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CULTIVAR DESCRIPTION

AAC Redwater hard red spring wheat

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Abstract: AAC Redwater is a hard red spring wheat (*Triticum aestivum* L.) adapted to the shorter season wheat-growing regions of the Canadian prairies. AAC Redwater was evaluated in the Parkland Wheat Cooperative Test in 2009, 2010, and 2011. AAC Redwater was significantly ($P < 0.05$) higher yielding than Katepwa (6.4%) and AC Splendor (7.5%) and was not significantly different in grain yield compared to CDC Teal and CDC Osler. AAC Redwater had maturity similar to AC Splendor, matured a day earlier than Katepwa, and was significantly earlier maturing (2 d) than CDC Teal and CDC Osler. AAC Redwater was significantly shorter than all check cultivars and had a similar mean lodging score to the check cultivars. AAC Redwater is resistant to moderately resistant to leaf and stem rust, comparable to AC Splendor. AAC Redwater was resistant to intermediate in its field reaction to stripe rust and intermediate in its reaction to the Ug99 stem rust race, similar to CDC Teal. At the time of registration, AAC Redwater met the end-use quality specifications of the Canada Western Red Spring wheat class.

Key words: Triticum aestivum L., hard red spring wheat, cultivar description, early maturity, disease resistance.

Résumé : AAC Redwater est une variété de blé roux vitreux de printemps (*Triticum aestivum* L.) acclimatée aux régions à plus courte période végétative des Prairies canadiennes où l'on cultive le blé. AAC Redwater a été évalué dans le cadre des essais coopératifs sur le blé de la région Parkland en 2009, 2010 et 2011. Le rendement d'AAC Redwater dépasse significativement ($P < 0,05$) celui de Katepwa (6,4 %) et d'AC Splendor (7,5 %), mais ne diffère pas de façon significative de celui de CDC Teal et de CDC Osler. AAC Redwater parvient à maturité en même temps qu'AC Splendor, mais un jour plus tôt que Katepwa et est significativement plus précoce (deux jours) que CDC Teal et CDC Osler. AAC Redwater a une paille significativement plus courte que celle des autres cultivars témoins, mais sa résistance à la verse est similaire. La résistance d'AAC Redwater à la rouille des feuilles et de la tige varie de normale à moyenne, et est comparable à celle d'AC Splendor. AAC Redwater affiche une résistance intermédiaire à la rouille jaune, au champ, et sa réaction à la rouille de la tige Ug99 ressemble à celle de CDC Teal. Lors de son homologation, AAC Redwater respectait les critères de qualité selon l'usage final correspondant à ceux de la catégorie « blé roux de printemps de l'Ouest canadien ». [Traduit par la Rédaction]

Mots-clés : Triticum aestivum L., blé roux vitreux de printemps, description de cultivar, précocité, résistance à la maladie.

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Introduction

AAC Redwater, a hard red spring wheat (*Triticum aestivum* L.), was developed at the Cereal Research Centre (CRC), Agriculture and Agri-Food Canada, in Winnipeg, MB. It received restricted registration no. 7231 from the Variety Registration Office of the Canadian Food Inspection Agency on 13 Aug. 2012. AAC Redwater is adapted to the wheat-growing regions of the Canadian prairies and when supported for registration met the end-use quality requirements of the Canada Western Red Spring wheat class.

Pedigree and Breeding Methods

AAC Redwater (PT457) is derived from a top cross of AC Intrepid (DePauw et al. 1999) onto an F_1 plant with the parentage Harvest/McKenzie (Graf et al. 2003; Fox et al. 2010). All parental lines are registered cultivars belonging to the Canada Western Red Spring marketing class. The final cross was conducted in 2002 at the Beaverlodge Research Station, Beaverlodge, AB. F_1 plants were grown in the greenhouse at the CRC during the winter of 2002–2003 under the designation 02B08 and F_2 plots were grown at the Beaverlodge Research Station in 2003. Spikes were collected from the F_2 plots and sent to the 2003–2004 Parkland Canadian Western Red Spring off-season nursery in Palmerston North, New Zealand. Spikes were selected from F_3 hill plots in Palmerston North and F_4 families were grown in row plots in the 2004 F_4 hybrid nursery in Beaverlodge. The F_4 row that gave rise to PT457 had the designation 02B08-CE1 and was grown as an F_5 row in the 2004–2005 Parkland off-season nursery in Palmerston North. 02B08-CE1 was yield-tested as an F_6 line in the 2005 PRF62 yield test. F_6 spikes were collected from 02B08-CE1 and grown as F_7 rows in the 2005–2006 Parkland off-season nursery in Leeston, New Zealand. The F_7 row that became PT457 was named 02B08-CE1C and yield tested under that designation in the 2006 PRF8 yield test. This line was subsequently evaluated in the 2007 Parkland "A" test and the 2008 Central Bread Wheat "A2" test. 02B08-CE1C was given the designation PT457 and evaluated over 3 yr (2009–2011) in the Parkland Wheat Cooperative Test. The check cultivars were Katepwa (Campbell and Czarnecki 1987), AC Splendor (Fox et al. 2007), CDC Teal (Hughes and Hucl 1993), and CDC Osler. The variables measured and the protocols followed in the Parkland Wheat Cooperative Test have been described by Graf and Fox (2000). The agronomic data were analyzed using SAS Statistical software (v9.3, SAS Institute, Cary, NC). The analyses treat station-years independently so that the least significant difference values for multi-location and multi-year comparisons are based on genotype × environment interactions.

End-use quality was evaluated by the Grain Research Laboratory, Canadian Grain Commission, Winnipeg, MB, using the methods of the American Association of Cereal Chemists. For the end-use quality evaluations, a 10–12 kg composite sample was generated each year from the 6 to 9 sites of the Parkland Wheat Cooperative test with the highest grades and suitable grain protein content.

Performance

AAC Redwater is adapted to the shorter season wheat-growing areas of the prairie provinces.

Agronomic data for AAC Redwater and the check cultivars is listed in Table 1. AAC Redwater was significantly ($P < 0.05$) higher yielding than Katepwa (6.4%) and AC Splendor (7.5%) and was not significantly different in grain yield compared with CDC Teal and CDC Osler over 3 yr of testing in the Parkland Wheat Cooperative Test (2009–2011). This trend in grain yield performance was consistent in all three zones of the Parkland Wheat Cooperative Test (Table 1). On average, AAC Redwater had maturity similar to AC Splendor and matured 1 d earlier than Katepwa and 2 d earlier than CDC Teal and CDC Osler ($P < 0.05$) over 3 yr of testing. AAC Redwater was significantly shorter compared with all check cultivars ($P < 0.05$). AAC Redwater ranged from 10 cm shorter than Katepwa to 4 cm shorter than CDC Osler. AAC Redwater was similar to all check cultivars for lodging score, mean test weight, and mean seed mass over 3 yr of testing.

Other Characteristics

Spike

Medium glaucosity; parallel-sided shape in profile; medium density; white at maturity; erect attitude; very sparse to sparse hairiness of convex surface of apical rachis segment; shorter than length awnlettes.

Kernel

Hard; medium red; medium size; short to medium length; narrow to medium width; oval shape; angular cheek; medium to long brush hairs; narrow to medium width and medium depth of crease; medium size germ; broad elliptical shape.

Disease reaction

Leaf and stem rust reactions were evaluated in an epiphytotic nursery as part of the cooperative testing. AAC Redwater was resistant to moderately resistant to leaf rust and stem rust and was similar to AC Splendor (Table 2). In Table 2, the leaf and stem rust seedling infection types are shown. AAC Redwater has leaf rust and stem rust seedling responses similar to AC Splendor. AAC Redwater is resistant to intermediate in its field reaction to stripe rust (caused by *Puccinia striiformis* f. sp. *tritici* Eriks.), intermediate in its reaction to "Ug99 stem rust" when evaluated in the Kenya stem rust field nurseries, and was similar to CDC Teal in reaction to both diseases (Table 3). AAC Redwater is intermediate to moderately susceptible to common bunt, and to loose

Table 1. Agronomic data for AAC Redwater and check cultivars based on data collected in the Parkland Wheat Cooperative Test (2009, 2010, and 2011).

Cultivar	Yield (kg ha^{-1})				Maturity (d)				Height (cm)	Lodging[d] (1–9)	Test weight (kg hL^{-1})	Seed mass (mg)
	Zone 1[a]	Zone 2[b]	Zone 3[c]	Overall mean	Zone 1[a]	Zone 2[b]	Zone 3[c]	Overall mean				
3-yr means (2009–2011)												
Katepwa	3848	4159	4240	4204	96	103	106	104	96.9	2.9	79.2	35.0
AC Splendor	4196	4156	4155	4161	94	101	105	103	93.3	2.8	78.9	35.7
CDC Teal	4667	4421	4498	4496	98	104	107	105	93.1	2.4	79.0	35.3
CDC Osler	4643	4378	4539	4501	99	105	107	105	90.6	2.5	79.3	35.3
AAC Redwater	4617	4414	4468	4471	94	102	105	103	87.4	2.3	79.1	34.7
LSD ($P < 0.05$, two-tailed test)[e]	500	181	209	143	2.9	1.3	0.9	0.7	1.5	0.6	0.6	1.1
Check cultivar means[f]	4339	4278	4378	4340	97	103	106	104	93.5	2.6	79.1	35.3
Station-years	5	12	20	37	3	12	18	33	37	10	37	37

[a]Zone 1 includes Roblin and Dauphin, MB (2010, 2011).
[b]Zone 2 includes Melfort, Kernen, Lake Lenore, and Glaslen, SK.
[c]Zone 3 includes Lacombe, Ellerslie, Westlock (2009), Neapolis (2011), Beaverlodge, Fort Vermillion, Fort St. John, and Dawson Creek, AB.
[d]Lodging scale: 1 = vertical; 9 = flat.
[e]LSD, least significant difference of arithmetic means based on checks and AAC Redwater, calculated using SAS PROC GLM v9.3 (SAS Institute Inc. 2011).
[f]Check cultivar means calculated using SAS PROC MEANS, v9.3.

Table 2. Disease reactions of AAC Redwater and check cultivars to leaf and stem rust in the Parkland Wheat Cooperative Test (2009, 2010, 2011) and greenhouse seedling tests.

Cultivar	Leaf rust[a]								Stem rust[b]								
				Seedling tests[c]													
	Field test			12–3	128–1	01–06–1	74–2	77–2	Field test			Seedling tests[d]					
	2009	2010	2011	MBDS	MBRJ	TDBG	MGBJ	TJBJ	2009	2010	2011	TPMK	TMRT	QTHJ	RKQS	RHTS	RTHJ
Katepwa	27.5 MR	78.3 MS–S	33.3 I	3+	3+	3+	3	3	5 R	20 I	20 MR	;1–	0	12–	;1–	0	12–
AC Splendor	11.7 MR	15.3 R–MR	15.3 MR	1+	1–	1+	1+3–	1+3–	1 R	15 R–MR	10 R	;1–	0	;1–	;	0	1
CDC Teal	8.3 R	6.7 R	0.3 R	3+	1–2–	1–2–	2+3–	;1=	15 I	15 I	30 I	1–1	0	12–	;	0	12
CDC Osler	0 R	0 R	0 R	;1=	;	;1=	0	;	1 R	10 R	30 I	0;	0	0;	0	0	1
AAC Redwater	5 R	3.3 R–MR	16.7 MR	1–	1–	1+	3–	3–	5 R	10 R–MR	10 R	0	0	1	0	0	1–1

[a]Caused by *Puccinia triticina* Eriks. Inoculum was a composite of all leaf rust races increased from collections made the previous year (McCallum et al. 2011, 2015). Ratings indicate percent severity and pustule type, respectively. R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible.
[b]Caused by *Puccinia graminis* Pers. f. sp. *tritici* Eriks. & E. Henn. Races used include TPMKR, TMRTK, RKQSR, QFCSH, RTHJT, and QTHST (Roelfs and Martens 1988; Fetch et al. 2015). Ratings indicate percent severity and pustule type, respectively.
[c]Leaf rust seedling reactions determined in 2009.
[d]Stem rust seedling reactions determined in 2011.

Table 3. Disease reaction and ratings of AAC Redwater and check cultivars to stripe rust and the "Ug99" stem rust (Parkland Wheat Cooperative Test, 2009, 2010, and 2011).

	Stripe rust[a]				Ug99 stem rust[b]		
		2010			2010		2011
Cultivar	2009	Lethbridge	Creston	2011	9 Oct. 2010	22 Oct. 2010	16 Oct. 2011
Katepwa	10 MR	10 I	25 S	38.3 I	—	—	5 MS
AC Splendor	25 MS	2 R	8 I	50 S	—	—	20 M
CDC Teal	8 MR	1 R	5 R	25 I	—	—	50 M
CDC Osler	0 R	40 S	20 S	36.7 I	—	—	10 MR
AAC Redwater	0.5 R	0 R	0 R	21.7 I	30 M	40 M	50 M

[a]Caused by *Puccinia striiformis* f.sp. *tritici* Eriks. Rust screening is conducted in field nurseries at Lethbridge, AB, and Creston, BC, where natural infestations of stripe rust occur annually. Ratings indicate percent severity and pustule type, respectively. R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible; —, no value.

[b]Caused by *Puccinia graminis Pers.* f. sp. *tritici* Eriks. & E. Henn. Data collected from the CIMMYT rust initiative collaborative Ug99 stem rust screening nursery in Njoro, Kenya. Ratings indicate percent severity and pustule type, respectively.

Table 4. Disease reactions of AAC Redwater and check cultivars in the Parkland Wheat Cooperative Test (2009, 2010, and 2011).

	Common bunt[a]			Loose smut[b]			Leaf spotting complex[c]				Common root rot[d]	
								2010				
Cultivar	2009	2010	2011	2009	2010	2011	2009	Melfort	Glenlea	2011	2009	2010
Katepwa	17 MR–I	9 I	15 I	3.0 R	8.3	0 R	9. 7 MS	9.7 S	34.7 MS	9.3 MS	0.0	4.5
AC Splendor	17 MR–I	19 MS	22 I	16.7 MR	16.3	13 R	8.7 MS	10 S	22.3 MR	9 MS	13.3	17.9
CDC Teal	26 I	23 MS	19 I	13.3 R	25.0	47 I	9 MS	8.7 MS	19.0 MR	9 MS	33.6	8.0
CDC Osler	12 MR–I	16 I	31 MS	13.8 R	11.6	15 R	10 S	9 MS	20.2 MR	8.7 MS	30.0	24.0
AAC Redwater	38 I–MS	2 R–MR	23 I	57.1 MS	51.4	53 I	10.7 S	11 S	39.3 MS	9.7 S	28.2	13.8

[a]Caused by *Tilletia tritici* (Bjerk.) Wint. and *T. laevis* Kühn. The inoculum used was a composite of races T1, T6, T13, and T19 of *T. tritici* and L1 and L16 of *T. laevis* mixed (*v*/*v*) in a 1:1:1:1:2:2 ratio (Gaudet and Puchalski 1989*a*) and represents the virulence spectrum of bunt isolates in western Canada (Gaudet and Puchalski 1989*b*). Rating indicates percent infection and relative classification. R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible.

[b]Caused by *Ustilago tritici* (Pers.) Rostr. Races include T2, T9, T10, and T39 (Nielsen 1987; Menzies et al. 2003).

[c]Scored from natural infection at Melfort (2009–2011) using a 1–11 scale (McFadden 1991). Pathogens isolated from lesioned leaves: Melfort (2009): % *Pyrenophora tritici-repentis* (Died.) Drechs. 15.0; % *Septoria nodorum* (Berk.) 5.0; % *S. tritici* Berk. & M.S. Curtis 58.3; % *Cochliobolus sativus* (S. Ito & Kurib.) Drechs. ex Dast. 13.3. Melfort (2010): % *P. tritici-repens* 20.2; % *Pyrenophora avenae* S. Ito & Kurib. 0.9; % *S. nodorum* 24.3; % *S. tritici* 46.7; % *C. sativus* 7.8.

[d]Percent common root rot: percentage of sub-crown internodes with dark discoloration in >50% of surface area. 2009 fungal ID: *C. sativus* (58.8%); *Fusarium acuminatum* Ellis & Everh. (5.9%); *F. graminearum* Schwabe (5.9%); *F. pseudograminearum* (4.3%); *F. oxysporum* Schltdl. (5.9%). 2010 fungal ID: % *C. sativus* (52.6%); *F. pseudograminearun* (15.8%); *F. avneaceum* (Fr.) Sacc. (5.3%).

smut (Table 4). AAC Redwater is moderately susceptible to susceptible to the leaf spotting complex of pathogens (Table 4). AAC Redwater was more susceptible to common root rot compared with Katepwa but more resistant than CDC Osler (Table 4). Leaf rust (caused by *Puccinia triticina* Eriks.) races used were those multiplied from field survey collections made the previous year in western Canada (McCallum et al. 2011, 2013) and were used in field evaluations and greenhouse seedling tests. Stem rust (caused by *Puccinia graminis* Pers. f. sp. *tritici* Eriks. & E. Henn.) races that were used in field evaluations and greenhouse seedling tests were TPMKR, TMRTK, RKQSR, QFCSH, RTHJT, and QTHST (Roelfs and Martens 1988; Fetch et al. 2015). The inoculum of common bunt [caused by *Tilletia tritici* (Bjerk.) Wint. and *T. laevis* Kühn.] was a composite of races T1, T6, T13, and T19 of *T. tritici* and L1 and L16 of *T. laevis* mixed in a 1:1:1:1:2:2 ratio (Gaudet and Puchalski 1989*a*, 1989*b*). Loose smut [caused by *Ustilago tritici* (Pers.) Rostr.] reactions were evaluated using a mixture of races including T2, T9, T10, and T39 (Nielsen 1987; Menzies et al. 2003). Leaf spotting complex was scored from natural infection

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Table 5. Wheat analytical data for AAC Redwater and check cultivars based on data from the Parkland Wheat Cooperative Test (2009, 2010, and 2011).[a]

Cultivar	Test weight (kg hL^{-1})	Kernel weight (mg)	Grain protein (%)	Flour protein (%)	Protein loss (%)	Falling number (s)	Amylograph (BU)	Flour yield (%)	Flour ash (%)	Agtron colour[b] (%)	Starch damage (%)	Particle size index (%)
3-yr means (2009–2011)												
Katepwa	81.0	34.6	13.7	13.1	0.7	407	542	76.9	0.44	81	7.7	55
AC Splendor	80.0	36.0	14.6	14.0	0.6	417	640	76.1	0.46	78	6.7	56
CDC Teal	80.7	35.7	14.2	13.7	0.5	412	582	78.1	0.42	80	7.1	57
CDC Osler	81.6	33.7	14.1	13.5	0.6	467	777	76.2	0.45	81	7.5	54
AAC Redwater	81.2	35.2	14.2	13.8	0.4	452	775	75.6	0.47	80	8.0	52
LSD ($P < 0.05$, two-tailed test)[c]	0.4	1.5	0.2	0.3	0.2	19	92	0.5	0.01	6	0.3	1
Station-years	3	3	3	3	3	3	3	3	3	2	3	3
Mean of checks	80.8	35.0	14.1	13.6	0.6	425	635	76.8	0.45	80	72	56

[a]End-use quality testing was performed by the Grain Research lab of the Canadian Grain Commission on a composite from each year of the Cooperative tests.
[b]Agtron flour colour was not determined in 2011.
[c]LSD, least significant difference of means was based on the checks and AAC Redwater, calculated using SAS v9.3.

Table 6. Flour analytical data for AAC Redwater and check cultivars based on data from the Parkland Wheat Cooperative Test (2009, 2010, and 2011).[a]

	Farinograph			Canadian short process (150 ppm ascorbic acid)								
Cultivar	Absorption (%)	Dough Development time (min)	Mixing tolerance index (BU)	Stability index (min)	Loaf volume (cm^3)	Loaf appearance	Crumb structure	Crumb colour	Absoption (%)	Mixing energy (W h kg^{-1})	Peak time (min)	Clean white flour yield[b] (%)
3-yr means (2009–2011)												
Katepwa	66.8	5.77	18	12.5	1090	7.6	6.0	7.7	67	6.9	4.8	74.7
AC Splendor	67.5	9.77	13	29.7	1125	7.6	6.0	7.9	67	7.8	4.9	74.8
CDC Teal	67.0	9.35	13	22.5	1178	7.8	5.9	7.9	67	8.2	5.3	75.0
CDC Osler	68.0	9.83	13	16.3	1130	7.7	5.8	7.5	68	6.1	3.9	74.3
AAC Redwater	70.2	7.92	15	16.3	1088	7.4	5.9	7.5	69	7.3	4.4	74.9
LSD ($P < 0.05$, two-tailed test)[c]	0.8	2.94	7	5.5	33	0.2	0.1	0.2	1	1.3	0.5	0.5
Station-years	3	3	3	3	3	3	3	3	3	3	3	2
Mean of checks	67.3	8.68	15	20.3	1131	7.7	5.9	7.8	67	7.3	4.7	74.7

[a]End-use quality testing was performed by the Grain Research lab of the Canadian Grain Commission on a composite from each year of the Cooperative tests.
[b]Clean flour yield was not determined in 2011.
[c]LSD, least significant difference of means was based on the checks and AAC Redwater, calculated using SAS v9.3.

at Melfort (2009–2011) using a 1–11 scale and common root rot was used as a percentage of sub-crown internodes with dark discoloration in >50% of surface area (see Table 4). Race descriptions followed those designated by Roelfs and Martens (1988) for stem rust, Nielsen (1987) for loose smut, and Hoffman and Metzger (1976) for common bunt.

End-use suitability

When supported for registration, AAC Redwater was eligible for all grades of the Canada Western Red Spring wheat class. The results of end-use quality testing are summarized in Tables 5 and 6. AAC Redwater has kernels that are significantly larger than CDC Osler over 3 yr of testing (2009–2011). Grain protein content was similar to CDC Teal and CDC Osler and significantly higher than Katepwa but significantly lower than AC Splendor. Flour protein content was similar to CDC Teal and AC Splendor but significantly higher than CDC Osler and Katepwa. AAC Redwater had significantly higher falling numbers compared to Katepwa, AC Splendor, and CDC Teal. AAC Redwater had significantly lower flour yield and greater kernel hardness (i.e., lower particle size index) compared to all four check cultivars. Over 3 yr of testing, AAC Redwater showed significantly higher farinograph absorption than the four check cultivars. AAC Redwater had a farinograph dough development time not significantly different from AC Splendor, CDC Teal, and CDC Osler but significantly longer than Katepwa. Farinograph stability was similar to CDC Osler and Katepwa but was significantly shorter than AC Splendor and CDC Teal. AAC Redwater had significantly higher Canadian short process absorption compared with all check cultivars. Canadian short process mixing energy for AAC Redwater was not significantly different from the check cultivars. Canadian short process peak time was significantly shorter than AC Splendor and CDC Teal but significantly longer than CDC Osler. Clean white flour yield of AAC Redwater was similar to Katepwa, AC Splendor, and CDC Teal and was significantly higher than CDC Osler.

Maintenance and Distribution of Pedigreed Seed

In 2010, the AAC Redwater isolation increase in Glenlea, MB, was irreparably damaged by flooding. Thus, approximately 225 spikes of PT457 were gathered from the rogued increase of the 2010 Parkland Cooperative Test seed increase in Saskatoon, SK. Seed from each spike was visually inspected and 209 spikes were grown in isolation in 1 m row plots in the 2010–2011 CRC off-season nursery near Leeston. The head rows were selected and rogued on the basis of plant type, height and maturity. Breeder lines were grown and rogued at the Indian Head Experimental Farm of Agriculture and Agri-Food Canada at Indian Head, SK, in 2011. Distribution and multiplication of pedigreed seed stocks is the responsibility of SeCan Association, 300 Terry Fox Dr., Kanata, ON K2K 0E3, Canada.

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