CULTIVAR DESCRIPTION

AAC Indus soft white spring wheat

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Randhawa, H. S., Graf, R. J. and Sadasivaiah, R. S. 2015. **AAC Indus soft white spring wheat**. Can. J. Plant Sci. **95**: 793–797. AAC Indus is a soft white spring wheat (*Triticum aestivum* L.) cultivar that meets the end-use quality specifications of the Canada Western Soft White Spring (CWSWS) class. AAC Indus is adapted to the irrigated wheat-growing regions of southern Alberta and southern Saskatchewan, and for dryland production in the western prairies. AAC Indus had higher ($P \leq 0.05$) grain yield under dryland conditions than all of the check cultivars. AAC Indus exhibited excellent straw strength and was 2 d later in maturity. AAC Indus exhibited good levels of resistance to the prevalent races of stripe rust and powdery, mildew and intermediate reactions to kernel black point and leaf rust. AAC Indus was susceptible to stem rust, common bunt, loose smut and *Fusarium* head blight.

Key words: *Triticum aestivum* L., cultivar description, soft white spring wheat, grain yield, quality, disease resistance

Randhawa, H. S., Graf, R. J. et Sadasivaiah, R. S. 2015. **Le blé de printemps tendre blanc AAC Indus**. Can. J. Plant Sci. **95**: 793–797. AAC Indus est une variété de blé de printemps (*Triticum aestivum* L.) tendre blanc respectant les normes de qualité concernant l'usage final de la catégorie « blé tendre blanc de printemps de l'Ouest canadien » (CWSWS). AAC Indus est adapté aux régions du sud de l'Alberta et du sud de la Saskatchewan où l'on cultive le blé sous irrigation, ainsi qu'aux zones d'aridoculture des Prairies, dans l'Ouest. La variété se caractérise par un meilleur ($P \leq 0{,}05$) rendement grainier sur sol aride que celui des cultivars témoins. AAC Indus possède une paille très robuste et parvient à maturité avec deux jours de retard. Le cultivar résiste bien aux races courantes de la rouille jaune ainsi que du blanc, et réagit modérément au point noir du grain de même qu'à la rouille des feuilles. AAC Indus est sensible à la rouille de la tige, à la carie, au charbon nu et à la brûlure de l'épi attribuable à *Fusarium*.

Mots clés: *Triticum aestivum* L., description de cultivar, blé tendre blanc de printemps, rendement grainier, qualité, résistance à la maladie

AAC Indus is a high-yielding, soft white spring wheat (*Triticum aestivum* L.) cultivar developed by Agriculture and Agri-Food Canada (AAFC), Lethbridge Research Centre (LRC), Lethbridge, AB, and released in 2014. It was granted registration number 7679 by the Variety Registration Office, Canadian Food Inspection Agency on 2015 Mar. 06.

AAC Indus is adapted for irrigated production in southern Alberta and southern Saskatchewan as well as dryland production in the western prairie region of western Canada. It meets the end-use quality requirements of the Canada Western Soft White Spring (CWSWS) wheat class.

Pedigree and Breeding Methodology

AAC Indus was developed from the cross Sadash/SWS340 made at the AAFC LRC in 2004. Sadash is a soft white spring wheat cultivar released by AAFC LRC in 2006 (Sadasivaiah et al. 2009). SWS340 is an experimental AAFC LRC breeding line tested in the Western Soft White Spring Wheat Cooperative Registrations trials (SWS Coop) in 2004. It has the pedigree AC Nanda/SWS214//AC Reed/SWS192. AC Reed and AC Nanda are both soft white spring wheat cultivars developed by AAFC LRC (Sadasivaiah et al. 1993, 2000).

The F_1 plants were increased in a greenhouse at Lethbridge in 2004 and F_2 plants were grown as a generation advance near Vauxhall, AB, in 2005. Following selection based on plant type in F_3 bulk plot in Lethbridge in 2006, 30 F_4 head rows were grown in a contra-season nursery near Lincoln, New Zealand, in 2006/2007. Five rows were selected based on plant type and grown as separate F_5 bulk plots near Lethbridge and Vauxhall, AB, in 2007. Heads were selected from the Lethbridge bulks based on agronomic traits and stripe rust resistance. In 2007/2008, 29 F_6 head rows were grown near Lincoln, New Zealand. In spring 2008, an F_7 line was identified and grown in a preliminary

[1]Deceased.

Abbreviations: **CWSWS**, Canada Western Soft White Spring; **DON**, deoxynivalenol; **FHB**, *Fusarium* head blight

yield trial near Lethbridge. Based on agronomic performance, disease resistance and suitable quality, it was evaluated in A level tests (three locations in Alberta) in 2009, and B level tests (four locations in Alberta) in 2010. High yield, acceptable agronomic and disease resistance traits, and favourable end-use quality allowed advancement into the SWS Coop as SWS427 where it was evaluated from 2011 to 2013.

The SWS Coop was grown at six irrigated locations (Lethbridge, Diamond City, Vauxhall, Bow Island, AB, and Saskatoon and Outlook, SK) and five dryland locations (Lethbridge, Lacombe and Edmonton, AB, Indian Head, SK, and Morden, MB) across western Canada. The criteria used for evaluation included grain yield, maturity, plant height, resistance to lodging and shattering, resistance to prevalent diseases, and end-use quality characteristics. The soft white spring wheat cultivars AC Andrew (Sadasivaiah et al. 2004) and Sadash (Sadasivaiah et al. 2009) were used as agronomic checks. Analyses of variance were conducted using a combined mixed effects model with years, locations, and their interactions treated as random effects, and cultivar treated as a fixed effect. The least significant difference (LSD) test was used to identify significant differences of the means for AAC Indus from the check cultivars.

Artificially inoculated field nurseries were used to determine reactions to leaf rust (*Puccinia triticina* Eriks. = *P. recondita* Roberge ex Desmaz.) and stem rust (*Puccinia graminis* Pers.: Pers. f. sp. *tritici* Eriks. & e. Henn.) at the AAFC Cereal Research Centre (CRC), Winnipeg, MB, using the modified Cobb scale (Peterson et al. 1948). Seedling infection type reactions were determined in the greenhouse for leaf rust races MBDS (12-3), MGBJ (74-2), TJBJ (77-2), TDBG (06-1-1) and MBRJ (128-1) (McCallum et al. 2013), and to stem rust races TMRTK (C10), RKQSR (C63), TPMKR (C53) RTHJT (C57), QTHST (C25) MCCF (C17) and RHTSK (C20) (Fetch et al. 2011). Reactions to stripe rust (*Puccinia striiformis* Westend) were recorded on a 1–100% disease severity scale based on natural field infection in Lethbridge and Creston, BC (Randhawa et al. 2012). *Fusarium* head blight (FHB) {caused by *Fusarium graminearum* Schwabe [teleomorph *Gibberella zeae* (Schwein.) Petch]} tolerance was evaluated at Glenlea and Carman, MB, in field nurseries that were spray inoculated with a macroconidial suspension and rated using a visual index (% incidence $\times$ % severity/100) as described by Gilbert and Woods (2006). Resistance to loose smut [*Ustilago tritici* (Pers.) Rostr.] was estimated as described by Menzies et al. (2003). Evaluation of common bunt [*Tilletia laevis* Kuhn in Rabenh. and *T. tritici* (Bjerk.) (Bjerk.) R. Wolff] resistance was conducted at the AAFC LRC using a composite of races L1, L16, T1, T6, T13 and T19, and planting into cold soil (Gaudet and Puchalski 1989; Gaudet et al. 1993) in early spring. Reactions to powdery mildew (*Blumeria graminis* DC. f. sp. *tritici* Em. Marchal) were recorded using a 1–6 scale (1 = resistant; 6 = highly susceptible) based on natural field infection in the registration trials. For leaf spot (*Pyrenophora tritici-repentis, P. nodorum*, *Mycosphaerella graminicola*, and *Cochliobolus sativus*) reactions, disease severity was observed from natural infection in the field but specific pathogens were not determined.

End-use quality was evaluated by the Canadian Grain Commission, Grain Research Laboratory, Winnipeg, Manitoba relative to AC Reed (Sadasivaiah et al. 1993) and Sadash (Sadasivaiah et al. 2009). Composite samples for each test entry were prepared from selected irrigated sites based on the protein concentration and grade of the check cultivars. Grain from locations where the checks produced a poor sample was not included in the quality composites.

Performance and Adaptation

Based on evaluation in the SWS Coop over 33 site-years (2011–2013), AAC Indus had significantly higher ($P \leq 0.05$) grain yield than the check cultivars AC Reed and AC Andrew, but was similar to Sadash (Table 1). Overall, AAC Indus (7143 kg ha^{-1}) yielded 22% more than AC Reed (5851 kg ha^{-1}), 8% more than AC Andrew (6584 kg ha^{-1}) and 3% more than Sadash (6928 kg ha^{-1}). Evaluated under irrigated conditions for 18 site-years, AAC Indus was 2% higher yielding than Sadash; however, across 15 site-years of dryland conditions, AAC Indus had significantly greater ($P \leq 0.05$) grain yield than all of the checks, being 6% and 4% higher than AC Andrew and Sadash, respectively (Table 1). The physiological maturity of AAC Indus (108.3 d) was about 3 d later than AC Andrew (105.6 d) and 2 d later than Sadash (106.2 d). AAC Indus was 6 cm taller than AC Andrew and 3.2 cm taller than Sadash, with straw strength similar to both. AAC Indus had test weight similar to the check cultivars, and a significantly higher 1000-kernel mass (39.5 g) than AC Andrew (37.1 g) (Table 2).

AAC Indus exhibited good levels of resistance to the prevalent races of stripe rust and powdery mildew (Table 3). It exhibited intermediate reactions to kernel black point [principally caused by *Alternaria alternata* (Fr.:Fr.) Keissl.], moderately resistant to moderately susceptible reactions to leaf rust, and susceptible reactions to stem rust (Table 3). Similar to other cultivars in this wheat class, AAC Indus was susceptible to common bunt, loose smut and *Fusarium* head blight.

End-use quality (milling and baking) assessment by the Canadian Grain Commission showed that AAC Indus had excellent quality with improved flour yield and lower flour ash than the checks (Table 4). Overall, AAC Indus had dough functionality and baking properties similar to AC Reed and Sadash (Table 4).

Other Characteristics

Plant characteristics were recorded from experimental field plots grown in 2014 at Lethbridge, AB.

Table 1. Least square means for grain yield of AAC Indus and the check cultivars in the Western Soft White Spring Wheat Cooperative Registration trials (2011–2013)

	Grain yield (kg ha^{-1})								
Entry	2011	2012	2013	Overall mean	% AC Andrew	Irrigated[z] mean	% AC Andrew	Dryland[y] mean	% AC Andrew
AC Reed	5759	5001	6834	5851*	88.9	6280*	92	5337*	85
AC Andrew	6303	5864	7599	6584*	100.0	6858*	100	6255*	100
Sadash	6903	5841	8096	6928	105.2	7387	108	6376*	102
AAC Indus	6910	6206	8301	7143	108.5	7559	110	6644	106
LSD	196	201	198	229		258		207	
Site-Years	11	11	11	33		18		15	

[z]Irrigated locations are Lethbridge, Vauxhall, Bow Island, Diamond City, Outlook and Saskatoon.
[y]Dryland locations are Lethbridge Dry, Lacombe, Edmonton, Indian Head, and Morden.
*Yield differences are significantly lower ($P \leq 0.05$) when compared with AAC Indus.

Seedling characteristics

Coleoptile colour: Very weak anthocyanin colouration.
Juvenile growth habit: Erect.
Seedling leaves: Blue green colour, glabrous leaf sheaths and blades of lower leaves.
Tillering capacity (at low densities): High.

Adult plant characteristics

Growth habit: Intermediate.
Flag leaf: Blue green with glabrous sheath and slightly waxy blade. Weak auricle colouration with slightly pubescent margins. Slight waxy bloom on flag leaf sheath.
Flag leaf attitude: Drooping.
Upper culm internode: Straight at maturity with weak waxiness; hollow stem with thin walls.
Culm Upper internode: Glabrous.

Spike characteristics

Shape: Tapering.
Length: Long.
Density: Dense.
Rachis: Glabrous rachis margin.
Colour: White at maturity.
Awns: Awned.

Spikelet characteristics

Glumes: White at maturity, medium length and width; glabrous; oblique shoulders; medium width; long and acuminate beak; no internal imprint.

Kernel characteristics

Type: Soft, white in colour.
Shape: Ovate with rounded cheeks.
Size: Large with medium width.
Brush: Medium sized with mid-long brush hairs.
Embryo: Medium sized, elliptical; crease mid-wide and mid-deep.

Maintenance and Distribution of Pedigreed Seed

Breeder Seed development of AAC Indus was initiated in 2013 by planting random head selections taken from a rogued F_{10}-derived F_{12} increase plot grown in Lethbridge. In winter 2013–2014, 94 pre-breeder seed lines were harvested from 120 head-rows that were grown near Leeston, New Zealand. Ninety rows were subsequently replanted at the AAFC Seed Increase Unit at Indian Head, SK. Following the elimination of variant and off-type rows in summer 2014, the remaining 78 F_{14} lines were inspected by the Canadian Food Inspection Agency in cooperation with the Canadian Seed Growers' Association and harvested in bulk to form the initial Breeder Seed. The breeder seed of AAC Indus will be maintained by the Indian Head Seed Increase Unit, AAFC, Indian Head, Saskatchewan, Canada S0G 2K0. Multiplication and distribution of all other pedigreed seed classes will be handled by SeCan, 501-300 March Rd., Kanata, Ontario, Canada K2K 2E2 (www.secan.com).

Table 2. Agronomic characteristics of AAC Indus and the check cultivars in the Western Soft White Spring Wheat Cooperative Registration trials (2011–2013)

Entry	Maturity (d)	Height (cm)	Lodging[z] (1–9)	Kernel wt. (g)	Test wt. (kg hL^{-1})	Protein (%)
AC Reed	103.7	85.0	2.6	35.4	77.8	11.5
AC Andrew	105.6	89.0	2.4	37.1	77.8	11.7
Sadash	106.2	91.8	2.4	37.9	79.2	11.6
AAC Indus	108.3	95.0	2.4	39.5	78.4	11.8
LSD	1.59	1.24	0.31	1.64	1.35	0.31
Site-years	29	33	21	21	21	21

[z]1 = erect; 9 = flat.

Table 3. Disease severity and ratings[z] for AAC Indus and the check cultivars in the Western Soft White Spring Wheat Cooperative registration trials (2011–2013)

	Leaf rust			Stem rust			Stripe rust				
Entry	2011	2012	2013	2011	2012	2013	2011 Leth	2011 Cres	2012 Leth	2013 Leth	2013 Cres
AC Reed	12.0 MR	63 S	32 I	20 S	90 S	90 S	80 S	65 S	40.0 MS	5 R	25 MR
AC Andrew	7.7 R	57 MS	25 MR	50 S	50 MR	10 MR	45 I	25 MR	22.5 I	20 MR	25 MR
Sadash	3.7 R	42 MS	23 MR	20 S	50 I	5 R	35 MR	15 MR	3.8 R	5 R	5 R
AAC Indus	15.3 MR	45 MS	42 I	80 S	99 S	90 S	25 MR	10 MR	4.3 R	10 R	5 R

	Common bunt			Loose smut			Powdery mildew			Black point		
Entry	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013
AC Reed	84 S	52.5 S	41 S	–	90 S	–	–	6.0 MS	7 MS	3 MR	15 I	16 I
AC Andrew	68 S	31.3 MS	23 I	55 I	38 I	55 I	–	1.0 R	1 R	3 MR	14 I	15 I
Sadash	74 S	43.5 S	33 MS	–	32 MR	–	–	1.0 R	1 R	4 I	14 I	17 I
AAC Indus	49 S	35.8 S	26 I	77 S	57 MS	77 S	–	2.5 MR	1 R	4 I	15 I	16 I

	Leaf spot			FHB index					DON		
Entry	2011	2012	2013	2011 Glenlea	2012 Carmen	2012 Glenlea	2013 Carmen	2013 Portage	2011	2012	2013
AC Reed	24 I	10 MR	24 I	5.3 MR	70 S	8.7 MR	41.1 I	32.3 S	10.6	2.6	–
AC Andrew	65 S	20 I	65 S	17.7 MS	65 S	11.8 I	69.4 S	18.3 I	–	5.6	–
Sadash	48 S	30 MS	48 S	13.7 I	46 MS	4.3 MR	61.3 S	30.7 S	–	2.7	–
AAC Indus	55 S	25 MS	55 S	13.7 I	56 S	30.1 S	49.3 MS	17 I	9.2	10.7	–

[z]Disease rating class: R = resistant, RMR = resistant to moderately resistant, MR = moderately resistant; I = intermediate rating; MS = moderately susceptible, S = susceptible.

Table 4. Mean end-use quality data[z] for AAC Indus and the check cultivars in the Western Soft White Spring Wheat Cooperative registration trials (2011–2013)

Test	Test wt.	Ker wt.	Wheat pro.	Flour pro.	Pro. loss	FN	Amyl peak	Flour yld	Flour ash	Flour colour *L**	Starch dmg	PSI	Farino abs	Farino DDT	Farino stab	Alveo length	Alveo P	Alveo P/L	Alveo W	Alveo area	Cookie spread	Cookie ratio
2011																						
AC Reed	82.7	39.7	10.3	9.2	1.1	380	485	73.5	0.51	95	3.7	72	53.8	1.3	1.5	52	28	0.54	29	4.0	84.1	9.0
Sadash	84.2	39.3	10.0	8.9	1.1	390	490	74.5	0.49	95	3.5	73	53.9	1.5	1.0	50	30	0.60	31	5.0	84.7	9.0
Mean of Checks	83.5	39.5	10.2	9.1	1.1	385	490	74.0	0.50	95	3.6	73	53.9	1.5	1.0	51	29	0.57	30	4.5	84.4	9.0
AAC Indus	82.4	43.5	9.9	8.9	1.0	370	430	76.0	0.46	95	3.7	73	53.2	1.75	2.5	127	31	0.24	71	11.0	83.5	8.4
2012																						
AC Reed	80.9	33.9	11.9	10.8	1.1	385	465	73.0	0.52	95	3.5	73	54.4	1.5	1.5	133	27	0.20	44	7.0	82.0	8.5
Sadash	82.4	36.3	11.5	10.4	1.1	380	445	74.5	0.49	95	3.3	75	54.1	1.5	1.0	103	31	0.30	44	7.0	81.6	8.9
Mean of Checks	81.7	35.1	11.7	10.6	1.1	385	455	73.8	0.51	95	3.4	74	54.3	1.5	1.0	118	29	0.25	44	7.0	81.8	8.7
AAC Indus	81.7	40.2	11.7	10.5	1.2	350	400	75.0	0.48	95	3.5	73	54.2	2.0	2.0	168	29	0.20	76	12.0	82.0	8.6
2013																						
AC Reed	78.4	37.6	11.4	10.5	0.9	340	275	73.0	0.51	–	3.3	–	54.7	1.50	1.0	111	25	0.23	36	–	83.0	9.4
Sadash	77.9	40.3	11.3	10.4	0.9	390	430	73.0	0.51	–	3.1	–	55.1	1.75	1.5	88	30	0.34	40	–	83.1	8.9
Mean of Checks	78.1	38.9	11.4	10.5	0.9	365	355	73.0	0.51	–	3.2	–	54.9	1.75	1.0	100	28	0.29	38	–	83.1	9.2
AAC Indus	78.4	39.4	11.5	10.4	1.1	395	435	75.0	0.47	–	3.2	–	54.0	2.50	2.5	162	30	0.19	71	–	83.0	8.8

[z]End-use quality testing was conducted by the Grain Research Laboratory of the Canadian Grain Commission on composite samples from various locations.

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