CULTIVAR DESCRIPTION

Shaw hard red spring wheat

S. L. Fox[1], I. L. Wise[1], M. A. H. Smith[1], D. G. Humphreys[1], P. D. Brown[1], B. D. McCallum[1], T. G. Fetch[1], J. G. Menzies[1], J. A. Gilbert[1], M. R. Fernandez[2], T. Despins[3], O. Lukow, and D. Niziol[1]

[1]Agriculture and Agri-Food Canada, Cereal Research Centre, 195 Dafoe Road, Winnipeg, Manitoba, Canada R3T 2M9; [2]Agriculture and Agri-Food Canada, Semiarid Prairie Agricultural Research Centre, P.O. Box 1030, Swift Current, Saskatchewan, Canada S9H 3X2; and [3]Agriculture and Agri-Food Canada, Lethbridge Research Centre, P.O. Box 3000, Lethbridge, Alberta, Canada T1J 4B1. *Received 19 June 2012, accepted 25 October 2012.*

Fox, S. L., Wise, I. L., Smith, M. A. H., Humphreys, D. G., Brown, P. D., McCallum, B. D., Fetch, T. G., Menzies, J. G., Gilbert, J. A., Fernandez, M. R., Despins, T., Lukow, O. and Niziol, D. 2013. **Shaw hard red spring wheat**. Can. J. Plant Sci. **93**: 299–305. Shaw is a hard red spring wheat that meets the end-use quality specifications of the Canada Western Red Spring (CWRS) class. Shaw contains the antibiosis resistance gene *Sm1*, which is effective against the wheat midge larvae (*Sitodiplosis mosellana* Géhin). Shaw is derived from the cross Harvest/BW313. Shaw 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 2006, 2007 and 2008. For registration testing, the performance of Shaw was estimated using a varietal blend called BW394 which consisted of 90% Shaw and 10% BA51*C222 (a midge-susceptible sibling of Shaw). In this report, Shaw VB refers to BW394. In comparison to the check cultivars (Katepwa, McKenzie, CDC Teal, Unity VB, and 5603HR), Shaw was the highest yielding cultivar overall; although not significant, Shaw was 1% higher yielding than Unity VB. Shaw matured significantly earlier than 5603HR. The plant stature of Shaw was significantly taller than all of the checks except Katepwa, but had similar lodging resistance scores as the checks. The test weight of Shaw was significantly higher than Katepwa and CDC Teal and within the range of the other checks. Shaw expressed resistance to leaf rust, stem rust and common bunt; susceptibility to fusarium head blight and to loose smut. Shaw had preharvest sprouting resistance with an overall sprouting score similar to the best checks McKenzie, Unity VB and 5603HR. The end-use suitability attributes of Shaw were within the range of the checks for all traits except for having significantly larger seeds.

Key words: *Triticum aestivum* L., cultivar description, red spring wheat, test weight, preharvest sprouting, wheat midge antibiosis resistance

Fox, S. L., Wise, I. L., Smith, M. A. H., Humphreys, D. G., Brown, P. D., McCallum, B. D., Fetch, T. G., Menzies, J. G., Gilbert, J. A., Fernandez, M. R., Despins, T., Lukow, O. et Niziol, D. 2013. **Le blé roux de printemps Shaw**. Can. J. Plant Sci. **93**: 299–305. Shaw est une variété de blé roux de printemps respectant les normes de qualité de la classe « blé roux de printemps de l'Ouest canadien » (CWRS) pour l'usage final. Shaw porte le gène de résistance antibiotique *Sm1*, efficace contre les larves de la cécidomyie du blé (*Sitodiplosis mosellana* Géhin). Issu du croisement Harvest/BW313, Shaw est bien adapté aux régions de l'est des Prairies canadiennes où l'on cultive le blé, ainsi que l'ont montré les essais d'homologation de la Central Bread Wheat Cooperative (CBWC) en 2006, 2007 et 2008. Lors de ces essais, le rendement de Shaw a été estimé au moyen du mélange variétal BW394, composé à 90 % de graines de Shaw et à 10 % de graines de BA51*C222 (cultivar apparenté à Shaw mais sensible à la cécidomyie). Dans le présent rapport, l'appellation Shaw VB désigne le mélange BW394. Shaw s'est avéré le cultivar au rendement le plus élevé comparativement aux témoins (Katepwa, McKenzie, CDC Teal, Unity VB et 5603HR); bien que non significatif, le rendement de Shaw a dépassé celui de Unity VB de 1 %. Shaw parvient à maturité sensiblement plus tôt que 5603HR. Shaw est significativement plus grand que les autres cultivars, sauf Katepwa, mais sa résistance à la verse est similaire à celle des témoins. Le poids spécifique de Shaw est significativement plus élevé que celui de Katepwa et de CDC Teal, et se situe dans la plage des autres variétés témoins. Shaw résiste à la rouille des feuilles, à la rouille de la tige et à la carie, tout en étant sensible à la brûlure de l'épi causée par *Fusarium* ainsi qu'au charbon nu. Shaw résiste à la germination sur pied et obtient une note similaire à celle des meilleurs témoins (McKenzie, Unity VB et 5603HR). Les attributs de Shaw relatifs à l'utilisation finale se situent dans la fourchette des témoins, outre le fait que cette variété produit des grains nettement plus gros.

Mots clés: *Triticum aestivum* L., description de cultivar, blé roux de printemps, poids spécifique, germination sur pied, résistance antibiotique à la cécidomyie

Shaw 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 2009. It was given the registration number 6681 by the Plant Variety Registration Office, Plant Production Division, Seed Section,

Canadian Food Inspection Agency (CFIA), Agriculture and Agri-Food Canada, on 2009 Dec. 02. Plant Breeder's Rights were obtained 2011 May 10 and given the certificate number 4061. The cultivar is named after Philip Shaw Barker, who originally discovered a source of previously unknown antibiotic resistance to wheat midge (Barker et al. 1996). This resistance has been widely distributed in western Canadian wheat breeding programs and is the source of resistance used in Shaw wheat.

Pedigree and Breeding Method

Shaw was selected from a group of 384 doubled haploids produced from F_1 plants of the cross BA51 = Harvest/BW313 made in 2001 at the CRC. Harvest has the parentage AC Domain*2/ND640 (Fox et al. 2010b) and BW313 has the parentage (RL4763*2/Howell). RL4763 = Roblin*4/BW553. Shaw derives its midge resistance from the soft red winter wheat Howell (Kolb and Brown 1992). The BA51 doubled haploid lines were produced in two groups: 205 and 179 lines. These lines were increased in 1.5-m rows in New Zealand winter nurseries in 2002 and 2003, respectively, where selection for suitable plant height, straw strength and maturity was conducted (Table 1). Of these lines, 109 were advanced for agronomic testing in 2003 and 42 in 2004. In addition to agronomic testing, these lines were tested for disease resistance in 1-m row nurseries near Portage La Prairie, MB, which were inoculated to allow for selection for resistance to leaf and stem rust caused by *Puccinia triticina* Eriks. and *P. graminis* Pers.:Pers. f. sp. *tritici* Eriks. & E. Henn., respectively. Selection for kernel appearance, grain protein concentration, flour yield and dough strength was carried out on lines identified as having sufficient agronomic and disease resistance merit relative to check cultivars. Fifteen BA51 doubled haploid lines were advanced for evaluation in the preregistration tests Central Bread Wheat "A" (CBWA) and Central Bread Wheat "B" (CBWB) in 2004 and 2005, respectively, before being entered into the Central Bread Wheat Cooperative (CBWC) test in 2006. For registration testing, the performance of BA51*B92 was estimated using the varietal blend BW394, which consisted of 90% BA51*B92 and 10% BA51*C222. The addition of the midge-susceptible BA51*C222 sibling line was done to provide an interspersed refuge for wheat midge (Smith et al. 2004). For registration, CFIA agreed that the data collected for BW394 adequately described BA51*B92. Thus, BA51*B92 was registered as Shaw and the commercially available form of this cultivar is in a varietal blend (VB) called Shaw VB which consists of 90% BA51*B92 and 10% of the midge-susceptible cultivar AC Domain (Townley-Smith and Czarnecki 2008).

In the CBWC, 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 [Manitoba: Glenlea (2006 and 2008 only), Portage La Prairie, Morden, Brandon, Dauphin (2006 and 2008 only), Souris; Saskatchewan: Regina, Indian Head, Kamsack (2008 only), Saskatoon, Melfort]. Of these sites, seven were operated by AAFC; two by Syngenta; one by Canterra Seeds; and one by the University of Saskatchewan. For registration decisions regarding

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

Name	Gen.	Year	Activity – Number of lines – Locations
	F_0	2001	Cross was made in a growth cabinet.
BA51	F_1	2002	Made 384 doubled haploids, CRC.
BA51*B92	DH	2002	New Zealand winter nursery, 1.5 m row: 205 lines grown with selection for agronomics and leaf rust resistance. An additional 175 lines were similarly managed in winter 2003.
BA51*B92	DH	2003	Yield test 109 lines, single replicate at 1–4 locations (MB: Glenlea, Brandon; SK: Melfort, Saskatoon). Selections based on agronomics, disease resistance and quality performance. An additional 42 lines were similarly tested in 2004.
BA51*B92	DH	2004	Trial 15 lines in the Central Bread Wheat "A" test. Yield test, 2 replicates at 5 locations (MB: Glenlea, Brandon: SK: Indian Head, Regina and Melfort).
BA51*B92	DH	2005	Trial 3 lines in the Central Bread Wheat "B" test. Yield test, 3 replicates at 8 locations (MB: Glenlea, Brandon, Morden; SK: Indian Head, Regina, Melfort, Saskatoon; AB: Beaverlodge).
BW394[z]	DH	2006–2008	Central Bread Wheat "C" registration test. Yield test, 3 replicates at 10 locations (MB: Glenlea, Portage la Prairie, Brandon, Morden, Souris, Dauphin; SK: Indian Head, Regina, Melfort, Kamsack, Saskatoon).
Breeder Seed Production			
BW394	DH	2006	Breeder seed spikes: 249 random spikes were selected from a rogued increase plot grown at Indian Head, SK.
BW394	DH	2007	Breeder seed isolation rows: 249 lines were grown in 1-m rows grown at Portage La Prairie with 10-m isolation distance from any other wheat. Eleven lines were discarded due to poor appearance. Following harvest, an additional 20 lines were discarded due to poor seed development. A further seven lines were used for other work.
BW394	DH	2008	Breeder seed rows: 211 lines were grown in 15-m rows grown at Indian Head, SK, with 10 m isolation distance from other wheat. One line was discarded prior to harvest due distinct blue glaucosity compared with the rest of the material. Another line was discarded as it was slightly taller. The remaining uniform plots were inspected and harvested in bulk producing 437 kg of breeder seed.

[z]BW394 is composed of 90% BA51*B92 and 10% BA51*C222.

cultivar value for cultivation and end-use suitability, BW394 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. 2010a) and 5603HR (Syngenta, unpublished data). At the CRC, response to diseases in artificially inoculated 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 and Seto-Goh 2009) 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 caused by *Fusarium graminearum* Schwabe [teleomorph *Gibberella zeae* (Schwein.) Petch] was evaluated in a field nursery that was spray inoculated with a macroconidial suspension and evaluated using a visual index (% incidence × % severity/100) (Gilbert and Woods 2006). 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 conducted at the Lethbridge Research Centre of AAFC using multiple races of *Tilletia tritici* (Bjerk.) R. and *T. laevis* Kuhn in Rabenh (Gaudet and Puchalski 1989; Gaudet et al. 1993). Assessment for kernel feeding damage by wheat midge was done by dissecting spikes using a stereomicroscope with 6 × magnification. The spikes were collected from field experiments where midge larvae were detected on susceptible cultivars. 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 Software. Inc. 2009). The SAS MIXED procedure (SAS Institute, Inc. 2006) was used to perform a multi-year 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 were no replicated observations within years.

Breeder Seed of Shaw was produced by randomly selecting 249 spikes from a BA51*B92 seed increase plot in 2006 that was rogued for uniformity. All of these spikes were grown as an isolated group of 1-m head rows in 2007 at Portage La Prairie, MB. Of these lines, 11 were discarded due to poor appearance, 20 lines were later discarded due to poor seed development and 7 lines were sacrificed for other work. In 2008, a 15-m row was grown from each of the remaining 211 isolation rows at the Indian Head Seed Increase Unit. Only two lines were discarded prior to harvest: one line exhibited blue glaucosity and another line was taller relative to the rest of the rows. The remaining uniform plots were inspected and harvested in bulk producing a minimum of 437 kg of breeder seed.

Performance

The grain yield of Shaw was 1% higher yielding (not significant) than the best check Unity VB over 3 yr of testing in the Central Bread Wheat Cooperative test (Table 2). Shaw exhibited the same maturity as McKenzie and Unity VB, but was significantly earlier maturing (1.9 d) than 5603HR (Table 3). Shaw was significantly taller than all of the checks except Katepwa in this test. Shaw exhibited lodging scores similar to the best check CDC Teal but not significantly better than any of the other checks. Shaw exhibited test weight within the range of the checks and had kernel weight significantly higher than all of the checks except Unity VB in the CBWC test (Table 3) and all of the checks in testing of the composite samples (Table 7).

Shaw has resistance to the prevalent races of leaf rust, stem rust and common bunt (Table 4). Shaw is susceptible to Fusarium head blight (FHB) and to loose smut.

Table 2. Yield (kg ha^{-1}) of Shaw VB and five check cultivars in the Central Bread Wheat Coop, 2006–2008

	Manitoba[z]				Saskatchewan				All Sites			
Cultivar	2006	2007	2008	Mean	2006	2007	2008	Mean	2006	2007	2008	Mean
Katepwa	3765	2437	3764	3322	3339	3686	4846	3957	3594	3061	4256	3725
McKenzie	4292	3658	4112	4021	3716	4044	5223	4328	4061	3851	4617	4235
CDC Teal	3927	3251	3814	3664	3686	3979	4854	4173	3831	3615	4287	3970
Unity VB	4254	3667	4312	4078	4004	4319	5561	4628	4154	3993	4880	4406
5603HR	3981	3616	4460	4019	3753	4264	5165	4394	3890	3940	4781	4257
Shaw VB	4240	3510	4167	3972	4358	4533	5607	4833	4287	4021	4822	4446
LSD ($P=0.05$)[y]	257	382	375	400	417	419	369	271	231	300	267	253
No. of tests	6	4	6	16	4	4	5	13	10	8	11	29

[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 Shaw and calculated using the SAS PROC MIXED procedure (SAS Institute, Inc. 2006).

Table 3. Summary of agronomic traits of Shaw VB and five check cultivars in the Central Bread Wheat Coop, 2006–2008

	Maturity (d)				Height (cm)				Lodging[z] (1–9 scale)				Test weight (kg hL^{-1})				Kernel weight (mg kernel^{-1})			
Cultivar	2006	2007	2008	Mean	2006	2007	2008	Mean	2006	2007	2008	Mean	2006	2007	2008	Mean	2006	2007	2008	Mean
Katepwa	86.2	90.2	97.5	91.6	100	103	96	100	2.5	2.4	2.7	2.5	78.3	75.1	76.5	76.6	30.8	28.4	33.8	31.0
McKenzie	86.1	91.9	98.0	92.2	97	100	93	97	2.3	3.1	2.6	2.7	78.2	77.3	77.6	77.7	30.1	29.0	33.5	30.9
CDC Teal	86.1	90.5	97.9	91.7	95	97	91	95	1.9	1.6	2.5	2.0	77.7	75.7	76.2	76.5	31.0	29.7	34.0	31.6
Unity VB	86.9	92.1	98.9	92.9	96	100	94	97	2.2	3.5	2.6	2.8	79.3	78.4	78.6	78.8	31.4	30.4	34.9	32.2
5603HR	88.5	94.5	99.6	94.4	97	101	93	97	2.2	2.7	2.6	2.5	78.0	78.0	77.5	77.8	30.7	30.4	33.0	31.4
Shaw VB	85.9	91.7	99.1	92.5	101	104	98	101	2.1	1.9	2.2	2.1	79.4	76.8	78.1	78.1	34.4	30.2	35.8	33.5
LSD (P=0.05)	1.1	1.1	0.8	1.1	2	2	2	2	NS[y]	NS	NS	NS	0.6	0.5	0.5	1.1	1.0	0.9	0.9	1.5
No. of tests	10	8	11	29	10	8	11	29	4	4	3	11	10	8	11	29	10	8	11	29

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

Table 4. Disease severities and ratings[z] of Shaw VB and five check cultivars in the Central Bread Wheat Coop, 2006–2008

	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	2006	2007	2008	2006	2007	2008	2006 Glenlea	2006 Carman	2007 Glenlea	2007 Carman	2008 Glenlea	2008 Carman	2008 Ottawa	2006	2007	2008	2006	2007	2008
Katepwa	7 RMS	tr R	5 R	42 MS	50 MS	70 MSS	24 MR	31 MS	38 MS	22 I	2 R	23 I	37	16 MR	32 MR	0 R	18 I	11 MR	18 MR-I
McKenzie	5 MS	tr R	10 RMR	0 R	0 R	0 R	30 MR	17 I	34 MS	24 I	19 MS	28 I	33	49 I	29 MR	11 R	2 VR	4 VR	2 VR
CDC Teal	15 I	tr R	15 I	20 MR	2 R	10 MR	61 S	63 S	51 S	46 S	20 S	78 S	43	41 I	20 MR	14 R	15 MR-I	14 MR-I	23 I
Unity	5 RMR	tr R	15 RMR	4 R	0 R	t R	50 MS	13 MR	37 MS	6 MR	1 R	27 I	33	21 MR	59 MS	11 R	1 VR	1 VR	2 VR
5603HR	15 RMR	2 R	20 RMR	3 R	8 R	0 R	22 MR	18 I	38 MS	25 I	1 R	30 I	22	68 MS	43 I	21 MR	5 VR	4 VR	15 MR
Shaw VB	3 R	tr R	5 R	17 MR	3 R	10 MR	58 S	25 I	33 MS	30 MS	14 I	50 S	42	81 S	58 MS	21 MR	2 VR	5 VR	14 MR

[z]Disease rating class: VR = very resistant, R = resistant, RMR = resistant to moderately resistant, MR = moderately resistant; I = intermediate rating; 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 and Seto-Goh 2006).
[w]Caused by *Fusarium graminearum* Schwabe [teleomorph *Gibberella zeae* (Schwein.) Petch]. Fusarium head blight index = (% infected spikelets × % infected spikes)/100.
[v]Cused 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 1:1:1:1:2:2 ratio (vol/vol).

Table 5. Frequency of spikes with larvae or larval feeding damaged seed present or absent for BA51*B92 or BW394 and check cultivars in a preregistration test (CBWA4) and 3 yr of registration testing (CBWC)

Test and year	Cultivar	*N*	Number of spikes: Larvae present	Larvae absent	% larvae present
CBWA4 2004	Superb		23	7	77
	BA51*B92		0	20	0
CBWC 2006	CDC Teal		24	0	100
	AC Barrie		24	1	96
	Superb		28	1	97
	Unity VB		4	20	17
	BW394		0	36	0
CBWC 2007	Katepwa		37	4	90
	McKenzie		36	1	97
	CDC Teal		26	2	93
	Superb		32	4	89
	Unity VB		7	30	19
	BW394		0	28	0
CBWC 2008	Katepwa		28	7	80
	McKenzie		16	20	44
	CDC Teal		23	13	64
	BW394		0	18	0
Mean	Katepwa	2	65	11	86
	McKenzie	2	52	21	71
	CDC Teal	3	73	15	83
	AC Barrie	1	24	1	96
	Superb	3	83	12	87
	Total susceptible checks	11	297	60	83
	Unity VB	2	11	50	18
	BA51*B92/ BW394	4	0	102	0

Shaw has the antibiotic midge resistance gene *Sm1* (McKenzie et al. 2002; Thomas et al. 2005). The type of feeding damage observed on resistant lines can be distinguished from damage observed on susceptible lines. On midge-resistant lines expressing antibiotic resistance, surface scarification and mottling from multiple feeding attempts can be observed along with distorted seed shape and absence of cast second instar skins from larvae. On midge-susceptible lines, seed damage is broader in area, more pronounced in level of seed damage, distortion and size reduction, and cast skins from midge larvae can be observed. The spikes from midge-susceptible checks ranged from 71 to 96% infested (Table 5), much higher than the midge-resistant cultivars Shaw and Unity. Although both Shaw and Unity have the *Sm1* gene, Shaw appears to express midge resistance more strongly as no spikes were observed to contain midge-damaged seed, even though BW394 contained the midge-susceptible refuge line BA51*C222, which had been analysed for resistance by spike dissection in 2003 (data not shown).

Assessments of preharvest sprouting resistance by exposure of spikes in a rain simulator and field weathering (Humphreys and Noll 2002) demonstrated that Shaw was not different from all of the checks for Falling number values from the wheat quality composite samples, but had significantly higher Falling number values than Katepwa and CDC Teal in both field and artificial weathering trials (Table 6). Also, Shaw had the lowest average preharvest sprouting scores compared with all of the checks.

The end-use quality of Shaw was deemed suitable for the CWRS class exhibiting milling and baking performance similar to the range of the checks for all attributes (Table 7).

Other Characteristics

The observations of plant characteristics were made using four-replicate, randomized complete block

Table 6. Falling numbers and sprouting scores of Shaw VB and five check cultivars from yield tests grown in 2006–2008. Quality composite samples were created from grain harvested from eight, six and six 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]				CBWC			
Cultivar	2006	2007	2008	Mean	2006	2008	Mean	2006	2007	2008	Mean	2006	2007	2008	Mean
Katepwa	380	425	430	412	226	253	240	151	229	96	159	6.5	8.5	5.8	6.9
McKenzie	365	400	430	398	382	351	367	343	300	198	280	1.4	7.2	2.1	3.6
CDC Teal	380	425	435	413	240	258	249	116	110	73	100	4.4	4.6	6.4	5.1
Unity	370	410	450	410	340	378	359	253	331	266	283	3.2	7.6	1.7	4.2
5603HR	410	410	460	427	351	326	339	235	313	248	265	2.4	6.7	1.9	3.7
Shaw VB	405	440	450	432	323	405	364	281	389	160	277	1.7	5.0	2.3	3.0
LSD ($P=0.05$)				21			76				82				3.0
Replicates	1	1	1	3	1	1	2	1	1	1	3	1	1	1	3

[z]((# spikes with 0 sprouts) $\times 1$ + (# spikes with 1 sprout) $\times 2$ + (# spikes with 2 sprouts) $\times 3$ + (# spikes with 3–5 sprouts) $\times 5$ + (# spikes with >3 sprouts) $\times 9$)/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 5 yr of tests using SAS PROC MIXED procedure.

[y]Field weathered samples are harvested when declines in falling number were observed for the sprouting susceptible cultivar Roblin.

[x]Collected at maturity, this material is placed in a rain simulator at 15°C for 48 h, dried and then seed is ground into meal for falling number determination.

Table 7. Wheat and flour analytical data for Shaw VB and five check cultivars in the Central Bread Wheat Coop, 2006–2008. End-use quality testing was conducted by the Grain Research Lab of the Canadian Grain Commission on composite samples created from grain harvested from eight, six and six 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[x] (%)	Flour protein[x] (%)	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 develop-ment time (min)	Mixing tolerance index (BU)	Stability Index (min)	Loaf Volume (cm^3)	Loaf appear-ance	Crumb structure	Crumb Colour	Absorp-tion (%)	Mixing energy (W·h kg^{-1})	Mixing time (min)
Katepwa	80.4	32.7	14.2	13.5	412	670	74.3	0.46	80	7.4	55	65.1	6.3	20.0	11.8	1138	7.8	6.0	7.9	66.7	7.0	3.8
McKenzie	80.7	33.1	14.0	13.4	398	697	75.9	0.46	81	8.1	51	65.9	5.3	21.7	9.3	1133	7.7	6.2	7.9	67.0	6.9	4.0
CDC Teal	79.9	32.6	14.7	14.2	413	703	75.3	0.44	80	6.5	57	65.1	10.0	10.0	24.2	1202	7.6	6.2	7.8	67.0	8.3	4.3
Unity	82.2	34.0	14.3	13.6	410	932	76.2	0.46	83	7.9	52	65.9	6.8	28.3	9.5	1148	7.7	6.2	7.9	66.7	8.0	4.1
5603HR	81.3	32.7	14.3	13.7	427	732	75.6	0.47	82	7.4	54	64.2	6.6	21.7	11.4	1117	7.7	6.1	7.8	66.3	8.4	4.7
Shaw VB	81.5	35.6	14.2	13.4	432	832	76.6	0.46	79	8.4	51	66.8	8.2	16.7	15.6	1095	7.2	6.1	7.8	68.0	7.8	4.3
LSD (P = 0.05)[v]	1.2	1.6	0.3	0.4	21	57	0.5	0.02	3	0.4	1	1.3	2.6	8.6	6.7	38	0.3	0.2	0.1	1.7	1.2	0.5

[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 (GRL) 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 of means was based on the checks and Shaw and calculated using the SAS proc-mixed procedure. Data consists of single measurements in each of the 3 yr of testing.

experiments grown in 2008 and 2009 at Portage La Prairie, MB, for collection of data for Plant Breeders' Rights. Observations were made using pure seed of BA51*B92 and comparisons were made with Harvest (Fox et al. 2010b) and AC Barrie (McCaig et al. 1996).

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

Adult Plant Characteristics
Growth habit. Semi-erect.
Leaves. High frequency of recurved leaves.
Flag leaf. Dark green with glabrous sheath and blade. The auricle colouration is absent, and auricle margins are slightly pubescent. Leaf sheath has a slightly waxy bloom.
Flag leaf attitude. Drooping.
Upper culm internode. Slight curvature at maturity and slightly waxy.
Culm colour. Weak to medium glaucousity.

Spike Characteristics
Shape. Semi-clavate.
Size. Similar to AC Barrie; slightly longer than Harvest.
Density. Medium dense.
Attitude. Inclined, slightly nodding.
Rachis. Sparse hairiness of convex surface of apical segment and slight pubescence of margins.
Colour. Weak glaucosity; white colour at maturity.
Awns. Awnlets present.

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

Kernel Characteristics
Shape. oval in shape with angular cheeks.
Size. Medium-sized with short to medium length and medium width.
Brush. Small to medium-sized with mid-long brush hairs.
Embryo. Medium-sized, round shape; crease is narrow to medium and is shallow in depth.

Maintenance and Distribution of Pedigreed Seed Stocks

The Agriculture and Agri-Food Canada Research Farm, Indian Head, Saskatchewan, will maintain the Breeder

Seed of Unity. Multiplication and distribution of other classes of pedigreed seed will be handled by SeCan, 501-300 March Road, Kanata, Ontario, Canada K2K 2E2.

The authors acknowledge all scientific and technical support of the Central Bread Wheat Cooperative Test provided by government, private and university institutions without which this data could not have been provided. Support from the Western Grain Research Foundation Producer Check-off is gratefully recognized.

Agronomix Software Inc. 2009. Agrobase Generation II. Version 18. Agronomix Software Inc., Winnipeg, MB.

American Association of Cereal Chemists. 2002. Approved methods of the AACC. 10th ed. The Association, St. Paul, MN.

Barker, P. S. and McKenzie, R. I. H. 1996. Possible sources of resistance to the wheat midge in wheat. Can. J. Plant Sci. **76**: 689–695.

Black, H. C., Hsieh, F. H., Tipples, K. H. and Irvine, G. N. 1980. GRL sifter for laboratory flour milling. Cereal Foods World **25**: 757–760.

Campbell, A. B. and Czarnecki, E. 1987. Katepwa hard red spring wheat. Can. J. Plant Sci. **67**: 229–230.

Dexter, J. E. and Tipples, K. H. 1987. Wheat milling at the Grain Research Laboratory. Part 3. Effect of grading factors on wheat quality. Milling **180**: 16, 18–20.

Fetch, T. G. 2005. Races of *Puccinia graminis* on wheat, barley, and oat in Canada, in 2002 and 2003. Can. J. Plant Pathol. **27**: 572–580.

Fox, S. L., McKenzie, R. I. H., Lamb, R. J., Wise, I. L., Smith, M. A. H., Humphreys, D. G., Brown, P. D., Townley-Smith, T. F., McCallum, B. D., Fetch, T. G., Menzies, J. G., Gilbert, J. A., Fernandez, M. R., Despins, T., Lukow, O. and Niziol, D. 2010a. Unity hard red spring wheat. Can. J. Plant Sci. **90**: 71–78.

Fox, S. L., Townley-Smith, T. F., Thomas, J. B., Humphreys, D. G., Brown, P. D., McCallum, B. D., Fetch, T. G., Menzies, J. G., Gilbert, J. A., Fernandez, M. R., Gaudet, D. A. and Noll, J. S. 2010b. Harvest hard red spring wheat. Can. J. Plant Sci. **90**: 503–509.

Gaudet, D. A. and Puchalski, B. L. 1989. Races of common bunt (*Tilletia caries* and *T. foetida*) in western Canada. Can. J. Plant Pathol **11**: 415–418.

Gaudet, D. A., Puchalski, B. L., Schallje, G. B. and Kozub, G. C. 1993. Susceptibility and resistance in Canadian spring wheat cultivars to common bunt (*Tilletia tritici* and *T. laevis*). Can. J. Plant Sci. **69**: 797–804.

Gilbert, J. and Woods, S. 2006. Strategies and considerations for multi-location FHB screening nurseries. Pages 93–102 *in* T. Ban, J. M. Lewis, and E. E. Phipps, eds. The global fusarium initiative for international collaboration: A strategic planning workshop. CIMMYT, El Batàn, Mexico; 2006 Mar. 14–17. Cross-ref Publication No. 7. CIMMYT, Mexico, D.F.

Graf, R. J., Hucl, P., Orshinsky, B. R. and Kartha, K. K. 2003. McKenzie hard red spring wheat. Can. J. Plant Sci. **83**: 565–569.

Hughes, G. R. and Hucl, P. J. 1993. CDC Teal hard red spring wheat. Can. J. Plant Sci. **73**: 193–197.

Humphreys, D. G. and Noll, J. 2002. Methods for characterization of preharvest sprouting resistance in a wheat breeding program. Euphytica **126**: 61–65.

Kolb, F. L. and Brown, C. M. 1992. Registration of 'Howell' Wheat. Crop Sci. **32**: 1292.

McCaig, T. N., DePauw, R. M., McLeod, J. G., Knox, R. E., Clarke, J. M. and Fernandez, M. R. 1996. AC Barrie hard red spring wheat. Can. J. Plant Sci. **76**: 337–339.

McCaig, T. N., DePauw, R. M., Clarke, J. M., McLeod, J. G., Fernandez, M. R. and Knox, R. E. 1996. AC Barrie hard red spring wheat. Can. J. Plant Sci. **76**: 337–339.

McKenzie, R. I. H., Lamb, R. J., Aung, T., Wise, I. L., Barker, P. and Olfert, O. O. 2002. Inheritance of resistance to wheat midge, *Sitodiplosis mosellana*, in spring wheat. Plant Breed. **121**: 383–388.

McCallum, B. D. and Seto-Goh, P. 2009. Physiologic specialization of *Puccinia triticina*, the causal agent of wheat leaf, in Canada in 2006. Can. J. Plant Pathol. **31**: 80–87.

Menzies, J. G., Knox, R. E., Nielsen, J. and Thomas, P. L. 2003. Virulence of Canadian isolates of *Ustilago tritici*; 1964–1998, and the use of the geometric rule in understanding host differential complexity. Can. J. Plant Pathol. **25**: 62–72.

Peterson, R. F., Campbell, A. B. and Hannah, A. E. 1948. A diagramatic scale for estimating rust intensity on leaves and stems of cereals. Can. J. Res. **26**: sec C: 496–500.

Preston, K. R., Kilborn, R. H. and Black, H. C. 1982. The GRL pilot mill. II. Physical dough and baking properties of flour streams milled from Canadian red spring wheats. Can. Inst. Food Sci. Technol. J. **15**: 29–36.

Roelfs, A. P. and Martens, J. W. 1988. An international system of nomenclature for *Puccinia graminis* f. sp. *Tritici*. Phytopathology **78**: 526–533.

SAS Institute, Inc. 2006. SAS software. Version 9.13. SAS Institute, Inc., Cary, NC.

Smith, M. A. H., Lamb, R. J., Wise, I. L. and Olfert, O. O. 2004. An interspersed refuge for *Sitodiplosis mosellana* (Diptera: Cecidomyiidae) and a biocontrol agent *Macroglenes penetrans* (Hymenoptera: Pteromalidae) to manage crop resistance in wheat. Bull. Entomol. Res. **94**: 179–188.

Thomas, J., Fineberg, N., Penner, G., McCartney, C., Aung, T., Wise, I. and McCallum, B. 2005. Chromosome location and markers of *Sm1*: a gene of wheat that conditions antibiotic resistance to orange wheat blossom midge. Mol. Breed. **15**: 183–192.

Townley-Smith, T. F. and Czarnecki, E. M. 2008. AC Domain hard red spring wheat. Can. J. Plant Sci. **88**: 347–350.

Williams, P., Sobering, D. and Antoniszyn, J. 1998. Protein testing methods at the Canadian Grain Commission. *In* Wheat Protein Symposium: proceedings; 1998 March 9–10. Saskatoon, SK.