AAC Redwater Hard Red Spring Wheat

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AAC Redwater Hard Red Spring Wheat

RUNNING HEADING: HUMPHREYS ET AL. -AAC REDWATER HRSW

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Can. J. Plant Sci. **xx**: xxx-xxx. 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 and matured a day earlier than Katepwa, and was significantly earlier maturing (2 days) than CDC Teal and CDC Osler. AAC Redwater was significantly shorter than all check cultivars and similar mean lodging scores as all check cultivars. AAC Redwater was resistant to moderately resistant to leaf and stem rust comparable to AC Splendor. AAC Redwater is 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 Hard Red Spring wheat class.

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

AAC Redwater, a hard red spring wheat (*Triticum aestivum* L.), was developed at the Cereal Research Centre (CRC), Agriculture and Agri-Food Canada, Winnipeg, MB. It received restricted registration No. 7231 from the Variety Registration Office of the Canadian Food Inspection Agency on 13 August 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 Method

AAC Redwater (PT457) is derived from a top cross of AC Intrepid (DePauw et al. 1999) onto a F1 plant with the parentage: Harvest/McKenzie (Fox et al. 2010; Graf et al. 2003). 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. F1 plants were grown in the greenhouse at the Cereal Research Centre during the winter 2002-2003 under the designation 02B08, and F2 plots were grown at the Beaverlodge Research Station in 2003. Spikes were collected from the F2 plots and sent the 2003-2004 Parkland CWRS off-season nursery in Palmerston North, New Zealand. Spikes were selected from F3 hill plots in Palmerston North and F4 families were grown in rows plots in the 2004 F4 Hybrid Nursery in Beaverlodge, AB. The F4 row that gave rise to PT457 had the designation 02B08-CE1, and was grown as a F5 row in the 2004-2005 Parkland CWRS off-season nursery in Palmerston North, New Zealand. 02B08-CE1 was yield tested as a F6 line in the 2005 PRF62 yield test. F6 spikes were collected from 02B08-CE1 and grown as F7 rows in the 2005-2006 Parkland CWRS off-season nursery in Leeston, New Zealand. The F7 row which 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 three

years (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 the SAS Statistical software (v9.3). The analyses treats station-years independently so that the LSD values for multi-location and multi-year comparisons are based on genotype $\times$ environment interactions.

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

Area of Adaptation

AAC Redwater is adapted to the shorter season wheat growing areas of the Prairie Provinces.

Performance

Agronomic data for AAC Redwater and 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 three years 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, matured a day earlier than

Katepwa, and two days earlier than CDC Teal and CDC Osler ($P < 0.05$) over three years of testing. AAC Redwater was significantly shorter compared to 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 scores. AAC Redwater was similar to the check cultivars for mean test weight and mean seed mass over three years 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 white 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 in 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 2a). In Table 2a, 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 striiformes* f. sp. *tritici* (Pst)], and intermediate in its reaction to “Ug99 stem rust” when evaluated in the Kenya stem rust field nurseries and was similar to CDC Teal for both diseases (Table 2b). AAC Redwater is intermediate to moderately susceptible to common bunt, and to loose smut (Table 3). AAC Redwater is moderately susceptible to

susceptible to the leaf spotting complex of pathogens (Table 3). AAC Redwater was more susceptible to common root rot compared with Katepwa but more resistant than CDC Osler (Table 3). 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 they were used for field evaluations and in greenhouse seedling test. Stem rust (caused by *Puccinia graminis* Pers. f. sp. *tritici*) races which were used field evaluations and in greenhouse seedling test 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, L16 of *T. laevis* mixed in a 1:1:1:1:2:2 ratio (Gaudet and Puchalski 1989a, 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 were scored from natural infection at Melfort (2009-2011) using 1-11 scale and common root rot were used percentage of sub-crown internodes with dark discoloration in >50% of surface area (see Table 3). Race descriptions followed those designated 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 Table 4. AAC Redwater has kernels which are significantly larger than CDC Osler over three years of testing (2009-2011). Grain protein content was similar to CDC Teal and CDC Osler, 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 PSI) compared to all four check cultivars. Over three years of testing, AAC Redwater showed significantly higher farinograph absorption than the four check cultivars. AAC Redwater had farinograph dough development time (FDDT) not significantly different from AC Splendor, CDC Teal and CDC Osler but had significantly longer FDDT 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 (CPS) absorption compared to all check cultivars. CPS mixing energy for AAC Redwater was not significantly different from check cultivars. CPS 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 Cereal Research Centre off-season nursery near Leeston, New Zealand. 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 & Agri-Food Canada in Indian Head, SK in 2011. Distribution and multiplication of pedigree seed stocks is the responsibility of SeCan Association, 300 Terry Fox Dr, Kanata, Ontario, Canada K2K 0E3.

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

Cultivar	Yield (kg ha ⁻¹)				Maturity (d)				Height (cm)	Lodging ^d (1-9)	Test weight (kg hL ⁻¹)	Seed Mass (mg)
				Overall				Overall				
	Zone 1 ^a	Zone 2 ^b	Zone 3 ^c	mean	Zone 1 ^a	Zone 2 ^b	Zone 3 ^c	mean				
Three year 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 (<i>P</i> < 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

^aZone 1 includes Roblin and Dauphin (2010, 2011)

^bZone 2 includes Melfort, Kernen, Lake Lenore, Glaslen

^cZone 3 includes Lacombe, Ellerslie, Westlock (2009), Neapolis(2011), Beaverlodge, Fort Vermillion, Fort St. John and Dawson Creek

^dLodging scale: 1 = vertical; 9 = flat.

^eLSD of arithmetic means based on checks and AAC Redwater and calculated using SAS proc GLM v9.3(SAS institute, Inc.)

^fCheck cultivar means calculated using SAS proc MEANS, v 9.3

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Table 2a. 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								
	Field test			Seedling Tests ^c					Field test			Seedling Tests ^d					
				12-3	128-1	01-06-1	74-2	77-2				TPMK	TMRT	QTHJ	RKQS	RHTS	RTHJ
	2009	2010	2011	MBDS	MBRJ	TDBG	MGBJ	TJBJ	2009	2010	2011	TPMK	TMRT	QTHJ	RKQS	RHTS	RTHJ
Katepwa	27.5 MR	78.3 MSS	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 RMR	15.3 MR	1+	1-	1+	1+3-	1+3-	1 R	15 RMR	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 RMR	16.7 MR	1-	1-	1+	3-	3-	5 R	10 RMR	10 R	0	0	1	0	0	1-1

^aCaused 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.

^bCaused 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.

^cLeaf rust seedling reactions determined in 2009.

^dStem rust seedling reactions determined in 2011.

Table 2b. Disease reaction and ratings of AAC Redwater and check cultivars to stripe rust and the “Ug99” stem rust (Parkland Wheat Cooperative test, 2009, 2010 & 2011).

Cultivar	Stripe Rust ^a				Ug99 Stem Rust ^b		
	2009	2010		2011	2010		2011
		Lethbridge	Creston		9/10/10	22/10/10	16/10/11
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	30M	40M	50 M

^aCaused by *Puccinia striiformis* f.sp. *tritici* (Pst.). 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.

^bCaused 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 3. Disease reactions of AAC Redwater and check cultivars in the Parkland Wheat Cooperative test (2009, 2010 & 2011).

	Common bunt ^a			Loose smut ^b			Leaf Spotting Complex ^c			Common Root Rot ^d		
Cultivar	2009	2010	2011	2009	2010	2011	2009	2010		2011	2009	2010
								Melfort	Glenlea			
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

^aCaused 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, L16 of *T. laevis* mixed (vol/vol) in a 1:1:1:1:2:2 ratio (Gaudet and Puchalski 1989a), and represents the virulence spectrum of bunt isolates in western Canada (Gaudet and Puchalski 1989b). Rating indicates percent infection and relative classification.

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

^cScored from natural infection at Melfort (2009-2011) using 1-11 scale (McFadden, 1991) . Pathogens isolated from lesioned leaves:
Melfort(2009): % *Pyrenophora tritici-repentis* 15.0; % *Septoria nodorum* 5.0; % *S. tritici* 58.3; % *Cochliobolus sativus* 13.3
Melfort(2010): % *P. tritici-repens* 20.2; % *P. avenae* 0.9; % *S. nodorum* 24.3; % *S. tritici* 46.7; % *C. sativus* 7.8.

^d % Common Root Rot: percentage of subcrown internodes with dark discoloration in >50% of surface area.

2009 Fungal ID: *C. sativus* (58.8%); *Fusarium acuminatum* (5.9%); *F. graminearum* (5.9%); *F. pseudograminearum* (4.3%); *F. oxysporum* (5.9 %)

2010 Fungal ID: % *C. sativus* (52.6%); *F. pseudograminearun* (15.8%); *F. aveaceum* (5.3%)

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Table 4. Wheat and flour analytical data for AAC Redwater and check cultivars based on data from the Parkland Wheat Cooperative test (2009, 2010 & 2011).^a

	Test	Kernel	Grain	Flour	Protein	Falling	Amylo-	Flour	Flour	Agtron	Starch	Particle size
	weight	weight	protein	protein	loss	number	graph	yield	ash	colour ^b	damage	index
Cultivar	(kg hL ⁻¹)	(mg)	(%)	(%)	(%)	(s)	(BU)	(%)	(%)	(%)	(%)	(%)
Three year 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

^aEnd-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.

^bAgtron flour colour was not determined in 2011. and Clean white flour yield.

^cLSD of means was based on the checks and AAC Redwater, and calculated using SAS (Version 9.3).

Table 4. Continued.

Cultivar	Farinograph				Canadian short process (150 ppm ascorbic acid)							
	Absorption	Dough	Mixing	Stability	Loaf	Loaf	Crumb	Crumb	Absoption	Mixing	peak	Clean
	(%)	development	tolerance	index	volume	appearance	structure	colour	(%)	energy	time	white
	(%)	time (min)	index (BU)	(min)	(cm ³)					(W h kg ⁻¹)	(min)	flour yield ^d (%)
Three year 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	0.8	2.94	7	5.5	33	0.2	0.1	0.2	1	1.3	0.5	0.5
(P<0.05,two-tailed test) ^c												
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
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^wClean flour yield was not determined in 2011.

For Review Only