AAC Westlock Canada Prairie Spring Red wheat

Authors: Randhawa, H.S., Dhariwal, R., Graf, R.J., Fetch, T., McCallum, B., et al.

Source: Canadian Journal of Plant Science, 102(4) : 949-955

Published By: Canadian Science Publishing

URL: https://doi.org/10.1139/cjps-2022-0018

Canadian Journal of
Plant Science

AAC Westlock Canada Prairie Spring Red wheat

H.S. Randhawa[a], **R. Dhariwal**[a], **R.J. Graf**[a], **T. Fetch**[b], **B. McCallum**[b], **M.A. Henriquez**[b], **and R. Aboukhaddour**[a]

[a]Lethbridge Research and Development Centre, Agriculture and Agri-Food Canada, 5403-1st Ave South, P.O. Box 3000, Lethbridge, AB T1J 4B1, Canada; [b]Morden Research and Development Centre, Agriculture and Agri-Food Canada, 101 Route 100, Morden, MB R6M 1Y5, Canada

Corresponding author: **H.S. Randhawa** (email: harpinder.randhawa@agr.gc.ca)

Abstract

AAC Westlock, an awned hard red spring wheat (*Triticum aestivum* L.) cultivar, combines high grain yield and good agronomic characteristics with excellent resistance to leaf, stripe, and stem rust (including variants of Ug99), *Fusarium head blight* (FHB), and common bunt. Based on 40 station-years of registration trial data from 2018 to 2020, the grain yield of AAC Westlock was 1% higher than AAC Foray and 7% over AAC Penhold. AAC Westlock was significantly shorter than AAC Foray, had straw strength similar to AAC Penhold, and maturity similar to AAC Foray. AAC Westlock had similar test weight and protein concentration but lower thousand kernel weight as compared to AAC Foray. AAC Westlock had milling and baking quality suitable for grades of the Canada Prairie Spring Red wheat market class.

Key words: *Triticum aestivum* L., cultivar description, Canada Prairie Spring Red wheat, grain yield, quality, disease resistance

Résumé

AAC Westlock, un cultivar barbu de blé roux vitreux de printemps (Triticum aestivum L.) se caractérise par un rendement grainier élevé et de bonne propriétés agronomiques, combinés à une excellente résistance à la rouille des feuilles, à la rouille jaune et à la rouille de la tige (y compris les variants de Ug99), à la fusariose de l'épi et à la carie. Selon les données des essais d'homologation couvrant 40 années-stations, de 2018 à 2020, le rendement grainier d'AAC Westlock dépasse celui d'AAC Foray de 1 % et celui d'AAC Penhold de 7 %. La paille d'AAC Westlock est nettement plus courte que celle d'AAC Foray, mais aussi robuste que celle d'AAC Penhold. Avec une précocité similaire à celle d'AAC Foray, AAC Westlock a un poids spécifique et une teneur en protéines semblables à ceux d'AAC Foray, malgré un poids de mille grains plus faible. Les qualités meunières et boulangères d'AAC Westlock en ont permis le classement dans la catégorie « blé roux de printemps Canada Prairie ». [Traduit par la Rédaction]

Mots-clés : *Triticum aestivum* L., description de cultivar, blé roux de printemps Canada Prairie, rendement grainier, qualité, résistance à la maladie

Introduction

AAC Westlock is a hard red 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 9479 by the Variety Registration Office, Plant Production Division, Canadian Food Inspection Agency, Ottawa, ON, on 3 December 2021. AAC Westlock is adapted to western Canada and meets the quality specifications of the Canada Prairie Spring Red (CPSR) wheat market class. Plant Breeders' Rights Application No. 21-10726 was accepted for filing on 21 October 2021.

Pedigree and breeding methodology

AAC Westlock was developed from the three-way cross AAC Foray/AAC Tenacious//AAC Penhold made at the AAFC-LeRDC in Lethbridge, Alberta in 2014. The primary objective of this cross was to develop a high-yielding CPSR wheat cultivar adapted to western Canada with resistance to *Fusarium* head blight (FHB) and rust diseases. AAC Foray is a high-yielding hard red spring wheat cultivar derived from the cross CPS03hnF45123.032/5701PR developed by the AAFC-Cereal Research Centre (CRC), Winnipeg, Manitoba and registered in 2014 (Brown et al. 2015*a*). AAC Tenacious is a *Fusarium*-resistant hard red spring wheat cultivar derived from the cross HY665/BW346, also developed by the AAFC-CRC, Winnipeg, Manitoba and registered in 2014 (Brown et al. 2015*b*). AAC Penhold, a semidwarf hard red spring wheat cultivar derived from the cross 5700PR/HY644-BE//HY469 was developed by AAFC Swift Current Research and Development Centre, Swift Current, SK and registered in 2014 (Cuthbert et al. 2018).

Table 1. Grain yield (kg ha^{-1}) of AAC Westlock as compared with the check cultivars in the High Yield Wheat Registration Trial (2018–2020).

Entry	Zone 1[a]			Zone 2			Zone 3			Zone 4			Mean[b]	
	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020	2019–2020	2018–2020
Carberry	–	4311	4729	–	4518	4881	–	5341	5321	–	5147	3915	4750	–
AAC Penhold	5500	4579	5535	3906	4962	5363	5626	5772	6123	7907	6566	6530	5482	5329
AAC Foray	5552	4883	5788	4098	5342	5529	5986	5876	6718	7646	7096	7177	5808	5623
CDC Terrain	5786	–	5823	4495	–	5622	5953	–	6449	8479	–	7299	–	–
AAC Westlock	**5873**	**4716**	**5798**	**4254**	**5298**	**5832**	**6079**	**6157**	**6276**	**8133**	**7140**	**7443**	**5798**	**5697**
$LSD_{0.05}$[c]	230	208	240	178	196	250	286	257	347	644	491	879	265	175
Stations	4	4	3	4	6	3	4	5	4	1	1	1	27	40

[a]Zone 1: Brandon, Souris, Indian Head, Rosebank, Fort Whyte; Zone 2: Yorkton, Kernen, Pense, Scott, Swift Current; Zone 3: Beaverlodge, St. Albert, Lacombe, Melfort, Morrin; Zone 4: Lethbridge (Irri).
[b]Means were generated using the LSMEANS statement of SAS.
[c]LSD, least significant difference ($P \leq 0.05$) includes the appropriate genotype × environment interaction variation.
–, No data.

During the summer of 2015, a total of 461 F_1-derived doubled haploids (DH) were produced using maize hybridization techniques (Sadasivaiah et al. 1999). These DH lines were grown as 1 m rows in a contraseason nursery at Leeston, New Zealand in 2015–2016. Following selection for plant type, height, maturity, and leaf rust resistance, 169 rows were harvested and evaluated in single-replicate yield trials at Lethbridge, Melfort, Kernen, and Portage. These lines were also screened in disease nurseries for 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 (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 FHB (caused by *Fusarium graminearum* Schwabe (teleomorph *Gibberella zeae* (Schwein.) Petch)) in 2016. After eliminating lines based on agronomic and disease resistance traits, selected lines were analyzed for end-use quality (grain protein, test weight, flour yield, flour ash, kernel hardness, sedimentation volume, falling number, and mixograph parameters). A total of 22 selected lines were tested in replicated B level trials grown over seven locations in Alberta, Saskatchewan, and Manitoba in 2017. These lines were also evaluated for resistance to leaf rust, stem rust (including Ug99 in Kenya), stripe rust, common bunt, and FHB in various disease nurseries. Based on agronomic, disease, and quality testing, one line (WB25597) was advanced to the 2018 High Yield Wheat Registration Trial and evaluated as HY2090 for 3 years (2018–2020).

The registration trials were grown at 15 locations across four 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. Three CPSR wheat cultivars (AAC Foray, AAC Penhold, CDC Terrain) along with one Canada Western Red Spring wheat cultivar (Carberry) 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. 2020*a*, 2020*b*; 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 × % severity/100) as described by Gilbert and Woods (2006). Deoxynivalenol (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-LeRDC using a composite of races L1, L16, T1, T6, T13, and T19, and planting into cold soil

Table 2. Agronomic performance of AAC Westlock as compared with the check cultivars in the High Yield Wheat Registration Trial (2018–2020).

	Maturity (days)				Height (cm)				Lodging (1–9)[b]			
Entry	2018	2019	2020	Mean[a]	2018	2019	2020	Mean[a]	2018	2019	2020	Mean[a]
Carberry		102	102			80	84		–	2.1	2.8	–
AAC Penhold	97	101	101	99	67	73	76	72	2.7	2.1	3.1	2.5
AAC Foray	98	103	102	101	82	85	91	86	3.3	1.9	4.2	3.0
CDC Terrain	98	–	101	–	81	–	92	–	3.4	–	4.7	–
AAC Westlock	**99**	**102**	**102**	**101**	**76**	**80**	**87**	**80**	4.1	2.1	3.6	**2.9**
$LSD_{0.05}$[c]	0.7	0.6	0.6	0.8	1.0	1.1	1.2	1.2	0.7	0.5	0.6	0.5
Stations	13	15	11	39	13	16	11	40	1	4	3	8

[a]Means were generated using the LSMEANS statement of SAS.
[b]Lodging scale of 1–9, where 1 indicates all plants in a plot are erect and 9 indicates all plants in a plot are lying horizontally.
[c]LSD, least significant difference ($P \leq 0.05$) includes the appropriate genotype × environment interaction variation.
–, No data.

Table 3. Grain characteristics of AAC Westlock as compared with the check cultivars in the High Yield Wheat Registration Trial (2018–2020).

	Test weight (kg hL^{-1})				Thousand kernel weight (mg)				Protein (%)			
Entry	2018	2019	2020	Mean[a]	2018	2019	2020	Mean[a]	2018	2019	2020	Mean[a]
Carberry	–	79.1	80.1	79.9	–	36.9	36.5	37.1	–	13.8	14.6	14.5
AAC Penhold	81.5	79.0	80.2	79.9	44.1	42.5	41.6	42.2	14.0	12.7	13.0	13.3
AAC Foray	80.1	77.7	78.3	78.4	48.4	45.3	43.8	45.3	13.2	11.9	12.3	12.5
CDC Terrain	79.6	–	78.3	78.1	44.4	–	41.4	42.2	13.2	–	12.5	12.6
AAC Westlock	**80.5**	**78.4**	**78.9**	**79.0**	**46.4**	**44.7**	**41.5**	**43.8**	**13.2**	**12.0**	**12.4**	**12.6**
$LSD_{0.05}$[b]	0.65	0.49	0.69	0.90	1.74	1.43	1.27	1.35	0.29	0.27	0.43	0.57
Stations	15	15	11	41	15	15	11	41	15	15	11	41

[a]Means were generated using the LSMEANS statement of SAS.
[b]LSD, least significant difference ($P \leq 0.05$) includes the appropriate genotype × environment interaction variation.
–, No data.

(Gaudet and Puchalski 1989; Gaudet et al. 1993). For the assessment of orange wheat blossom midge (*Sitodiplosis mosellana* Géhin) resistance, 10 spikes from each replicate of the agronomic trial 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 (GRL), Canadian Grain Commission (CGC) in Winnipeg, MB, relative to quality checks AAC Foray, AAC Penhold, and CDC Terrain. 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 Westlock from those of the check cultivars.

Performance and adaptation

Based on 40 station-years of data in the registration trials from 2018 to 2020, the yield of AAC Westlock was significantly higher than AAC Penhold but similar to AAC Foray in western Canada (Table 1). Overall, AAC Westlock yielded (5697 kg ha^{-1}), about 7% higher than AAC Penhold ($P \leq 0.05$). In 2 years of testing (2019, 2020), AAC Westlock yielded about 6% higher than AAC Penhold ($P \leq 0.05$). AAC Westlock was 1 day later maturing ($P \leq 0.05$) than AAC Penhold but similar to AAC Foray. Plant height was significantly shorter than AAC Foray ($P \leq 0.05$). Lodging resistance was similar ($P > 0.05$) to both AAC Foray and AAC Penhold (Table 2). AAC Westlock had similar test weight and protein concentration but lower thousand kernel weight as compared to AAC Foray (Table 3).

AAC Westlock was resistant to the predominant races of leaf, stem, and stripe rust and common bunt present in western Canada (Table 4). AAC Westlock expressed improved resistance to FHB, with moderately resistant reactions as compared with the check cultivars (Table 4 and Fig. 1).Over years of testing (2017–2021, except for 2019) against the variants of Ug99 in the international stem rust screening nursery in Kenya, AAC Westlock expressed immune reactions as compared with the check cultivars (Table 5).AAC Westlock expressed susceptibility to the orange wheat blossom midge (Table 6).

Table 4. Reaction of AAC Westlock to various diseases as compared with the check cultivars in the High Yield Wheat Registration Trial (2018–2020).

	Leaf rust			Stem rust			Stripe rust			Common bunt		
Entry	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020
Carberry	–	17 MR	9 R	–	10 R	1 R	–	18 MR	5 R	–	5 R	–
AAC Penhold	0 R	0 R	2 R	5 MR	5 MR	1 R	15 MR	35 I	35 I	3 R	30 I	–
AAC Foray	0 R	22 MR	12 MR	1 R	5 R	1 R	6 R	23 MR	25 MR	28 MS	10 MR	–
CDC Terrain	4 R	–	8 R	10 I	–	1 R	2 R	–	5 R	0 R	–	–
AAC Westlock	**0 R**	**0 R**	**0 R**	**1 R**	**1 R**	**1 R**	**6 R**	**5 R**	**5 R**	**1 R**	**3 R**	**–**

FHB Carman

	2018				2019				2020			
Entry	VRI[a]	Rating	DON[b]	Rating	VRI	Rating	DON	Rating	VRI	Rating	DON	Rating
Carberry	–	–	–	–	20	MR	7	MR	28	I	7	MR
AAC Penhold	5	MR	4	I	19	MR	17	MS	45	MS	15	I
AAC Foray	18	I	10	MS	35	MS	20	S	53	MS	14	I
CDC Terrain	35	S	13	MS	–	–	–	–	64	S	22	MS
AAC Westlock	**9**	**MR**	**3**	**MR**	**10**	**MR**	**6**	**MR**	**18**	**MR**	**12**	**I**

FHB Morden[b]

	2018				2019				2020			
Entry	VRI	Rating	DON	Rating	VRI	Rating	DON	Rating	VRI	Rating	DON	Rating
Carberry	–	–	–	–	33	I	11	MR	25	I	22	MS
AAC Penhold	32	MS	10	I	43	MS	12	MR	28	MS	21	MS
AAC Foray	39	S	6	I	44	MS	13	I	33	MS	23	MS
CDC Terrain	43	S	12	MS	–	–	–	–	33	MS	26	MS
AAC Westlock	**21**	**I**	**7**	**I**	**25**	**MR**	**10**	**MR**	**21**	**I**	**12**	**MR**

Note: For the rust diseases numeric ratings are severity in percentage of tissue affected, for common 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.
[a]VRI, visual rating index for FHB = (percentage of infected spikes × percentage of diseased florets on infected spikes)/100.
[b]DON, deoxynivalenol content as measured in ppm from respective FHB nursery.

Fig. 1. Biplot showing relative position of AAC Westlock as compared to check cultivars using standardized disease index values of 9 *Fusarium* head blight visual rating index scores and 8 DON values (data source: Table 4).

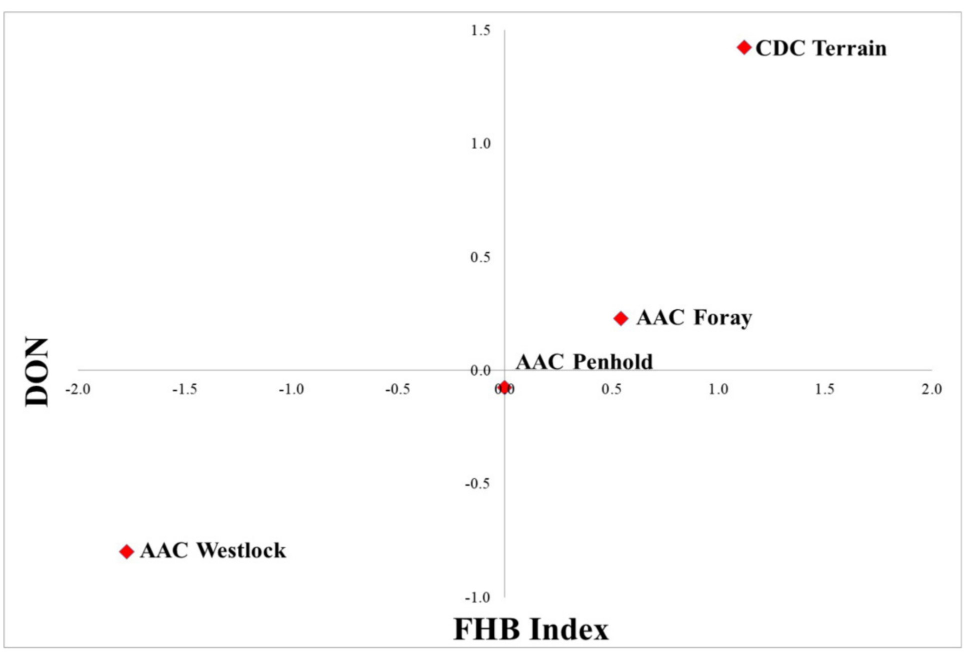

Table 5. Disease reactions of AAC Westlock as compared with the check cultivars in the Ug99[a] nursery in Kenya during 2017–2021.

	2017		2018		2019		2021	
Entry	Severity	Rating	Severity	Rating	Severity	Rating	Severity	Rating
Carberry	30	M	40	M	30	MSS	50	MS
AAC Penhold	15	MSS	10	MS	20	MS	10	MS
AAC Foray	10	MSS	10	M	20	MRMS	10	MS
AAC Westlock	**0**	**Immune**	**0**	**Immune**	**–**	**–**	**0**	**Immune**

[a]Races in the nursery: In 2017—TTKSK (Ug99), TTKST (Ug99 + Sr24 virulence), TTTSK (Ug99 + Sr36 virulence), TTKTK (virulent to SrTmp), TTKTT (virulent to Sr24 and SrTmp).
In 2021—TTKSK (Ug99), TTKST (Ug99 + Sr24 virulence), TTKTK (virulent to SrTmp), TTKTT(virulent to Sr24 and SrTmp), TTKTT + Sr8155B1 (virulence to Sr24, SrTmp, and Sr8155B1), TTTTF (low on Sr24 and Sr31).

Table 6. Wheat Midge Reaction of AAC Westlock and check cultivars based on data from the High Yield Wheat Registration Trial (2018–2020).AUTHOR: Why are the values in the "AAC Westlock" row in bold?

	2018			2019			2020		
Entry	R	S	U	R	S	U	R	S	U
Carberry	–	–	–	0	18	12	0	30	0
AAC Penhold	0	13	2	0	22	8	0	28	2
AAC Foray	8	0	7	9	0	21	4	1	25
CDC Terrain	0	19	11	–	–	–	0	16	14
AAC Westlock	**0**	**19**	**11**	**0**	**27**	**3**	**0**	**23**	**7**

Note: Abbreviations: R, resistant; S, susceptible; U, undamaged.

Three years of end-use suitability testing at the CGC-GRL allowed the Quality Evaluation Team to establish that AAC Westlock had milling and baking quality suitable for grades of the CPSR wheat class (Table 7). The protein concentration of AAC Westlock (12.7%) was lower than the mean of the checks. It had lower Hagberg falling number and higher amylograph peak viscosity (753 BU) over the mean of the checks. It had improved flour yield (77.7% at 0.5% ash) as compared with 76.8% of the mean of the checks. Extensograph area and R_{max} value indicated that AAC Westlock had stronger rheological properties as compared to the CPSR check cultivars. All other quality parameters and baking properties were similar to the checks (Table 7).

Other characteristics

Plant characteristics were recorded from experimental trial grown as randomized complete block design with three replicates in 2020–2021 at Lethbridge, AB.

Seedling characteristics

Coleoptile color: Absent.
Juvenile growth habit: Intermediate.
Seedling leaves: Light green, Glabrous.
Tillering capacity (at low densities): Moderately high.

Adult plant characteristics

Growth habit: Erect.
Flag leaf: Light green, glabrous, medium length and width, leaf auricle with weak anthocyanin and glabrous margin.
Flag leaf attitude: Intermediate.
Culm color: Glabrous.

Spike characteristics

Shape: Tapering.
Length: Medium.
Density: Dense.
Attitude: Erect.
Color: White.
Awns: Awned; Awns equal in length to spike.

Spikelet characteristics

Glumes: White at maturity, medium to long in length and mid-wide; glabrous; broad shoulder width, with straight beak shape with slightly elevated shoulder shape.

Kernel characteristics

Type: Hard, medium red in color.
Size: Medium to large.

Maintenance and distribution of pedigreed seed

Breeder seed of AAC Westlock was produced by collecting random spikes from a rogued seed increase plot grown at Lethbridge in 2019. One hundred fourteen single head isolation rows were seeded in Lethbridge during 2020. These were observed for uniformity within and among rows, and off-type rows were discarded. Seed from each of the selected 74 progeny rows were seeded at Indian Head in spring 2021. Following the elimination of off-types, the remaining breeder 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

Table 7. End-use quality characteristics of AAC Westlock and check cultivars with mean data from the High Yield Wheat Registration Trial (2018–2020).

	Wheat and flour characteristics					Milling performance			
Entry	Wheat protein (%)	Flour protein (%)	Protein loss (%)	Hagberg falling number(s)	Amylograph viscosity (BU)	Flour yield (%)	Flour yield PB 0.50 Ash	Flour ash (%)	Starch damage (%)
Carberry	14.4	13.6	0.9	360	380	75.6	76.0	0.46	7.8
AAC Foray	12.7	11.7	1.0	425	623	76.4	77.7	0.43	8.0
CDC Terrain	13.1	12.4	0.6	430	585	76.1	75.0	0.48	7.3
AAC Penhold	13.4	12.6	0.8	440	717	77.4	77.0	0.44	7.1
Mean of checks	13.1	12.2	0.8	432	649	76.7	76.8	0.45	7.5
AAC Westlock	**12.7**	**11.9**	**0.8**	**427**	**753**	**76.2**	**77.7**	**0.43**	**7.3**
Standard deviation	0.6	0.7	0.17	16	81	0.6	1.41	0.03	0.4

Dough properties						
	Farinograph			Extensograph		
Entry	Absorption (%)	Dough development time (min)	Stability (min)	Area (cm^2)	R_{max} (BU)	Length (cm)
Carberry	65.8	5.9	5.3	89	323	21.3
AAC Foray	64.1	6.5	16.0	112	577	15.6
CDC Terrain	61.9	7.9	9.0	119	596	16.3
AAC Penhold	63.8	6.8	10.5	108	543	16.3
Mean of checks	63.4	7.0	12.2	112	569	16.0
AAC Westlock	**63.5**	**6.2**	**12.5**	**124**	**698**	**14.8**
Standard deviation	1.0	1.2	5.1	11	95	0.8

	Baking quality					Water dough color		
Entry	LNT[a]/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*
Carberry	72.5	3.0	7.4	678	0.4	76.4	2.5	24.1
AAC Foray	71.7	4.3	11.0	728	0.6	79.5	2.2	24.9
CDC Terrain	69.0	3.8	10.1	735	0.6	78.8	2.5	20.1
AAC Penhold	71.3	3.6	9.7	752	0.5	77.4	2.6	24.8
Mean of checks	70.9	3.9	10.3	739	0.6	78.5	2.4	23.7
AAC Westlock	**71.0**	**4.1**	**9.6**	**740**	**0.6**	**77.5**	**2.7**	**25.7**
Standard deviation	1.4	0.4	1.0	29	0.02	1.9	0.6	2.2

Note: 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. Carberry data were not included in mean of checks. Only CPSR checks were used. CDC Terrain was used in 2018 and 2020 only
[a]LNT (lean no time) was done according to Dupuis and Fu 2017.

breeder seed. The breeder seed of AAC Westlock will be maintained by the AAFC Seed Increase Unit, Indian Head, SK S0G 2K0, Canada following the CGSA Breeder Seed Production Guidelines. Multiplication and distribution of all other pedigreed seed classes will be handled by SeCan, 400-300 Terry Fox Dr, Ottawa, ON K2K 0E3, Canada (www.secan.com).

Acknowledgements

Sincere gratitude is expressed to the technical staff at AAFC-LeRDC who contributed to the development of AAC Westlock spring wheat, in particular: L. Bihari and Z. Akter for production of doubled haploids, and M. Virginillo, K. Ryan, and K. Ziegler for their expert technical assistance in conducting field trials. Appreciation is expressed to the following: D. Niziol (CRC, AAFC, Winnipeg, MB), Kun Wang (GRL-CGC, Winnipeg, MB) for end-use suitability analysis; A. Brule-Babel and R. Larios (University of Manitoba), A. Burt (AAFC-ORDC, Ottawa, ON) for assessing reaction to *Fusarium* head blight; R. Gourlie, and T. Despins (AAFC-LeRDC) for assessing reaction to stripe rust and common bunt, S. Wolfe and C. McCartney (AAFC-CRC and University of Manitoba) for assessing reaction to wheat midge, M. Randhawa (Rust Pathologist with CIMMYT's Global Wheat Program, Nairobi, Kenya) for assessing stem rust Ug99 and H. Naeem, (AAFC Seed Increase Unit, Indian Head, SK) for production of breeder seed.

Article information

History dates

Received: 21 January 2022
Accepted: 31 March 2022
Accepted manuscript online: 4 August 2022
Version of record online: 4 August 2022

Author information

Funding

Financial support from the producer supported Western Grains Research Foundation check-off on wheat and the P4 wheat partnership (Canterra Seeds, Alberta Wheat Commission, and Agriculture and Agri-Food Canada) is gratefully acknowledged.

References

American Association of Cereal Chemists (AACC). 2000. Approved Methods of the AACC. 10th ed. American Association of Cereal Chemists, St. Paul, MN.

Brown, P.D., Randhawa, H.S., Mitchell Fetch, J., Fox, S.L., Humphreys, D.G., Meiklejohn, M., et al. 2015a. AAC Foray Red Spring wheat. Can. J. Plant Sci. **95**(4): 799–803. doi:10.4141/cjps-2015-007.

Brown, P.D., Randhawa, H.S., Mitchell Fetch, J., Meiklejohn, M., Fox, S.L., Humphreys, D.G., et al. 2015b. AAC Tenacious Red Spring wheat. Can. J. Plant Sci. **95**(4): 805–810. doi:10.4141/cjps-2015-011.

Cuthbert, R.D., DePauw, R.M., Knox, R.E., Singh, A.K., McCaig, T.N., McCallum, B., et al. 2018. AAC Penhold Canada Prairie Spring Red wheat. Can. J. Plant Sci. **98**(1): 207–214. doi:10.1139/cjps-2017-0186.

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. doi:10.1016/j.jcs.2017.01.017

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. **43**: 463–471. doi: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. **43**: 101–107. doi: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. doi:10.1080/07060668909501089.

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 trit ici* and *T. laevis*). Can. J. Plant Sci. **69**: 797–804. doi:10.4141/cjps89-095.

Gilbert, J., and Woods, S. 2006. Strategies and considerations for multi-location FHB screening nurseries. *In* The Global Fusarium Initiative for International Collaboration: A Strategic Planning Workshop. CIMMYT, El Batàn, Mexico; 14–17 March 2006. *Edited by* T. Ban, J.M. Lewis and E.E. Phipps. CIMMYT, Mexico, D.F.pp. 93–102

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. **42**: 520–526. 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. doi:10.1139/cjr48c-033.

Randhawa, H.S., Puchalski, B.J., Frick, M., Goyal, A., Despins, T., Graf, R.J., et al. 2012. Stripe rust resistance among western Canadian spring wheat and triticale varieties. Can. J. Plant Sci. **92**: 713–722. doi:10.4141/cjps2011-252.

Roelfs, A.P., and Martens, J.W. 1988. An international system of nomenclature for *Puccinia graminis* f. sp. *tritici*. Phytopathology, **78**: 526–533. doi:10.1094/Phyto-78-526.

Sadasivaiah, R.S., Orshinsky, B.R., and Kozub, G.C. 1999. Production of wheat haploids using anther culture and wheat × maize hybridization techniques. Cereal Res. Commun. **27**: 33–40. doi: https://doi.org/10.1007/BF03543916.

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