CULTIVAR DESCRIPTION

Cardale hard red spring wheat

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Fox, S. L., Humphreys, D. G., Brown, P. D., McCallum, B. D., Fetch, T. G., Menzies, J. G., Gilbert, J. A., Fernandez, M. R., Despins, T. and Niziol, D. 2013. **Cardale hard red spring wheat**. Can. J. Plant Sci. **93**: 307–313. Cardale is a hard red spring wheat that meets the end-use quality specifications of the Canada Western Red Spring (CWRS) class. Cardale is a semi-dwarf statured wheat with moderate resistance to *Fusarium* head blight (FHB). Cardale is derived from the cross McKenzie/Alsen. Cardale was found to be adapted to the eastern wheat growing regions of the Canadian prairies as represented in the Central Bread Wheat Cooperative (CBWC) Registration Test in 2008, 2009 and 2010. In comparison with the check cultivars, Cardale was significantly lower yielding than Unity VB, but overall similar to McKenzie and 5603HR. Cardale matured at the same time as 5603HR, but significantly later (1.5–2.5 d) than the other check cultivars. The plant stature of Cardale was significantly shorter (7–13 cm) than all of the checks, and Cardale had significantly lower lodging scores (0.5–0.7 units) than all of the checks except for CDC Teal. The test weight of Cardale was significantly lower (0.4–0.8 kg hL^{-1}) than that of McKenzie and Unity VB but similar to the other three checks. Cardale expressed resistance to leaf rust and stem rust and moderate resistance to FHB. Disease reactions for common bunt and loose smut were variable but suggested susceptibility and intermediate resistance, respectively. Cardale had preharvest sprouting resistance similar to the best checks McKenzie, Unity VB and 5603HR and significantly better than the poor check CDC Teal in three different determinations. The end-use suitability attributes of Cardale were within the range of the checks except for slightly higher water absorption due to slightly harder kernels (lower particle size index) that led to slightly higher starch damage which occurs during milling.

Key words: *Triticum aestivum* L., cultivar description, red spring wheat, Fusarium head blight resistance, short stature

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Mots clés: *Triticum aestivum* L., description de cultivar, blé roux vitreux de printemps, résistance à la brûlure de l'épi par *Fusarium*, paille courte

Cardale is a hard red spring wheat (*Triticum aestivum* L.) developed by Agriculture and Agri-Food Canada (AAFC), Cereal Research Centre (CRC), Winnipeg, Manitoba, and released in 2011. It was given the registration number 7045 by the Plant Variety Registration Office, Plant Production Division, Seed Section,

Table 1. Population size and activities at each generation leading to the registration of Cardale hard red spring wheat

Name	Gen.	Year	Activity – Number of lines – Locations
BA77	F_0	2001	Final cross made in a growth cabinet.
BA77	F_1	2001–2002	30 F1 seeds grown in a pair of 1.5 m rows near Leeston, NZ.
BA77	F_2	2002	Approximately 3000 seeds distributed over 10 plots, 300 seeds/3.25 m^2 plot grown near Glenlea, MB.
BA77-BM	$F_{2:3}$	2002–2003	224 lines were grown near Palmerston North (PN), NZ, as hills. Selection for agronomics and leaf rust resistance.
BA77-BM	$F_{2:4}$	2003	139 lines were grown in a 1-m row nursery near Portage la Prairie, MB. Selection for agronomics, seed appearance, resistance to rusts and common bunt, protein concentration, flour yield, and dough strength measured by mixograph.
BA77-BM	$F_{2:5}$	2003–2004	40 lines were grown near PN in 1.5-m rows. Selection for agronomics and leaf rust resistance.
BA77-BM	$F_{2:6}$	2004	24 lines were tested in an unreplicated yield test at two to three locations (MB: Brandon, Glenlea, Portage la Prairie; SK: Saskatoon, Melfort). Selection based on agronomics, disease resistance and quality performance. Approximately 35 spikes were selected per line; however, only 11 families totalling 355 $F_{6:7}$ lines were advanced.
BA77-BM-19	$F_{6:7}$	2004–2005	355 lines were grown near PN in 1.5-m rows. Selection for agronomics and leaf rust resistance.
BA77-BM-19	$F_{6:8}$	2005	148 lines were tested in unreplicated yield tests at two to three locations (MB: Brandon, Glenlea, Portage la Prairie; SK: Saskatoon, Melfort). Selection based on agronomics, disease resistance and quality.
BA77-BM-19	$F_{6:9}$	2006	25 lines in the Central Bread Wheat ‘‘A3’’ test. Yield test, two replicates at five locations (MB: Glenlea, Brandon, Portage la Prairie, Morden; SK: Indian Head).
BA77-BM-19	$F_{6:10}$	2007	Five lines in the Central Bread Wheat ‘‘B’’ test. Yield test, three replicates at eight locations (MB: Glenlea, Brandon, Morden; SK: Indian Head, Regina, Melfort, Saskatoon; AB: Beaverlodge).
BW429	$F_{6:11–13}$	2008–2010	One line in the Central Bread Wheat ‘‘C’’ registration test. Yield test, three replicates at 11 locations/year (MB: Glenlea, Portage la Prairie, Brandon, Morden, Souris, Dauphin; SK: Indian Head, Kamsack, Regina, Melfort, Saskatoon).
Breeder Seed Production			
BW429	$F_{6:11}$	2008	Breeder seed spikes: 250 random spikes were selected from a rogued increase plot grown at Indian Head, SK. Of these spikes, 30 were discarded due to shrivelled seed or having few seeds.
BW429	$F_{6:12}$	2009	Breeder seed isolation rows: 220 lines were grown in 1-m rows grown near Glenlea, MB with a 10-m isolation distance from any other wheat. Eighteen lines were discarded prior to harvest due to lack of uniformity. After harvest, an additional nine lines were discarded due to low seed amounts (<30 g) (6), seed colour (1), shrivelled seed (1) or green seed (1).
BW429	$F_{6:13}$	2010	Breeder seed rows: 15-m rows grown at Indian Head, SK, with 10-m isolation distance from other wheat. One hundred and ninety-three rows were grown with lines being discarded due to presence of taller plants (52), the whole row being 5-10 cm taller than the group (5), 50:50 mixture of tall and short plants (1), presence of awnless plants (3), or later maturity (1). Thus, 131 lines were combined to produce 150 kg of breeder seed.

Table 2. Yield (kg ha^{-1}) of Cardale and five check cultivars in the Central Bread Wheat Coop, 2008–2010

	Manitoba[z]				Saskatchewan				All sites			
Cultivar	2008	2009	2010	Mean	2008	2009	2010	Mean	2008	2009	2010	Mean
Katepwa	3764	4665	3432	3876	4846	4808	3114	4256	4256	4744	3288	4081
McKenzie	4112	4716	4191	4304	5223	5205	3408	4612	4617	4988	3835	4475
CDC Teal	3814	4536	3600	3926	4854	4938	3376	4389	4287	4759	3498	4170
Unity VB	4312	5257	4284	4549	5561	5401	4096	5019	4879	5337	4199	4798
5603HR	4460	5274	4130	4551	5165	5211	3711	4696	4781	5239	3940	4646
Cardale	4269	5200	4071	4439	5243	5053	3344	4546	4712	5118	3740	4513
LSD ($P = 0.05$)[y]	404	559	343	229	385	207	274	250	272	271	237	156
No. of tests	6	4	6	16	5	5	5	15	11	9	11	31

[z]Manitoba test locations: Glenlea, Portage la Prairie, Brandon, Morden, Souris, Dauphin; Saskatchewan test locations: Indian Head, Regina, Melfort, Kamsack, Saskatoon.
[y]LSD of means was based on the checks and Cardale and calculated using the SAS PROC MIXED procedure (SAS Institute, Inc. 2006).

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Pedigree and Breeding Method

Cardale was developed through a conventional modified pedigree selection method (Table 1) from the cross McKenzie/Alsen. McKenzie has the parentage Columbus/Amidon (Graf et al. 2003) and Alsen has the parentage ND674//ND2710/ND688 (Frohberg et al. 2006). Following production of 300–500 g of F_2 seed near Leeston, New Zealand, F_2 bulk plots were grown near Glenlea, MB, in an irrigated disease nursery designed to identify resistance to leaf and stem rust caused by *Puccinia triticina* Eriks. and *P. graminis* Pers.:Pers. f. sp. *tritici* Eriks. & E. Henn., respectively (Fetch 2005; McCallum et al. 2011). From the 250 selected spikes, 224 F_3 hills were grown in a contra-season nursery near Palmerston North (PN), New Zealand, where screening for appropriate plant height, maturity and resistance to leaf rust was done, resulting in 139 lines being advanced to F_4. The F_4 lines were similarly grown near Portage la Prairie, MB, with the addition of inoculation of the seed with spores of *Tilletia tritici* (Bjerk.) R. and *T. laevis* Kuhn in Rabenh to screen the material for resistance to common bunt (Gaudet and Puchalski 1989). Only agronomically suitable, disease resistant lines were harvested and tested for grain protein concentration, flour yield and dough strength as determined by mixograph (American Association of Cereal Chemists 2002). Forty lines were advanced to the F_5 generation of which 24 lines were further advanced to F_6 agronomic and disease resistance testing. Disease testing was conducted in 1-m-row irrigated nurseries near Portage La Prairie, MB, which were inoculated to allow for selection for resistance to leaf and stem rust and FHB, caused by *Fusarium graminearum* Schwabe [teleomorph *Gibberella zeae* (Schwein.) Petch]. Selection for kernel appearance, grain protein concentration, flour yield and dough strength were carried out on lines identified as having sufficient agronomic and disease resistance merit relative to the check cultivars. Approximately 35 selections per F_6 line were made; however, only 355 $F_{6:7}$ lines derived from 11 families were grown in PN with 148 of these being advanced into the F_8 generation. Twenty-five F_8 lines were advanced for evaluation in the pre-registration test Central Bread Wheat “A” and five of these lines advanced to the Central Bread Wheat “B” test in 2007 before being entered into the Central Bread Wheat Cooperative (CBWC) test in 2008. For registration testing, BA77-BM-19 was named BW429.

In the CBWC test, agronomic performance was evaluated in a 30-entry yield test grown using a rectangular lattice design with three replications at each of 11 locations/year. Of these sites, six were operated by AAFC, two by Syngenta, one by Canterra Seeds, and one by the University of Saskatchewan. For registration decisions regarding cultivar value for cultivation and end-use suitability, BW429 was compared with five check cultivars: Katepwa (Campbell and Czarnecki 1987), McKenzie (Graf et al. 2003), CDC Teal (Hughes and Hucl 1993), Unity VB (Fox et al. 2010) and 5603HR. At the CRC, response to diseases in artificially inoculated irrigated field nurseries was assessed for leaf rust and stem rust using the modified Cobb scale (Peterson et al. 1948). Several greenhouse seedling evaluations were conducted to observe infection type reactions to *P. triticina* races MBDS (12-3), MGBJ (74-2), TJBJ (77-2) and MBRJ (128-1) (McCallum et al. 2011) and to *P. graminis* f. sp. *tritici* races TMRTK (C10), RKQSR (C63), TPMKR (C53) RTHJT (C57), QTHST (C25) and RHTSK (C20) (Roelfs and Martens 1988; Fetch 2005). Fusarium head blight was evaluated in irrigated field nurseries near Glenlea and Carman, MB, that were spray inoculated with a macroconidial suspension of *F. gramineaum*, and evaluated using a visual index (% incidence × % severity/100) (Gilbert and Woods 2006). Seed samples from the Glenlea nursery was used to measure deoxynivalenol (DON) concentration (Sinha and Savard 1996). Resistance to loose smut caused by *Ustilago tritici* (Pers.) Rostr. was assessed using multiple races (Menzies et al. 2003). Evaluation for response to common bunt was

Table 3. Summary of agronomic traits of Cardale and five check cultivars in the Central Bread Wheat Coop, 2008–2010

Cultivar	Maturity (d)				Height (cm)				Lodging[z] (1–9 scale)				Test weight (kg h^{-1})				Kernel weight (mg kernel^{-1})			
	2008	2009	2010	Mean	2008	2009	2010	Mean	2008	2009	2010	Mean	2008	2009	2010	Mean	2008	2009	2010	Mean
Katepwa	97.5	104.0	97.4	99.7	95.9	105.8	101.5	101.0	2.7	2.6	1.6	2.2	76.5	78.5	74.4	76.4	33.8	34.8	30.1	32.8
McKenzie	98.0	104.7	98.1	100.3	93.4	99.0	97.2	96.6	2.6	2.5	1.8	2.2	77.6	79.1	76.4	77.7	33.5	33.5	31.0	32.6
CDC Teal	97.9	104.7	98.6	100.5	90.6	99.2	94.6	94.8	2.5	1.8	1.4	1.8	76.2	77.7	75.0	76.3	34.0	34.5	30.7	32.9
Unity VB	98.9	104.8	98.6	100.9	94.0	100.2	97.8	97.3	2.6	2.0	1.9	2.1	78.6	79.8	77.3	78.5	34.9	34.0	30.2	33.0
5603HR	99.6	105.5	100.9	102.4	93.1	101.8	98.2	97.7	2.6	1.9	1.8	2.0	77.5	78.7	75.8	77.3	33.0	32.6	30.2	31.9
Cardale	99.5	107.4	100.7	102.5	85.4	90.9	88.5	88.3	2.2	1.4	1.2	1.5	76.9	78.5	75.5	76.9	33.3	33.5	30.5	32.5
LSD ($P=0.05$)	0.8	1.4	1.3	0.8	1.9	1.7	2.0	1.7	NS[y]	0.7	NS	0.4	0.7	0.6	0.6	0.6	0.9	1.0	NS	NS
No. of tests	11	9	11	31	11	10	11	32	4	5	7	16	11	10	11	32	11	10	11	32

[z]Lodging scale: 1 = vertical, 9 = flat.
[y]NS = not significant at $P=0.05$.

conducted at the Lethbridge Research Centre, Lethbridge, AB, of AAFC using multiple races of *Tilletia tritici* (Bjerk.) R. and *T. laevis* Kuhn in Rabenh (Gaudet and Puchalski 1989; Gaudet et al. 1993). End-use quality was evaluated by the Grain Research Laboratory, Canadian Grain Commission, Winnipeg, MB, based on composite samples for each test entry that were prepared from test locations selected based on grade and protein concentration of the check cultivars. Grain from locations where the checks produced poor quality grain was not included in quality composites. Annual statistical analysis of experiments was conducted using Agrobase Generation II (Agronomix Inc. 2009). The SAS PROC MIXED procedure (SAS Institute, Inc. 2006) was used to perform a multiyear analysis: for agronomic data, a mixed model was used with years, locations and replications set as random variables and cultivars set as a fixed variable. For end-use quality data, the analysis was similar except that there was only replication of observations each year.

Summarized in Table 1, breeder Seed of Cardale was produced by randomly selecting 250 spikes from a BW429 seed increase plot grown at Indian Head, SK, in 2008 that was rogued for uniformity. Of these spikes, 220 were grown as an isolated group of 1-m head rows in 2009 near Glenlea, MB. Of these lines, 36 were discarded due to lack of uniformity, low seed amount, seed colour or shrivelled seed. In 2010, a 15-m row was grown from each of the remaining 193 isolation rows at the Indian Head Seed Increase Unit of AAFC, Indian Head, SK. Sixty-one lines were discarded prior to harvest primarily due to variable plant height, but also due to the presence of awnless plants and later maturity. The remaining uniform plots were inspected and harvested in bulk producing a minimum of 150 kg of breeder seed.

Performance

The grain yield of Cardale was similar to that of McKenzie, but significantly less than the best check Unity VB over 3 yr of testing in the CBWC test (Table 2). Cardale exhibited the same maturity as 5603HR but was significantly later maturing (2.2 d) than McKenzie (Table 3). Cardale was significantly shorter than all of the checks and had lodging scores significantly lower than all of the checks except CDC Teal. The test weight and kernel weight of Cardale were within the range of the checks (Tables 3 and 6).

Cardale had resistance to the prevalent races of leaf rust and stem rust (Table 4) and had moderate resistance to FHB. It has been shown that Cardale has the gene *Lr21* (Huang et al. 2003) that confers resistance to a broad range of leaf rust races and has the *F. graminearum* resistance gene *Fhb1* (Liu et al. 2008) and the quantitative trait locus located on chromosome 5AS (McCartney et al. 2007) (data not shown). Cardale exhibited variable disease reactions to common bunt

Table 4. Disease severities and ratings[z] of Cardale and five checks in the Central Bread Wheat Coop, 2008–2010

	Stem rust[y] (% severity, rating)			Leaf rust[x] (% severity, rating)			*Fusarium* head blight index[w] (% incidence × % severity/100, rating)							Loose smut[v] (% infection, rating)			Common bunt[u] (% infection, rating)		
Cultivar	2008	2009	2010	2008	2009	2010	2008 Glenlea	2008 Carman	2009 Glenlea	2009 Carman	2010 Glenlea	2010 Carman	2010 Ottawa	2008	2009	2010	2008	2009	2010
Katepwa	5 R	3 R	10 MR	70 MSS	10 R	62 MSS	2 R	23 I	9 R	11 I	19 I	22 I	51	0 R	3 R	8 R	18 MR-I	21 I	20 MS
McKenzie	10 RMR	5 R	20 MR	0 R	0 R	0 R	19 MS	28 I	26 I	8 MR	14 MR	37 MS	47	11 R	22 MR	42 I	2 VR	5 MR	2 R/MR
CDC Teal	15 I	10 RMR	20 MR	10 MR	5 R	3 R	20 S	78 S	21 I	43 S	41 S	64 S	73	14 R	13 R	25 MR	23 I	31 I	21 MS
Unity VB	15 RMR	7 R	10 MR	t R	3 R	2 MR	1 R	27 I	17 MR	12 I	14 MR	29 I	52	11 R	30 MR	54 I	2 VR	2 R	1 R/MR
5603HR	20 RMR	5 R	25 MR	0 R	2 R	0 R	1 R	30 I	22 I	15 I	21 I	28 I	18	21 MR	25 MR	41 I	15 MR	7 MR	8 R/MR
Cardale	5 R	5 R	10 MR	0 R	0 R	0 R	0.3 R	13 MR	17 MR	5 R	8 R	15 MR	45	20 MR	51 I	48 I	19 MR-I	7 MR	34 S

[z]Disease rating class: VR = very resistant, R = resistant, RMR = resistant to moderately resistant, MR = moderately resistant; I = intermediate; MRMS = moderately resistant to moderately susceptible, MSS = moderately susceptible to susceptible, S = susceptible.
[y]Caused by *Puccinia graminis* Pers.:Pers. f. sp. *tritici* Eriks. E. Henn. Races used include TMRTK, RKQSR, TPMKR, QTHST, RHTSK and MCCFR.
[x]Caused by *P. triticina* Eriks. Inoculum was a composite of all leaf rust disease survey collections made the previous year from Manitoba and Saskatchewan (McCallum et al. 2011).
[w]Caused by *Fusarium graminearum* Schwabe (teleomorph *Gibberella zeae* (Schwein.) Petch). Fusarium head blight index = (% infected spikelets × % infected spikes)/100.
[v]Caused by *Ustilago tritici* (Pers.) Rostr. Races used include T2, T9, T10 and T39. Rating based on previous and current tests after artificial inoculation.
[u]Caused by *Tilletia tritici* (Bjerk.) R. Wolff and *T. laevis* Kuhn in Rabenh. The inoculum used was a composite of races T-1, T-6, T-13, and T-19 of *T. tritici* and L-7 and L-16 of *T. laevis* mixed in a 1:1:1:2:2 ratio (vol/vol).

and to loose smut, suggesting an intermediate level of resistance to both of these diseases.

Assessments of preharvest sprouting resistance by exposure of spikes in a rain simulator and field weathering (Humphreys and Noll 2002) demonstrated that Cardale was not different from all of the checks for Hagberg Falling number values from the wheat quality composite samples but had significantly higher Hagberg Falling number values than CDC Teal in both field and artificial weathering trials (Table 5). Cardale had significantly lower preharvest sprouting scores compared to the checks Katepwa and CDC Teal but was similar to the other checks.

The end-use quality of Cardale was deemed suitable for the CWRS class exhibiting milling and baking performance similar to the range of the checks. However, it was noted that Cardale had a slightly harder kernel that resulted in slightly higher starch damage and higher water absorption as seen in both the farinograph and Canadian Short Process assessments (Table 6).

Other Characteristics

The observations of plant characteristics were made using four-replicate, randomized complete block experiments grown in 2010 and 2011 at Portage La Prairie, MB, for collection of data for Plant Breeders Rights.

Seedling Characteristics

Coleoptile colour. Reddish-purple, weak anthocyanin colouration.
Juvenile growth habit. Semi-erect.
Seedling leaves. Glabrous leaf sheaths and blades of lower leaves.

Adult Plant Characteristics

Growth habit. Semi-erect.
Leaves. High frequency of recurved leaves.
Flag leaf. Medium green with glabrous sheath and blade. The auricle colouration is absent, and auricle margins are slightly pubescent. Leaf sheath has a moderately waxy bloom.
Flag leaf attitude. Drooping.
Upper culm internode. Some curvature at maturity and slightly waxy.
Culm colour. Medium glaucosity.

Spike Characteristics

Shape. Parallel-sided.
Size. Similar to Vesper; slightly longer than Superb, Unity and Waskada.
Density. Medium dense.
Attitude. Erect.
Rachis. Very sparse hairiness of convex surface of apical segment and slight pubescence of margins.
Colour. Medium glaucosity; white colour at maturity.
Awns. Awned.

Table 5. Falling numbers and sprouting scores of Cardale and five checks from yield tests grown in 2008–2010. Quality composite samples were created from grain harvested from 6, 10 and 8 locations for respective years of the Central Bread Wheat Coop

	Falling number (s)											Sprouting score[z] (1–9 scale)				
	Quality composite				Field weathered[y]			Artificially weathered[x]				CBWB[w]	CBWC			
Cultivar	2008	2009	2010	Mean	2008	2010	Mean	2008	2009	2010	Mean	2007	2008	2009	2010	Mean
Katepwa	430	435	370	412	253	238	245	96	88	174	119	7.1	5.8	5.0	6.2	5.7
McKenzie	430	440	405	425	351	304	327	198	172	261	210	9.0	2.1	6.3	3.7	4.0
CDC Teal	435	430	390	418	258	114	186	73	72	104	83	9.5	6.4	6.6	6.8	6.6
Unity	450	475	435	453	378	386	382	266	130	210	202	5.4	1.7	3.9	1.7	2.4
5603HR	460	440	450	450	326	268	297	248	217	303	256	N/C	1.9	3.0	1.4	2.1
Cardale	420	430	395	415	312	330	321	111	161	260	177	7.8	4.4	3.5	1.7	3.2
LSD ($P = 0.05$)				26			108				70					2.1
Replicates	1	1	1	3	1	1	2	1	1	1	3	1	1	1	1	3

[z][(no. spikes with 0 sprouts) × 1 + (no. spikes with 1 sprout) × 2 + (no. spikes with 2 sprouts) × 3 + (no. spikes with 3–5 sprouts) × 5 + (no. spikes with > 3 sprouts) × 9]/ total number of spikes evaluated. Spikes were collected at maturity and stored at −20°C until they were evaluated. The mean was calculated over the three years of tests using SAS PROC MIXED procedure.
[y]Field weathered samples were harvested when declines in falling number were observed for the sprouting susceptible cultivar Roblin.
[x]Collected at maturity, this material was placed in a rain simulator at 15°C for 48 h, dried and then seed was ground into meal for falling number determination.
[w]The CBWB is a pre-registration test.

Table 6. Wheat and flour analytical data for Cardale and five checks in the Central Bread Wheat Coop, 2008–2010. End-use quality testing was conducted by the Grain Research Lab of the Canadian Grain Commission on composite samples created from grain harvested from 6, 10 and 8 locations for respective years of the Central Bread Wheat Coop

												Farinograph 54-21[z]				Canadian Short Process (150 ppm ascorbic acid)[y]						
Cultivar	Test weight (kg hL^{-1})	Kernel weight (mg kernel^{-1})	Wheat protein (%)	Flour protein (%)	Falling number (s) 56-81B	Amylo-graph (BU) 22-10	Flour yield (%)[w]	Flour ash (%) 08-01	Agtron colour (%) 14-30	Starch damage (%) 76-31	Particle size index 55-30	Absorp-tion (%)	Dough devel-opment time (min)	Mixing toler-ance index (BU)	Stability index (min)	Loaf volume (cm^3)	Loaf appear-ance	Crumb struc-ture	Crumb Colour	Absorp-tion (%)	Mixing energy (W-h kg^{-1})	Mixing time (min)
Katepwa	80.3	34.6	14.0	13.4	411.7	516.7	75.6	0.5	78.3	7.5	54.3	66.2	5.3	2.0	10.8	1118.3	7.8	6.0	7.9	66.7	8.1	3.4
McKenzie	80.7	35.3	13.9	13.3	425.0	588.3	76.3	0.5	79.0	8.2	50.7	67.3	4.9	28.3	7.7	1106.7	7.7	6.0	7.9	67.0	9.4	3.9
CDC Teal	80.0	35.3	14.4	14.0	418.3	578.3	75.8	0.5	80.7	6.6	56.0	66.2	7.9	15.0	15.0	1180.0	7.7	6.1	8.0	66.0	10.2	3.8
Unity	82.1	36.1	14.0	13.4	453.3	865.0	77.6	0.5	79.3	8.1	50.7	67.6	5.8	33.3	7.7	1116.7	7.7	6.1	7.9	66.3	9.5	3.6
5603HR	81.0	33.6	14.0	13.3	450.0	678.3	75.9	0.5	80.0	7.5	53.7	64.4	6.3	25.0	9.8	1073.3	7.6	6.2	7.8	64.3	10.6	4.3
Cardale	80.2	36.0	14.4	13.7	415.0	585.0	76.5	0.5	77.7	8.4	50.0	68.2	7.0	25.0	9.7	1091.7	7.5	6.1	7.8	67.7	10.6	3.9
LSD ($P = 0.05$)[v]	0.6	0.7	0.4	0.4	25.6	95.9	1.0	NS	NS	0.3	1.1	1.0	1.7	5.4	2.3	43.2	NS	NS	NS	0.9	NS	0.4

[z]American Association of Cereal Chemists (2002).
[y]Preston et al. (1982).
[x]Williams et al. (1998).
[w]Dexter and Tipples (1987). All millings at the Canadian Grain Commission's Grain Research Laboratory are performed in rooms with environmental control maintained at 21°C and at 60% relative humidity. Common wheat is milled on an Allis-Chalmers laboratory mill using the GRL sifter flow as described by Black et al. (1980). Flour yield is expressed as a percentage of cleaned wheat on a constant moisture basis.
[v]LSD ($P < 0.05$) of means was based on the checks and Cardale and calculated using the SAS Proc Mixed procedure. Data consist of single measurements in each of the 3 yr of testing. NS, not significant.

Spikelet Characteristics
Glumes. Long length; narrow to medium width; lower glume is pubescent; glume shoulders are slightly sloping to square; narrow to medium shoulder width; glume beak is slightly curved and of short to medium length; sparse internal glume hairs. Glumes are white in colour at maturity.
Lemma. Slightly curved beak shape.

Kernel Characteristics
Shape. Oval in shape with rounded cheeks.
Size. Medium-sized with mid-long length and mid-wide width.
Brush. Small to medium-sized with mid-long to long brush hairs.
Embryo. Medium-sized, oval shape; crease is narrow to medium and is mid-deep in depth.

Maintenance and Distribution of Pedigreed Seed Stocks

The Agriculture and Agri-Food Canada Research Farm, Indian Head, SK, will maintain the Breeder Seed of Cardale. Multiplication and distribution of other classes of pedigreed seed will be handled by Seed Depot Corp., Box 208, 4–5 Londesboro Rd., Pilot Mound, Manitoba, Canada R0G 1P0.

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