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CULTIVAR DESCRIPTION

AAC Vortex hard red winter wheat

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Abstract: AAC Vortex is a hard red winter wheat (*Triticum aestivum* L.) cultivar well-adapted to all areas of western Canada and classified for grades of Canada Western Red Winter (CWRW) wheat. It was developed using doubled-haploid methodology. AAC Vortex was evaluated for registration relative to CDC Buteo, Emerson, Moats, and AAC Elevate across Alberta, Saskatchewan and Manitoba. Based on 44 replicated trials over 4 y (2016/17–2019/20), AAC Vortex had significantly higher grain yield than CDC Buteo and Emerson, and higher grain protein concentration than all of the checks except Emerson. AAC Vortex expressed winter survival and lodging resistance equal to the best checks, medium maturity and height, and acceptable test weight. AAC Vortex was resistant to stem, leaf and stripe rust, moderately resistant to *Fusarium* head blight, and susceptible to common bunt. AAC Vortex produced flour of higher protein concentration than all of the checks except Emerson, had higher clean wheat flour yield and loaf volume than all of the checks, and was similar in gluten strength to Emerson.

Key words: Triticum aestivum L., wheat (winter), cultivar description, doubled haploid, grain yield, cold tolerance, disease resistance, protein concentration.

Résumé : AAC Vortex est une variété de blé de force rouge d'hiver (*Triticum aestivum* L.) bien acclimatée aux régions de l'Ouest canadien. Elle est classée « blé rouge d'hiver de l'Ouest canadien » (CWRW). Créée par la technique de l'haploïdie double, la variété a été évaluée en Alberta, en Saskatchewan et au Manitoba en regard des variétés CDC Buteo, Emerson, Moats et AAC Elevate en vue de son homologation. Lors des 44 essais répétés sur quatre ans (de 2016-2017 à 2019-2020), AAC Vortex a donné un rendement grainier nettement supérieur à celui de CDC Buteo et d'Emerson, et son grain était plus riche en protéines que celui des variétés témoins, sauf Emerson. AAC Vortex a une rusticité et une résistance à la verse identiques à celles des meilleurs témoins. De précocité et de hauteur moyennes, la variété a un poids spécifique acceptable. AAC Vortex résiste à la rouille de la tige et des feuilles ainsi qu'à la rouille jaune, elle résiste modérément à la brûlure de l'épi causée par *Fusarium* mais est sensible à la carie. Sa farine est plus riche en protéines que celle des cultivars témoins, sauf Emerson. Son rendement net en farine est plus élevé et sa farine donne des pains d'un volume supérieur à celui des autres témoins. La fermeté de son gluten est semblable à celle d'Emerson. [Traduit par la Rédaction]

Mots-clés : Triticum aestivum L., blé (d'hiver), description de cultivar, haploïde double, rendement grainier, rusticité, résistance à la maladie, concentration en proteins.

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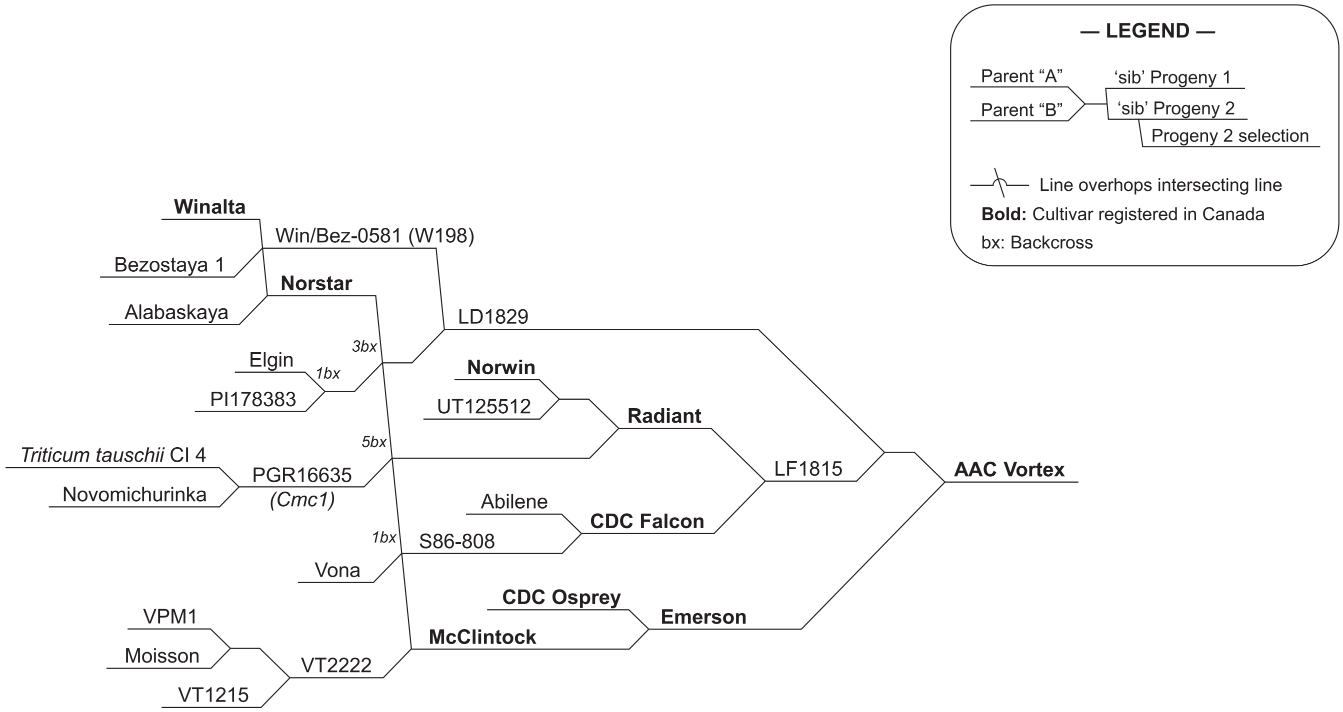
Fig. 1. Expanded ancestry of AAC Vortex hard red winter wheat.



Introduction

AAC Vortex hard red winter wheat (*Triticum aestivum* L.) was developed at the Agriculture and Agri-Food Canada (AAFC) Lethbridge Research and Development Centre (LeRDC) in Lethbridge, AB. Tested as LQ148 and W583, AAC Vortex was granted registration No. 9385 by the Variety Registration Office, Plant Production Division, Canadian Food Inspection Agency on 11 June 2021. Plant Breeders' Rights application No. 21-10477 was accepted for filing on 27 Apr. 2021.

High grain yield and winter survival, desirable agronomic traits, and resistance to stem rust (*Puccinia graminis* Pers.: Pers. f.sp. *tritici* Eriks. & E. Henn.), leaf rust (*Puccinia triticina* Eriks.), stripe rust (*Puccinia striiformis* Westend.), and *Fusarium* head blight {caused by *Fusarium graminearum* Schwabe [teleomorph *Gibberella zeae* (Schwein.) Petch]} make AAC Vortex Canada Western Red Winter (CWRW) wheat well-suited for production in all areas of western Canada. AAC Vortex replaced Emerson (Graf et al. 2013) as a CWRW wheat registration trial check in 2020/2021 based on improved agronomic performance over Emerson and similarities in disease resistance and end-use quality profile.

Residents of temperate climates are generally familiar with the effects of a polar vortex, a persistent area of low atmospheric pressure and extremely cold air above the Earth's poles. During winter in the northern hemisphere, the polar vortex will regularly expand southward, causing temperatures to plummet over wide areas. Accordingly, AAC Vortex is a fitting name for this winter wheat cultivar as it alludes to its excellent survival in western Canada, where endurance of frigid winter conditions is essential.

Pedigree and Breeding Method

AAC Vortex is an F_1-derived doubled haploid (DH) cultivar selected from the three-way cross LF1815/LD1829//Emerson completed in 2008 at the AAFC LeRDC. All of the parents were developed at AAFC LeRDC and have the following pedigrees: LF1815 (W448) = CDC Falcon/Radiant; LD1829 = Norstar*4//Elgin*2/PI178383/3/W198; Emerson = McClintock/CDC Osprey. An expanded ancestry of AAC Vortex is presented in Fig. 1.

Between 2009 and 2011, 207 F_1-derived DH lines were produced from 39 plants using wheat × maize pollination techniques (Fedak et al. 1997; Knox et al. 2000). Nine DH lines were derived from the F_1 plant from which AAC Vortex originated. Field evaluation of a 124 genotype subset began in 1.5 m observation rows grown under irrigation near Lethbridge in 2012, from which 29 desirable lines were selected based on winter survival, spring vigour, plant type, height, straw strength, stripe rust resistance, and general leaf health. The remaining lines began field evaluation in 2013 or 2014. The 29 selections from 2012 were rated for stem and leaf rust resistance in an artificially inoculated nursery at the University of Manitoba in Winnipeg, MB in 2013. Nine lines with acceptable resistance were then tested in a single replicate preliminary agronomic trial under irrigation in Lethbridge, as well as in inoculated nurseries for stem and leaf rust in Winnipeg, stripe rust in Lethbridge, and FHB in Carman, MB. Favourable agronomic performance, resistance to all three rusts and FHB, and acceptable end-use quality encouraged replicated testing of two lines in 2015 and one line in 2016 at sites across western Canada. Disease screening protocols were similar to those for registration testing and are described in the *Performance* section. Evaluation of resistance to wheat curl mite (*Aceria tosichella* Keifer) colonization was also conducted based on resistance expressed by parent LF1815 (Thomas and Connor 1986). Following 11 site-years of replicated agronomic trials across western Canada, up to four years of disease resistance assessment, and three years of end-use quality evaluation, LQ148 was evaluated as W583 in the Western Canadian Winter Wheat Cooperative (WWWC) registration trial for three years (2016/17–2018/19) for the purposes of registration, plus one additional year as a transitional check (2019/20).

Performance

Grain yield and agronomics

AAC Vortex was assessed in the WWWC registration trials relative to CDC Buteo (Fowler 2010), Emerson (Graf et al. 2013), Moats (Fowler 2012), and AAC Elevate (Graf et al. 2015). Agronomic test sites across western Canada were in Alberta (Beaverlodge, Lacombe, Lethbridge, Olds, Warner), Saskatchewan (Indian Head, Melfort, Saskatoon, Swift Current), and Manitoba (Brandon, Carman, Portage la Prairie, Winnipeg), through the collaborative efforts of AAFC, Alberta Agriculture and Forestry, and the University of Manitoba. Analyses of variance were conducted using a combined mixed effects model where environments were considered random and genotypes were fixed. The least significant difference (LSD) test was used to identify significant differences from the check cultivars.

Data from across western Canada collected from 44 sites over 4 yr provided a detailed synopsis of the grain yield and agronomic performance of AAC Vortex. Data for CDC Falcon, a previously popular cultivar in the eastern prairies and currently a Canada Western Special Purpose wheat check, are also reported. The mean grain yield of AAC Vortex was 5% higher than the CWRW check mean ($P \leq 0.05$) across all sites. Relative to specific checks, AAC Vortex had significantly higher grain yield than CDC Buteo (+7%), Emerson (+10%), and CDC Falcon (+5%), but was similar to Moats (+2%) and AAC Elevate (+1%). On a regional basis, AAC Vortex was particularly well-adapted to the more northerly parkland area (Zone 2) where it yielded 11% more than the CWRW check mean and 8% more than Moats, the highest yielding check in the zone ($P \leq 0.05$). Notably, AAC Vortex was 10% higher yielding than Emerson in Saskatchewan ($P \leq 0.05$), and although the difference in yield (+5%) was not significant in Manitoba, the similarities in disease resistance suggest that it could be a suitable replacement for Emerson in these areas where it

Table 1. Mean grain yield ($t{\cdot}ha^{-1}$) of AAC Vortex and the check cultivars, Western Canadian Winter Wheat Cooperative registration trials (2017–2020).

Cultivar	2017	2018	2019	2020	Grand mean		Alberta		Saskatchewan		Manitoba		Zone 1[a]		Zone 2[a]		Zone 3[a]		Zone 4[a]	
					$t{\cdot}ha^{-1}$	% Ck[b]	$t{\cdot}ha^{-1}$	% Ck[b]	$t{\cdot}ha^{-1}$	% Ck[b]	$t{\cdot}ha^{-1}$	% Ck[b]	$t{\cdot}ha^{-1}$	% Ck[b]	$t{\cdot}ha^{-1}$	% Ck[b]	$t{\cdot}ha^{-1}$	% Ck[b]	$t{\cdot}ha^{-1}$	% Ck[b]
CDC Buteo	4.790	4.239	4.241	5.357	4.655	98	4.838	97	3.944	101	5.022	99	4.518	94	4.933	102	3.736	102	4.743	99
Emerson	4.458	3.907	4.427	5.181	4.501	95	4.666	93	3.674	94	5.000	99	4.498	93	4.560	94	3.409	93	4.659	97
Moats	5.188	4.193	4.545	5.577	4.890	103	5.186	104	3.988	102	5.200	103	5.029	104	4.982	103	3.792	104	4.919	103
AAC Elevate	5.153	4.162	4.669	5.593	4.907	104	5.272	106	4.008	103	5.075	100	5.220	108	4.923	102	3.705	101	4.868	101
CDC Falcon	5.235	4.064	4.291	5.343	4.750	100	5.117	103	3.860	99	4.904	97	4.981	103	4.931	102	3.672	100	4.645	97
CWRW check mean[b]	4.897	4.125	4.471	5.427	4.738	100	4.990	100	3.903	100	5.069	100	4.816	100	4.849	100	3.660	100	4.797	100
AAC Vortex	5.170	4.269	4.680	5.691	4.969	105	5.292	106	4.033	103	5.259	104	4.978	103	5.398	111	3.595	98	4.927	103
LSD ($P \leq 0.05$)	0.276	0.322	0.326	0.406	0.159		0.238		0.278		0.308		0.275		0.332		0.477		0.242	
No. of tests	12	10	11	11	44		22		11		11		13		11		3		17	

Note: All means are weighted by the number of tests. LSD, least significant difference includes variation from the appropriate genotype × environment interaction.

[a]Zone 1, Southern Alberta sites (Lethbridge "dry land", Lethbridge "irrigated", Lethbridge "evergreen" (dry land + foliar fungicide when required), Warner); Zone 2, Parkland sites (Beaverlodge, Lacombe, Olds, Melfort); Zone 3, Semi-arid prairie site (Swift Current); Zone 4, Eastern prairie rust-hazard sites (Brandon, Carman, Indian Head, Portage la Prairie, Saskatoon, Winnipeg).

[b]Percent of CWRW check mean (CDC Buteo, Emerson, Moats, AAC Elevate). CDC Falcon is a CWSP check not included in the mean.

Table 2. Mean agronomic and seed characteristics of AAC Vortex and the check cultivars, Western Canadian Winter Wheat Cooperative registration trials (2017–2020).

Cultivar	Grain yield		Winter survival	Heading[b]	Maturity[b]	Height[c]	Lodging[d]	Test weight	Seed weight	Grain protein[e]	Grain protein
	$t \cdot ha^{-1}$	% Ck[a]	(%)	(d)	(d)	(cm)	(1–9)	($kg \cdot hL^{-1}$)	(mg)	(%)	yield ($kg \cdot ha^{-1}$)
CDC Buteo	4.655	98	90	169	213	82	4.0	82.3	33.3	12.3	590
Emerson	4.501	95	89	169	214	80	1.8	81.1	29.4	13.2	608
Moats	4.890	103	89	170	213	82	3.0	80.9	32.3	12.4	623
AAC Elevate	4.907	104	88	169	213	77	1.9	79.9	37.5	11.8	597
CDC Falcon	4.750	100	87	168	211	69	1.9	80.2	30.5	12.0	592
CWRW check mean[a]	4.738	100	89	169	213	80	2.7	81.1	33.1	12.4	604
AAC Vortex	4.969	105	90	169	213	78	1.8	81.1	34.9	12.8	649
LSD ($P \leq 0.05$)	0.159		2.5	0.4	0.7	1.1	0.64	0.34	0.56	0.18	19.9
No. of tests	44		23	37	39	43	12	41	41	41	41

Note: LSD, least significant difference includes variation from the appropriate genotype × environment interaction.
[a]Percent of the CWRW check mean (CDC Buteo, Emerson, Moats, AAC Elevate). CDC Falcon is a CWSP check not included in the mean.
[b]Days to heading and maturity expressed as day of the year.
[c]Height measured from soil surface to tip of spike, excluding awns.
[d]Lodging scale: 1 = all plants vertical, 9 = all plants horizontal.
[e]Grain protein concentration determined using whole grain near infrared reflectance analysis.

Table 3. Disease reactions of AAC Vortex and the check cultivars, Western Canadian Winter Wheat Cooperative registration trials (2017–2020).

Disease	Year	CDC Buteo	Emerson	Moats	AAC Elevate	CDC Falcon	AAC Vortex
Stem rust[a]	2017	20 MS	tr R	5 R	tr R	5 MR	tr R
	2018	—	—	—	—	—	—
	2019	10 R-70 S	5 R	5 R	10 R-MR	10 R	5 R
	2020	30 I	tr R	tr MR	10 MR	5 MR	tr R
Leaf rust[a]	2017	10 I	5 MR	tr R-MR	20 S	15 I	tr R-MR
	2018	—	—	—	—	—	—
	2019	15 MR-S	5 R-MR	5 R-MR	10-20 I	5 MR	tr R
	2020	15 MR	5 R-MR	5 R-MR	5 MR	5 MR	5 R-MR
Stripe rust	2017	70 S	1 R	1 R	70 S	50 S	1 R
	2018	70 S	15 MR	5 R	70 S	60 S	5 R
	2019	90 S	—	2 R	90 S	60 S	0 R
	2020	60 S	15 R	1 R	80 S	30 I	5 R
Common bunt	2017	44 S	60 S	31 MS	8 MR	33 MS	48 S
	2018	30 MS	33 S	33 S	7 R	35 S	29 MS
	2019	29 I	49 S	38 MS	15 MR	29 I	56 S
	2020	33 MS	—	23 I	1 R	15 MR	33 MS

Note: Percent infection and type of reaction: tr, trace; R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible; VS, very susceptible.

[a]Despite repeated inoculations, 2018 data were not available due to environmental conditions that prevented adequate infection and spread of the pathogens.

has been popular (see Canadian Grain Commission, Grain varieties by acreage insured) (Table 1).

AAC Vortex exhibited winter survival that was similar to the CWRW check cultivars and higher than CDC Falcon ($P \leq 0.05$). The heading date was similar to CDC Buteo, Emerson and AAC Elevate, one day earlier than Moats, and a day later than CDC Falcon ($P \leq 0.05$). Physiological maturity was reached at the same time as CDC Buteo, Moats, and AAC Elevate. AAC Vortex was similar in height to AAC Elevate, 2–4 cm shorter than the remaining CWRW checks, and 9 cm taller than CDC Falcon ($P \leq 0.05$). Lodging resistance was similar to Emerson, AAC Elevate and CDC Falcon, and significantly better than CDC Buteo and Moats ($P \leq 0.05$). The test weight and seed weight of AAC Vortex were within the range of the CWRW checks. AAC Vortex had higher grain protein concentration than all of the checks except Emerson ($P \leq 0.05$), and greater grain protein yield per hectare than all of the checks ($P \leq 0.05$) (Table 2).

Disease resistance

During registration testing, resistance to the major diseases of economic importance to winter wheat in both the eastern and western prairies was assessed by AAFC and the University of Manitoba using methodologies described in the Operating Procedures (Appendix E) of the Prairie Recommending Committee for Wheat, Rye and Triticale (www.pgdc.ca). Supplementary checks were included in the various nurseries to aid in making accurate assessments. The adult plant reactions to stem and leaf rust were determined in artificially inoculated field nurseries conducted by the University of Manitoba in Winnipeg using race composites supplied by the AAFC Morden Research and Development Centre (MRDC), and reported using the modified Cobb scale (Peterson et al. 1948). The stem rust races used for one or more years included: MCC (P0001), QTH (P0005), RHT (P0002), RKQ (P0003), RTH (P0007), TMR (P0006), and TPM (P0004) (Fetch et al. 2021). The leaf rust races were a representative mixture collected in western Canada during the previous field season (McCallum et al. 2021). Seedling reactions to individual races of stem and leaf rust prevalent in Canada were also determined under controlled-environment conditions by personnel at AAFC, MRDC. The races of stem rust were the same as those used in the field nurseries whereas the leaf rust races used for one or more years included MBDS (12-3), MBRJ (128-1), MGBJ (74-2), TDBG (06-1-1), TDBG (11-180-1) and TJBJ (77-2). Stripe rust ratings were determined in irrigated, inoculated nurseries at AAFC, LeRDC (Puchalski and Gaudet 2011). The reaction to common bunt [*Tilletia tritici* (Bjerk.) G. Wint. in Rabenh. and *T. laevis* Kühn in Rabenh.] was also estimated in nurseries conducted at AAFC, LeRDC by planting into cold soil at two locations in mid-October. All seed was inoculated with a composite of races that included L1, L16, T1, T6, T13, and T19 (Hoffman and Metzger 1976; Gaudet and Puchalski 1989). FHB response was determined by staff at the University of Manitoba using a mist-irrigated field nursery with three replicates in Carman. Spray-inoculation of each line occurred at 50% anthesis and again three to four days later using a suspension of *F. graminearum* macroconidia that

Table 4. *Fusarium* head blight (FHB) reaction of AAC Vortex, check cultivars and supplementary checks, Western Canadian Winter Wheat Cooperative registration trials (2017–2020).

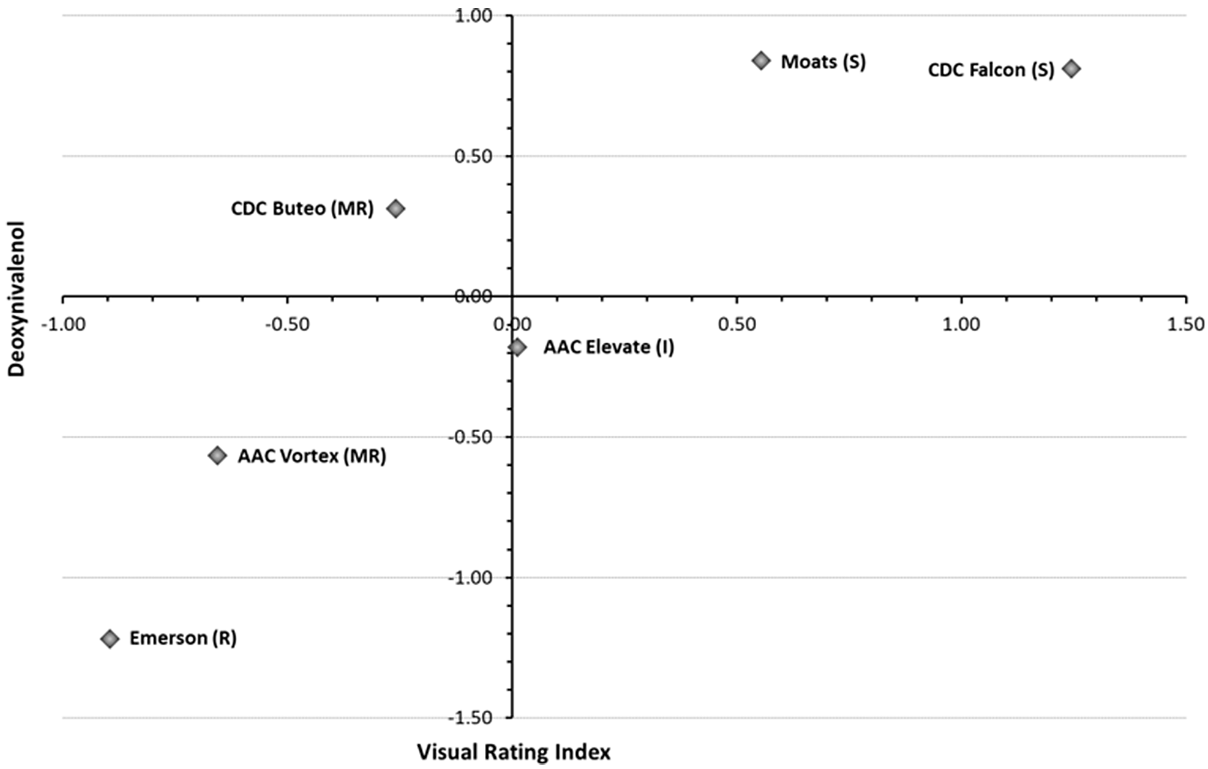
	Visual rating[a] (index and response)										Deoxynivalenol (ppm)						*Fusarium* damaged kernels[b] (%)					
	Carman			Winnipeg		Ottawa			MB Mean	Grand mean	Carman			Winnipeg		MB Mean	Carman			Winnipeg		MB Mean
	2017	2019	2020	2019	2020	2018	2019	2020	(*n* = 5)	(*n* = 8)	2017	2019	2020	2019	2020	(*n* = 5)	2017	2019	2020	2019	2020	(*n* = 5)
CDC Buteo	15 MR	1 MR	68 MS	20 I	6 MR	21	11	13	22	19	22	3	24	16	3	14	14	1	13	6	2	7
Emerson	1 R	2 MR	38 MR	12 MR	11 I	11	8	9	13	12	2	1	14	6	2	5	2	1	6	3	2	3
Moats	17 MR	3 MR	61 I	42 S	37 S	15	10	19	32	26	16	5	22	19	10	14	8	2	9	11	5	7
AAC Elevate	19 MR	2 MR	56 I	31 MS	16 I	16	15	13	25	21	16	3	19	9	4	10	12	2	7	5	3	6
CDC Falcon	16 MR	3 MR	80 S	61 S	37 S	57	31	14	39	37	16	2	28	24	11	16	9	1	26	17	6	12
AAC Vortex	3 R	0 R	41 MR	25 I	16 I	21	10	13	17	16	6	2	13	15	5	8	4	1	6	6	3	4
Supplementary checks																						
DH00W32C*17	3 R	0 R	20 R	5 R	1 R	—	—	—	6	—	4	2	11	7	1	5	4	1	4	3	1	3
FHB148	2 R	2 MR	22 R	4 R	2 R	—	—	—	6	—	6	2	9	7	2	5	8	1	2	2	1	3
Freedom	15 I	5 I	37 MR	22 I	7 I	—	—	—	17	—	23	5	18	16	7	14	4	2	7	7	5	5
DH01W43I*45	9 MR	2 MR	35 MR	27 I	3 MR	—	—	—	15	—	8	4	18	15	3	10	17	1	11	6	2	7
Caledonia	56 S	29 S	83 S	55 S	16 MS	—	—	—	48	—	49	10	30	35	16	28	14	3	22	12	9	12
Hanover	61 S	27 S	37 MR	72 S	25 S	—	—	—	44	—	58	11	13	57	25	33	31	5	5	23	19	17

Note: Disease response category: R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible. Supplementary checks were chosen to differentiate resistance levels based on long term data collection.

[a]Visual rating index = % incidence × % severity/100.

[b]*Fusarium* damaged kernels = damaged kernel weight/total weight × 100.

Fig. 2. Biplot of the mean standardized values [(observed value – mean)/standard deviation] for Visual Rating Index (8 sites) versus deoxynivalenol concentration (5 sites) for AAC Vortex and the check cultivars, Western Canadian Winter Wheat Cooperative registration trials (2017–2020). Data reported in Table 4. Values in parentheses are long-term ratings provided by the PRCWRT Disease Evaluation Team.



contained equal quantities of two 3-acetyldeoxynivalenol (3-ADON) and two 15-acetyldeoxynivalenol (15-ADON) producing chemotypes at a final concentration of 50 000 macroconidia ml^{-1}. Visual index (% incidence × % severity/100) rating typically occurred 18 to 21 d after anthesis or when symptoms were well developed (Gilbert and Woods 2006; Cuthbert et al. 2007). At maturity, a 50 g sample was harvested from each row to determine the percentage of *fusarium* damaged kernels (FDK) and to quantify the deoxynivalenol (DON) content using enzyme-linked immunosorbent assays (ELISA). The response to WCM infestation was conducted each year using non-viruliferous mites under controlled-environment conditions at AAFC LeRDC. Several replicates of 10 to 15 plants were rated for the typical symptoms of leaf rolling and trapping of new leaves following 2 to 3 wk of mite exposure.

Following three years of data collection, the Prairie Recommending Committee for Wheat, Rye and Triticale (PRCWRT) Disease Evaluation Team summarized the disease ratings for AAC Vortex as resistant to the prevalent races of stem rust, leaf rust and stripe rust, moderately resistant to FHB, and susceptible to common bunt. Data from a fourth year of disease testing is also presented (Tables 3 and 4, Fig. 2). As a cultivar with moderate resistance to FHB, AAC Vortex is an important component in management strategies directed towards mitigating the effects of this disease (Ye et al. 2017, Beres et al. 2018). To prevent potential losses from common bunt, seed of AAC Vortex and all similarly susceptible cultivars should be treated with an effective fungicide prior to planting (Gaudet et al. 2013, Aboukhaddour et al. 2020). AAC Vortex did not express resistance to the wheat curl mite (data not presented).

End-use quality

End-use quality analyses were conducted annually at the Grain Research Laboratory (GRL) of the Canadian Grain Commission (CGC), following protocols of the American Association of Cereal Chemists (2000). Following CGC determination of grain grade and protein concentration for the check cultivars at all of the agronomic test locations, a common site blending formula for the checks and all experimental lines was provided to produce composite samples where the mean protein concentration of the checks was approximately 12.5%. Grain from test sites with serious down-grading factors was not included in the quality composites.

Following three years of end-use suitability testing, the PRCWRT Quality Evaluation Team considered AAC Vortex eligible for all grades of the CWRW wheat market class. Four years of available data (2017–2020) showed

Table 5. Mean end-use quality characteristics of AAC Vortex and the check cultivars, Western Canadian Winter Wheat Cooperative registration trials (2017–2020).

Cultivar	Wheat protein (%)	Flour protein (%)	Protein loss (%)	Hagberg falling No. (s)	Amylograph-peak viscosity (BU)	Clean wheat flour yield (%)	Flour yield (0.5% ash)	Flour ash (%)	Starch damage (%)	Water dough colour (2 h)		
										L*	a*	b*
CDC Buteo	12.8	11.9	1.0	428	555	76.9	81.1	0.36	6.7	80.58	2.40	22.10
Emerson	13.6	12.7	0.9	405	623	76.6	81.1	0.36	5.9	79.76	2.68	23.71
Moats	12.8	12.0	0.8	449	750	75.7	79.4	0.39	7.4	80.08	2.43	22.59
AAC Elevate	12.3	11.3	1.0	420	611	76.8	80.5	0.37	7.2	79.87	2.51	22.57
Check mean	12.9	12.0	0.9	425	635	76.5	80.5	0.37	6.8	80.07	2.51	22.74
AAC Vortex	13.2	12.3	0.9	385	503	77.4	79.9	0.38	6.9	79.86	2.43	27.08
SD[a]	0.1	0.1	0.1	15	5	0.3	0.3	0.01	0.1	NA	NA	NA

	Extensograph			Farinograph[b]			Lean No Time (LNT) bake				
	Area (cm^2)	R_{max} (BU)	Length (cm)	Water absorption (%)	DDT (min)	Stability (min)	Bake bsorption (%)	Peak time (m)	Mixing energy (Wh kg^{-1})	Loaf volume (cm^3)	Loaf top ratio
CDC Buteo	89	404	17.5	58.9	5.63	7.3	66.0	3.0	7.7	756	0.54
Emerson	162	905	15.4	56.5	8.19	23.0	64.5	4.9	12.9	808	0.65
Moats	108	533	16.4	58.8	6.63	9.0	65.8	3.7	9.7	728	0.54
AAC Elevate	93	495	15.1	57.5	4.81	7.6	64.5	3.2	8.3	754	0.59
Check mean	113	584	16.1	57.9	6.31	11.7	65.2	3.7	9.6	761	0.58
AAC Vortex	156	911	14.8	57.6	11.06	23.8	65.5	5.1	14.0	818	0.65
SD[a]	4	20	6	0.2	0.4	1.4	0.0	0.1	0.3	14	0.04

Note: American Association of Cereal Chemists (AACC) methods were followed for determining the end-use quality characteristics on a composite of several locations per year. NA, not available.

[a]SD, standard deviation is based on repeated testing of Allis-Chalmers mill check samples and standard bake flour samples with replicate tests performed over time each year. Values from the CGC, GRL.

[b]Farinograph parameters: DDT = Farinograph dough development time.

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that AAC Vortex produced grain and flour of higher protein concentration than all of the checks except Emerson, had higher clean wheat flour yield and loaf volume than all of the checks, and was similar in gluten strength to Emerson. (Table 5).

Other Characteristics

Seedling: leaf sheath and blade glabrous.

Plant: juvenile growth habit semi-prostrate to prostrate; flag leaf blade glabrous, medium glaucosity, mid-long, mid-wide, medium to highly recurved; flag leaf sheath glabrous, strong glaucosity; auricle anthocyanin colouration very weak to weak, glabrous margins; culm neck straight to weakly curved, hollow, anthocyanin intensity at maturity absent or very weak.

Spike: awned, tapering, medium density, medium length, medium weak glaucosity, light yellow, inclined, awns white to light brown, spreading; lower glume mid-wide, mid-long, glabrous; glume shoulders primarily strongly sloping, width absent or very narrow; glume beak mid-long, straight; rachis margins slight pubescence; resistant to shattering.

Kernel: medium red, texture medium hard, medium size.

Maintenance and Distribution of Pedigreed Seed

A standard head-row derivation approach was used to produce Breeder Seed of AAC Vortex to preserve its inherent DH purity. Head rows were grown under isolation at an irrigated site near Lethbridge in 2019, each derived from a single random spike taken from rogued increase plots grown at Lethbridge in 2018. Following elimination of rows that appeared to express minor morphological differences or contamination, seed from 61 head rows was transferred to the AAFC Seed Increase Unit where they were grown individually as several 20 m long rows in 2020. Following the removal of 5 lines, 56 breeder lines were inspected, harvested in bulk and cleaned to form 604 kg of Breeder Seed, which was released to pedigreed seed growers in fall 2020. Bulking of the Breeder Seed occurred 10 generations after the creation of the original DH plant. Breeder Seed of AAC Vortex will be maintained by the AAFC Seed Increase Unit. All other pedigreed seed classes will be multiplied and distributed by Alliance Seed, 24th Floor, 333 Main Street, Winnipeg, MB, Canada R3C 4E2. Tel: 1-877-270-2890; www.allianceseed.com.

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