CULTIVAR DESCRIPTION

Carberry hard red spring wheat

R. M. DePauw[1], R. E. Knox[1], T. N. McCaig[1], F. R. Clarke[1], and J. M. Clarke[2]

[1]Agriculture and Agri-Food Canada, Semiarid Prairie Agricultural Research Centre, Swift Current, Saskatchewan, Canada S9H 3X2 (e-mail: ron.depauw@agr.gc.ca); and [2]Crop Development Centre, University of Saskatchewan, Saskatoon, SK, Canada. Received 11 September 2010, accepted 25 January 2011.

DePauw, R. M., Knox, R. E., McCaig, T. N., Clarke, F. R. and Clarke, J. M. 2011. **Carberry hard red spring wheat**. Can. J. Plant Sci. **91**: 529–534. On average, over 36 replicated trials over 3 yr, Carberry, a doubled haploid hard red spring wheat (*Triticum aestivum* L.), expressed significantly higher grain yield than all checks except Superb. Wheat and flour protein concentrations were greater than Superb. Carberry matured significantly later than AC Barrie, Katepwa, and Lillian. Carberry was significantly shorter than all of the checks and was significantly more resistant to lodging than Katepwa, Laura and Lillian. Carberry had significantly higher test weight than all of the checks, intermediate kernel weight relative to the checks, and meets the end-use quality specifications of the Canada Western Red Spring wheat market class. Carberry expressed improved resistance to fusarium head blight relative to the checks, resistance to prevalent races of leaf rust, stem rust, common bunt, and moderate resistance to loose smut.

Key words: *Triticum aestivum* L., cultivar description, grain yield, protein, disease resistance, doubled haploid

DePauw, R. M., Knox, R. E., McCaig, T. N., Clarke, F. R. et Clarke, J. M. 2011. **Le blé roux vitreux de printemps Carberry**. Can. J. Plant Sci. **91**: 529–534. En moyenne, sur 36 essais répétés en trois ans, le cultivar à double haploïdie Carberry du blé roux vitreux de printemps (*Triticum aestivum* L.) a donné un rendement grainier sensiblement plus élevé que celui des variétés témoins, sauf Superb. La teneur en protéines du grain et de la farine dépasse celle de Superb. Carberry parvient à maturité significativement plus tard que AC Barrie, Katepwa et Lillian. Carberry a une paille est sensiblement plus courte que l'ensemble des cultivars témoins, et est sensiblement plus résistant à la verse que Katepwa, Laura et Lillian. Le poids spécifique de Carberry était sensiblement plus élevé que celui des cultivars témoins. Son poids d'amandes avait une valeur intermédiaire, et la variété respecte les paramètres de qualité de la classe marchande «Blé roux de printemps de l'Ouest canadien» eu égard à l'usage final. Carberry manifeste une meilleure résistance à la brûlure de l'épi par *Fusarium* que celle des témoins, résiste aux races courantes de rouille des feuilles, de rouille de la tige et de carie du blé, et résiste modérément au charbon nu.

Mots clés: *Triticum aestivum* L., description de cultivar, rendement grainier, protéines, résistance à la maladie, double haploïdie

Carberry, a hard red spring wheat (*Triticum aestivum* L.), was developed at the Semiarid Prairie Agricultural Research Centre (SPARC), Agriculture and Agri-Food Canada (AAFC), Swift Current, SK. It received registration No. 6661 from the Variety Registration Office, Plant Production Division, Canadian Food Inspection Agency on 2009 Sep. 18.

Pedigree and Breeding Method

Carberry derives from the cross Alsen/Superb designated B0065, which was made in 2000 at SPARC, AAFC, Swift Current, Saskatchewan. Alsen (Frohberg et al. 2006) derives from the cross of ND674/ND2710// ND688. Superb (Townley-Smith et al. 2010) derives from the cross Grandin*2/AC Domain. Six hundred and forty nine F_1-derived doubled haploid lines (B0065&) were generated using the maize pollen method (Knox et al. 2000). The "&" was assigned to the cross name to identify lines as doubled haploids and incrementing alpha characters were assigned for each F_1 plant of the cross followed by a numeric character that indicated the specific doubled haploid derivative of an F_1 plant. In 2002, seed of the individual doubled haploid lines was inoculated with common bunt [*Tilletia laevis* Kühn in Rabenh., and *T. tritici* (Bjerk.) G. Wint. in Rabenh.] races L1, L16, T1, T6, T13 and T19 (Hoffmann and Metzger 1976). The seed was planted in 1.5-m-long rows spaced 23 cm apart with every second row planted with CDC Kestrel winter wheat (Fowler 1997), which is susceptible to leaf (*Puccinia triticina* Eriks.) and stem rust (*P. graminis* Pers.:Pers. f.sp. *tritici* Eriks. & E. Henn.). An irrigated leaf rust and stem rust epiphytotic nursery was established by planting genotypes susceptible to prevalent races of leaf and stem rust in every 12th plot and needle inoculating a sample of plants in each row with representative rust races found the previous year (McCallum and Seto-Goh 2006). Stem rust races used were: QTHST (C25), RHTSK (C20), RKQSR (C63), RTHJT (C57), TMRTK (C10), and TPMKR (C53) (Roelfs and Martens 1988; Fetch 2005). Spikes were selected from 534 disease-resistant doubled haploid lines that matured early and had strong stems of

acceptable height. The seed from each spike was grown in 2-m rows either near the village of Irwell or Lincoln, New Zealand. In 2003, 191 doubled haploid lines were assessed for agronomic performance in four row plots 3 m long and replicated twice in nurseries near Swift Current, Regina, Indian Head, SK. and Morden, MB. Grain protein concentration was measured using near infrared reflectance (NIR) spectroscopy (Williams 1979) on a composite sample of each doubled haploid from each location. Reaction to leaf and stem rust was assessed in an epiphytotic nursery near Glenlea, MB, and response to *Fusarium graminearum* Schwabe [teleomorph *Gibberella zeae* (Schwein. Petch] was assessed in a fusarium head blight (FHB) nursery near Carman, MB. Remnant seed from the yield trials was used to assess grain quality and kernel characteristics. Selected doubled haploid lines were screened for reaction to a mixture of races T2, T9, T10 and T39 of loose smut [*Ustilago tritici* (Pers.) Rostr.] (Nielsen 1987), and races L1, L16, T1, T6, T13 and T19 of common bunt. This procedure identified the line B0065&AK043, which met all of the selection criteria at each stage of selection.

The experimental line B0065&AK043 was evaluated in the Western Bread Wheat "A_3" test in 2004, Western Bread Wheat B test in 2005, and as BW874 in the Western Bread Wheat Cooperative (WBWC) test from 2006 to 2008. Annually, the WBWC consisted of 25 experimental lines and five check cultivars grown in a 5×6 lattice design with three replications at up to 13 locations. The check cultivars were AC Barrie (McCaig et al. 1996), Katepwa (Campbell and Czarnecki 1987), Laura (DePauw et al. 1988), Lillian (DePauw et al. 2005) and Superb (Townley-Smith et al. 2010). The variables measured and protocols followed in the WBWC test have been described by Fox and McCallum (2006). The PROC MIXED procedure was used to analyze the data annually and to perform a combined analysis over years using a mixed model with environments and replications considered random and genotypes considered fixed (SAS Institute, Inc. 2003).

Response to several diseases was assessed in specialized disease nurseries from 2005 to 2007. Leaf and stem rust seedling infection types were assessed using stem rust races: QTHST (C25), RHTSK (C20), RKQSR (C63), RTHJT (C57), TMRTK (C10), and TPMKR (C53) (Roelfs and Martens 1988; Fetch 2005), and leaf rust races: MBDS (12-3), MBRJ (128-1), MGBJ (74-2), TDBG (06-1-1), TDBJ (70-1) and TJBJ (77-2) (McCallum and Seto-Goh 2006). Field evaluations of leaf and stem rust reactions, using leaf rust races representative of those found the previous year and the same stem rust races as for the seedling tests, were measured annually in epiphytotic nurseries near Glenlea, MB. Reaction to fusarium head blight was assessed in artificially inoculated field tests conducted annually near Glenlea and Carman, MB (Gilbert and Woods 2006). To determine response to loose smut, a mixture of the prevalent races T2, T9, T10 and T39 was injected into florets at anthesis of plants grown in the field and the inoculated seed subsequently grown out in a greenhouse (Menzies et al. 2003). To determine response to common bunt, a mixture of prevalent races L1, L16, T1, T6, T13 and T19 was used to inoculate the seed planted in mid-April of each year near Lethbridge, AB (Fox and McCallum 2006).

A sample of grain of the checks from each location was submitted to the Canadian Grain Commission to determine grain grade and protein concentration. End-use suitability was determined on a composite sample made up from sites with grain samples representative only of the top hard red spring wheat grades. The quantity of grain from a location was adjusted to achieve a final composite protein concentration approximating that of the average for the crop. A consistent quantity

Table 1. Grain yield of Carberry compared with the check cultivars in the Western Bread Wheat Cooperative test, 2006 to 2008

	Yield (Kilograms hectare^{-1})									
	Zone 1[z]			Zone 2			Zone 3			Mean[y]
	2006	2007	2008	2006	2007	2008	2006	2007	2008	2006–2008
Katepwa	2425	2400	2885	3430	3294	4205	5004	4110	5840	3742
Superb	2529	2966	3566	3543	3834	4898	5619	4474	6987	4250
Laura	2009	2283	3270	3690	3281	4532	5526	4374	5990	3916
AC Barrie	2663	2586	2905	3299	3453	4192	5547	4605	6305	3859
Lillian	2165	2435	3165	3371	3239	4072	5032	4166	5748	3689
Mean of checks	2358	2534	3158	3467	3420	4380	5346	4346	6174	3891
Carberry	3357	2932	3263	3901	3944	4563	5698	4546	6562	4266
$LSD^{x}_{0.05}$	317	379	363	263	201	286	684	882	978	246
No. of trials	1	2	2	7	9	9	2	2	2	36

[z]Locations: Zone 1: Stewart Valley, Swift Current; Zone 2: Beiseker, Goodale, Indian Head, Irricana, Kernen, Kindersley, Lethbridge, Neapolis, Regina, Scott, Watrous; Zone 3: Lacombe, Melfort.
[y]Means are based on LS means procedure of SAS.
[x]Least significant difference ($P \leq 0.05$) includes the appropriate genotype by environment interaction variation.

Table 2. Three-year averages for agronomic characteristics of Carberry compared with the check cultivars in the Western Bread Wheat Cooperative test, 2006 to 2008

	Maturity (d) 2006–2008[y]	Height (cm) 2006–2008	Lodging[z] (1–9) 2006–2008	Test weight (kg hL^{-1}) 2006–2008	Kernel size (mg) 2006–2008	Protein (%) 2006–2008
Katepwa	97.5	101	3.1	78.4	32.0	14.9
Superb	100.8	90	2.1	79.5	38.2	14.7
Laura	100.0	100	3.8	79.0	31.9	15.0
AC Barrie	98.6	97	2.1	79.6	33.8	15.2
Lillian	98.8	97	3.1	78.1	35.0	16.3
Mean of checks	99.1	97	2.8	78.9	34.2	15.2
Carberry	101.0	85	1.7	80.8	35.0	15.2
No. of trials	33	38	10	37	37	37
$LSD^{x}_{0.05}$	1.2	2.6	0.8	0.6	1.1	0.4

[z]Straw strength rated on a scale of 1 indicating that all plants in plot are erect to 9 indicating that all plants in a plot are lying horizontal.
[y]Means are based on LS means procedure of SAS.
[x]Least significant difference ($P \leq 0.05$) includes the appropriate genotype by environment interaction.

of grain within a location for all experimental lines was used to make up the composite. All end-use suitability analyses were performed by personnel at the Grain Research Laboratory, Canadian Grain Commission, Winnipeg, MB, following protocols of the American Association of Cereal Chemists (2000). Determination of kernel attributes and eligibility to meet grades of the CWRS market class was done by personnel of the Inspection Division, Canadian Grain Commission.

Performance

On average over 36 trials over 3 yr, grain yield of Carberry was 9.6% higher than the mean of the checks ($P \leq 0.05$) (Table 1), and similar to that of Superb, the

Table 3. Disease reactions of Carberry and check cultivars based on the Western Bread Wheat Cooperative Trials 2006 to 2008

	Field leaf rust						Field stem rust										Stripe rust		
	Glenlea						Nolette	Glenlea			Winnipeg				Winnipeg seedling	Regina	Neapolis		
	2006		2007		2008		2006	2007		2008	2007		2008		2006	2006	2007		
Katepwa	40[z]	MS	52	MS	75	S	5[x]	RMR[y]	tr	R	3	MR	20	I	10	RMR	8[w]	2.7[v]	6		
Superb	67	S	83	S	65	S	5	R		VR	7	MR	40	I	15	RMR	5	1.4	6		
Laura	0	R	0	R	5	R	2	R		VR	5	RMR	10	R	5	R	7	3.0	5		
AC Barrie	47	MS	72	S	77	S	7	RMR	tr	R	10	I	30	I	10	R	7	5.0	8		
Lillian	6	R	0	R	5	R	2	R		VR	15	I	15	I	2	R	4	1.1	3		
Carberry	2	R	0	R	0	R	3	R		VR	15	RMR	15	RMR	5	R	5	0.9	6		

	Common bunt						Loose smut					
	2006		2007		2008		2006[r]		2007		2008	
Katepwa	9[u]	MR[y]	4	VR	18	I-	16[t]	MR[y]	32	MR	0	R
Superb	2	VR	14	MR-I	14	MR	13	MR	10	R	15	R
Laura	50	VS	51	VS	58	VS	51	MS	37	I	33	MR
AC Barrie	17	I	4	VR	27	I	68	MS	12	R	8	R
Lillian	4	VR	13	MR	20	I-	42	I	11	R	50	I
Mean of checks	16		17		27		38		20		21	
Carberry	2	VR	3	VR	4	R	12	MR	17	MR	21	MR

[z]Leaf rust rating scale based on severity and percent leaf area affected: 0–10 R, 11–30 MR, 31–39 I, 40–60 MS, >60 S.
[y]Disease response category: R = resistant, RMR = resistant/moderately resistant, MR = moderately resistant, MRMS is equal to I = intermediate in reaction, MS = moderately susceptible, S = susceptible, and VS = very susceptible.
[x]Percent of the stem infected with stem rust based on modified Cobb scale.
[w]Seedling stripe rust assessment performed in Winnipeg using an isolate from U of M plots.
[v]Stripe rust ratings scored on field plots at Regina, SK, and Neapolis, AB, using a 1 = resistant to 9 = susceptible scale.
[u]Percentage of plants with common bunt symptoms.
[t]Percentage of plants with loose smut symptoms.

highest-yielding check. Carberry had protein concentration equal to the mean of the checks (Table 2) and 0.5 units higher ($P \leq 0.05$) than Superb. The time to maturity was later ($P \leq 0.05$) than the mean of the checks, but not later than Superb, the latest maturing check. Carberry had shorter ($P \leq 0.05$) plant height than Superb, the shortest stature check. Carberry expressed less ($P \leq 0.05$) lodging than the mean of the checks and slightly less than AC Barrie and Superb, the checks with the lowest lodging scores. Carberry had higher ($P \leq 0.05$) test weight than AC Barrie, the check with the highest test weight. Seed size of Carberry did not differ from the mean of the checks and was intermediate to AC Barrie and Superb.

Other Characteristics

SPIKE. Parallel sided, medium density, erect to inclined attitude at maturity, medium glaucosity, white chaff colour at maturity, medium length awns; glumes are glabrous with medium width, short length, rounded to square shoulder of medium width, and short beak length.

KERNEL. Hard red type, medium red colour, small to medium size kernel, oval kernel shape, round to angular cheek shape, midlong brush hairs, large to midsize germ, round shape of germ, and medium wide crease of shallow to medium depth.

DISEASE REACTIONS. Carberry expressed resistance to prevalent races of leaf rust, stem rust and common bunt, moderate resistance to prevalent races of loose smut (Table 3). Carberry expressed better resistance to FHB than the best check AC Barrie (Table 4). In 10 of 13 tests, the FHB disease indices of Carberry were numerically identical to or lower than those of AC Barrie. The DON content of Carberry was numerically equal to or lower than that of AC Barrie in three out of five trials. The number of fusarium-damaged kernels was similar to that for AC Barrie at Charlottetown. The percentage susceptible kernels, percentage weight of

Table 4. Response to fusarium head blight of Carberry and check cultivars based on the Western Bread Wheat Cooperative Trials 2006 to 2008

	Fusarium head blight index																		
	Carman[z]						Ottawa[z]			Charlottetown[y]			Glenlea[z]						Lévis[z]
	2006		2007		2008		2006	2007	2008	2006	2007	2008	2006		2007		2008		2008
Katepwa	25	I[x]	17	I	18	I	32	28	40	15	21	14	36	I	21	MR	4	MR	52
Superb	23	I	4	R	47	MS	42	20	48	14	23	13	44	MS	39	MS	11	I	78
Laura	22	I	13	MR	29	I	77	32	37	21	24	20	43	MS	24	I	8	MR	87
AC Barrie	33	MS	19	I	17	I	40	25	20	14	20	15	28	MR	33	MS	2	R	57
Lillian	64	S	65	S	53	S	77	72	48	18	20	20	65	S	72	S	47	S	87
Mean of checks	33		24		33		53	35	39	16	21	16	43		38		14		72
Carberry	1	R	14	MR	8	MR	50	9	20	17	17	13	11	MR	7	R	5	MR	50
CV	25		22		19		9.7	22	21	9.7		28	38		44		65		12
$LSD_{0.05}$[w]	8.9		8.6		9		12.0	8.8	12	3.3	6	7	25		23		10		13

	Fusarium head blight index			Deoxynivalenol (ppm)					FDK[u] (w:w as %)	
	Mean[v]	Mean	Mean	Charlottetown	Carman	Glenlea	Charlottetown	Glenlea	Charlottetown	
	2006	2007	2008	2006	2007	2007	2007	2008	2006	2007
Katepwa	27	22	34	4.6	3.5	1.9	9.4	3.6	20	27
Superb	31	21	44	8.9	10.9	4.8	21.5	7.6	25	34
Laura	40	23	48	6.0	5.7	2.7	15.3	6.0	34	36
AC Barrie	29	25	35	4.4	3.8	1.7	12.0	4.4	10	29
Lillian	56	70	69	10.6	6.3	3.8	11.5	9.2	27	33
Mean of checks	37	32	46	6.9	6.0	3.0	13.9	6.2	23	32
Carberry	20	10	23	4.4	4.9	0.8	13.3	4.4	17	25
CV	30	34	29	34						NA
$LSD_{0.05}$	15	15	11	3.7	NA	NA	NA	NA	11.5	NA
No. of trials	4	4	5							

[z]Fusarium head blight disease index = (percentage of infected heads × percentage of diseased florets on infected heads)/100.
[y]Percentage of spikes with FHB symptoms.
[x]Disease response category: R = resistant, RMR = resistant/moderately resistant, MR = moderately resistant, MRMS is equal to I = intermediate in reaction, MS = moderately susceptible, S = susceptible.
[w]Least significant difference ($P \leq 0.05$) includes the appropriate genotype by environment interaction.
[v]Calculated using LS means procedure of SAS.
[u]Fusarium-damaged kernels on a weight of damaged kernels to total seed weight basis multiplied by 100.

Table 5. Fusarium damaged kernels and deoxynivalenol of Carberry and checks based on eight replicates in the 2008 fusarium head blight nursery near Portage la Prairie, MB

	FDK[z] (%)		FDK[y] (w:w as %)		Deoxynivalenol (ppm)	
	Mean	$Duncan^{x}_{0.05}$	Mean	$Duncan_{0.05}$	Mean	$Duncan_{0.05}$
AC Elsa	53	*a*	46	*a*	28	*a*
AC Barrie	36	*b*	25	*b*	19	*b*
5602HR	24	*cd*	17	*cd*	15	*bc*
Alsen	23	*cd*	15	*cd*	12	*dc*
ND2710	24	*cd*	18	*cd*	8	*de*
Carberry	20	*de*	15	*cd*	10	*de*

[z]Fusarium-damaged kernels as a percentage of all kernels.
[y]Fusarium-damaged kernels a percentage of total seed weight.
[x]Duncan's mean separation test ($P \leq 0.05$) using PROC MIXED (SAS Institute, Inc. 2003).

susceptible kernels and DON content of Carberry were significantly less than AC Barrie in the 2008 FHB nursery near Portage la Prairie (Table 5).

END-USE SUITABILITY. Carberry had quality parameters within the range of the checks and improved protein concentration, lower flour ash, higher farinograph absorption and better crumb structure than the mean of the checks (Table 6).

Maintenance and Distribution of Pedigreed Seed

The 117 Breeder Lines originate from random single plants of the doubled haploid line BW874 and grown out as 144 Breeder-Lines in 3-m-long rows in isolation near Swift Current in 2007 and again as 15-m rows near Indian Head in 2008. Approximately 285 kg of Breeder Seed is available. Breeder Seed will be maintained by the Seed Increase Unit of the Research Farm, Indian Head, Saskatchewan, Canada S0G 2K0. Application for Plant Breeders' Rights has been filed. The variety will be

Table 6. End-use suitability[z] of Carberry and checks from the 2006 to 2008 Western Bread Wheat Cooperative tests

	Wheat protein (%)	Flour protein (%)	Protein loss (%)	Hagberg falling no. (sec)	Amylo-graph viscosity (BU)	Flour yield (%)	Flour ash (%)	Flour color (Agtron)	Starch damage (mega-zeme)	Particle size index
Katepwa	14.1	13.4	0.7	388	562	74.5	0.45	81.5	7.7	56.4
Superb	13.7	13.0	0.7	385	700	75.9	0.43	75.7	8.0	53.3
Laura	14.1	13.3	0.8	375	580	74.7	0.43	86.0	6.9	56.3
AC Barrie	14.3	13.5	0.7	398	728	76.5	0.42	83.4	7.3	56.2
Mean of checks	14.2	13.5	0.7	389	634	75.4	0.44	81.3	7.4	55.4
Carberry	14.6	13.6	1.0	377	603	74.8	0.42	79.9	7.7	52.6
SD[y]	0.05	0.05		15	5	0.34	0.005	0.9	0.08	0.9

	Farinograph				Canadian short process (150 ppm ascorbic acid)			
	Absorption (%)	DDT[x] (min)	MTI[w]	Stability (min)	Loaf volume (cc)	Baking absorption (%)	Work (kg)	Mixing time (min)
Katepwa	66.3	5.8	22	11	1130	66.7	7.3	3.6
Superb	67.2	7.9	20	16	1100	68.3	8.3	4.2
Laura	66.7	10.6	13	23	1147	68.0	8.3	4.3
AC Barrie	64.6	8.3	15	17	1138	67.7	9.3	4.9
Mean of checks	66.4	7.9	17	16	1127	68.0	8.1	4.2
Carberry	67.0	8.3	20	14	1135	68.0	9.0	4.6
SD[y]	0.2	0.4	2.6	1.4	45	NA[v]	0.3	0.2

[z]American Association of Cereal Chemists methods were followed by the Grain Research Laboratory, Canadian Grain Commission for determining the various end-use suitability traits on a composite of 6 to 10 locations each year.
[y]SD is the standard deviation based on repeated testing of Allis mill check samples, and standard bake flour sample with replicate tests carried out over an extended period of time each season, provided by GRL, CGC.
[x]DDT is the farinograph dough development time measured in minutes.
[w]MTI is farinograph mixing tolerance index expressed in Brabender units (BU).
[v]NA, not available.

added to the OECD list of Cultivars. Carberry has been released for distribution and multiplication to SeCan Association, 501 – 300 March Rd. Kanata, Ontario, Canada K2K 2E2. Phone: 1-800-764-5487, fax: (613) 592-9497, e-mail: seed@secan.com.

Financial support from the producer check-off on wheat collected by the Canadian Wheat Board and administered by the Western Grains Research Foundation is gratefully acknowledged. Appreciation is expressed to the following: N. Edwards and E. Lysenko (Grain Research Laboratory, Canadian Grain Commission, Winnipeg, MB) and D. Niziol (Cereal Research Centre, AAFC, Winnipeg) for end-use suitability analysis; N. Woodbeck (Inspection Division, Canadian Grain Commission) for kernel attribute analysis; A. Brule-Babel (University of Manitoba) and J. Gilbert (CRC, AAFC, Winnipeg) for assessing reaction to fusarium head blight and leaf spots; J. G. Menzies (CRC, AAFC, Winnipeg) for determining reaction to loose smut; and T. Fetch and B. McCallum (CRC, AAFC, Winnipeg) for assessing reaction to stem and leaf rust; D.A Gaudet and T. Despins (Lethbridge Research Centre, AAFC, Lethbridge, AB) for assessing reaction to common bunt; D. T. Gehl, Research Farm (AAFC, Indian Head, SK) for production of Breeder Seed; and B. Neudorf, J. Zhang, K. Warkentin, G. McClare, D. Dahlman, H.L Campbell and M. Poppy (SPARC, AAFC, Swift Current, SK), M. Knelsen, Regina Research Farm, AAFC, Regina, SK), O. Thompson (Research Farm, AAFC, Indian Head, SK), B. Beres and R. Dyck (Lethbridge Research Centre, AAFC, Lethbridge, AB) and C. Vera (Melfort Research Farm, AAFC, Melfort, SK) for their expert technical assistance in doubled haploid production, and conducting and analyzing field trials.

American Association of Cereal Chemists. 2000. Approved methods of the AACC. 10th ed. AACC, St. Paul, MN.

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

DePauw, R. M., Townley-Smith, T. F., Humphreys, G., Knox, R. E., Clarke, F. R. and Clarke, J. M. 2005. Lillian hard red spring wheat. Can. J. Plant Sci. **85**: 397–401.

DePauw, R. M., Townley-Smith, T. F., McCaig, T. N. and Clarke, J. M. 1988. Laura hard red spring wheat. Can. J. Plant Sci. **68**: 203–206.

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.

Fowler, D. B. 1997. CDC Kestrel winter wheat. Can. J. Plant Sci. **77**: 673–675.

Fox, S. L. and McCallum, K. 2006. Operating procedures. Prairie Recommending Committee for Wheat, Rye and Triticale. [Online] Available: http://www.pgdc.ca/pdfs/PRCWRT%20Updated%20Operating%20Procedures%202008.pdf.

Frohberg, R. C., Stack, R. W., Oslon, T., Miller, J. D. and Mergoum, M. 2006. Registration of 'Alsen' wheat. Crop Sci. **46**: 2311–2312.

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 held at CIMMYT, El Batàn, Mexico; March 14–17, 2006. CIMMYT, Mexico, D.F.

Hoffmann, J. A. and Metzger, R. J. 1976. Current status of virulence genes and pathogenic races of the wheat bunt fungi in the northwestern USA. Phytopathology **66**: 657–660.

Knox, R. E., Clarke, J. M. and DePauw, R. M. 2000. Dicamba and growth condition effects on doubled haploid production in durum wheat crossed with maize. Plant Breed. **119**: 289–298.

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.

McCallum, B. D. and Seto-Goh, P. 2006. Physiologic specialization of Puccinia triticina, the causal agent of wheat leaf rust, in Canada in 2004. Can. J. Plant Pathol. **28**: 566–576.

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.

Nielsen, J. 1987. Races of *Ustilago tritici* and techniques for their study. Can. J. Plant Pathol. **9**: 91–105.

Roelfs, A. P. and Martens, J. W. 1988. An international system of nomenclature for *Puccinia graminis* f. sp. *tritici*. Phytopathology **78**: 525–533.

SAS Institute, Inc. 2003. SAS software. Version 9. SAS Institute Inc. Cary, NC.

Townley-Smith, T. F., Humphreys, D. G., Czarnecki, E., Lukow, O. M., McCallum, B. M., Fetch, T. G., Gilbert, J. A., Menzies, J. G. and Brown, P. D. 2010. Superb hard red spring wheat. Can. J. Plant Sci. **90**: 347–352.

Williams, P. C. 1979. Screening wheat for protein and hardness by near infrared reflectance spectroscopy. Cereal Chem. **56**: 169–172.