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CULTIVAR DESCRIPTION

AAC Whitehead hard white spring wheat

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Randhawa and Graf 2021. AAC Whitehead Hard White Spring Wheat

Can. J. Plant Sci. xx: xx-xx. AAC Whitehead, an awned hard white spring wheat (*Triticum aestivum* L.) cultivar, combines high grain yield and good agronomic characteristics with excellent disease resistance. Based on 34 station years of registration trial data from 2017 to 2019, AAC Whitehead had grain yield significantly higher than all of the check cultivars. AAC Whitehead had maturity similar to the checks, low lodging scores, and significantly shorter plant height than Snowstar and Whitehawk. AAC Whitehead had significantly lower test weight and higher kernel mass than than all the check cultivars. AAC Whitehead expressed resistance to the prevalent races of leaf, stripe and stem rust, and common bunt; and moderate resistance to *Fusarium* head blight. It also expressed tolerance to the orange wheat blossom midge. AAC Whitehead expresses quality attributes within the range of the check cultivars and is eligible for grades of Canada Western Hard White Spring wheat.

List of Abbreviations: CWHWS: Canada Western Hard White Spring, DON: deoxynivalenol, FHB: *Fusarium* head blight, CGC: Canadian Grain Commission, OWBM: Orange Wheat Blossom Midge.

Key Words: *Triticum aestivum* L., cultivar description, Canada Western Hard White Spring, grain yield, quality, disease resistance

AAC Whitehead is a hard white spring wheat (*Triticum aestivum* L.) cultivar developed by the Agriculture and Agri-Food Canada (AAFC), Lethbridge Research and Development Centre (LeRDC), Lethbridge, AB. It was granted registration number 9185 by the Variety Registration Office, Plant Production Division, Canadian Food Inspection Agency (CFIA), Ottawa, ON, on 29 Jan 2021.

Pedigree and Breeding Methodology:

AAC Whitehead was developed from the three-way cross AAC Iceberg//Carberry/Vesper made at the Agriculture and Agri-Food Canada, (AAFC) Lethbridge Research and Development Centre in Lethbridge, Alberta in 2012. The primary objective of this cross was to develop a high-yielding hard white wheat cultivar adapted to western Canada, with broad resistance to diseases and orange wheat blossom midge (OWBM, *Sitodiplosis mosellana* Géhin) tolerance. AAC Iceberg is a hard white wheat developed by the AAFC, Cereal Research Centre, Winnipeg, MB. It is derived from BW275*2/Argent, where BW275 is a sister line of Snowbird (Humphreys et al. 2007) and Argent is a hard white wheat derived from Grandin*5/ND614 by North Dakota State University in 1999. Carberry (DePauw et al. 2011) is a hard red spring wheat derived from Alsen/Superb that was developed by the AAFC, Swift Current Research and Development Centre, Swift Current, SK. Vesper is a hard red spring wheat developed by the AAFC, Cereal Research Centre, Winnipeg, MB and derived from an inter-cross of two different F₁s of complex parentage. The female parent of the cross was Augusta/Hard White Alpha//3*AC Barrie while the pollen parent was BW150*2//Tp/Tm/3/2*Superb/4/ 94B35-R5C/5/Superb (Thomas et al. 2013).

During the summer of 2013, a total of 280 F₁-derived doubled haploids were produced using maize hybridization techniques (Sadasivaiah et al 1999). These DH lines were grown as 1 m rows in a contra-season nursery at Leeston, New Zealand in 2013-14. Following selection for plant type, height, maturity and leaf rust resistance, 165 rows were harvested and evaluated in single-replicate irrigated and dryland yield trials at Lethbridge in 2014. These lines were also screened in disease nurseries for stripe rust (caused by *Puccinia striiformis* Westend. f.sp. *tritici* Erikss.) common bunt (caused by *Tilletia tritici* (Bjerk.) G. Wint. in Rabenh. and *T. laevis* Kühn in Rabenh.) and *Fusarium* head blight {FHB, caused by *Fusarium graminearum* Schwabe [teleomorph *Gibberella zeae* (Schwein.) Petch]} in 2014. After culling based on agronomic and disease resistance traits, selected lines were analyzed for end-use quality (grain protein, test weight, flour yield, flour ash, and mixograph parameters). A total of 16 selected lines were tested in replicated A level trials in Lethbridge, AB (under irrigation), Bow Island, AB and Melfort, SK during 2015. The lines were also evaluated for resistance to leaf rust (caused by *Puccinia triticina* Eriks. = *P. recondita* Roberge ex Desmaz.), stem rust (caused by *Puccinia graminis* Pers.: Pers. f. sp. *tritici* Eriks. & e. Henn.), stripe rust, common bunt and FHB in various disease nurseries. Several selected lines were analyzed for quality traits (grain protein, test weight, flour yield, flour ash, mixograph and farinograph parameters) and from these, 8 lines were advanced to a B level trial in 2016 (3 replicates, 7 locations in AB, MB, SK). Based on yield, agronomic, disease and quality testing, one line (W13798) was advanced to the Hard White Wheat Registration Trial and evaluated as HW506 for three years (2017-2019).

The registration trials were grown at 12 locations across 3 zones in western Canada.

The criteria for evaluation included grain yield, maturity, plant height, resistance to lodging, resistance to economically important diseases, and end-use quality characteristics. The Canada Western Hard White (CWHWS) wheat cultivars Snowstar, Whitehawk, and AAC Cirrus were used as checks.

To assess for disease and insect resistance, artificially inoculated field nurseries were used to determine reactions to leaf rust and stem rust at AAFC-MRDC (Morden, MB) using the modified Cobb scale (Peterson et al. 1948). Seedling 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 2020) and to stem rust races TMRTK (C10), RKQSR (C63), TPMKR (C53) RTHJT (C57), QTHST (C25) and RHTSK (C20) (Fetch et al. 2020a, 2020b); Roelfs and Martens 1988). Severity reaction to stripe rust was recorded based on natural field infection in stripe rust nurseries near Lethbridge, AB (Randhawa et al. 2012). *Fusarium* head blight tolerance was evaluated at Morden and Carman, MB in mist-irrigated field nurseries spray inoculated with a macroconidial suspension and rated using a visual index (% incidence x % severity/100) as described by Gilbert and Woods (2006). DON analysis was conducted on composite samples collected from respective FHB nurseries as described by Sinha et al. (1995). Evaluation of common bunt resistance was conducted at the AAFC Lethbridge Research and Development Centre 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). For the assessment of OWBM resistance, 10 spikes from each agronomic trial replicate were collected at Brandon, MB (a site known for heavy midge pressure) after maturity. Each spike was assessed and rated as either resistant, susceptible, or undamaged.

End-use quality was evaluated by the Grain Research Laboratory, Canadian Grain

Commission (CGC) in Winnipeg MB, relative to quality checks Snowstar, Whitehawk, and AAC Cirrus. Composite samples for each test entry were prepared from selected 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. All end-use suitability analyses were performed following protocols of the American Association of Cereal Chemists (AACC 2000).

Analyses of variance were conducted on data from the registration tests using a combined mixed effects model for agronomic data with years, environments and their interactions treated as random effects and cultivar treated as a fixed effect. The least significant difference ($LSD_{0.05}$ Type I) generated from the analysis of variance was used to identify significant differences of the means of AAC Whitehead from those of the check cultivars.

Performance and Adaptation:

Based on 34 station-years of data in the registration trials from 2017 to 2019 in western Canada, the yield of AAC Whitehead was significantly higher than all the check cultivars (Snowstar, Whitehawk, and AAC Cirrus). Overall, AAC Whitehead yielded 21% higher than Snowstar, 24% higher than Whitehawk and 16% over AAC Cirrus ($P \leq 0.05$) (Table 1). AAC Whitehead was similar in maturity and straw strength to the checks ($P > 0.05$). Plant height was significantly shorter than both Snowstar and Whitehawk ($P \leq 0.05$) but similar to AAC Cirrus. AAC Whitehead had lower test weight but higher kernel mass than all the check cultivars ($P \leq 0.05$). The protein concentration of AAC Whitehead was

similar to Snowstar and Whitehawk but was lower ($P \leq 0.05$) than AAC Cirrus (Table 2).

AAC Whitehead was resistant to the races of leaf, stem and stripe rust and common bunt prevalent in western Canada (Table 3). AAC Whitehead expressed improved resistance to *Fusarium* head blight, with intermediate (I) to moderately resistant (MR) reactions as compared to the check cultivars. AAC Whitehead expressed tolerance to the orange wheat blossom midge and carries *Sm-1* gene (Table 3).

Three years of end-use suitability testing at the CGC, Grain Research Laboratory allowed the Quality Evaluation Team to establish that AAC Whitehead had milling and baking quality suitable for grades of the CWHWS wheat class (Table 4). It had lower amylograph peak viscosity (608 B.U.) and lower flour yield (77.7%) with slightly higher ash content than the checks cultivars. The farinograph, extensograph and LNT bake test indicated that AAC Whitehead had good rheological and baking properties. All other quality parameters were similar to the checks (Table 4).

Other Characteristics

Plant characteristics were recorded from experimental trial grown as randomized complete block design with three replicates in 2019 at Lethbridge, AB.

SEEDLING CHARACTERISTICS

Coleoptile color: absent

Juvenile growth habit: erect

Seedling leaves: medium green, glabrous

Tillering capacity (at low densities): Moderately high

ADULT PLANT CHARACTERISTICS

Growth habit: erect

Flag leaf: dark green, glabrous, medium length and width, leaf auricle with weak anthocyanin and glabrous margin

Flag leaf attitude: drooping

Culm color: glabrous

SPIKE CHARACTERISTICS

Shape: tapering

Length: medium

Density: dense

Attitude: inclined

Color: white

Awns: awned; awns equal in length to spike

SPIKELET CHARACTERISTICS

Glumes: white at maturity, medium to long in length and wide; glabrous; narrow shoulder width, with slightly curved beak shape with strongly sloping shoulder shape

KERNEL CHARACTERISTICS

Type: hard, white in color

Size: medium to large;

Maintenance and Distribution of Pedigreed Seed

Breeder Seed of AAC Whitehead was produced by collecting random spikes from a rogued seed increase plot grown at Lethbridge in 2018 and growing about 199 head rows in isolation near Irwell, New Zealand in the winter of 2018-19. These rows were observed for uniformity within and among the rows, with contaminated and off-type rows discarded. Seed from each of the selected 150 single-plant progeny lines were subsequently planted at the AAFC Seed Increase Unit at Indian Head in spring 2019. Following the elimination of variant and off type rows in summer 2019, the remaining lines were inspected by the Canadian Food Inspection Agency in cooperation with the Canadian Seed Growers' Association. These lines were harvested as a bulk to constitute the initial breeder seed. The breeder seed of AAC Whitehead will be maintained by the AAFC Seed Increase Unit, Indian Head, SK Canada S0G 2K0 following the CGSA breeder seed production guidelines. Multiplication and distribution of all other pedigreed seed classes will be handled by FP Geentics 426 McDonald Street, Regina, SK S4N 6E1 (www.fpgenetics.ca)

AAC Whitehead is an OWBM resistant variety and to preserve the effectiveness of the *Sm1* gene, certified seed will be marketed as a varietal blend with AAC Tomkins as a 10% interspersed susceptible refuge.

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References

- AACC. 2000.** Approved methods of the AACC, 10th ed. American Association of Cereal Chemists, St. Paul, MN.
- DePauw, R. M., Knox, R. E., McCaig, T. N., Clarke, F. R., and Clarke, J. M. 2011.** Carberry hard red spring wheat. *Canadian Journal of Plant Science*. **91**(3): 529-534.
<https://doi.org/10.4141/cjps10187>
- Dupuis, B., and Fu, B. X. 2017.** A new lean no time test baking method with improved discriminating power. *J. Cereal Sci.* **74**, 112–120.
- Fetch, T., Mitchell Fetch, J., Zegeye, T., and Xue, A. 2020a.** Races of *Puccinia graminis* on barley, oat, and wheat in Canada from 2015 to 2019. *Can. J. Plant Pathol.*
DOI: [10.1080/07060661.2020.1829066](https://doi.org/10.1080/07060661.2020.1829066)

Fetch, T., Mitchell Fetch, J., Zegeye, T., and Xue, A. 2020b. Races of *Puccinia graminis* on barley, oat, and wheat in Canada in 2013 and 2014. Can. J. Plant Pathol.

DOI: [10.1080/07060661.2020.1745892](https://doi.org/10.1080/07060661.2020.1745892)

Gaudet, D. A., and Puchalski, B. L. 1989. Races of common bunt (*Tilletia caries* and *T. foetida*) in western Canada. Can. J. Plant Pathol. **11**:415-418.

Gaudet, D. A., Puchalski, B. L., Schallje, G. B. and Kozub, G. C. 1993. Susceptibility and resistance in Canadian spring wheat cultivars to common bunt (*Tilletia tritici* and *T. laevis*). Can. J. Plant Sci. **69**:797-804.

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. CIMMYT, El Batàn, Mexico; March 14-17, 2006. CIMMYT, Mexico, D.F.

Humphreys, D. G., Townley-Smith, T. F., Czarnecki, E., Lukow, O.M., McCallum, B., Fetch, T., Gilbert, J., and Menzies, J. 2007. Snowbird hard white spring wheat. Canadian Journal of Plant Science. 87(2): 301-305. <https://doi.org/10.4141/P06-139>

McCallum, B.D., Reimer, E., McNabb, W., Foster, A., and Xue, A. 2020. Physiologic specialization of *Puccinia triticina*, the causal agent of wheat leaf rust, in Canada in 2014. Can. J. Plant Pathol., doi: 10.1080/07060661.2020.1723705

Peterson, R. F., Campbell, A. B., and Hannah, A. E. 1948. A diagrammatic scale for estimating rust intensity on leaves and stems of cereal. Can. J. Res. **26**: 496-500

Randhawa, H.S., Puchalski, B.J., Frick, M., Goyal, A., Despins, T., Graf, R. J., Laroche A., Gaudet, D. A. 2012. Stripe rust resistance among western Canadian spring wheat and triticale varieties. Can. J. of Plant Sci. **92**:713-722.

Roelfs, A.P., and Martens, J.W. 1988. An international system of nomenclature for *Puccinia graminis f. sp. tritici*. *Phytopathology* **78**:526-533.

Sadasivaiah, R.S., Orshinsky, B.R. & Kozub, G.C 1999. Production of Wheat Haploids Using Anther Culture and Wheat x Maize Hybridization Techniques. *Cer. Research Comm.* **27**, 33–40 <https://doi.org/10.1007/BF03543916>

Sinha R.C., Savard, M.E., Lau, R. 1995. Production of monoclonal antibodies for the specific detection of deoxynivalenol and 15-acetyldeoxynivalenol by ELISA. *J Agr Food Chem* **43**:1740–1744. <https://doi.org/10.1021/jf00054a061>

Thomas J., Fox S., McCallum B., Fetch T., Gilbert J., Menzies J., Wise I., Smith M., Despins T., Niziol D, Humphreys G., and Brown D. 2013. Vesper hard red spring wheat. *Canadian Journal of Plant Science.* **93**(2): 315-321. <https://doi.org/10.4141/cjps2012-233>.

Table 1: Grain yield (Kg ha⁻¹) of AAC Whitehead as compared to the check cultivars in the Hard White Wheat Registration Trial (2017-2019)

Entry	Zone 1 ^a			Zone 2			Zone 3			Mean ^b
	2017	2018	2019	2017	2018	2019	2017	2018	2019	3 Years
Snowstar	4806	4790	4378	4591	3874	4741	5115	4808	5133	4581
Whitehawk	4943	5083	4427	4527	3795	4508	5065	4646	4105	4468
AAC Cirrus	5145	5375	4727	4746	3829	4770	5482	5181	5599	4778
AAC Whitehead	6429	5825	5224	5358	4694	5434	6635	5453	6771	5557
Stations	4	4	4	5	5	6	2	2	2	34
LSD _{0.05} ^c	479	315	385	316	350	350	702	593	1277	329

^a Zone 1: Brandon, Fort Whyte, Indian Head, Rosebank; Zone 2: Lethbridge, Kernen, Pense, Scott, Stewart Valley, Swift Current; Zone 3:Edmonton, Melfort

^b Means were generated using the LSMEANS statement of SAS.

^c LSD, least significant difference ($P \leq 0.05$) includes the appropriate genotype $\times$ environment interaction variation.

Table 2: Agronomic characteristics^a of AAC Whitehead as compared to the check cultivars in the Hard White Wheat Registration Trial (2017-2019)

Entry	Maturity	Height	Lodging ^b	Test Weight	Kernel Size	Protein
	(days)	(cm)	(1-9)	(kg hL ⁻¹)	(mg)	(%)
Snowstar	96.3	84.9	2.9	82.4	30.2	13.6
Whitehawk	96.6	90.1	2.5	81.3	31.6	13.8
AAC Cirrus	97.5	81.7	2.1	82.0	31.8	14.8
AAC Whitehead	97.6	81.0	2.1	79.4	39.0	14.0
Stations	31	34	5	35	35	35
LSD _{0.05} ^c	1.3	3.7	1.4	0.8	2.2	0.5

^a Means were generated using the LSMEANS statement of SAS..

^b Lodging scale of 1 to 9, where 1 = all plants in a plot are erect and 9 = all plants in a plot are lying horizontally.

^c LSD, least significant difference ($P \leq 0.05$) includes the appropriate genotype $\times$ environment interaction variation

Table 3: Reaction to various diseases^a of AAC Whitehead as compared to the check cultivars in the Hard White Wheat Registration Trial (2017-2019).

Entry	Leaf Rust			Stem Rust			Stripe Rust		
	2017	2018	2019	2017	2018	2019	2017	2018	2019
Snowstar	48 MS	40 MR	43 MS	10 MR	10 I	40 MR	90 S	90 S	80 S
Whitehawk	28 MR	43.3 MS	48 MS	10 I	10 I	40 I	40 MS	20 I	80 S
AAC Cirrus	0 R	3 R	20 MR	5 MR	10 MR	10 MR	15 MR	2 R	5 R
AAC Whitehead	0 R	0 R	10 R	1 R	5 R	1 R	2 R	1 R	25 MR

Entry	Common Bunt			Orange Wheat Blossom Midge								
				2017			2018			2019		
	2017	2018	2019	R	S	U	R	S	U	R	S	U
Snowstar	31 S	31 S	35 MS	0	27	3	0	44	1	0	29	1
Whitehawk	29 S	29 S	25 I	3	17	10	0	39	6	0	29	1
AAC Cirrus	5 MR	5 MR	4 R	0	26	4	0	44	16	0	30	0
AAC Whitehead	2 MR	2 MR	5 R	13	6	11	36	5	19	44	0	16

Entry	2017				2018				2019			
	VRI ^b	Rating	DON	Rating	VRI	Rating	DON	Rating	VRI	Rating	DON	Rating
Snowstar	19.0	I	16.0	I	17.3	I	4.3	I	22.4	I	2.3	R
Whitehawk	15.4	I	16.3	I	13.3	I	5.9	I	15.0	MR	2.4	MR
AAC Cirrus	25.0	I	17.3	I	18.6	I	6.9	MS	11.3	MR	4.9	MR
AAC Whitehead	13.3	MR	16.7	I	21.8	MR	3.8	I	8.8	MR	5.2	MR

Entry	2017				2018				2019			
	VRI	Rating	DON	Rating	VRI	Rating	DON	Rating	VRI	Rating	DON	Rating
Snowstar	34.0	I	8.0	MR	34.5	MS	10.6	I	42.5	MS	14.6	I
Whitehawk	30.7	MR	9.7	MR	19.8	MR	5.7	MR	40.6	MS	12.2	I
AAC Cirrus	41.4	I	14.7	I	24.0	I	4.0	MR	45.7	MS	11.9	I
AAC Whitehead	30.2	MR	10.7	MR	14.4	MR	12.4	MS	22.8	MR	12.5	I

^a For the rust diseases numeric ratings are severity in percentage of tissue affected, for bunt numeric ratings are incidence of disease in percentage of spikes infected over total spikes and for FHB numeric values are disease index. Infection response or disease rating class are: R=resistant, MR=moderately resistant, I=intermediate rating, MS=moderately susceptible, S=susceptible.

^b VRI = Visual Rating Index for FHB = (percentage of infected heads × percentage of diseased florets on infected heads)/100.

Table 4: End-use quality characteristics^a of AAC Whitehead and check cultivars in the Hard White Wheat Registration Trial (2017-2019)^b

Variety	Wheat and Flour Characteristics					Milling Performance			
	Wheat Protein (%)	Flour Protein (%)	Protein Loss %	Hagberg Falling Number (s)	Amylograph Viscosity (BU)	Clean Wheat Flour Yield %	Flour Yield 0.50 Ash (%)	Flour Ash (%)	Starch Damage (%)
Snowstar	13.8	12.9	0.87	427	685	76.9	80.7	0.37	6.9
Whitehawk	14.1	13.3	0.80	440	962	76.9	79.8	0.38	7.4
AAC Cirrus	14.9	14.3	0.57	392	747	76.7	79.3	0.39	7.3
Mean of Checks	14.2	13.5	0.74	419	798	76.8	79.9	0.38	7.2
AAC Whitehead	14.1	13.3	0.77	413	608	76.9	77.7	0.43	7.1
Standard deviation	0.7	0.8	0.14	31.7	141	0.3	1.4	0.03	0.2

Variety	Dough Properties					
	Farinograph			Extensograph		
	Absorption (%)	Dough Development Time (min)	Stability (min)	Area (cm ²)	R _{max} (BU)	Length (cm)
Snowstar	63.4	6.8	8.8	115	495	18.9
Whitehawk	63.5	8.6	14.2	144	727	16.6
AAC Cirrus	63.6	6.1	10.5	156	694	18.2
Mean of Checks	63.5	7.2	11.2	138	639	17.9
AAC Whitehead	63.3	6.2	9.8	116	514	18.6
Standard deviation	1.1	1.2	2.5	19.6	113.5	1.0

Variety	Baking Quality					Water dough color 2hr		
	LNT ^c /Remix Abs (%)	LNT/Remix Pk Time (Min)	LNT/Remix energy (Whr/kg)	LNT/Remix Loaf volume (cc)	LNT/Remix Loaf top ratio	L*	a*	b*
Snowstar	70.3	3.6	9.2	775	0.5	80.8	2.3	22.6
Whitehawk	71.7	5.0	12.5	783	0.6	80.4	2.3	23.7
AAC Cirrus	71.7	4.4	11.3	795	0.5	79.3	2.8	23.7
Mean of Checks	71.2	4.3	11.0	784	0.5	80.2	2.5	23.3
AAC Whitehead	70.3	3.6	9.7	775	0.5	79.9	2.7	24.2
Standard deviation	1.3	0.6	1.5	20.4	0.0	0.9	0.3	0.7

^a American Association of Cereal Chemists (AACC) methods were followed by the CGC for determining the various end-use quality characteristics on a composite of several locations per year.

^b Values are means of three years data from 2017-2019.

^c LNT (lean no time) was done in 2016 (Dupuis and Fu 2017);