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CDC Reign Canada Prairie Spring Red wheat

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Abstract

CDC Reign, a hard red spring wheat (*Triticum aestivum* L.), is adapted to the wheat growing regions of Western Canada and is eligible for the Canada Prairie Spring Red (CPSR) market class. This conventional height wheat combines high grain yield and grain protein concentration with strong straw, intermediate resistance to *Fusarium* head blight, and excellent milling properties. CDC Reign is resistant to leaf rust and moderately resistant to stem rust and demonstrated end-use quality suitable for the CPSR market class.

Key words: *Triticum aestivum* L., spring wheat, yield, grain protein, cultivar description

Résumé

La variété de blé roux vitreux de printemps (*Triticum aestivum* L.) CDC Reign est acclimatée aux régions de l'Ouest canadien où on cultive le blé et est admissible à la classe « blé roux de printemps Canada Prairie » (CPSR). Ce cultivar de hauteur normale combine un rendement grainier élevé à un grain ultra riche en protéines. Il se caractérise par une paille robuste, une résistance intermédiaire à la fusariose de l'épi (FHB) et d'excellentes propriétés meunières. CDC Reign résiste bien à la rouille des feuilles et modérément à celle de la tige. Ses qualités au titre de l'usage final permettent de le classer dans la catégorie marchande CPSR. [Traduit par la Rédaction]

Mots-clés : *Triticum aestivum* L., blé de printemps, rendement, protéines du grain, description de cultivar

Introduction

CDC Reign, a hard red spring wheat (*Triticum aestivum* L.) cultivar, was developed at the Crop Development Centre (CDC), University of Saskatchewan, Saskatoon, SK, Canada. It received registration No. 8893 from the Canadian Food Inspection Agency (CFIA) on 9 July 2019, and a Plant Breeders' Rights protection was filed with the CFIA (No. 19-9970).

Breeding methods, pedigree, and field testing

CDC Reign is derived from the cross ACS51638/Alsen made at the CDC, University of Saskatchewan, in the summer of 2008. ACS51638 is a German breeding line obtained as part of germplasm exchange program and Alsen (Frohberg et al. 2006) is a hard red spring wheat cultivar released in 2000 by the North Dakota State University for its resistance to *Fusarium* head blight (FHB) (caused by *Fusarium graminearum* Schwabe (teleomorph *Gibberella zeae* (Schwein.) Petch)) combined with high grain yield and excellent end-use quality. The F₁ generation was increased at a contra season nursery near Christchurch, New Zealand. The F₂ and F₃ generations were increased in bulk in 2009 in Saskatoon, SK, and

near Christchurch. In 2010, the F₄ generation was grown in a space-planted nursery in Saskatoon, and desirable plants expressing suitable plant height, time to maturity, and plant stature were selected and planted as F_{4:5} head rows in a leaf and stem rust nursery in 2011. Rows with suitable plant height, time to maturity, and leaf and stem rust resistance were identified, and from them three random individuals were selected. The resulting F_{5:6} lines were again evaluated as head rows in 2012 in leaf and stem rust nurseries, and for FHB resistance at Carman, MB. HY08.34.182 was selected and in 2013 was evaluated in unreplicated early generation yield tests at the Kernen Crop Research Farm near Saskatoon. In the same year, HY08.34.182 was evaluated in artificially inoculated common bunt, leaf and stem rust nurseries in Saskatoon, and FHB nursery at Carman. Quality analysis (grain protein concentration (%), SDS sedimentation (cc), falling number (s)) was performed on harvested samples from the Kernen Crop Research Farm, and HY09.24.182 was selected. In 2014, HY08.34.182 was evaluated with check cultivars for agronomic traits in replicated yield trials at the Kernen, and Goodale Crop Research Farms, Wakaw, SK, and Edmonton, AB. Disease testing in artificially inoculated nurseries included FHB (Carman), leaf and stem rust resistance (Saskatoon), common bunt resistance (Saskatoon), and stripe

rust (Saskatoon). Quality testing was performed on equal composite samples. Based on these trials, HY08.34.182 was advanced in 2015 to the High Yield Wheat B-Test and was evaluated in the High Yield Wheat Cooperative Registration Test from 2016 to 2018 and associated disease nurseries as HY2062.

The variables measured and the operating protocols followed in the High Yield Wheat Cooperative Registration Test were those approved each year by the Prairie Recommending Committee for Wheat, Rye, and Triticale; http://pgdc.ca/committees_wrt_pd.html). In agronomic performance trials, the check cultivars over all three years of trialling were Glenn (Mergoum et al. 2006), AAC Foray (Brown et al. 2015), and CDC Terrain. In Cooperative trials, the stem rust races were TPMKC, TMRTF, RHTSC, QTHJF, RTHJF, RKQSC, and MC-CFC (Roelf and Martens 1988; Fetch et al. 2021). The leaf rust inoculum consisted of a mixture of prevalent races isolated from the western Canadian prairies as determined from yearly survey studies (McCallum et al. 2021). Resistance to races L1, L16, T1, T6, T13, and T19 of common bunt *Tilletia laevis* Kühn in Rabenh. and *Tilletia tritici* (Bjerk.) G. Wint. in Rabenh. (Hoffman and Metzger 1976) were evaluated in the High Yield Wheat Cooperative Registration Test. End-use quality was assessed at the Grain Research Laboratory, Canadian Grain Commission, using methods approved by the American Association of Cereal Chemists (American Association of Cereal Chemists 2000) each year on composite grain samples as per approved protocols (http://pgdc.ca/committees_wrt_pd.html).

Data presented here were analysed using the PROC MIXED procedure in SAS version 9.4 (Littell et al. 2006), with replications, sub-blocks, zones, locations, and years considered as random effects and entries considered as fixed. The *diff* command was used to estimate the standard error of the difference between entries, which in turn was used to estimate an F-protected least significant difference at a significance level of 5% (LSD_{0.05}). For end-use quality data, years were considered as replications.

Performance

Agronomy

On average CDC Reign yielded 18% more than Glenn, 1% more than AAC Foray, and 2% more than CDC Terrain in three years of testing in the High Yield Wheat Cooperative Registration Test (Table 1). CDC Reign was shorter than all the check cultivars and expressed stronger straw than AAC Foray and CDC Terrain (Table 2). Test weight was at least 2 kg hL⁻¹ higher than AAC Foray and CDC Terrain, but lower than Glenn (Table 2). Kernel weight was within the range of the checks (Table 2). The protein concentration of CDC Reign was 0.8% higher than AAC Foray, 0.6% higher than CDC Terrain, and 0.8% less than Glenn (Table 2).

Disease

CDC Reign is resistant to leaf rust and moderately resistant to stem rust (Table 3). Stripe rust reaction was variable and ranged from intermediate (I) to resistant (R) (Table 3). The

Table 1. Grain yield (kg ha⁻¹) of CDC Reign and check cultivars in the High Yield Wheat Cooperative Registration Test (2016–2018).

Cultivar	Zone 1				Zone 2				Zone 3				Zone 4				Mean of three years
	2016	2017	2018	Mean	2016	2017	2018	Mean	2016	2017	2018	Mean	2016	2017	2018	Mean	
Glenn	3895	6142	4821	4953	3859	3953	3642	3818	5822	4860	4390	5024	6719	6985	6499	6734	4803
AAC Foray	4384	6507	5552	5481	4752	4263	4098	4371	7376	5967	5472	6272	8075	8344	7646	8022	5639
CDC Terrain	3855	6467	5786	5369	4715	4387	4495	4532	6885	5888	5488	6087	7608	8122	8479	8070	5576
CDC Reign	4530	6629	5793	5651	4848	4209	4221	4426	6863	6360	5603	6275	8192	7599	8037	7943	5683
CV (%)	9.2	4.7	5		6.3	4.7	6		4.8	7.3	9.2		4.8	4.3	5.9		8.3
LSD _{0.05} ^a	309	340	230		205	252	178		258	396	671		484	672	644		178
No. of tests	4	4	4		5	3	5		4	5	5		1	1	1		42

Note: Zone 1: Brandon, Souris, Indian Head, Rosebank; Zone 2: Kamsack, Kernen, Pense, Scott, Swift Current; Zone 3: Beaverlodge, St. Albert, Lacombe, Melfort, Morrin (2017 and 2018); Zone 4: Lethbridge (irrigated).
^aLeast significant difference at 5% significance level.

Table 2. Agronomic performance of CDC Reign and check cultivars in the High Yield Wheat Cooperative Registration Test (2016–2018).

Cultivar	Maturity (days)	Height (cm)	Lodging (1–9) ^a	Test weight (kg hL ⁻¹)	1000-kernel weight (g)	Protein (%)
Glenn	102.8	90	1.9	82.1	35.7	14.4
AAC Foray	104.3	89	2.4	78	44.5	12.8
CDC Terrain	104.2	88	2.4	77.7	41.5	13
CDC Reign	104.8	84	1.9	80	36	13.6
CV (%)	1.9	4.1	24	2.5	7.8	2
LSD _{0.05} ^b	0.8	1.5	0.3	3.7	5.8	0.5
No. of tests	42	44	19	43	43	43

^aLodging score on a scale of 1–9, where 1 = vertical and 9 = flat.^bLeast significant difference at 5% significance level.**Table 3.** Reaction to leaf, stem, and stripe rusts, and common bunt of CDC Reign and check cultivars in the High Yield Wheat Cooperative Registration Test (2016–2018).

Cultivar	Leaf rust			Stem rust			Stripe rust			Common bunt		
	2016	2017	2018	2016	2017	2018	2016	2017	2018	2016	2017	2018
Glenn	22I	10I	4R	7R	5R	5MR	30I	20I	20I	3R	3MR	13MR
AAC Foray	4R	9I	0.3R	5R	5R	1R	25I	5R	6R	2R	15I	28MS
CDC Terrain	7I	13I	3.8R	10MR	5R	10I	15MR	0R	2R	0R	2MR	0R
CDC Reign	9I	0R	0R	15MR	30MR	20MR	25I	TR	26I	30MS	24MS	45S

Note: Numbers indicate, severity % of rust infection on the plant for the rusts and % of spikes with bunt symptoms for common bunt. R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible; T, trace.

Table 4. Reaction of CDC Reign and check cultivars to *Fusarium* head blight in the High Yield Wheat Cooperative Registration Test (2016–2018).

Year	Cultivar	Carmen				Morden				Ottawa	
		Index ^a	DON	ISD ^b	Rating	Index ^a	DON	ISD ^b	Rating	Index ^a	DON
2016	Glenn	11	26	17	MR	23	22	16	MR	42	5
	AAC Foray	33	60	38	MS	60	29	21	I	72	11
	CDC Terrain	13	33	22	MR	52	35	24	MS	70	7
	CDC Reign	17	33	22	I	36	24	17	MR	65	5
2017	Glenn	16	20	14	MS	27	11	9	MR	40	5
	AAC Foray	29	16	12	I	55	17	13	I	60	18
	CDC Terrain	34	24	17	MS	58	24	17	MS	54	17
	CDC Reign	18	18	13	I	40	15	11	I	35	10
2018	Glenn	11	2	3	MR	17	4	4	MR	—	—
	AAC Foray	18	10	8	MS	39	6	6	I	39	—
	CDC Terrain	35	13	10	MS	43	12	10	MS	51	—
	CDC Reign	13	7	6	MS	27	6	5	I	37	—

Note: R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible. DON (mg kg⁻¹), deoxynivalenol; —, data not available.

^a*Fusarium* head blight index: (% infected spikelets × % infected heads)/100.

^bISD (incidence/severity/DON) = (0.2 × mean incidence) + (0.2 × mean severity) + (0.6 × DON).

FHB reaction of CDC Reign ranged from moderately susceptible (MS) to moderately resistant (MR), with the majority of ratings being an “I” (Table 4). The deoxynivalenol (DON) concentration (mg kg⁻¹) across nine FHB nurseries was lower for CDC Reign than for AAC Foray and CDC Terrain (Table 4). CDC Reign is susceptible to common bunt (Table 3).

End-use quality

CDC Reign expressed higher grain protein concentration in composite samples over 3 years of testing than AAC Foray and CDC Terrain (Table 5). Falling number of CDC Reign was

within the range of the check cultivars (Table 5). Flour yield (0.5% ash basis) was like Glenn, and the ash content of CDC Reign was lower than CDC Terrain (Table 5). Farinograph dough development time of CDC Reign was lower than all the check cultivars. In contrast, extensograph dough maximum resistance and mixing energy of CDC Reign were higher than all the checks (Table 6). Loaf volume (cm³) of CDC Reign was higher than AAC Foray and CDC Terrain and the loaf top ratio was higher than all of the checks, except Glenn (Table 6). The remaining dough and baking properties of CDC Reign were within the range of the checks (Table 6).

Table 5. Average values for quality attributes measured on yearly composite samples for CDC Reign and check cultivars from the High Yield Wheat Cooperative Registration Test (2016–2018).

Cultivar	Grain protein (%)	Flour protein (%)	Protein loss (%)	Falling number (s)	Amylograph viscosity (BU) ^a	Milling performance			
						Flour yield (%)	Flour yield 0.5 ash (%)	Flour ash (%)	Starch damage (%)
Glenn	14.2	13.7	0.6	330	567	75.5	79.0	0.40	8.5
AAC Foray	12.9	11.8	1.1	433	665	76.0	78.5	0.41	7.9
CDC Terrain	12.9	12.2	0.7	412	502	76.2	75.7	0.47	7.2
CDC Reign	13.5	12.6	0.9	370	457	76.5	79.3	0.39	8.2
LSD _{0.05} ^b	0.36	0.30	0.16	47	181.7	0.78	0.94	0.02	0.47

^aAmylograph viscosity expressed in Brabender units (BU).

^bLeast significant difference at 5% significance level.

Table 6. Average values for dough properties and baking qualities measured on yearly composite samples for CDC Reign and check cultivars from the High Yield Wheat Cooperative Registration Test (2016–2018).

Cultivar	Dough properties						Baking quality				
	Farinograph			Extensograph			Lean no time method ^a				
	Abs. (%)	DDT (min)	Stability (min)	Area (cm ²)	R _{max} (BU) ^b	Length (cm)	Baking Abs. (%)	Peak time (min)	Mixing energy (W h kg ⁻¹)	Loaf volume (cm ³)	Loaf top ratio
Glenn	65.7	8.08	11.0	148	649	19.0	73	4.0	10.1	867	0.64
AAC Foray	63.5	7.83	20.7	115	597	15.7	71	4.2	10.5	760	0.57
CDC Terrain	61.1	7.17	8.5	122	590	17.1	68	3.6	9.4	757	0.55
CDC Reign	61.4	3.00	11.5	146	746	16.4	70	5.9	14.5	785	0.63
LSD _{0.05} ^c	1.17	1.51	8.99	16.9	80.7	1.68	1.3	0.46	2.02	22	0.04

Note: Abs., absorption; DDT, farinograph dough development time measured in minutes.

^aSee Dupuis and Fu (2017).

^bMaximum resistance expressed in Brabender units (BU).

^cLeast significant difference at 5% significance level.

Other characteristics

SPIKES

Spikes of CDC Reign express weak to medium glaucosity at heading, have tapering shape in profile, medium density, yellow at maturity, erect attitude, and dense hairiness of convex surface of apical rachis segment. Spikes express white awns that are shorter than the spike with a spreading attitude; the glumes and their lower width are medium, glabrous; glume shoulders are medium width with straight to strongly elevated shape with second point present; long, moderately curved glume beak; straight to slightly curved lemma beak.

KERNELS

Kernels are medium red in colour, medium in size and length, between medium and wide width, ovate shape; cheeks are rounded; crease is medium to wide, and mid-deep to deep; brush size is between medium and large; the embryo is medium sized with round or broad elliptical shape.

END-USE SUITABILITY

CDC Reign is eligible for the Canada Prairie Spring Red wheat market class grades.

Maintenance and distribution of pedigreed seed

Approximately 200 single spikes of CDC Reign were selected from an F_{5:10} increase grown at Saskatoon in 2016. The

spikes were threshed and grown as single 1 m F_{10:11} row plots in 2017. Off-type rows were discarded, and the remaining head rows were harvested individually and used to establish one hundred ninety-seven 27 m rows in 2018. Again, off-type rows were discarded and the remainder were bulk harvested to produce breeder seed. In total, 181 F_{10:12} breeder lines were composited to form the breeder seed. Breeder seed will be maintained by the CDC, University of Saskatchewan, Saskatoon, SK S7N 5A8, Canada. Distribution and multiplication of pedigreed seed stocks will be handled by FP Genetics Inc., 426 McDonald Street, Regina, SK S4N 6E1, Canada; phone: +1-306-791-1045; fax: +1-306-791-1046; website: <https://www.fpgenetics.ca/contact.php>; email: info@fpgenetics.ca.

Author Notes

J.M. Clarke is deceased.

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Data availability

All data supporting this manuscript are included in the manuscript text.

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Author contributions

CP: conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project admin-

istration, resources, supervision, validation, and writing—review and editing.

JC: conceptualization, investigation, and methodology.

JH: formal analysis, investigation, methodology, writing—original draft, and writing—review and editing.

TH: formal analysis, and writing—review and editing.

Competing interests

The authors declare that there are no competing interests.

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