CULTIVAR DESCRIPTION

AAC Foray red spring wheat

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Received 7 January 2015, accepted 6 March 2015. Published on the web 19 March 2015.

Brown, P. D., Randhawa, H. S., Mitchell Fetch, J., Fox, S. L., Humphreys, D. G., Meiklejohn, M., Green, D., Wise, I., Fetch, T., Gilbert, J., McCallum, B. and Menzies, J. 2015. **AAC Foray red spring wheat**. Can. J. Plant Sci. **95**: 799–803. AAC Foray, an orange wheat blossom midge (*Sitodiplosis mosellana* Géhin) tolerant hard red spring wheat (*Triticum aestivum* L.), combined high grain yield and good agronomic performance with excellent resistance to leaf and stem rust, and improved resistance to *Fusarium* head blight. AAC Foray had maturity, straw strength, and test weight similar to the check cultivars. AAC Foray is eligible for grade of the Canada Prairie Spring Red wheat market class.

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

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Mots clés: *Triticum aestivum* L., description de cultivar, blé de printemps Canada Prairie, rendement grainier, qualité, résistance à la maladie, germination sur pied, cédidomyie du blé

AAC Foray is a hard red spring wheat (*Triticum aestivum* L.) cultivar developed by the Agriculture and Agri-Food Canada (AAFC), Cereal Research Centre (CRC), Winnipeg, MB, and released in 2013. It was assigned registration number 7625 by the Variety Registration Office, Canadian Food Inspection Agency on 2014 Dec. 18. AAC Foray is adapted to western Canada and meets the quality specifications of the Canada Prairie Spring Red (CPSR) wheat market class.

Pedigree and Breeding Methodology

AAC Foray was derived from the cross CPS03hnF4 5123.032/5701PR made at AAFC-CRC during the winter of 2003–2004. The primary objective of this cross was to develop a high-yielding CPSR wheat variety adapted to western Canada, with broad disease and orange wheat blossom midge (*Sitodiplosis mosellana* Géhin) resistance. The parentage of CPS03hnF4 5123.032 is 97M27/AC Vista, which combined high yield, *Fusarium* head blight (FHB) and midge resistance with early maturity. It is of note that Enchant, a midge resistant CPSR cultivar released in 2011 is also derived from the 97M27 source of midge resistance (McKenzie et al. 2002). 5701PR is a registered CPS red cultivar developed by AgriPro in 2001. A modified pedigree breeding method was used to develop AAC Foray. Twenty F_1 plants were grown during the winter of 2003–2004 in the greenhouse. The F_2 seeds derived from individual F_1 plants

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Abbreviations: **CPSR**, Canada Prairie Spring Red; **EPW**, Eastern Prairie Wheat; **HYWC**, High Yield Wheat Cooperative; **FHB**, *Fusarium* head blight; **TW**, test weight; **TKWT**, 1000-kernel weight

Table 1. Least square means for grain yield of AAC Foray compared with the check cultivars in the High Yielding Wheat Co-operative Registration Trials, 2010–2012

Line	Zone 1	Zone 2	Zone 3	Zone 4	Mean	% of 5700PR	Maturity	Height	Lodging	TW	TKWT
5700PR	3467	4586	4826	3697	4233	100	106.4	80.7	1.5	77.2	37.3
5701PR	3985	4970	4873	5339	4666	110	104.9	82.2	1.8	75.6	37.9
AAC Foray	**4090**	**5303**	**5525**	**6046**	**5035**	**119**	**104.9**	**89.0**	**2.0**	**77.0**	**47.1**
LSD	623	574	883	1303	437		3.3	2.2	0.4	1.1	6.6
Site years	14	12	11	3	40	40	34	41	19	34	34

were space-planted in four-row 1.2-m^2 plots in an early generation disease nursery at Glenlea, MB, in 2004. The nursery was established on land where the previous crop was corn mulched to provide *Fusarium graminearum* inoculum. Prior to planting, the F_2 seeds were inoculated with common bunt [*Tilletia laevis* Kuhn in Rabenh. and *T. tritici* (Bjerk.) (Bjerk.) R. Wolff] spores. Susceptible spreader rows on either side of each plot were inoculated with leaf (*Puccinia triticina* Eriks. = *P. recondita* Roberge ex Desmaz.), and stem rust (*Puccinia graminis* Pers.: Pers. f. sp. *tritici* Eriks. & e. Henn.). The F_2 plants that were rust, bunt and/or FHB susceptible, tall or prone to lodging, late maturing or showed a slight vernalization requirement were discarded. All of the remaining plants were harvested in bulk. After cleaning and sizing, F_3 seeds were space-planted in six 40-m-long rows near Palmerston North, New Zealand, during the winter of 2004–2005. After discarding plants based on criteria that were similar to those used in the F_2 generation, 750 heads were selected from agronomically desirable plants. These were threshed individually and 525 F_4 head rows were planted near Portage la Prairie, MB, in a 2005 disease nursery that was artificially inoculated with common bunt, leaf and stem rust. This F_4 nursery was also inoculated with FHB-infested corn spawn to permit screening for FHB resistance/tolerance as described by Gilbert and Woods (2006). Mist irrigation was used every second day to encourage good disease incidence. Based on visual disease ratings and midge resistance, plant type, grain yield and kernel appearance, seed from 61 head rows was advanced to the next generation. The F_5 generation was planted in 1-m rows near Palmerston, North, New Zealand (2005–2006). These lines were concurrently screened for common bunt resistance in the AAFC–CRC greenhouses and for rudimentary quality (protein content, kernel hardness and sedimentation) at the CRC Cereal Quality Laboratory. Based on bunt and quality data plus the agronomic performance and disease resistance in New Zealand, 42 F_5 rows were harvested. Out of these, only lines yielding more than 176 g in New Zealand were advanced to the F_6Yield Trial. The selected 38 F_6 lines were planted in single-replicate yield trials with alternating checks every 10th plot at Glenlea and Brandon, MB, and Saskatoon, SK, and in rust/common bunt/FHB disease nurseries planted at Glenlea and Portage la Prairie. Twenty of these lines were selected for advancement based on high yield, agronomic performance, leaf rust, stem rust, common bunt, and FHB resistance. Fifteen heads were randomly collected from each selected F_6 line and screened for midge resistance, with five heads advanced for further selection in New Zealand in 2006–2007. Ninety-seven F_7 head rows were planted near Palmerston North, New Zealand, and 54 lines were selected based on selection criteria similar to those in the F_4 generation, including concurrent greenhouse and quality lab screening. These $F_{6:8}$ lines were planted in a 2007 F_8 yield trial planted at Glenlea, Brandon and Saskatoon. Twenty-five F_9 lines were advanced to the 2008 Eastern Prairie Wheat (EPW) 'A' trial, a replicated yield trial grown at five locations with supplemental disease nurseries. Based on agronomic performance, disease resistance and quality analysis, five F_{10} lines were advanced to the EPW 'B' test grown at seven locations in 2009. One entry EPWB09-260 was advanced to the High Yield Wheat Cooperative (HYWC) Registration tests as HY1610 in 2010 to 2012. As part of these tests, artificially inoculated field nurseries were used to determine reactions to leaf rust and stem rust at AAFC–CRC (Winnipeg) using the modified Cobb

Table 2a. Reaction to various diseases[z] of AAC Foray compared with the check cultivars in the High Yielding Wheat Co-operative Registration Trials, 2010–2012

	Leaf rust			Stem rust – Winnipeg			Stem rust – Kenya			Stripe rust		
Line	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
5700PR	–	10 R	25 MR	20 R	20 I	20 I	15 RMR	15 MR	10 R	5 R	30 I	68 S
5701PR	0 R	1 R	0.3 R	7 R	5 R	5 R	15 M	–	20 M	5 R	17 I	25 I
AAC Foray	**2 R**	**0 R**	**13 MR**	**10 MR**	**15 MR**	**5 R**	**10 M**	**5 M**	**1 M**	**15 I**	**43 S**	**16 I**

[z]Disease rating class: VR = very resistant, R = resistant, RMR = resistant to moderately resistant, MR = moderately resistant; I = intermediate rating; MRMS = moderately resistant to moderately susceptible, MSS = moderately susceptible to susceptible, S = susceptible (% incidence –% severity/100, rating).

Table 2b. Reaction to various diseases and wheat midge of AAC Foray compared with the check cultivars in the High Yielding Wheat Co-operative Registration Trials, 2010–2012

	Common bunt			Loose smut			Leaf spot – Glenlea[y]			Midge (S/R/U)[x]		
Line	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
5700PR	2 R/MR	10 MR	3 R	16 MR	25 MR	11 R	28 I	37 MS	12 I	20/0/4 S	22/0/8 S	30/0/0 S
5701PR	21 MS	18 I	17 MR	48 I	38 I	49 I	22 MR	48 S	21 MS	20/0/4 S	18/0/12 S	29/0/1 S
AAC Foray	**13 I**	**25 I**	**22 I**	**63 MS**	**42 I**	**54 I**	**35 MS**	**47 S**	**24 MS**	**0/9/22 R**	**0/2/28 R**	**0/2/28 R**

[y]Caused by main leaf spotting pathogens: *P. tritici-repentis*, *P. nodorum*, *M. graminicola*, and *C. sativus*.
[x]Wheat midge caused by *Sitodiplosis mosellana* (Géhin): S = susceptible, R = resistant U = undamaged.

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) and MBRJ (128-1) (McCallum and Seto-Goh 2006) and to stem rust races TMRTK (C10), RKQSR (C63), TPMKR (C53) RTHJT (C57), QTHST (C25) and RHTSK (C20) (Roelfs and Martens 1988; Fetch 2005). Severity reaction to stripe rust (*Puccinia striiformis* Westend) was recorded based on natural field infection in stripe rust nurseries near Lethbridge (Randhawa et al. 2012). *Fusarium* head blight tolerance was evaluated at Glenlea and Carman, MB, in field nurseries spray inoculated with a macroconidial suspension and rated using a visual index (% incidence × % 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) using a composite of races T2, T9, T10 and T39. Evaluation of common bunt resistance was conducted at the AAFC Lethbridge Research 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).

End-use quality was evaluated by the Grain Research Laboratory, Canadian Grain Commission in Winnipeg based on composite samples for each test entry prepared from test locations selected on the basis of protein content and grade of the check cultivars.

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) test was used to identify significant differences of the means for AAC Foray from those of the check cultivars. For end-use quality data there were no replicated observations within years.

Performance and Adaptation

Based on 40 station years of data in the HYWC test from 2010 to 2012, the yield of AAC Foray was higher than the checks, 5700PR and 5701PR, within each zone and over all zones within western Canada (Table 1). Overall, AAC Foray yielded about 19% higher yield than 5700PR ($P \leq 0.05$) and 9% higher than 5701PR ($P > 0.05$). AAC Foray (Table 1) was equal in maturity and 1 d earlier than 5701PR and 5700PR, respectively. Straw strength was similar to 5701PR and height was 7–8 cm taller the checks. AAC Foray had higher test weight than 5701PR but was similar to 5700PR. It had slightly heavier kernels than both checks.

AAC Foray was resistant to moderately resistant to the prevalent western Canadian races of leaf and stem rust, and intermediate in reaction to common bunt (Table 2a). The stripe rust reaction of AAC Foray was variable, ranging from intermediate to susceptible. AAC Foray expressed improved resistance to *Fusarium* head blight, with intermediate to moderately resistant reactions and lower deoxynivalenol production compared to the check cultivars (Table 2c, 2d). Based on 3 yr of screening in the HYWC registration tests, AAC Foray expressed resistance or was undamaged by the orange wheat blossom midge; this resistance is conferred by *Sm1* (Table 2b) as confirmed by the presence of the molecular marker (Thomas et al. 2005). End-use quality assessment by the Canadian Grain Commission showed

Table 2c. *Fusarium* head blight (FHB) reaction of AAC Foray compared with the check cultivars in the High Yielding Wheat Co-operative Registration Trials, 2010–2012

	Glenlea – Index			Carman – Index			Ottawa – Index			PEI – Index		
Line	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
5700PR	24 I	14 I	20 MS	52 S	50 MS	56 S	18.3	42	41	25.7	36.0	41.0
5701PR	26 MS	21 S	9 MR	49 S	43 MS	45 MS	16.7	55	38	25.0	32.0	40.0
AAC Foray	**8 R**	**19 MS**	**7 MR**	**32 MS**	**44 MS**	**37 I**	**29.6**	**47**	**38**	**34.7**	**40.7**	**42.7**

Table 2d. Deoxynivalenol (DON) Level of AAC Foray compared with the check cultivars in the High Yielding Wheat Co-operative Registration Trials, 2010–2012

	DON – Glenlea (ppm)			DON – Ottawa (ppm)			PEI – DON (ppm)		
Line	2010	2011	2012	2010	2011	2012	2010	2011	2012
5700PR	25.7	4.1	7.78	–	19.3	9.2	–	24.8	2.2
5701PR	18.7	5.5	9.13	–	17.8	4.2	–	17.7	1.6
AAC Foray	**24.5**	**3.7**	**5.35**	–	**14.2**	**6.8**	–	**13.7**	**2.8**

that AAC Foray has acceptable quality with improved Farinograph absorption for the CPSR class (Table 3a, 3b).

Other Characteristics

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

Seedling Characteristics

Coleoptile colour: 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, rectilinear curvature, glabrous, slightly waxy blade, medium length and width, leaf auricle with weak anthocyanin and slightly pubescent margin.
Flag leaf attitude: Intermediate.
Culm colour: Glabrous.

Spike Characteristics

Shape: Fusiform.
Length: Medium.
Density: Medium.
Attitude: Erect.
Colour: White.
Awns: Awned; awns equal in length to spike.

Spikelet Characteristics

Glumes: White at maturity; medium length and width; glabrous; medium width, rounded shoulder, medium length beak with acuminate shape.
Lemma: Slightly curved.

Kernel Characteristics

Type: Hard, red in colour.
Size: Large; long, medium width; elliptical shape; rounded cheeks; medium length brush hairs; heavy; narrow, medium crease depth.
Embryo: Medium oval.

Maintenance and Distribution of Pedigreed Seed

Breeder Seed of AAC Foray was produced by collecting random heads from a F_6-derived F_{11} rogued increase plot grown at Regina in 2010 and growing about 250 heads as F_{12} head rows in isolation at Glenlea in 2011. Two hundred twenty seven F_{13} single-plant progeny lines were grown as single 15-m rows at Indian Head in 2012. Two hundred eight selected breeder lines produced 487 kg of Breeder Seed. The Breeder Seed of AAC Foray will be maintained by the AAFC Seed Increase Unit, 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). To preserve the effectiveness of the *Sm1* gene, as

Table 3a. Grain and milling characteristics of AAC Foray compared with the check cultivars in the High Yielding Wheat Co-operative Registration Trials, 2010–2012

	Grain			Milling									
2010	Test wt.	Kernel wt.	Wheat Pro	Flour pro	Pro loss	Falling number	Amylograph peak	Flour yield	Flour yield 0.50 ash	Flour ash	Flour colour *L**	Starch dmg	Particle size index
5700PR	80.1	41.2	12.4	11.7	0.7	280	325	76.1	77.0	0.44	78	8.3	52
5701PR	77.4	38.5	13.1	12.2	0.9	330	370	75.5	78.5	0.41	79	7.10	55
AAC Foray	**79.5**	**42.0**	**12.9**	**12.0**	**0.9**	**380**	**455**	**76.1**	**78.0**	**0.42**	**75**	**7.9**	**55**
2011													
5700PR	82.1	38.0	12.5	11.7	0.8	385	775	75.8	78.5	0.43	94.6	7.9	57
5701PR	81.0	38.8	12.6	11.9	0.7	435	905	76.0	79.5	0.41	94.9	6.8	60
AAC Foray	**81.7**	**44.7**	**13.1**	**12.2**	**0.9**	**455**	**905**	**76.5**	**79.0**	**0.42**	**94.4**	**7.7**	**58**
2012													
5700PR	81.1	38.1	13.2	12.2	1.0	405	770	75.2	77.0	0.44	94.9	7.7	58
5701PR	78.7	38.1	13.6	12.7	0.9	435	760	76.1	78.0	0.42	94.9	6.7	61
AAC Foray	**79.8**	**43.0**	**13.3**	**12.2**	**1.1**	**460**	**820**	**75.5**	**77.5**	**0.43**	**94.8**	**7.6**	**59**

Table 3b. Dough mixing and baking characteristics of AAC Foray compared with the check cultivars in the High Yielding Wheat Co-operative Registration Trials, 2010–2012

	Farinograph				Remix baking							
2010	Absorption	Dough development time	Mixing tolerance index	Stability	Absorption	Peak time	Energy whr kg^{-1}	Loaf volume	Loaf volume/ unit protein	Loaf appearance	Crumb structure	Colour
5700PR	66.8	8.75	–	9.5	62	2.8	6.7	943	80.6	8.8	5.4	6.0
5701PR	62.7	10.25	–	23.5	62	2.7	4.6	945	77.5	8.8	5.2	5.4
AAC Foray	**65.9**	**11.75**	**–**	**34.5**	**65**	**3.2**	**5.9**	**860**	**71.7**	**8.7**	**5.9**	**5.7**
2011												
5700PR	65.5	8.50	30	10.0	64	3.5	6.1	935	79.9	8.5	5.4	6.0
5701PR	62.2	15.50	10	29.0	61	2.8	5.1	965	81.1	8.8	5.5	6.0
AAC Foray	**66.0**	**24.25**	**5**	**33.5**	**64**	**3.7**	**6.7**	**940**	**77.0**	**8.7**	**5.8**	**5.9**
2012												
5700PR	64.4	9.25	15	13.5	60	2.3	4.5	990	81.1	7.8	5.6	8.0
5701PR	61.3	13.00	10	26.0	59	1.8	3.7	1025	80.7	7.7	5.8	8.0
AAC Foray	**63.7**	**10.00**	**10**	**39.5**	**61**	**2.0**	**3.4**	**920**	**75.4**	**7.5**	**5.8**	**7.9**

detailed in the Midge Tolerant Wheat Stewardship Plan (www.midgetolerantwheat.ca), Certified Seed of AAC Foray will include a 10% interspersed susceptible wheat refuge of AAC Penhold and designated as AAC Foray VB (varietal blend).

Financial support from the producer supported Western Grains Research Foundation check-off on wheat is gratefully acknowledged. Appreciation is expressed to the following: D. Niziol (CRC, AAFC, Winnipeg) and N. Edwards (Grain Research Laboratory, Canadian Grain Commission, Winnipeg, MB) for end-use suitability analysis; A. Brule-Babel and R. Larios (University of Manitoba), H. Voldeng (AAFC-ECORC, Ottawa), R. Martin (AAFC-CLRC, Charlottetown) for assessing reaction to *Fusarium* head blight; D. A Gaudet, B. Puchalski, and T. Despins (AAFC-Lethbridge Research Centre) for assessing reaction to common bunt and stripe rust, D. T. Gehl, (AAFC-Seed Increase Unit, Indian Head, SK) for production of Breeder Seed.

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