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Cultivar description

Forefront Canada Prairie spring red wheat

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Abstract

Forefront is an awned hard red spring wheat (*Triticum aestivum* L.) cultivar with high yield potential, shorter stature with good lodging tolerance, and excellent rust resistance. During the three years of testing in the High Yield Wheat Cooperative test (2017–19), Forefront yielded similar to and matured one day later than the highest yielding check cultivar AAC Foray. Forefront had 10 cm shorter plants than AAC Foray, with a similar lodging score. Forefront had slightly higher test weight, lower grain weight, and higher grain protein content than AAC Foray. Forefront was rated "resistant" to the prevalent races of leaf, stem, and stripe rusts, whereas "moderately susceptible" to common bunt and Fusarium head blight (FHB) during the three years of testing. The end-use quality characteristics of Forefront were within the range of the checks of the Canada Prairie Spring Red market class.

Key words: *Triticum aestivum* L., Canada Prairie Spring Red, rust resistance, lodging tolerance

Résumé

Forefront est une variété barbue de blé roux vitreux de printemps (*Triticum aestivum* L.) au rendement potentiel élevé. Il se caractérise par une paille plus courte et illustre une bonne tolérance à la verse ainsi qu'une excellente résistance à la rouille. Au cours des trois années des essais coopératifs sur le blé à rendement élevé (2017-2019), Forefront a enregistré un rendement similaire à celui d'AAC Foray, le cultivar témoin le plus productif, et est parvenu à maturité un jour plus tard. Les plants de Forefront étaient de 10 cm plus courts que ceux d'AAC Foray, mais l'indice pour la verse était le même. Comparativement à AAC Foray, Forefront a un poids spécifique légèrement plus élevé et des grains plus légers ainsi que plus riches en protéines. Durant les trois années d'essai, Forefront a été classé « résistant » aux races prévalentes de rouille de la feuille, de la rouille de la tige et de la rouille jaune, et « modérément sensible » à la carie ainsi qu'à la fusariose de l'épi. Les propriétés de cette variété selon l'usage final se situent dans la plage des variétés témoins de la catégorie « blé roux de printemps Canada Prairie ». [Traduit par la Rédaction]

Mots-clés : *Triticum aestivum* L., blé roux de printemps Canada Prairie, résistance à la rouille, tolérance à la verse

Introduction

Forefront, a hard red spring wheat (*Triticum aestivum* L.) cultivar, was developed at the University of Alberta, Edmonton, AB, Canada and is well adapted to the wheat-growing regions of western Canada. Forefront has been accepted in the Canadian Grain Commission CPSR variety list (https://www.grainscanada.gc.ca/en/grain-quality/variety-lists/2021/2021-20.html). The Variety Registration Office of the Canadian Food Inspection Agency registered Forefront (Registration No. 9305) on 23 April 2021.

Pedigree and breeding method

Forefront derives from a cross made at the University of Alberta in 2012 between the Canada Prairie Spring Red (CPSR) wheat line HY1317 and CPSR cultivar 5701PR. HY1317 is a line derived from the cross AC Vista/Alsen//HY485. Forefront was developed using a modified bulk-breeding method. The F_1 seed from the cross was planted in the F_1 nursery as 1 m row in 2012 in Edmonton, and the F_2 seed was bulk harvested. Two envelopes of 25 g each of bulked F_2 seed were planted in New Zealand in four rows of 25 m in 2012–13, and 200 plants were selected based on plant height, maturity, and disease resistance. The 200 F_3 heads from the selected plants were bulked, and two 25 g random samples were planted in two rows (50 m long) in Edmonton, AB, in 2013, of which 50 heads were selected based on rust resistance, plant height, and maturity. The 50 F_4 heads were planted in head rows in New Zealand in 2013–14, and 27 rows were selected. The 27 F_5 rows were tested in an un-replicated preliminary yield trial in 3 m × 1.14 m plots in Edmonton, AB, and in leaf, bunt, and leaf spot nurseries in Edmonton and

stripe rust nurseries in Lethbridge, AB, and Creston, BC, in 2014. Based on agronomic, disease, and end-use quality traits, a line UAW1219 × F5MBK08 was selected and subsequently evaluated in replicated multi-location Advanced Yield Trials in 2015. This line was subsequently assessed in the High Yield Wheat Cooperative B test as entry number 27 in 2016 and as HY2082 in the High Yield Wheat Cooperative test from 2017 to 2019.

The agronomic, disease resistance, and end-use quality attributes of Forefront were evaluated in the High Yield Wheat Cooperative test following protocols described in the operating procedures of the Prairie Recommending Committee for Wheat, Rye, and Triticale (PRCWRT) (Anonymous 2020). Agronomic performance was evaluated in 45 environments across AB, MB, and SK from 2017 to 2019. The trials were set up in a rectangular lattice design with three replications per environment. The data for the test were analyzed for individual years and locations and combined environments using the MIXED procedure of SAS software version 9.4 (SAS Institute Inc. 2013), with the environment, genotype × environment interaction, replication as random effects, and genotype as a fixed effect. The reaction of Forefront to stem rust (*Puccinia graminis* Pers.: Pers. f. sp. *tritici* Eriks. and E. Henn.) was assessed at the seedling stage and in the field using the stem rust races QTHJF, RKQSC, RHTSC, RTHJF, TMRTF, and TPMKC (Fetch et al. 2021). For leaf rust (*Puccinia triticina* Eriks.) assessment, representative leaf rust races from previous years were used at seedling and adult plant stages (McCallum et al. 2020). Field evaluation of leaf and stem rusts was conducted annually in epiphytotic nurseries in Morden and Brandon, MB, respectively. The reaction of Forefront to stripe rust (*Puccinia striiformis* Westend.) was evaluated in natural stripe-rust nurseries near Lethbridge, AB (Randhawa et al. 2012). Response to Fusarium head blight (FHB) [*Fusarium graminearum* Schwabe; teleomorph *Gibberella zeae* (Schwein.) Petch] was assessed by inoculation of field nurseries at Carman and Morden, MB, and Ottawa, ON, with a macroconidial suspension (Gilbert and Woods 2006). Response to common bunt was evaluated by inoculating seed with prevalent races L1, L16, T1, T6, T13, and T19 of common bunt and planting in mid-April of each year in Lethbridge, AB, following protocols of Gaudet and Puchalski (1989). The disease resistance evaluation protocols are described in Appendix E of the PRCWRT operating procedures (Anonymous 2020)

The end-use quality was analyzed at the Grain Research Laboratory, Canadian Grain Commission, Winnipeg, MB, following the American Association of Cereal Chemists (AACC 2000). Grain grade and protein contents for the check cultivars at all test locations were first determined. Then, a common site-blending formula for the checks and candidate cultivars was devised to develop composite samples. The composites did not include grain samples from test locations with serious downgrading factors. Quality data were analyzed in the MIXED procedure of SAS software version 9.4 (SAS Institute Inc. 2013), considering the year as replication.

Plant descriptive characteristics of Forefront were recorded from a trial conducted in a randomized complete block design (RCBD) with three replications at the University of Alberta Research Farm, Edmonton, Canada, in 2019 and 2020. This trial included the reference cultivars 5701PR (CFIA 2004), AAC Foray (Brown et al. 2015), and AAC Penhold (Cuthbert et al. 2018). Plant characteristics at different growth stages were recorded following the guidelines in the objective description form of the Variety Registration Office, Canadian Food Inspection Agency.

Performance

During the three years of testing in the High Yield Wheat Cooperative test from 2017 to 2019, Forefront yielded similar to and matured one day later than AAC Foray (Table 1). Based on two years of (2018–19) data, Forefront yielded 4% higher than AAC Penhold (Table 1). Forefront (76 cm) had 10 cm shorter plants than AAC Foray, with a similar lodging score (Table 1). The test weight of Forefront (79.2 kg hL^{-1}) was slightly higher than AAC Foray (78.8 kg hL^{-1}) (Table 1). Grain weight of Forefront (42.1 g) was lower than AAC Foray (45.9 g). The grain protein concentration, as determined by near-infrared spectroscopy (NIRS) of Forefront (12.8), was slightly higher than that of AAC Foray (12.5) (Table 1).

Other characteristics

Botanical description

Seedling characteristics

Anthocyanin coloration of coleoptile: medium to strong.
Lower leaf sheath pubescence: glabrous.
Lower leaf blade pubescence: glabrous.

Plant characteristics at booting

Plant growth habit (5–9 tiller stage): semi-erect.
Flag leaf sheath pubescence: glabrous.
Flag leaf sheath glaucosity: strong.
Flag leaf blade pubescence: glabrous.
Flag leaf blade glaucosity: weak to medium.
Frequency of plants with recurved flag leaves: high.
Anthocyanin coloration of flag leaf auricles: weak to medium.

Plant characteristics after heading

Culm neck shape: straight.
Culm uppermost node pubescence: absent or very sparse.
Culm uppermost node glaucosity: strong.
Stem color at maturity: white.
Anthocyanin intensity of straw at maturity: absent or very weak.
Straw pith in cross-section (middle of internode below the neck): thin.

Spike characteristics

Shape: parallel-sided.
Attitude at maturity: erect.

Table 1. Least squares means for agronomic traits of Forefront and check cultivars in the High Yield Wheat Cooperative test, 2017–19.

	Yield (kg ha^{-1})			Yield (%Chk)[a]			Maturity (days)			Height (cm)		
Cultivar	2017–18	2018–19	2017–19	2017–18	2018–19	2017–19	2017–18	2018–19	2017–19	2017–18	2018–19	2017–19
Glenn	4916	–	–	88	–	–	102	–	–	86	–	–
CDC Terrain	5724	–	–	102	–	–	104	–	–	85	–	–
AAC Penhold	–	5234	–	–	96	–	–	98	–	–	70	–
AAC Foray	5613	5465	5650	100	100	100	104	100	100	86	83	86
Forefront	**5681**	**5460**	**5677**	**101**	**100**	**101**	**104**	**101**	**101**	**75**	**73**	**76**
LSD (0.05)	253	186	108				1.2	1	0.5	1.6	1.3	0.8
Stations	28	30	43				29	29	42	30	30	44

	Lodging (1–9)[b]			Test Weight (kg hL^{-1})			Grain Weight (g 1000^{-1})			NIR Protein (%)		
Cultivar	2017–18	2018–19	2017–19	2017–18	2018–19	2017–19	2017–**18**	2018–19	2017–19	2017–18	2018–19	2017–19
Glenn	1.7	–	–	82.9	–	–	35.8	–	–	14.4	–	–
CDC Terrain	1.9	–	–	79.0	–	–	42.8	–	–	12.9	–	–
AAC Penhold	–	1.5	–	–	80.4	–	–	43.5	–	–	13.4	–
AAC Foray	1.8	1.5	1.7	79.3	78.9	78.8	46.2	47.1	45.9	12.9	12.5	12.5
Forefront	**1.8**	**1.7**	**1.7**	**79.5**	**79.4**	**79.2**	**41.9**	**44.1**	**42.1**	**13**	**12.8**	**12.8**
LSD (0.05)[c]	0.3	1.8	0.2									
Stations	10	10	19	28	31	45	28	31	45	28	31	45

[a]Percent of AAC Foray.
[b]1 means no lodging (erect); 9 means completely lodged (flat).
[c]Least significant difference.

Table 2. Reaction of Forefront to stripe, stem, and leaf rusts and common bunt in High Yield Wheat Cooperative test, 2017–19.

		Stripe rust		Stem rust		Leaf rust		Common bunt	
Year	Cultivar	Severity	Rate	Severity	Rate	Severity	Rate	Mean	Rate
2017	Glenn	20	I	5	R	10	M	3	MR
2018	Glenn	20	I	5	MR	4	R	13	MR
2019	Glenn	–	–	–	–	–	–	–	–
2017	CDC Terrain	0	R	5	R	13.3	MR	2	R
2018	CDC Terrain	2	R	10	I	3.8	R	0	R
2019	CDC Terrain	–	–	–	–	–	–	–	–
2017	AAC Penhold	–	–	–	–	–	–	–	–
2018	AAC Penhold	15	MR	5	MR	0	R	3	R
2019	AAC Penhold	35	I	5	MR	0	R	10	I
2017	AAC Foray	5	R	5	R	9	M	15	I
2018	AAC Foray	6	R	1	R	0.3	R	28	MS
2019	AAC Foray	23	MR	5	R	22	MR	10	MR
2017	**Forefront**	**T**	**R**	**1**	**R**	**0**	**R**	**5**	**MR**
2018	**Forefront**	**10**	**MR**	**5**	**R**	**0**	**R**	**1**	**R**
2019	**Forefront**	**5**	**R**	**5**	**R**	**3**	**R**	**40**	**MS**

Note: R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible; –, not tested.

Table 3. Reaction of Forefront to Fusarium head blight in High Yield Wheat Cooperative test at Morden and Carman, MB, 2017–19.

		Morden								Carmen							
Year	Cultivar	Mean INC	Mean SEV	VRI[a]	VRI Rate	DON	DON Rate	ISD[b]	ISD Rate	Mean INC	Mean SEV	VRI	VRI Rate	DON	DON Rate	ISD	ISD Rate
2017	Glenn	8.5	3.2	26.9	MR	11.3	–	9.1	MR	6.7	2.3	15.7	I	20	–	13.8	MS
2018	Glenn	5.7	3.0	17.2	MR	4.4	MR	4.3	MR	5.8	1.8	11.0	MR	2.1	MR	2.8	MR
2019	Glenn	–	–	–	–	–		–	–	–	–	–	–	–	–		–
2017	CDC Terrain	8.5	6.8	58.0	S	23.9	–	17.4	MS	8.0	4.2	33.7	MS	24.3	–	17.0	MS
2018	CDC Terrain	6.8	6.3	42.8	MS	12.1	MS	9.9	MS	7.0	5.0	34.8	S	12.6	MS	10.0	MS
2019	CDC Terrain	7.3	5.6	40.9	MS	7.8	MR	–	–	9.7	6.2	59.7	S	21.7	S	–	–
2017	AAC Penhold	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2018	AAC Penhold	6.2	5.2	32.1	MS	10.2	I	8.4	I	4.7	1.0	4.5	MR	3.7	I	3.4	MR
2019	AAC Penhold	8.8	4.8	42.5	MS	11.6	MR	–	–	8.2	2.3	19.0	MR	16.5	MS	–	–
2017	AAC Foray	8.7	6.3	54.8	MS	16.6	–	12.9	I	7.8	3.7	28.7	I	16.3	–	12.1	I
2018	AAC Foray	7.3	5.3	39.2	MS	6.3	I	6.3	I	4.0	2.5	17.8	I	9.9	MS	7.9	MS
2019	AAC Foray	7.3	6.0	44.1	MS	12.7	I	–	–	8.7	4.0	34.7	MS	20	S	–	–
2017	**Forefront**	**8.8**	**6.2**	**54.6**	**MS**	**21.7**	**–**	**16.0**	**I**	**8.5**	**3.5**	**29.7**	**I**	**28.3**	**–**	**19.4**	**MS**
2018	**Forefront**	**7.5**	**5.2**	**38.9**	**MS**	**12.5**	**MS**	**10.0**	**MS**	**7.8**	**2.7**	**20.9**	**I**	**12.6**	**MS**	**9.7**	**MS**
2019	**Forefront**	**8.8**	**6.0**	**53.1**	**S**	**20.8**	**MS**	**–**	**–**	**8.7**	**3.8**	**33.3**	**MS**	**23.7**	**S**	**–**	**–**

Note: INC, incidence; SEV, severity; R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible, S, susceptible; DON, deoxynivalenol; –, not tested or rated.
[a]Visual rating index = ((R1inc × R1sev) + (R2inc × R2sev) + (R3inc × R3sev))/3.
[b]Incidence + Severity + DON = (0.2 × mean incidence + 0.2 × mean severity + 0.6 × mean DON).

Table 4. Least squares means of end-use quality traits for Forefront and check cultivars from the High Yield Wheat Cooperative test, 2017–19.

	Wheat and flour characteristics					Milling performance			
Cultivar	Grain protein (%)	Flour protein (%)	Protein loss (%)	Falling number (seconds)	Amylograph peak viscosity (BU)	Clean flour yield	Flour yield PB 0.50 ash	Flour ash (%)	Starch damage (mega-zeme)
Glenn	14.1	13.5	0.6	353.9	636.5	75.6	78.5	0.4	8.4
CDC Terrain	12.7	12.0	0.7	416.4	566.5	76.1	75.3	0.5	7.3
AAC Penhold	13.5	12.6	0.9	446.8	694.0	77.4	77.7	0.4	7.1
AAC Foray	12.7	11.6	1.1	430.0	628.3	76.2	78.2	0.4	8.1
Forefront	**12.9**	**12.0**	**0.8**	**411.7**	**598.3**	**76.8**	**77.7**	**0.4**	**8.7**
CV (%)	1.1	0.8	14.1	2.9	5.7	0.36	0.60	2.2	2.0
LSD ($p \leq 0.05$)[c]	0.27	0.20	0.22	22.3	66.4	0.49	0.86	0.02	0.27

	Dough properties										
	Farinogram			Extensogram			Baking quality (lean no time)				
Cultivar	Absorption (%)	Dough development Time (min)	Stability (min)	Area (cm^2)	Rmax (BU)	Length (cm)	Absorption (%)	Mixing time (min)	Mixing energy (W-h kg^{-1})	Loaf Volume (cm^3 100 g^{-1})	Loaf top ratio
Glenn	65.6	8.2	9.9	142.1	610.6	18.8	73.2	4.0	9.8	839.8	0.6
CDC Terrain	61.3	7.5	7.6	123.1	595.1	16.7	68.7	3.8	9.4	732.3	0.5
AAC Penhold	63.4	7.0	12.5	109.9	562.8	16.4	71.4	3.8	9.9	763.1	0.5
AAC Foray	63.9	7.4	21.0	110.3	588.7	15.4	71.7	4.3	10.5	741.7	0.6
Forefront	**63.2**	**7.3**	**11.8**	**124.7**	**627.3**	**16.4**	**70.3**	**4.2**	**10.8**	**785.0**	**0.6**
CV (%)	0.72	9.8	28.0	6.2	3.5	5.0	0.92	4.6	7.2	1.4	1.8
LSD ($p \leq 0.05$)[a]	0.84	1.4	7.1	13.3	39.6	1.4	1.2	0.31	1.4	19.8	0.02

Note: Quality data were obtained by the Grain Research Laboratory of the Canadian Grain Commission using approved methods of the American Association of Cereal Chemists (AACC 2000). Means of Glenn and CDC Terrain are for 2017 and 2018; means of AAC Penhold are for 2018 and 2019; means of AAC Foray and Forefront are for 2017, 2018, and 2019.
[a]Least significant difference = standard error of the difference between means × 1.96.

Density: medium to dense.
Length: medium.
Glaucosity: medium to strong.
Colour at maturity: white.
Awnedness: awns present.
Location of awns: full length of the spike.
Length of awns at the tip of spike: medium to long.
Awn color: white.
Awn attitude: medium spreading to spreading.

Glume characteristics

Lower glume length: medium.
Lower glume width: mid-wide.
Lower glume pubescence of external surface: absent.
Lower glume shoulder shape: 45% strongly sloping; 30% strongly to slightly sloping; 25% slightly sloping to straight.
Lower glume shoulder width: medium.
Lower glume beak shape: 75% straight to slightly curved; 25% slightly curved.
Lower glume beak length: medium to long.
Glume color at maturity: white.

Kernel characteristics

Texture: hard.
Colour: medium red.
Kernel size: medium.
Kernel length: short to medium.
Kernel width: medium.
Kernel shape: broad-elliptical.
Kernel cheek shape: rounded to slightly angular.
Kernel brush hair length: mid-long.
Kernel brush size: small to medium.
Germ shape: broad elliptical.
Germ size: mid-size.
Kernel crease width: mid-wide.
Kernel crease depth: shallow to medium.

Disease resistance

Forefront was rated resistant (R) to the prevalent races of leaf rust, whereas moderately resistant (MR) to resistant (R) to stem and stripe rusts and common bunt during the three years of testing (Table 2). Based on the visual rating index of FHB, Forefront was rated moderately susceptible (MS) in two years and susceptible (S) in one year in Morden, while intermediate (I) in two years and MS in one year in Carman (Table 2). Based on the incidence/severity/DON index of FHB, Forefront was rated MS to I during the three years of testing in Morden, whereas MS in Carman (Table 3). The disease evaluation team of the PRCWRT gave Forefront a final rating of R for leaf, stem, and stripe rusts and MS for the common bunt and FHB.

End-use quality

Three years of end-use quality evaluation conducted by the Grain Research Laboratory of the Canadian Grain Commission indicated that Forefront is acceptable for the CPSR wheat market class (Table 4). Clean flour yield of Forefront was higher than all checks except AAC Penhold, whereas flour yield on 0.5 ash basis of Forefront was higher than CDC Terrain but similar to other checks. Extensogram area was higher than AAC Foray and AAC Penhold, similar to CDC Terrain but lower than Glenn. The gluten strength of Forefront was higher than those of AAC Foray and AAC Penhold but similar to those of CDC Terrain and Glenn. Loaf volume of Forefront was higher than all CPSR market class checks. Loaf top ratio of Forefront was higher than those of AAC Penhold and CDC Terrain but similar to the other checks.

Maintenance and distribution of pedigreed seed

The breeder seed of Forefront derives from 200 heads picked from the High Yield Wheat Coop seed increase in 2017 at Lethbridge. Seed from 150 heads was planted in pre-breeder rows in 2018 in Edmonton, of which 114 rows were harvested. Seeds of 114 rows were planted in 15 m breeder rows in 2019 in Edmonton, and 94 uniform rows were harvested and bulked to produce approximately 220 kg of breeder seed. Breeder seed of Forefront will be maintained by the University of Alberta's Cereal Breeding Program, Edmonton, AB. Penwest Seeds, Three Hills, AB, will handle the multiplication and distribution of all other classes of pedigreed seed.

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Data availability

Data used in this manuscript are available online on the Prairie Recommending Committee for Wheat, Rye, and Triticale (PRCWRT) website to committee members at https://www.pgdc.ca/committees_wrt_pd.html.

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