CULTIVAR DESCRIPTION

Muchmore hard red spring wheat

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DePauw, R. M., Knox, R. E., McCaig, T. N., Clarke, F. R. and Clarke, J. M. 2011. **Muchmore hard red spring wheat**. Can. J. Plant Sci. **91**: 797–803. Based on 36 replicated trials over 3 yr, Muchmore, a doubled haploid hard red spring wheat (*Triticum aestivum* L.), averaged up to 20% more grain yield than the checks. It matured significantly later than AC Barrie, Katepwa and Lillian. Muchmore was significantly shorter than all of the checks and was significantly more resistant to lodging than Katepwa, Laura and Lillian. Muchmore had significantly higher test weight than Katepwa and Lillian, intermediate kernel weight relative to the checks, and meets the end-use quality specifications of the Canada Western Red Spring wheat market class. Muchmore expressed resistance to prevalent races of leaf rust, stem rust and common bunt, moderate resistance to loose smut, and moderate susceptibility to fusarium head blight.

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 Muchmore**. Can. J. Plant Sci. **91**: 797–803. Au terme de 36 essais répétés répartis sur trois ans, le blé roux vitreux de printemps (*Triticum aestivum* L.) à double haploïdie Muchmore a enregistré un rendement grainier moyen de jusqu'à 20% supérieur à celui des variétés témoins. Ce cultivar parvient à maturité sensiblement plus tard que AC Barrie, Katepwa et Lillian. Muchmore a une paille passablement plus courte que celle des témoins et est sensiblement plus résistant à la verse que Katepwa, Laura et Lillian. Muchmore a un poids spécifique sensiblement plus élevé que celui de Katepwa et Lillian, son poids d'amandes est moyen, comparativement à celui des témoins, et son grain respecte les normes relatives à l'usage final de la classe « Blé roux de printemps e l'Ouest canadien ». Muchmore résiste aux races de rouille des feuilles, de rouille de la tige et de carie les plus courantes, résiste modérément au charbon nu, et est modérément sensible à la brûlure de l'épi causée par *Fusarium*.

Mots clés: *Triticum aestivum* L., description de cultivar, rendement grainier, protéine, résistance aux maladies, double haploïde

Muchmore, 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. 6660 from the Variety Registration Office, Plant Production Division, Canadian Food Inspection Agency on 2009 Sep. 18.

Pedigree and Breeding Method

Muchmore derives from the cross Alsen/Superb designated B0065 made in 2000 at Swift Current. 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 haploid 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, which were 23 cm apart with every second row planted with CDC Kestrel winter wheat (Fowler 1997), which is susceptible to leaf rust (*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

Abbreviation: **WBWC**, Western Bread Wheat Cooperative

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

	Yield (kg ha^{-1})									
	Zone 1[z]			Zone 2			Zone 3			Mean[y]
Entry	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
Muchmore	2456	2978	3517	4214	4147	4674	6012	4432	6839	4432
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 × environment interaction variation.

the village of Irwell or Lincoln, New Zealand. In 2003, seed of the individual doubled haploid lines, derived from the seed source of rows from Lincoln, was inoculated with common bunt and grown in 1.5-m-long rows. A rust epiphytotic nursery was established similar to the previous year. A single 3-m-long plot was grown to multiply seed for testing the following year. In 2004, agronomic performance was assessed on 18 doubled haploid lines, which were grown in 3-m-long four row plots with two replications in nurseries near Swift Current and Indian Head, SK, and Morden, MB. Grain protein concentration was measured using near infrared reflectance spectroscopy (Williams 1979) on a composite sample for 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 the fusarium head blight 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 resulted in the identification of the line B0065&BE057, which met all of the selection criteria at each stage of selection.

The experimental line B0065&BE057 was evaluated in the Western Bread Wheat 'A_3' test in 2005 and as BW875 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 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

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

	Maturity (d)	Height (cm)	Lodging[z] (1–9)	Test weight (kg hL^{-1})	Kernel size (mg)	Protein (%)
Entry	2006–2008[y]	2006–2008	2006–2008	2006–2008	2006–2008	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
Muchmore	100.8	82	1.7	79.6	35.1	14.7
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 the plot are erect, to 9, indicating that all plants in a plot are lying horizontally.
[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.

Table 3. Disease reactions of Muchmore 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[y]	RMR[x]	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
Muchmore	4	R	3	R	0	R	3	R		VR	7	R	10	R	5	R	5	1.7	7

	Common bunt						Loose smut					
	2006		2007		2008		2006		2007		2008	
Katepwa	9[u]	MR[x]	4	VR	18	I-	16[t]	MR[x]	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	
Muchmore	0	VR	4	VR	3	R	22	MR	18	MR	10	R

[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]Percent of the stem infected with stem rust based on modified Cobb scale.
[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, and VS=very susceptible.
[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.

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

	Fusarium head blight index																		
	Carman[z]						Ottawa[y]			Charlottetown[z]				Glenlea[z]					Levi[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
Muchmore	15	MR	25	I	22	I	63	22	42	16	24	14	39	I	38	MS	7	MR	75
CV	25		22		19		9.7	22	21	9.7		28	38		44		65		12
$LSD^{w}_{0.05}$	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] (wt:wt 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
Muchmore	33	28	44	11.0	6.7	2.7	18.9	11.2	25	31
CV	30	34	29	34						N/A
$LSD_{0.05}$	15	15	11	3.7	N/A	N/A	N/A	N/A	11.5	N/A
No. 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 fusarium head blight 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 Muchmore and checks based on eight reps in the 2008 fusarium head blight nursery near Portage la Prairie, MB

	FDK[z] (%)		FDK[y] (wt:wt 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	*dc*	17	*cd*	15	*bc*
Alsen	23	*dc*	15	*cd*	12	*dc*
ND2710	24	*dc*	18	*cd*	8	*de*
Muchmore	27	*c*	21	*cb*	19	*b*

[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).

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 the 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 the 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 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

Based on 36 trials over 3 yr, the grain yield of Muchmore was significantly higher (13.9%) than the mean of the checks ($P \leq 0.05$) (Table 1). Generally, Muchmore yielded significantly more than the checks especially in Zone 2. Averaged over 36 trials, Muchmore yielded 20.1% more than Lillian, 18.4% more than Katepwa, 14.8% more than AC Barrie, 13.2% more than Laura, and 4.3% more than Superb. Muchmore had protein concentration significantly less ($P \leq 0.05$) than the mean of the checks, but not different from Superb (Table 2). The time to maturity was significantly later ($P \leq 0.05$) than the mean of the checks, but not different from Superb, the latest maturing check. Muchmore was significantly shorter ($P \leq 0.05$) than Superb, the shortest stature check. Muchmore expressed significantly less ($P \leq 0.05$) lodging and significantly higher ($P \leq 0.05$) test weight than the mean of the checks. Kernel size of Muchmore 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 shoulder of narrow to medium width, and short beak length.

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

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

	Wheat protein (%)	Flour protein (%)	Protein loss (%)	Hagberg falling no. (s)	Amylo- graph viscosity (BU)	Flour yield (%)	Flour ash (%)	Flour colour (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
Muchmore	14.0	13.1	0.9	365	577	75.5	0.44	79.2	7.9	52.8
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 (%)	Mixing energy (W-h kg^{-1})	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
Muchmore	66.7	8.2	23	14	1140	7.7	6.1	7.7
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.

SHATTERING: Resistant to spike shelling seeds caused by wind.

DISEASE REACTIONS: Muchmore expressed resistance to prevalent races of leaf rust, stem rust and common bunt, moderate resistance to prevalent races of leaf loose smut (Table 3). Muchmore expressed resistance to fusarium head blight intermediate to AC Barrie and Superb (Tables 4 and 5).

END-USE SUITABILITY: Muchmore has quality parameters within the range of the checks, higher protein loss upon milling and harder kernels than Superb, which has the hardest kernels of the checks (Table 6).

Maintenance and Distribution of Pedigreed Seed

The 128 Breeder Lines originate from random single plants of the doubled haploid line B0065&BE057 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 330 kg of Breeder Seed is available. Breeder Seed will be maintained by the Seed Increase Unit of the Research Farm, Indian Head, Saskachewan, Canada S0G 2K0. The cultivar will be added to the list of ''OECD List of Cultivars''. Muchmore has been released for distribution and multiplication to FarmPure Genetics Inc. 426 McDonald Street, Regina, Saskatchewan, Canada S4N 6E1. Phone (306) 791-1045, Fax (306) 791-1046 e-mail: info@fpgenetics.ca.

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; 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; 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, B. 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; 2006 Mar. 14–17. 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.