

# AC METCALFE

Two-rowed, a cross of Oxbow/Manley, was fully registered in 1997, and was developed by Dr. Bill Legge, Brandon Research Centre, Agriculture and Agri-Food Canada.

## Agronomic traits

- Higher yield
- Early maturity than Manley
- Fair lodging resistance
- Good disease resistance

## Malting quality traits

- Improved resistance to peeling
- Higher extract
- Average enzyme levels and soluble protein
- Low wort beta-glucan
- Fast modification


## Brewing quality traits

- Good overall brewhouse performance
- Fast conversion time
- Acceptable lautering performance
- Good yield and material efficiencies

## Overall comments

AC Metcalfe's high levels of extract and enzymes make this variety very suitable when used with higher levels of adjuncts. Its low Beta-glucan content makes AC Metcalfe attractive to brewers who experience problems with slow runoffs and poor beer filtration.

## Comparative malt quality parameters

 CMBTC™ CANADIAN MALTING BARLEY TECHNICAL CENTRE	AC Metcalfe	CDC Copeland
Fine Extract, %	~81.5	~81.0
Color, EBC	3.0 - 4.5	2.0 - 3.5
Total Protein, %	~12.5	~12.5
Soluble Protein, %	4.7 - 5.3	4.5 - 5.0
Kolbach Index	42 - 48	42 - 44
Diastatic Power, °L	110 - 150	100 - 130
Wort Beta – Glucan, ppm	70 - 120	70 - 110
FAN, ppm (Mean ± Std.)	218 ± 27.9	194 ± 31.2

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## AC Metcalfe barley

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Legge, W. G., Metcalfe, D. R., Haber, S., Harder, D. E., Noll, J. S., Tekauz, A. and Thomas, P. L. 2003. **AC Metcalfe barley**. *Can. J. Plant Sci.* **83**: 381–384. AC Metcalfe is a two-row spring malting barley (*Hordeum vulgare* L.) cultivar widely adapted to western Canada with high yield, good agronomic traits, moderate disease resistance and excellent malting quality. Of note are its good resistance to loose smut and moderate resistance to *Fusarium* head blight.

**Key words:** Malting barley, *Hordeum vulgare* L., cultivar description, yield, disease resistance, malting quality

Legge, W. G., Metcalfe, D. R., Haber, S., Harder, D. E., Noll, J. S., Tekauz, A. et Thomas, P. L. 2003. **L'orge AC Metcalfe**. *Can. J. Plant Sci.* **83**: 381–384. AC Metcalfe est une variété brassicole d'orge de printemps à deux rangs (*Hordeum vulgare* L.) bien adaptée aux conditions de culture de l'Ouest canadien. Elle se démarque par un rendement élevé, de bons caractères agronomiques, une résistance moyenne à la maladie et une excellente qualité brassicole. Sa bonne résistance au charbon nu et sa résistance moyenne à la brûlure de l'épi causée par *Fusarium* méritent d'être soulignées.

**Mots clés:** Orge brassicole, *Hordeum vulgare* L., description de cultivar, rendement, résistance à la maladie, qualité brassicole

AC Metcalfe is a two-row spring malting barley (*Hordeum vulgare* L.) cultivar developed by the Agriculture and Agri-Food Canada (AAFC) Research Centre, Brandon, MB, and AAFC Cereal Research Centre, Winnipeg, MB. It received registration No. 4659 from the Variety Registration Office, Plant Products Division, Canadian Food Inspection Agency (CFIA) on 28 November 1997. Plant Breeders' Rights for AC Metcalfe (certificate No. 0399) were granted by the Plant Breeders' Rights Office, CFIA on 7 November 1997.

### Breeding Methods and Pedigree

AC Metcalfe was developed from the cross AC Oxbow/Manley made in 1986 at the AAFC Cereal Research Centre, Winnipeg, MB. Early generations were handled by a conventional pedigree method. The F<sub>1</sub> and F<sub>2</sub> generations were grown in growth cabinets. The F<sub>2</sub> plants were inoculated with loose smut spores [*Ustilago nuda* (Jens.) Rostr.]. F<sub>3</sub> plants with loose smut resistance were selected in the greenhouse and inoculated again with *U. nuda* spores. F<sub>4</sub> plants with loose smut resistance were selected in the greenhouse, and 500 single F<sub>5</sub> progeny rows were grown in the field in 1987. Progeny rows were selected on the basis of height, maturity, lodging resistance, general appearance, resistance to net blotch (*Pyrenophora teres* Drechs.) and preliminary malting quality analyses (i.e., alpha amylase activity, diastatic power, fine grind extract and amino nitrogen concentration), and grown as F<sub>6</sub> bulk rows in the winter nursery at Brawley, California, USA. Selected lines, one of which was WM8612-1, were transferred to the AAFC Research Centre, Brandon, MB, where they were grown in replicated yield tests in 1988 and 1989. Selection was made using the same criteria plus yield, heading date, test weight,

kernel weight, advanced malting quality analyses (i.e., above quality traits plus coarse grind extract, difference between fine and coarse extracts, soluble protein concentration and viscosity), and resistance to stem rust (*Puccinia graminis* Pers.), common root rot [*Cochliobolus sativus* (Ito & Kurib.) Drechs. ex Dast.] and net blotch. WM8612-1 was grown in the 1990 Eastern Prairie Barley Test at seven locations in Manitoba and Saskatchewan, and evaluated for the same traits as in 1989 plus kernel plumpness and resistance to loose smut, covered smut [*U. hordei* (Pers.) Lagerh.], false loose smut (*U. nigra* Tapke), scald [*Rhynchosporium secalis* (Oud.) J.J. Davis], and speckled leaf blotch (*Septoria passerinii* Sacc.). It was advanced in 1991 to the Western Cooperative Two-row Barley Registration Test, where it was evaluated for 3 years as TR232.

### Performance

AC Metcalfe is widely adapted to western Canada, and out-yielded the check cultivar Harrington by 8% on average across all soil zones over 3 yr of evaluation in the Western Cooperative Two-row Barley Registration Test (Table 1). In these trials, it was about a day later maturing, taller and more lodging resistant than Harrington, and had higher kernel weight (Table 2). AC Metcalfe was about 3 d earlier maturing and 3% lower yielding than the other check cultivar Manley. It was similar to Manley in height, lodging resistance and kernel weight. AC Metcalfe had higher test weight and plumper kernels than Harrington and Manley. Overall, AC Metcalfe had excellent malting quality (Table 3). It exceeded Harrington and Manley in most malting quality characteristics, with its main advantages being higher fine grind and 70°C course grind extracts and a

**Table 1. Grain yield (kg ha<sup>-1</sup>) of AC Metcalfe and check cultivars in the Western Cooperative Two-row Barley Registration Test, 1991–1993**

Cultivar	Soil zone			Overall
	Black <sup>z</sup>	Brown <sup>y</sup>	Black and Grey <sup>x</sup>	
Harrington	4760	5285	5792	5270
Manley	5324	5984	6402	5910
AC Metcalfe	5182	5701	6279	5706
LSD <sub>0.05</sub> <sup>w</sup>	250	166	292	123
No. of tests	14	24	13	51

<sup>z</sup>Black Soil Zone: Brandon, Glenlea, Indian Head (1992, 1993), Lake Lenore (1993 – yield data lost due to early snow), Melfort, North Battleford (1992), Portage la Prairie (1992, 1993).

<sup>y</sup>Brown Soil Zone: Acme (1992, 1993), Elrose, Irricana, Lethbridge, Regina (1992, 1993), Saskatoon, Scott (1992, 1993), Swift Current, Watrous.

<sup>x</sup>Black and Grey Soil Zone: Beaverlodge, Calmar (1992, 1993), Fort Vermilion (1992, 1993), Lacombe, Provost.

<sup>w</sup>Least significant difference among cultivar means at the 5% probability level, where each test was treated as one replication.

smaller difference between these two values, and lower beta glucan concentration. Although levels of starch-degrading enzymes were higher for AC Metcalfe than for Harrington and Manley as evidenced by alpha amylase activity and diastatic power, they were not excessive during malting. AC Metcalfe had less favorable values for soluble protein concentration, ratio of soluble to total protein concentration, and viscosity than Harrington and Manley.

## Other Characteristics

**PLANT.** Erect to semi-erect juvenile growth; whitish coleoptile with medium elongation; medium green leaves of medium length and width, green leaf sheath, glabrous sheath and blade; intermediate to upright flag leaf, medium green in colour, medium length and width, purplish to white auricles, glabrous sheath, blade and auricles, waxy sheath; green, waxy, medium to fine (4–5 mm) stem with slight stem exertion above the flag leaf (0–3 cm), 5 nodes, straight neck, and predominantly closed to slightly V-shaped collar.

**SPIKE.** Two-row type, strap shape, medium density and length, semi-nodding to erect attitude, spike usually emerged above flag leaf; rough lemma awns longer than spike with green tips; glumes slightly more than one half length of lemma with long hairs concentrated in a band but there may be some hairs covering rest of glume, rough glume awns slightly longer than the glumes with green tips, awnletted empty glumes; first segment of rachis medium length with weak curvature, rachis edges covered with numerous long hairs, weak to medium humping of rachis segments.

**KERNEL.** Covered, medium length and width, yellow aleurone, short rachilla with long hairs, a few abnormal rachillas, green lateral lemma veins with a few barbs near the tip, clasping lodicules, 50% of kernels have hairs on

**Table 2. Agronomic traits of AC Metcalfe and check cultivars in the Western Cooperative Two-row Barley Registration Test, 1991–1993**

Cultivar	Days to heading	Days to maturity	Height (cm)	Lodging (1–9) <sup>z</sup>	Test weight (kg hL <sup>-1</sup> )	1000-kernel weight (g)	Plump (%) <sup>y</sup>
Harrington	60.1	97.0	80.4	5.1	62.8	40.2	78.4
Manley	63.3	100.9	82.2	3.9	63.6	41.4	75.9
AC Metcalfe	60.1	98.2	82.2	3.9	64.7	41.0	84.2
LSD <sub>0.05</sub> <sup>x</sup>	0.6	0.6	1.0	0.4	0.7	0.9	2.4
No. of tests	33	35	45	26	40	39	40

<sup>z</sup>1= no lodging; 9 = completely lodged.

<sup>y</sup>Kernel plumpness (%) as determined over a 6/64 (238 mm) screen.

<sup>x</sup>Least significant difference among cultivar means at the 5% probability level, where each test was treated as one replication.

**Table 3. Malting quality characteristics<sup>z</sup> of AC Metcalfe and check cultivars in the Western Cooperative Two-row Barley Registration Test, 1991–1993<sup>y</sup>**

Cultivar	Grain protein (g hg <sup>-1</sup> ) <sup>xw</sup>	Fine grind extract (g hg <sup>-1</sup> ) <sup>xv</sup>	70°C coarse grind extract (g hg <sup>-1</sup> ) <sup>xv</sup>	Fine-coarse difference (g hg <sup>-1</sup> ) <sup>xv</sup>	Soluble protein (g hg <sup>-1</sup> ) <sup>xv</sup>	Ratio of soluble to total protein (%) <sup>x</sup>	Diastatic power (°L) <sup>wu</sup>	Alpha amylase (DU) <sup>wt</sup>	Beta glucan (mg L <sup>-1</sup> ) <sup>s</sup>	Viscosity (cps) <sup>wr</sup>
Harrington	11.5	78.7	72.2	6.5	4.37	39.8	97	51.5	488	1.62
Manley	11.1	79.2	74.2	4.9	4.30	40.2	113	51.9	373	1.61
AC Metcalfe	11.5	79.9	77.1	2.8	4.76	43.5	118	54.2	255	1.69
LSD <sub>0.05</sub> <sup>q</sup>	0.5	0.6	1.5	1.2	0.12	1.7	6	3.1	67	0.08

<sup>z</sup>Malting quality characteristics determined at the Grain Research Laboratory, Canadian Grain Commission, Winnipeg, MB, as described by Mather et al. (1997).

<sup>y</sup>Mean of 9 site years for each cultivar comparison: Beaverlodge (1992), Brandon (1992, 1993), Elrose (1991), Provost (1991, 1993), Regina (1993), Saskatoon (1992), Swift Current (1991).

<sup>x</sup>Expressed as % by the malting and brewing industries.

<sup>w</sup>On a grain dry matter basis.

<sup>v</sup>On a malt dry matter basis.

<sup>u</sup>Degrees Lintner.

<sup>t</sup>Dextrinizing unit measure of alpha amylase activity.

<sup>s</sup>On a malt extract basis, expressed as ppm by the malting and brewing industries.

<sup>r</sup>Centipoise, international viscosity units used by the malting and brewing industries.

<sup>q</sup>Least significant difference among cultivar means at the 5% probability level, where each test was treated as one replication.

**Table 4. Disease reactions of AC Metcalfe and check cultivars in the Western Cooperative Two-row Barley Registration Test, 1991–1993**

Cultivar	Net blotch										Common root rot				Scald					
	<i>Ustilago smuts</i> (% infected) <sup>z</sup>					Field <sup>x</sup>					(% infected) <sup>y</sup>		Inoculated <sup>t</sup>		Fields <sup>s</sup>					
	<i>nuda</i>	<i>hordeii</i>	<i>nigra</i>	102	858	857	SASK (1–9)	CHAR (0–9)	BRAN (1–10)	GLEN (1–10)	Septoria 692 <sup>w</sup>	SASK	SCOT	Stem rust <sup>u</sup>	837	1493	EDMT	LA-1	LA-2	CALM
<i>1991</i>																				
Harrington	92	15	20	9	9	7	6.5	4.8	7.5	– <sup>r</sup>	S	100	50MS	S	S	8.0	–	–	9.0	–
Manley	49	2	8	8	9	2	3.5	2.3	6.5	–	S	85	60MS-S	S	S	7.0	–	–	9.0	–
AC Metcalfe	0	5	17	9	10	5	3.5	2.3	5.5	–	S	100	40MRMS	S	S	7.5	–	–	7.0	–
<i>1992</i>																				
Harrington	94	27	51	9	10	7	3.5	–	–	8	S	–	50MRMS-S	–	S	7.0	–	–	8.5	9.0
Manley	20	7	9	10	9	3	2.5	–	4	S	47	–	50MRMS-S	–	S	6.5	–	–	5.0	2.5
AC Metcalfe	14	16	7	10	10	5	2.8	–	3	S	42	–	30MRMS	–	S	6.0	–	–	6.0	3.0
<i>1993</i>																				
Harrington	92	37	44	10	10	7	6.0	–	–	–	S	0.7	40MRMS-S	–	S	8.5	7	–	6.5	8.3
Manley	15	1	2	3/10	–	3	2.6	–	–	–	S	0.7	50MS-S	–	S	8.0	6	–	3.0	7.3
AC Metcalfe	0	2	5	10	9	5	2.8	–	–	–	S	0.0	30MRMS	–	S	6.5	5	–	4.5	6.0

<sup>z</sup> % infected plants; 10% or less is considered resistant.

<sup>y</sup>Seedlings inoculated with *Pyrenophora teres* net-form isolates 102 and 858, and spot-form isolate 857 from the Agriculture and Agri-Food Canada (AAFC) Cereal Research Centre, Winnipeg, MB; 1 = very resistant, 10 = very susceptible; x/y = segregating.

<sup>x</sup>Field ratings on a scale where lowest number = very resistant, highest number = very susceptible; SASK = Saskatoon, CHAR = Charlottetown (observation site), BRAN = Brandon, GLEN = Glenlea.

<sup>w</sup>Seedlings inoculated with *Septoria passerinii* isolate 692 from the Cereal Research Centre, Winnipeg; S = susceptible.

<sup>u</sup>% infected plants where SASK = Saskatoon and SCOT = Scott.

<sup>t</sup>Stem rust rating where 0–100 = % severity, and R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible reaction types.

<sup>s</sup>Seedlings inoculated with *Rhynchosporium secalis* isolates 837 and 1493 from the Cereal Research Centre, Winnipeg; S = susceptible.

<sup>r</sup>Field ratings on a 1–9 scale where 1 = very resistant, 9 = very susceptible; EDMT = Edmonton, LA-1 = AAFC Lacombe, LA-2 = Alberta Agriculture Lacombe, CALM = Calmar.

<sup>n</sup>Not determined.

ventral furrow while 50% do not, horseshoe depression basal marking.

QUALITY. Excellent malting quality (Table 3).

DISEASE REACTION. Good resistance to loose smut; moderate resistance to covered smut and false loose smut; moderate resistance to stem rust (carries the *Rpg1* gene) but susceptible to race Pgt-QCCJ; intermediate resistance to the spot-form and susceptible to the net-form of net blotch; intermediate resistance to common root rot; susceptible to scald and speckled leaf blotch (Table 4). When AC Metcalfe was being evaluated in the Western Cooperative Two-row Barley Registration Test, *Fusarium* head blight (FHB) caused by *Fusarium graminearum* Schwabe was not a concern in western Canada and no data were collected on reaction to this pathogen. While AC Metcalfe was undergoing market development and commercialization, FHB became a serious problem in Manitoba and Saskatchewan. AC Metcalfe was found to have moderate resistance to FHB (Tekauz et al. 2000).

#### Availability of Propagating Material

Breeder seed will be maintained by the AAFC Seed Increase Unit, Experimental Farm, Box 760, Indian Head, SK,

Canada S0G 2K0. The initial breeder seed was produced in 1992 by the Seed Increase Unit at Indian Head from a bulk of 178 F<sub>11</sub> lines derived from F<sub>0</sub> single plant selections originally made at the AAFC Research Centre, Brandon, MB. Distribution and multiplication of other classes of pedigreed seed stocks will be handled by SeCan Association, 201 – 52 Antares Drive, Ottawa, ON, Canada K2E 7Z1.

We gratefully acknowledge the assistance of D. Gehl (AAFC Seed Increase Unit, Experimental Farm, Indian Head, SK) in producing and maintaining the breeder seed and facilitating the winter nurseries, and the technical assistance of P. Green and B. McLeod (AAFC Research Centre, Brandon, MB) and P. Wardle (AAFC Cereal Research Centre, Winnipeg, MB). We also thank Dr. B.G. Rossnagel and J.A. Weller (Crop Development Centre, University of Saskatchewan, Saskatoon, SK) for providing spot-form net blotch data from the field nursery, and Dr. K.L. Bailey (AAFC Research Centre, Saskatoon, SK) for common root rot ratings.

**Mather, D. E., Tinker, N. A., LaBerge, D. E., Edney, M., Jones, B. L., Rossnagel, B. G., Legge, W. G., Briggs, K. G., Irvine, R. B., Falk, D. E. and Kasha, K. J. 1997.** Regions of the genome that affect grain and malt quality in a North American two-row barley cross. *Crop Sci.* **37**: 544–554.

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### Western Regional Spring Barley Nursery

Variety	Year	Barley Kernel Weight (mg)	on 6/64 (%)	Barley Color (Agtron)	Malt Extract (%)	Wort Color	Relative Viscosity	Turbidity (Hach)	Barley Protein (%)	Wort Protein (%)	S/T (%)	DP (°)	Alpha-amylase (20°DU)	Beta-glucan (ppm)	FAN (ppm)	Yield bu/a	Yield kg/ha	Test Wt. lb/bu	Test Wt. Kg/hl	Height in	Height cm	Heading	Plump	Protein	
AC Metcalfe	2009	39.6	98.8	75.0	82.0	2.14	1.46	9.4	11.0	5.13	48.9	127	76.9	86	198	98.6	5.31	52.7	67.8	31.5	80.0	186	93.0	11.1	
AC Metcalfe	2010	39.8	95.7	60.0	80.5	2.12	1.46	7.4	12.8	5.90	47.8	159	82.2	61	225	94.2	5.07	51.1	65.7	33.1	84.0	84	84.2	15.8	
AC Metcalfe	2011	39.8	94.3	75.7	80.5	2.20	1.44	4.8	13.0	5.32	43.1	175	93.9	55	242	80.0	4.30	51.4	66.2	27.8	70.5	189	85.3	12.7	
AC Metcalfe	2012	36.5	90.6	78.3	79.6	1.80	1.44	5.6	13.8	6.03	46.1	185	96.7	66	221	78.2	4.21	49.4	63.6	33.1	84.1	180	85.9	13.3	
AC Metcalfe	2013	39.8	94.3	75.7	80.5	2.20	1.44	4.8	13.0	5.32	43.1	175	93.9	55	242	92.8	4.99	51.6	66.5	34.3	87.2	183	92.0	11.6	
AC Metcalfe	2014	39.6	97.2	48.0	80.1	3.50	1.46	9.3	12.3	4.85	40.4	133	71.4	38	242	96.4	5.05	49.9	64.2	34.0	76.6	173	83.9	11.9	
Harrington	2009	40.0	97.9	74.5	82.0	1.62	1.47	6.1	10.9	5.02	49.5	116	73.6	112	183	100.3	5.40	52.2	67.3	30.9	78.4	186	93.0	10.8	
Harrington	2010	41.5	95.2	60.0	80.5	1.74	1.48	5.0	12.3	5.50	47.3	138	73.6	139	219	93.7	5.04	50.9	65.5	32.4	82.2	82	85.1	15.2	
Harrington	2011	39.6	93.7	70.0	79.9	2.10	1.45	4.4	12.8	5.30	42.1	162	84.2	112	238	79.8	4.29	50.9	65.5	26.2	66.6	189	87.6	12.4	
Harrington	2012	38.2	93.7	75.3	80.6	1.60	1.47	5.8	12.8	5.59	45.7	145	82.0	146	203	79.9	4.30	48.9	62.9	31.5	80.1	181	84.8	12.4	
Harrington	2013	39.6	93.7	70.0	79.9	2.10	1.45	4.4	12.8	5.30	42.1	162	84.2	112	238	89.2	4.80	49.8	64.0	32.3	82.0	184	89.8	11.1	
Harrington	2014	40.8	97.1	44.0	78.9	2.90	1.44	7.0	11.8	4.80	41.4	124	72.2	64	247	94.7	5.01	49.1	63.2	33.3	75.4	174	90.1	11.0	
<b>2009-2014 Averages</b>																									
AC Metcalfe		39.2	95.1	68.8	80.5	2.33	1.5	6.9	12.7	5.43	44.9	159	85.8	60	228	90.0	4.8	51.0	65.7	32.3	80.4	166	87.4	12.7	
Harrington		39.9	95.2	65.6	80.3	2.01	1.5	5.4	12.2	5.25	44.7	141	78.3	114	221	89.6	4.8	50.3	64.7	31.1	77.4	166	88.4	12.1	
Baronesse		41.9	96.6	66.1	77.7	2.54	1.5	29.4	12.1	3.87	34.1	103	47.4	141	131	101.5	5.4	51.8	66.7	29.8	74.1	165	88.9	12.2	

Agronomic data (last nine columns) is based on an average of a number of sites throughout the western US. Most of the data is based on an average of 8-12 sites with protein (last column) done only on a few sites.

Quality data is based on micro-malting by the USDA-ARS CCRU in Madison, WI. Only a few sites (usually 3 or 4), but sometimes (2014) only a single site is sent for testing.

Breeders in Montana have noted that AC Metcalfe is latitude sensitive and does not display the same yield advantages over Harrington as it does in Canada.

AC Metcalfe is a two-rowed spring malting barley. It was released by Agriculture and Agri-Food Canada in 1997. It was selected from the cross AC Oxbow/Manley. Its experimental designations were TR 232 and WM8612-1. It is widely adapted to western Canada and has excellent malting and brewing quality, particularly malt extract. It is tall (averages about 40 inches in plant height) with fair straw strength and is medium late maturing (about one day later than Harrington). At the time of release it was resistant to stripe rust, stem rust, loose smut, moderately resistant to the surface-borne smuts and the spot-form of net blotch (and had adult plant resistance to some net-form pathotypes), and susceptible to scald, leaf rust, speckled leaf blotch, common root rot, and BYD.