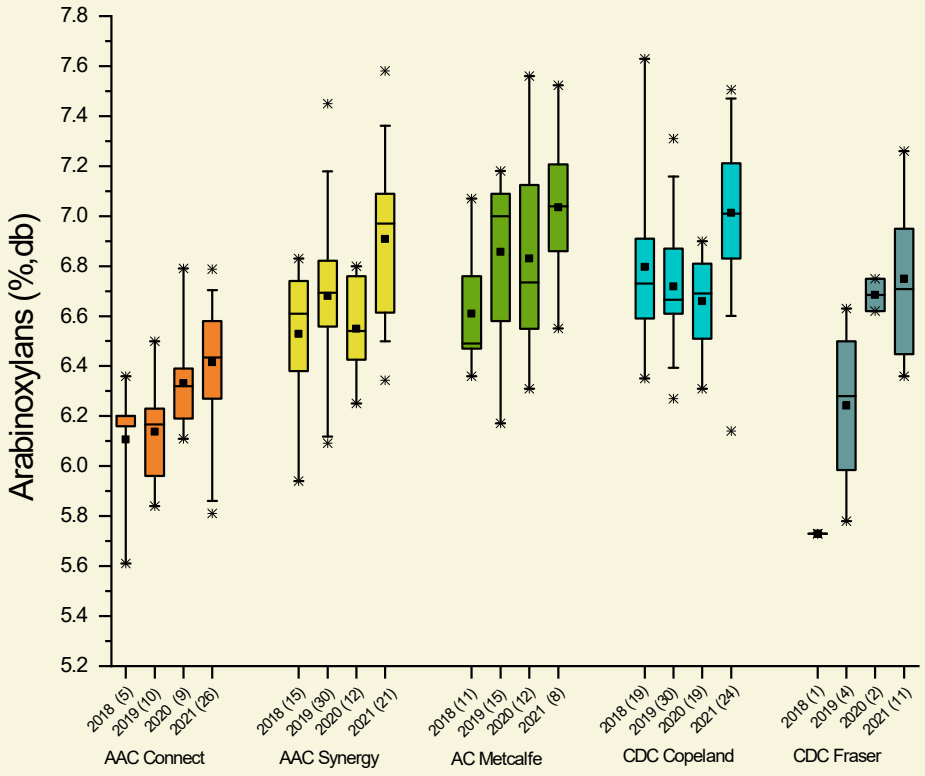


Figure 3.8 Content of arabinoxylans in selected barley varieties in recent years.

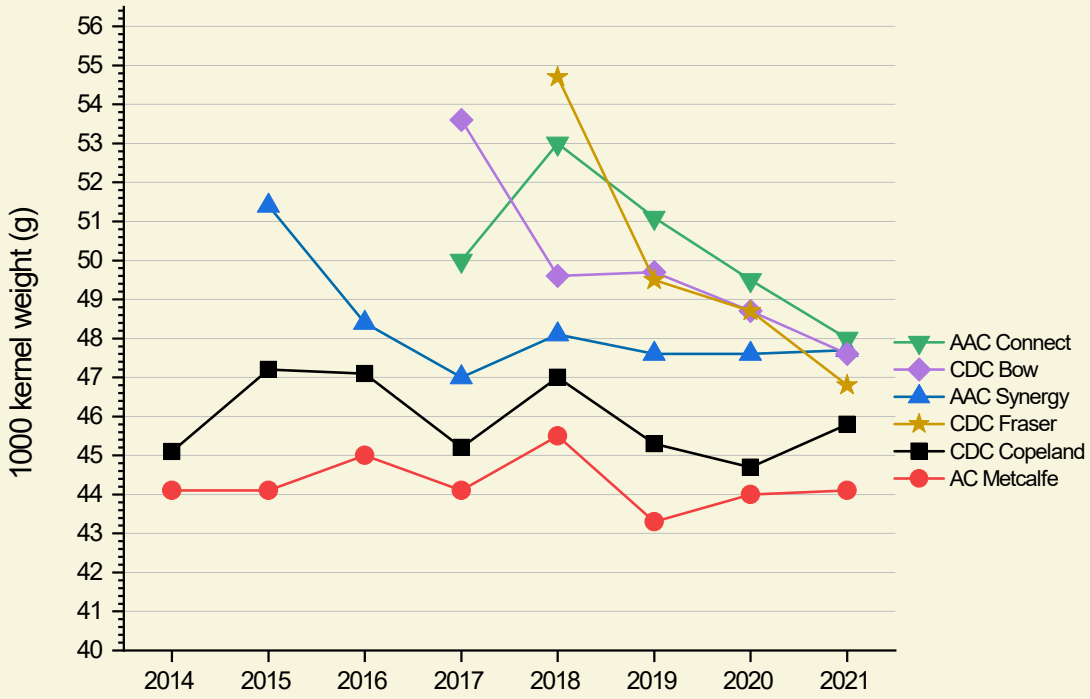


Figure 3.9 Comparison of the average 1000 kernel weight of selected barley varieties from 2014 to 2021. Values represent arithmetic averages.

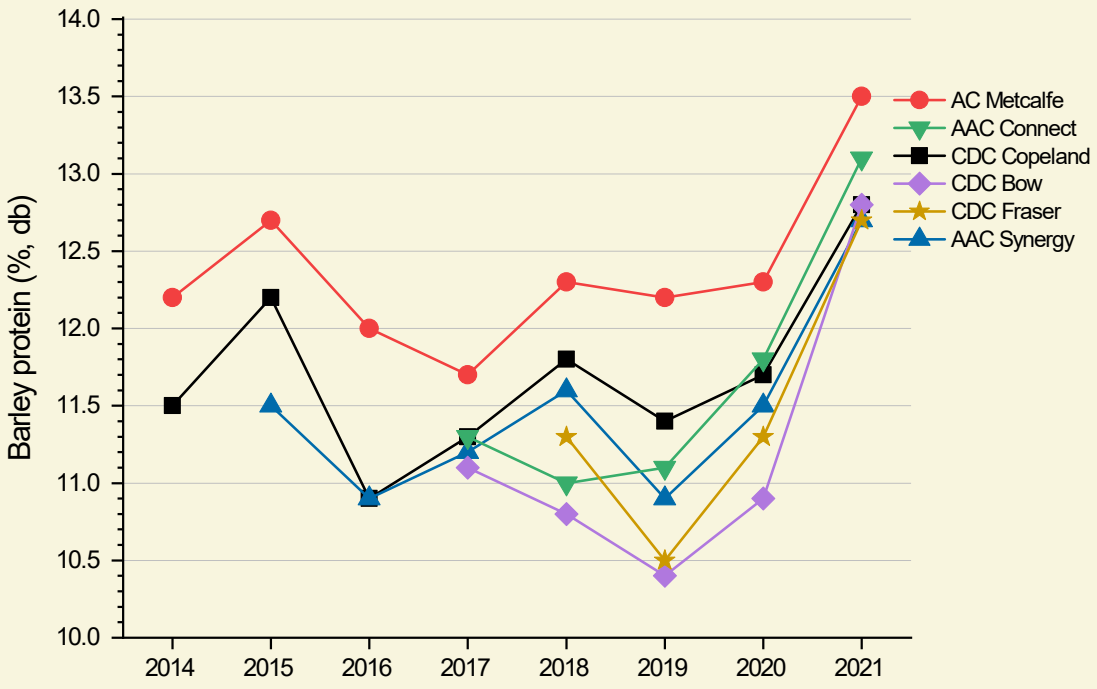


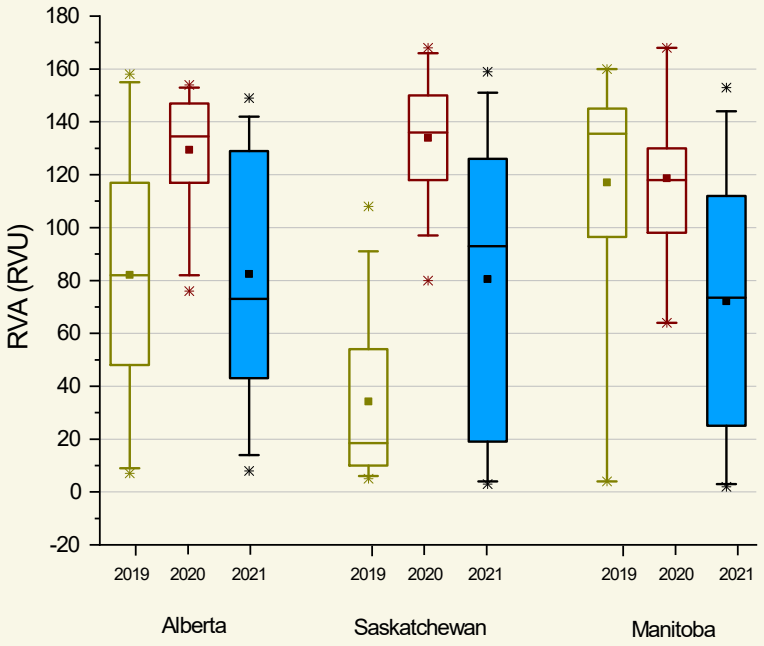
Figure 3.10 Comparison of the average protein content in selected barley varieties from 2014 to 2021. Values represent arithmetic averages.

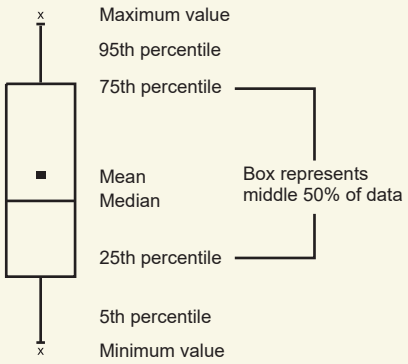
3.4 Pre-harvest sprouting

Premature sprouting of grain occurs when mature grain remains unharvested in the field during prolonged periods of wet weather. 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 that in 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 viscosity results are expressed in Rapid Visco Units (RVU) which then 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 greater than 120 RVU are considered sound, and the probability that they will retain germination energy after storage is very high. Samples with RVA values of 50-120 RVU are moderately pre-germinated while samples with RVA values less than 50 RVU are substantially pre-germinated and have a high probability of losing germination energy during storage. They should be malted as soon as possible. To more accurately predict safe storage time, storage conditions (temperature and relative humidity) and the initial moisture content of the grain must be considered in addition to the RVA values.

Barley grown in 2021 shows a variable degree of pre-harvest sprouting as indicated by a wide range of RVA values (19-150 RVU) (Figure 3.11). Despite the generally very dry growing conditions in 2021, the occurrence of rain at the end of August contributed to pre-harvest sprouting in some grain. The results indicate that it is very important to measure the degree of pre-harvest sprouting in barley to manage the 2021 stock appropriately.





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

Figure 3.11 Rapid visco analysis (RVA) results for barley selected for malting in 2021 in comparison with previous years.

3.5 Malting conditions and methodologies

Initial malting trials indicated that this year's barley easily absorbed water during steeping and needed substantially shorter wet steep cycles to achieve adequate hydration levels compared to last year. Consequently, the first and second steep cycles were reduced by 1 and 4 hours, respectively, compared to 2020. In addition, the temperature of steeping was decreased to 14 ºC from 15 ºC, which was used in 2020. Germination was conducted at 15 ºC for the whole germination process (96 h). The kilning steps were conducted according to the same schedules as last year. All analytical methods used to assess barley, malt and wort quality in this survey are listed in Appendix I.

Table 3.1 Comparison of micromalting conditions used with the Grain Research Laboratory Phoenix Micromalting System in 2020 and 2021

	2020	2021
Steeping		
1st wet cycle	10 h	9 h
1st dry cycle	14 h	14 h
2nd wet cycle	11 h	7 h
2nd dry cycle	13 h	14 h
Temperature	15 °C	14 °C
Germination	48 h at 15 ºC; 48 h at 16 ºC	96 h at 15 °C
Kilning	12 h at 60-65 °C, 6 h at 65 °C, 2 h at 75 °C, 5 h at 83-85 °C, 2 h at 60 °C, 2 h at 40 °C	12 h at 60-65 °C, 6 h at 65 °C, 2 h at 75 °C, 5 h at 83-85 °C, 2 h at 60 °C, 2 h at 40 °C

3.6 Malting quality in 2021: varietal and yearly comparisons

Figures 3.12 to 3.17 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 varieties annually evaluated in our survey since 2014. Values shown in the graphs represent arithmetic averages. This year, we received a limited number of CDC Churchill and CDC Copper and as a result, these two varieties are not included in our varietal comparison.

Examining barley during malting in the Phoenix Micromalting System (left) and wort samples collected after the mashing of malt (right) at the malting lab of the Grain Research Laboratory.

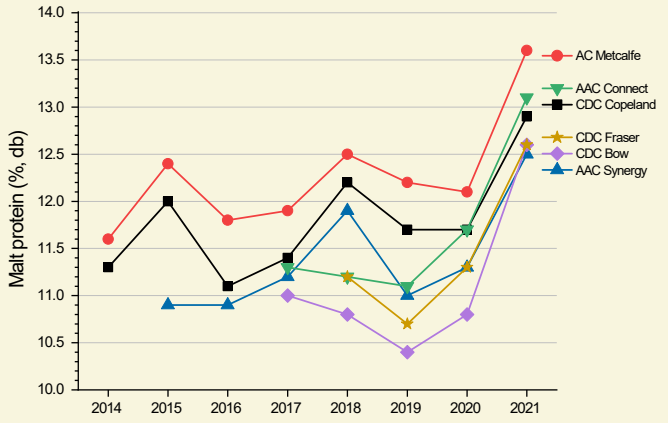


Figure 3.12 Comparison of the average concentration of proteins in malt for selected barley varieties from 2014 to 2021.

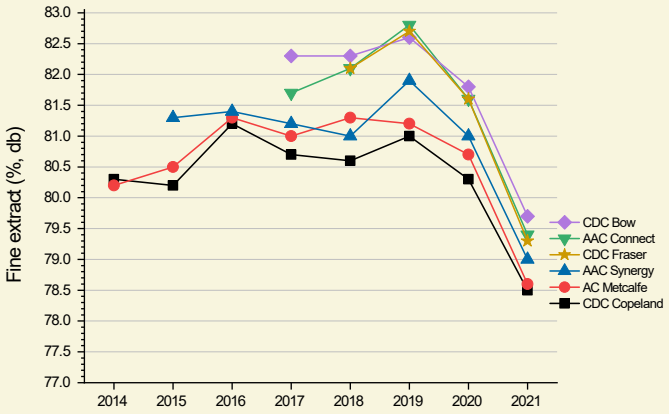


Figure 3.13 Comparison of the average extract levels from malt for selected barley varieties from 2014 to 2021.

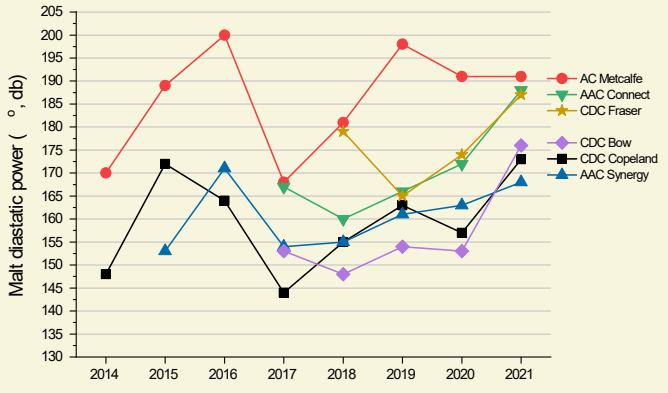


Figure 3.14 Comparison of the average diastatic power in malt for selected barley varieties from 2014 to 2021.

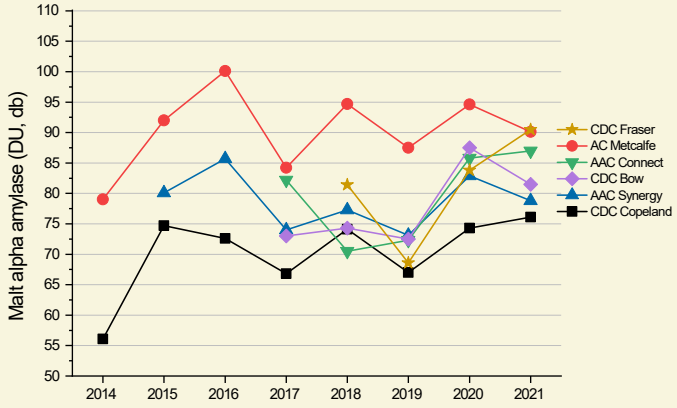


Figure 3.15 Comparison of the average activity of α-amylase in malt for selected barley varieties from 2014 to 2021.

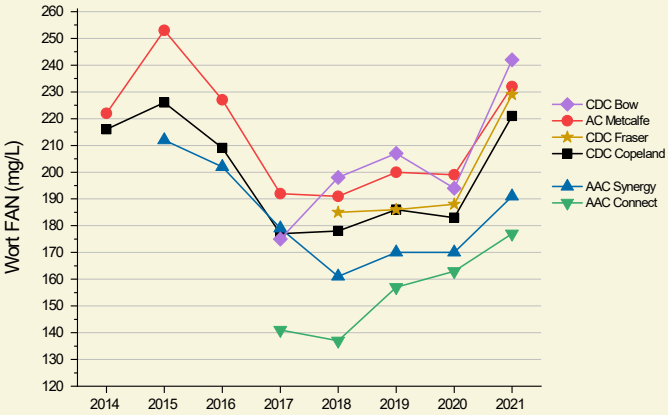


Figure 3.16 Comparison of the average FAN level in wort produced from malt of selected barley varieties from 2014 to 2021.

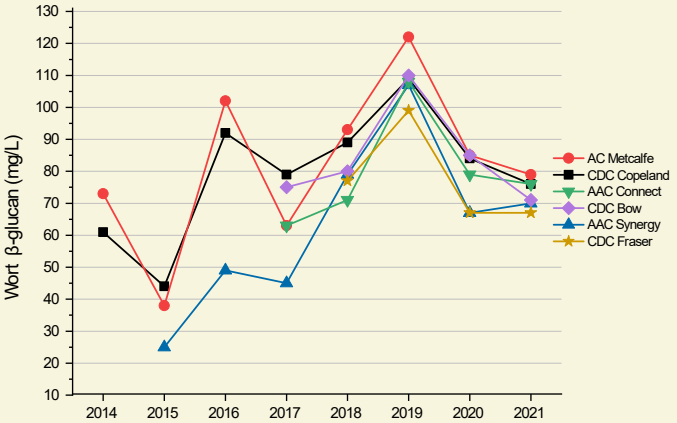


Figure 3.17 Comparison of the average β-glucan concentration in wort produced from malt of selected barley varieties from 2014 to 2021.

3.7 Highlights of malting barley quality in 2021

- The severe drought across the Prairie Provinces in 2021 significantly reduced barley yield and curtailed the supply of malting barley for both the domestic and international markets.
- CDC Copeland and AAC Synergy predominated the acreage seeded with malting barley cultivars in western Canada in 2021. The popularity of newer varieties (AAC Connect and CDC Fraser) increased noticeably in 2021, whereas the area seeded with AC Metcalfe declined drastically. These changes are reflected in the varietal make up of this survey. AC Connect and CDC Fraser had much larger effects and AC Metcalfe had a lesser effect on the average values and trends in the 2021 survey compared to previous years.
- The dry growing conditions affected the content of grain proteins. The average level of barley proteins was 13.2% in 2021, which is considerably higher than last year (11.8%).
- This year barley exhibited an excellent average germination energy (98%) which is equal to the 10-year average. It also showed very little water sensitivity.
- This year's average 1000 kernel weight of 45.3 g is only slightly lower than last year's average value of 45.5 g, and higher than the 10-year average value of 45.2 g. The newer varieties with kernels larger than AC Metcalfe and CDC Copeland, contributed to the overall high average kernel weight.
- The average plumpness of this year barley is 96.1%, which is higher than last year (92.4%) and higher than the 10-year average (93.0). Test weight, however, is lower (64.8 kg/hL) than the 10-year average (67 kg/hL).
- The pre-harvest sprouting in 2021 barley was quite variable due to the incidence of rain in certain part of the prairies in mid and late August.
- Water uptake during steeping was very good and resulted in adequate cell wall modification, a low concentration of β-glucans in wort and low wort viscosity.
- Higher concentration of grain proteins in 2021 barley contributed to lower malt extract levels by about 2% compared with previous years but contributed to high levels of malt enzymes (especially diastatic power) and free amino nitrogen (FAN) making this year's barley suitable for adjunct brewing.

Part 4: Quality data for individual varieties

CDC Copeland

CDC Copeland remains the predominant malting barley variety grown in western Canada in 2021. Its excellent brewing characteristics, combined with lower protein and enzyme levels than AC Metcalfe, provides an excellent balance among malting barley varieties.

AAC Synergy

The popularity of AAC Synergy on the prairies continues to increase. AAC Synergy is a high-yielding variety that is characterized by relatively high kernel weight and plumpness, and relatively low grain protein content. AAC Synergy has shorter and stronger straw than AC Metcalfe and CDC Copeland. It is resistance to spotted net blotch, netted net blotch and spot blotch. 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, registered in 2016, was a popular choice this year. It has excellent agronomic traits and disease resistance: shorter and stronger straw than AC Metcalfe and CDC Copeland, heavier and plumper kernels than AC Metcalfe and CDC Copeland, maturity similar to AC Metcalfe, resistance to spotted net blotch, surface-borne smuts and stem rust, and moderate resistance to fusarium head blight (FHB). This variety offers high extract, moderate to high enzymes and relatively low FAN levels, as well as good brewhouse performance and fermentability.

AC Metcalfe

In 2021, the production of AC Metcalfe declined drastically with only 11% of the area seeded with malting barley growing this variety. With high levels of starch-degrading enzymes, however, AC Metcalfe exhibits excellent brewing performance.

CDC Fraser

CDC Fraser, registered in 2016, is a high yielding variety with shorter and stronger straw and excellent lodging resistance. Its yields are 14% higher than AC Metcalfe and 8% higher than CDC Copeland. High kernel weight and plumpness and good resistance to spot blotch and spotted net blotch characterize CDC Fraser. This variety offers high extract, and high enzyme and FAN levels.

CDC Bow

CDC Bow, registered in 2015, is a high-yielding malting barley variety with excellent agronomic traits and disease resistance. Its yields are 9% higher than AC Metcalfe and 3% higher than CDC Copeland. CDC Bow has strong straw and good resistance to lodging. It is resistant to covered smut and stem rust. It is characterized by high kernel weight and plumpness. CDC Bow offers high extract, moderate to high enzymes, high FAN levels, high fermentability and good overall brewhouse performance.

CDC Copper

CDC Copper is a recently registered variety (2018) with still very limited production on the prairies. It is a high yielding variety with a strong leaf disease package. It is a low grain protein variety with malt enzymatic activity similar to Copeland and high extract potential.

CDC Churchill

CDC Churchill is a recently registered variety (2019) with still very limited production on the prairies. It is a high yielding variety with low grain protein, low to moderate levels of malt enzymes, low wort β-glucans, and high extract potential.

CDC Copeland

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

Origin of selected samples	Alberta		Saskatchewan		Manitoba		Prairie Provinces		
Crop year	**2021**	**2020**	**2021**	2020	**2021**	2020	**2021**	2020	2016-2020 Average
Number of samples	**12**	12	**10**	17	**4**	4	**26**	33	
Tonnage represented by samples (thousands of tonnes)[b]	**85**	324	**152**	655	**11**	53	**248**	1,032	1,012
Barley									
Test Weight (kg/hL)	**64.1**	67.1	**63.7**	66.5	**63.2**	66.6	**63.8**	66.7	66.9
1000 kernel weight (g)	**44.6**	44.1	**42.7**	44.9	**42.5**	45.4	**43.4**	44.7	45.9
Plump, over 6/64" sieve (%)	**96.2**	90.5	**95.4**	91.7	**95.4**	91.6	**95.7**	91.3	93.3
Intermediate, over 5/64" sieve (%)	**2.8**	7.9	**3.3**	6.9	**3.3**	6.8	**3.1**	7.2	5.2
Moisture[c] (%)	**12.0**	10.8	**12.5**	11.8	**11.9**	10.6	**12.3**	11.4	12.0
Protein (%, db)	**13.0**	11.6	**13.5**	11.8	**13.1**	11.5	**13.3**	11.7	11.4
Germination, 4 ml (%)	**99**	100	**99**	99	**98**	99	**99**	99	99
Germination, 8 ml (%)	**90**	98	**92**	98	**89**	96	**91**	98	95
Malt									
Yield (%)	**90.2**	91.5	**89.2**	90.5	**89.1**	91.0	**89.5**	90.8	91.2
Steep-out moisture (%)	**46.1**	45.1	**46.7**	45.6	**46.8**	45.4	**46.5**	45.4	45.0
Friability (%)	**74.1**	78.6	**72.4**	78.2	**75.8**	80.1	**73.1**	78.4	77.1
Moisture (%)	**4.4**	4.2	**4.4**	4.5	**4.4**	4.1	**4.4**	4.4	5.0
Protein (%, db)	**13.0**	11.5	**13.6**	11.8	**13.1**	11.4	**13.4**	11.7	11.6
Diastatic power (°, db)	**181**	146	**189**	156	**189**	148	**186**	157	157
α-Amylase (DU, db)	**80.2**	73.1	**80.3**	74.7	**83.2**	75.8	**80.4**	74.3	71.0
Wort									
Fine grind extract (F) (%, db)	**78.9**	80.5	**78.6**	80.2	**78.9**	80.8	**78.8**	80.3	80.8
Coarse grind extract (C) (%, db)	**78.1**	79.8	**77.8**	79.7	**78.0**	79.8	**77.9**	79.7	80.1
F-C difference (%, db)	**0.8**	0.7	**0.8**	0.6	**0.9**	1.0	**0.8**	0.6	0.7
ß-Glucan (mg/L)	**91**	85	**79**	83	**81**	90	**83**	84	91
Viscosity (cP)	**1.43**	1.45	**1.42**	1.43	**1.42**	1.44	**1.42**	1.44	1.44
Soluble protein (%, db)	**5.35**	5.12	**5.52**	5.15	**5.48**	5.15	**5.46**	5.14	4.62
Ratio S/T (%)	**41.2**	44.5	**40.6**	43.8	**41.7**	45.2	**40.8**	44.1	39.8
FAN (mg/L)	**190**	179	**210**	185	**201**	182	**203**	183	187
Colour (°)	**2.0**	2.0	**2.0**	2.0	**2.1**	2.3	**2.0**	2.0	1.9

[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; cP =centipoise

AAC Synergy

Table 4.2 Quality data for AAC Synergy malting barley[a]

Origin of selected samples	Alberta		Saskatchewan		Manitoba		Prairie Provinces		
Crop year	**2021**	2020	**2021**	2020	**2021**	2020	**2021**	2020	2016-2020 Average
Number of samples	**12**	11	**8**	11	**2**	5	**22**	27	
Tonnage represented by samples (thousands of tonnes)[b]	**80**	237	**81**	225	**6.8**	18	**168**	480	231
Barley									
Test Weight (kg/hL)	**65.5**	67.6	**65.5**	67.4	**64.9**	66.6	**65.5**	67.5	67.1
1000 kernel weight (g)	**50.0**	47.6	**46.2**	47.6	**46.2**	47.6	**48.0**	47.6	47.7
Plump, over 6/64" sieve (%)	**97.3**	95.3	**96.7**	94.6	**96.2**	94.3	**97.0**	95.0	96.0
Intermediate, over 5/64" sieve (%)	**1.4**	3.6	**2.4**	4.3	**2.8**	4.5	**2.0**	3.9	3.0
Moisture[c] (%)	**12.4**	11.8	**12.8**	11.6	**12.3**	10.5	**12.6**	11.7	12.2
Protein (%, db)	**12.5**	11.2	**13.2**	11.9	**13.2**	11.9	**12.9**	11.5	11.2
Germination, 4 ml (%)	**95**	99	**99**	99	**99**	98	**97**	99	99
Germination, 8 ml (%)	**90**	93	**96**	96	**94**	93	**93**	94	91
Malt									
Yield (%)	**90.3**	89.5	**90.2**	90.2	**89.2**	89.7	**90.2**	89.8	90.8
Steep-out moisture (%)	**47.0**	46.5	**46.2**	46.2	**47.2**	46.7	**46.6**	46.4	45.8
Friability (%)	**59.3**	77.7	**65.6**	73.9	**63.9**	72.3	**62.6**	75.7	74.2
Moisture (%)	**4.9**	4.7	**4.7**	4.7	**4.8**	4.9	**4.8**	4.7	5.1
Protein (%, db)	**12.3**	11.0	**13.1**	11.7	**12.8**	11.7	**12.7**	11.3	11.3
Diastatic power (°, db)	**163**	158	**169**	167	**168**	173	**166**	163	161
α-Amylase (DU, db)	**77.3**	82.1	**81.8**	83.5	**85.7**	87.6	**79.8**	82.9	78.6
Wort									
Fine grind extract (F) (%, db)	**79.5**	81.1	**78.2**	80.9	**78.3**	81.0	**78.8**	81.0	81.3
Coarse grind extract (C) (%, db)	**78.7**	80.8	**77.4**	80.4	**77.9**	80.4	**78.0**	80.6	80.9
F-C difference (%, db)	**0.8**	0.2	**0.8**	0.5	**0.4**	0.6	**0.8**	0.4	0.4
ß-Glucan (mg/L)	**70**	68	**74**	66	**67**	69	**72**	67	69
Viscosity (cP)	**1.41**	1.42	**1.40**	1.41	**1.39**	1.41	**1.40**	1.42	1.42
Soluble protein (%, db)	**5.10**	4.99	**4.88**	5.03	**4.98**	5.12	**4.99**	5.01	4.50
Ratio S/T (%)	**41.5**	45.6	**37.3**	43.2	**38.8**	43.9	**39.4**	44.4	40.2
FAN (mg/L)	**194**	169	**184**	170	**191**	176	**189**	170	176
Colour (°)	**1.9**	1.9	**1.7**	1.8	**1.9**	1.9	**1.8**	1.9	1.8

[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; cP =centipoise

AAC Connect

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

Origin of selected samples	Alberta	Saskatchewan	Manitoba	Prairie Provinces		
Crop year	**2021**	**2021**	**2021**	**2021**	2020	2017-2020 Average
Number of samples	**8**	**9**	**13**	**30**	21	
Tonnage represented by samples (thousands of tonnes)[b]	**33**	**39**	**6**	**78**	72	22
Barley						
Test Weight (kg/hL)	**65.1**	**65.1**	**64.6**	**65.0**	67.9	67.5
1000 kernel weight (g)	**47.0**	**45.9**	**46.6**	**46.4**	49.5	50.9
Plump, over 6/64" sieve (%)	**95.6**	**95.2**	**95.2**	**95.4**	94.4	95.8
Intermediate, over 5/64" sieve (%)	**3.2**	**3.6**	**3.6**	**3.4**	4.4	3.3
Moisture[c] (%)	**12.2**	**12.2**	**12.8**	**12.6**	11.8	13.2
Protein (%, db)	**13.2**	**13.6**	**13.1**	**13.4**	11.8	11.3
Germination, 4 ml (%)	**98**	**99**	**99**	**99**	98	99
Germination, 8 ml (%)	**92**	**96**	**95**	**94**	95	93
Malt						
Yield (%)	**90.2**	**89.9**	**89.9**	**90.0**	89.8	91.2
Steep-out moisture (%)	**46.3**	**46.2**	**46.8**	**46.3**	46.0	45.0
Friability (%)	**71.1**	**72.5**	**78.3**	**72.3**	80.5	80.2
Moisture (%)	**4.7**	**4.7**	**4.7**	**4.7**	4.7	4.9
Protein (%, db)	**13.4**	**13.6**	**13.1**	**13.4**	11.7	11.3
Diastatic power (°, db)	**200**	**206**	**192**	**203**	172	166
α-Amylase (DU, db)	**91.4**	**94.9**	**89.1**	**93.0**	85.8	77.7
Wort						
Fine grind extract (F) (%, db)	**79.5**	**79.1**	**79.4**	**79.3**	81.6	82.1
Coarse grind extract (C) (%, db)	**78.7**	**78.2**	**78.7**	**78.4**	81.3	81.5
F-C difference (%, db)	**0.8**	**0.9**	**0.7**	**0.9**	0.3	0.6
ß-Glucan (mg/L)	**95**	**97**	**89**	**80**	79	80
Viscosity (cP)	**1.41**	**1.41**	**1.41**	**1.41**	1.42	1.43
Soluble protein (%, db)	**5.23**	**5.18**	**5.08**	**5.19**	5.05	4.27
Ratio S/T (%)	**39.2**	**37.8**	**38.4**	**38.4**	43.2	37.7
FAN (mg/L)	**194**	**191**	**188**	**192**	163	150
Colour (°)	**1.9**	**1.8**	**1.9**	**1.9**	2.0	1.8

[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; cP =centipoise

AC Metcalfe

Table 4.4 Quality data for AC Metcalfe malting barley[a]

Origin of selected samples	Prairie Provinces			
Crop year	**2021**	2020	2019	2016-2020 Average
Number of samples	**7**	19	16	
Tonnage represented by samples (thousands of tonnes)[b]	**53**	365	360	598
Barley				
Test Weight (kg/hL)	**67.2**	68.4	66.9	68.6
1000 kernel weight (g)	**43.6**	44.0	43.3	44.4
Plump, over 6/64" sieve (%)	**95.9**	91.6	90.8	92.6
Intermediate, over 5/64" sieve (%)	**2.7**	6.7	7.5	5.7
Moisture[c] (%)	**12.4**	11.9	13.2	12.0
Protein (%, db)	**13.2**	12.3	12.2	12.1
Germination, 4 ml (%)	**99**	99	97	98
Germination, 8 ml (%)	**95**	93	89	92
Malt				
Yield (%)	**90.2**	90.1	91.3	90.7
Steep-out moisture (%)	**46.1**	46.1	45.9	45.3
Friability (%)	**70.5**	65.9	58.7	64.8
Moisture (%)	**4.5**	4.8	5.3	5.3
Protein (%, db)	**13.4**	12.1	12.2	12.1
Diastatic power (°, db)	**186**	191	198	188
α-Amylase (DU, db)	**91.4**	94.6	87.5	92.2
Wort				
Fine grind extract (F) (%, db)	**78.8**	80.7	81.2	81.1
Coarse grind extract (C) (%, db)	**78.3**	80.2	80.6	80.4
F-C difference (%, db)	**0.5**	0.5	0.6	0.7
ß-Glucan (mg/L)	**86**	85	122	93
Viscosity (cP)	**1.42**	1.43	1.44	1.43
Soluble protein (%, db)	**5.35**	5.29	5.02	4.83
Ratio S/T (%)	**39.9**	43.6	41.1	39.9
FAN (mg/L)	**225**	199	200	202
Colour (º)	**2.1**	2.0	1.9	2.0

[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; cP =centipoise

CDC Fraser

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

Origin of selected samples	Prairie Provinces			
Crop year	**2021**	2020	2019	2018-2020 Average
Number of samples	**11**	13	4	
Tonnage represented by samples (thousands of tonnes)[b]	**33**	7.7	2.2	2.7
Barley				
Test Weight (kg/hL)	**64.6**	66.7	66.5	67.5
1000 kernel weight (g)	**45.9**	48.7	49.5	51.0
Plump, over 6/64" sieve (%)	**97.2**	95.6	97.0	97.4
Intermediate, over 5/64" sieve (%)	**1.7**	3.3	1.8	1.7
Moisture[c] (%)	**12.7**	12.5	14.3	13.0
Protein (%, db)	**13.1**	11.3	10.5	11.0
Germination, 4 ml (%)	**99**	98	99	99
Germination, 8 ml (%)	**91**	84	89	91
Malt				
Yield (%)	**88.6**	88.9	90.2	90.1
Steep-out moisture (%)	**47.1**	47.4	46.2	46.4
Friability (%)	**82.5**	87.7	83.6	82.8
Moisture (%)	**4.6**	4.7	5.4	5.2
Protein (%, db)	**13.2**	11.2	10.7	11.0
Diastatic power (°, db)	**182**	174	165	173
α-Amylase (DU, db)	**90.7**	83.8	68.6	77.9
Wort				
Fine grind extract (F) (%, db)	**78.7**	81.6	82.7	82.1
Coarse grind extract (C) (%, db)	**78.1**	81.2	82.4	81.9
F-C difference (%, db)	**0.6**	0.4	0.3	0.2
ß-Glucan (mg/L)	**66**	67	99	81
Viscosity (cP)	**1.40**	1.43	1.42	1.42
Soluble protein (%, db)	**5.34**	5.44	4.61	4.77
Ratio S/T (%)	**40.5**	48.8	43.3	43.4
FAN (mg/L)	**225**	188	186	186
Colour (°)	**2.1**	2.5	2.0	2.1

[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; cP =centipoise

CDC Bow

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

Origin of selected samples	Prairie Provinces			
Crop year	**2021**	2020	2019	2017-2020 average
Number of samples	**4**	17	12	
Tonnage represented by samples (thousands of tonnes)[b]	**12.7**	11.2	6.0	5.5
Barley				
Test Weight (kg/hL)	**65.7**	68.5	67.9	68.8
1000 kernel weight (g)	**47.6**	48.7	49.7	50.4
Plump, over 6/64" sieve (%)	**97.3**	95.8	97.8	96.9
Intermediate, over 5/64" sieve (%)	**2.0**	2.9	1.6	2.2
Moisture[c] (%)	**11.8**	11.7	13.8	12.6
Protein (%, db)	**12.8**	10.9	10.4	10.8
Germination, 4 ml (%)	**98**	98	98	99
Germination, 8 ml (%)	**91**	88	89	93
Malt				
Yield (%)	**89.2**	89.8	91.1	90.8
Steep-out moisture (%)	**47.0**	46.1	46.1	45.4
Friability (%)	**78.1**	83.0	76.8	79.6
Moisture (%)	**4.6**	4.6	5.0	4.7
Protein (%, db)	**12.6**	10.8	10.4	10.8
Diastatic power (°, db)	**176**	153	154	154
α-Amylase (DU, db)	**81.5**	87.5	72.5	76.8
Wort				
Fine grind extract (F) (%, db)	**79.7**	81.8	82.6	82.3
Coarse grind extract (C) (%, db)	**79.3**	81.6	82.2	82.0
F-C difference (%, db)	**0.3**	0.2	0.4	0.3
ß-Glucan (mg/L)	**72**	85	110	88
Viscosity (cP)	**1.41**	1.42	1.45	1.44
Soluble protein (%, db)	**5.83**	5.37	4.90	4.83
Ratio S/T (%)	**46.2**	50.0	46.0	44.8
FAN (mg/L)	**242**	194	207	194
Colour (º)	**2.4**	2.3	2.0	2.0

[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; cP =centipoise

CDC Copper

Table 4.7 Quality data for CDC Copper malting barley[a]

Origin of selected samples	Prairie Provinces	
Crop year	**2021**	2020
Number of samples	**4**	6
Barley		
Test Weight (kg/hL)	**65.7**	66.8
1000 kernel weight (g)	**45.9**	47.7
Plump, over 6/64" sieve (%)	**94.5**	94.3
Intermediate, over 5/64" sieve (%)	**4.2**	4.6
Moisture[b] (%)	**13.2**	12.8
Protein (%, db)	**13.3**	10.8
Germination, 4 ml (%)	**98**	97
Germination, 8 ml (%)	**96**	63
Malt		
Yield (%)	**89.1**	88.3
Steep-out moisture (%)	**47.0**	47.6
Friability (%)	**63.6**	80.8
Moisture (%)	**5.1**	4.7
Protein (%, db)	**13.2**	11.0
Diastatic power (°, db)	**170**	152
α-Amylase (DU, db)	**74.5**	74.7
Wort		
Fine grind extract (F) (%, db)	**78.1**	81.5
Coarse grind extract (C) (%, db)	**77.5**	81.0
F-C difference (%, db)	**0.6**	0.5
ß-Glucan (mg/L)	**82**	80
Viscosity (cP)	**1.43**	1.45
Soluble protein (%, db)	**4.64**	4.98
Ratio S/T (%)	**35.2**	45.6
FAN (mg/L)	**169**	157
Colour (°)	**2.1**	3.2

CDC Churchill

Table 4.8 Quality data for CDC Churchill malting barley[a]

Origin of selected samples	Prairie Provinces	
Crop year	**2021**	2020
Number of samples	**3**	5
Barley		
Test Weight (kg/hL)	**64.9**	69.5
1000 kernel weight (g)	**46.7**	47.5
Plump, over 6/64" sieve (%)	**95.2**	93.4
Intermediate, over 5/64" sieve (%)	**3.8**	5.3
Moisture[b] (%)	**11.5**	12.0
Protein (%, db)	**13.7**	10.6
Germination, 4 ml (%)	**99**	99
Germination, 8 ml (%)	**96**	82
Malt		
Yield (%)	**90.7**	90.0
Steep-out moisture (%)	**45.7**	45.4
Friability (%)	**71.9**	83.0
Moisture (%)	**4.8**	4.6
Protein (%, db)	**13.9**	11.0
Diastatic power (°, db)	**188**	146
α-Amylase (DU, db)	**87.0**	76.4
Wort		
Fine grind extract (F) (%, db)	**78.9**	81.8
Coarse grind extract (C) (%, db)	**78.0**	81.4
F-C difference (%, db)	**0.9**	0.4
ß-Glucan (mg/L)	**99**	85
Viscosity (cP)	**1.41**	1.43
Soluble protein (%, db)	**5.09**	4.82
Ratio S/T (%)	**36.6**	43.9
FAN (mg/L)	**178**	160
Colour (°)	**1.7**	2.0

[a] Values represent arithmetic averages for samples analysed.
[b] 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; cP =centipoise

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 (db).

α-Amylase activity
α-Amylase activity was 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.

Arabinoxylans
Total arabinoxylan in grain content was determined after acid hydrolysis by gas-chromatographic (GC) analysis of alditol acetates using a flame ionization detector.

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

β-Glucan content in grain
β-Glucan content was determined in ground barley according to the Megazyme Streamlined Method – assay procedure for determination of mixed linkage β-glucan content in oat and barley flour (Association of Official Analytical Chemists (AOAC) Method 995.16, American Association for Cereal Chemistry (AACC) International Method 32-23, International Association for Cereal Chemistry (ICC) Standard Method No 168).

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

Fine-grind and coarse-grind extracts
Extracts were 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 (FAN) was determined in the fine extract according to the official ASBC method Wort-12 by segmented flow analysis.

Germination energy
Germination energy was determined by placing 100 kernels of barley on two layers of Whatman No.1 filter paper in a 9.0 cm diameter petri dish and adding 4.0 ml of purified water. Samples were germinated at 20 ºC and 90% relative humidity in a germination chamber. Germinated kernels were removed after 24 h and 48 h and a final count was made at 72 h (ASBC Barley 3C).

Kolbach index (ratio S/T)
Kolbach index was calculated from the formula: (% soluble protein / % malt protein) x 100.

Micromalting
Malts were prepared using an Automated Phoenix Micromalting System designed to handle 24 barley samples of 500 g or 48 barley samples of 250 g per batch.

Malt mills
Fine-grind malt was prepared with a Bühler-Miag disc mill set to fine-grind. Coarse-grind malt was 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 was predicted on dockage-free barley using the Foss Infratec™ 1241 whole grain near infrared analyzer.

Moisture content of malt
Moisture content of malt was determined on a ground sample by oven drying at 104 ºC for 3 h (ASBC Malt-3).

Protein content (N x 6.25)
Barley protein content was predicted on dockage-free barley using the Foss Infratec™ 1241 whole grain near infrared analyzer. The Foss Infratec™ 1241 performance is checked annually against the reference combustion nitrogen analysis (CNA) method. Annual reference check barley protein and malt protein was measured by CNA using a LECO Model FP-628 CNA analyzer calibrated by ethylenediamine tetraacetic acid (EDTA). Samples were ground on a UDY Cyclone Sample Mill fitted with a 1.0 mm screen. A moisture analysis was also performed and results were reported on a dry matter basis (ASBC Barley 7C).

Rapid Viscosity Analysis
The degree of pre-germination in barley was determined as described by Izydorczyk (2005) https://www.grainscanada.gc.ca/en/grain-research/scientific-reports/rva/. Samples were analyzed using the RVA 4500 (PerkinElmer) and the Stirring Number Program. Final viscosity values are reported in Rapid Visco Units (RVU).

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

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

Weight per thousand kernels
A 500 g sample of dockage-free barley was divided several times in a mechanical divider to obtain one representative sub-sample weighing 40 g. All foreign material and broken kernels were removed from a single 40 g portion and the net weight determined. The number of kernels was then counted with a mechanical counter and the 1000 kernel weight was calculated (as is basis) (Institute of Brewing's Recommended Methods of Analysis, Barley 1.3 (1997)).

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

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

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