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CULTIVAR DESCRIPTION

Zealand hard red spring wheat

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Abstract: Zealand hard red spring wheat (*Triticum aestivum* L.) was developed using a modified bulk breeding method at the University of Alberta in Edmonton, AB. Zealand is an apically awn-letted, hollow-stemmed cultivar with a combination of high yield potential, tall plant type, large leaves, and early maturity. In three years of testing in the Western Bread Wheat Cooperative Registration Test during 2013–2015, Zealand exhibited grain yield similar to Glenn and Carberry and 5%–6% lower than Unity and AAC Viewfield, though this difference was not significant ($p > 0.05$). Zealand yielded 37% greater than the highest-yielding Canada Western Red Spring (CWRS) check, CDC Osler, in A-level testing at a certified organic farm. Zealand matured 1–4 d earlier and was taller than all the check cultivars, but exhibited lodging resistance better than Unity and similar to the other checks. The test weight of Zealand (79.1 kg hL^{-1}) was lower than Glenn and similar to the other checks, while its seed mass was in the range of the check cultivars. Overall, Zealand was rated as resistant (R) to the prevalent races of leaf rust, moderately resistant (MR) to stripe rust and loose smut, intermediate (I) to stem rust and leaf spot, and moderately susceptible (MS) to common bunt and *Fusarium* head blight. Three years of end-use quality evaluation indicated that Zealand is acceptable for the CWRS class, with relatively few weaknesses. The tall plant type, large leaves, and early maturity render Zealand suitable for organic/high weed environments.

Key words: Triticum aestivum L., Canada Western Red Spring, rust resistance, lodging resistance, organic.

Résumé : Zealand est une variété de blé roux vitreux de printemps (*Triticum aestivum* L.) créée au moyen d'une méthode d'hybridation de masse modifiée à l'Université de l'Alberta d'Edmonton (Canada). Zealand est un cultivar à tige creuse, faiblement aristé au sommet. Le plant, de taille élevée, a de grandes feuilles et parvient rapidement à maturité. Au cours des trois années d'essais d'homologation de la Western Bread Wheat Cooperative, de 2013 à 2015, Zealand a donné un rendement grainier similaire à celui de Glenn et de Carberry, mais de 5 à 6 % inférieur à celui d'Unity et d'AAC Viewfield, même si l'écart n'était pas significatif ($p > 0{,}05$). Zealand a produit 37 % plus de grains que CDC Osler, le meilleur cultivar témoin pour le blé de la classe CWRS, lors des essais de niveau A dans une ferme certifiée pour l'agriculture biologique. Zealand parvient à maturité un à quatre jours plus tôt que les cultivars témoins, qu'il dépasse en hauteur. Sa résistance à la verse est supérieure à celle d'Unity et semblable à celles des autres témoins. Zealand a un poids spécifique (79,1 kg par hL) inférieur à celui de Glenn, mais similaire à celui des autres variétés témoins, et la masse de ses grains se situe dans la plage des cultivars témoins. De manière générale, Zealand résiste aux races courantes de rouille de la feuille et est modérément résistant à la rouille jaune ainsi qu'au charbon nu. La variété présente une résistance intermédiaire à la rouille de la tige et à la tache des feuilles, et est modérément sensible à la carie de même qu'à la brûlure fusarienne de l'épi. Après trois années d'évaluation de la qualité selon l'usage final, Zealand peut être classé dans la catégorie « blé roux de printemps de l'Ouest canadien » (CWRS), avec relativement peu de faiblesses. La hauteur du plant, ses grandes feuilles et sa précocité en font une variété qui convient à la culture biologique et à la production des endroits très infestés de mauvaises herbes. [Traduit par la Rédaction]

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Mots-clés : Triticum aestivum L., blé roux de printemps de l'Ouest canadien, résistance à la rouille, résistance à la verse, biologique.

Introduction

Zealand, a hard red spring wheat (*Triticum aestivium* L.), was developed at the University of Alberta in Edmonton, AB, and is well adapted to the wheat-growing regions of western Canada, particularly organically managed or high weed environments. Zealand is an early-maturing, tall, high-yielding cultivar with good lodging resistance compared with cultivars of similar height. It has all the quality characteristics necessary for the Canada Western Red Spring (CWRS) wheat class, with good stripe and leaf rust resistance. Zealand was issued registration no. 8123 by the Variety Registration Office, Plant Production Division, Canadian Food Inspection Agency, Ottawa, ON, on 10 Nov. 2016.

Pedigree and Breeding Methods

Zealand was developed using a modified bulk breeding method. The F_1 generation was a simple cross between Alvena, a CWRS wheat cultivar (Knox et al. 2008) and a CIMMYT-derived putative *Fusarium* head blight (FHB) resistant line (IAS64/ALDAN//URES/3/TNMU/4/TNMU) selected from a nursery grown in Edmonton in 2005. Thirty F_1 seeds derived from crossing during the winter of 2007–2008 were planted in the field at the University of Alberta Edmonton Research Station (ERS) in Edmonton in the summer of 2008. The F_2 generation was grown in two 25 m row plots near Lincoln, New Zealand, in the winter of 2008–2009, where single plants were selected based on plant type, height, maturity, and rust resistance. One hundred and five 2-m-long F_3 head-rows were grown in a leaf rust (*Puccinia triticina* Erikss.) nursery at ERS during the summer of 2009 and 60 head-rows were selected on the basis of plant type, maturity, lodging, and disease resistance. Single heads from the selected rows were grown as F_4 head-rows in New Zealand in the winter of 2009–2010, where a line designated UAW0848 * F4MBK006 was selected on the basis of plant type, early maturity, straw strength, and reaction to stripe and leaf rust. Seeds (F_5) from this bulked, harvested head-row were grown as a single entry in an un-replicated preliminary yield trial in Edmonton; leaf rust, common bunt [*Tilletia laevis* Kühn in Rabenh. and *Tilletia tritici* (Bjerk.) G. Wint. in Rabenh.], and leaf spot nurseries in Edmonton; and a stripe rust (*Puccinia striiformis* Westend.) nursery near Creston, BC, in 2010. Based on cumulative agronomic, disease resistance, and quality data, this line was evaluated in replicated yield trials at one Saskatchewan and five Alberta environments in 2011. UAW0848 * F4MBK006 was evaluated in the Parkland B Test in 2012 as entry number 15 and subsequently evaluated as BW986 in the Western Bread Wheat Cooperative (WBWC) Test from 2013 to 2015.

Evaluation in the WBWC registration tests followed protocols described by the Prairie Recommending Committee for Wheat, Rye and Triticale (PRCWRT 2013). Agronomic performance was evaluated in a 30-entry multi-environment trial conducted during 2013–2015 at a total of 38 sites. The trials were conducted in a rectangular lattice design with three replications per environment. The data for the test were analyzed for individual years and combined following a mixed model design in SAS (SAS Institute Inc. 2003), with environments and replications as random effects and genotype as a fixed effect. Response to stem rust (*Puccinia graminis* Pers.: Pers. f. sp. *tritici* Erikss. & E. Henn.) was assessed at the seedling stage and in the field using seven stem rust races: TPM, RHT, TMR, RKQ, QTH, RTH, and MCC. For leaf rust assessment, representative leaf rust races from previous years were used at both the seedling and adult plant stages. Field evaluation of leaf and stem rust was carried out annually in epiphytotic nurseries near Glenlea and Winnipeg, MB, in 2013–2014 and in Brandon and Morden, MB, in 2015. Resistance to FHB [*Fusarium graminearum* Schwabe; teleomorph *Gibberella zeae* (Schwein.) Petch] was assessed using a visual index (% incidence × % severity/100) following inoculation of field nurseries at Carmen and Morden, MB, with a macroconidial suspension (Gilbert and Woods 2006). Loose smut resistance was assessed by injecting prevalent races of *Ustilago tritici* (Pers.) Rostr. into the florets of plants at anthesis in the field and subsequently growing the inoculated seed in the greenhouse (Menzies et al. 2003). Response to common bunt was evaluated by inoculating seed with prevalent races of common bunt and planting in mid-April of each year in Lethbridge, AB (Gaudet and Puchalski 1989).

End-use quality analyses were carried out at the Grain Research Laboratory, Canadian Grain Commission, Winnipeg, MB, following standard protocols of the American Association of Cereal Chemists (AACC 2000). The Canadian Grain Commission first determined the grain grade and protein concentration for the check cultivars at all test locations and then devised a common site-blending formula for the checks and candidate cultivars to develop composite samples. Grain samples from test locations with serious down-grading factors were not included in the composites.

Plant descriptive characteristics were recorded from a three-replicate trial conducted in a randomized complete block design at the University of Alberta Research Farm in Edmonton, AB, during 2015 and 2016. This trial included the reference cultivars Alvena, AC Intrepid (DePauw et al. 1999), AC Splendor (Fox et al. 2007), and CDC Teal (Hughes and Hucl 1993). All characteristics were recorded as prescribed in the Objective

Table 1. Means of agronomic traits of Zealand and check cultivars in the Western Bread Wheat Cooperative Registration Test (2013–2015).

Cultivar	Yield (kg ha^{-1})	Yield (% check)[a]	Maturity (d)	Lodging (1–9)	Height (cm)	Test weight (kg hL^{-1})	Seed mass (g 1000^{-1})	Protein (%)
Katepwa[b]	3736	87.9	96.0	3.2	102	77.9	33.1	14.4
Unity (Pure Sm1)	4315	101.6	96.7	2.8	98	80.1	34.5	14.1
Glenn	4163	98.0	99.0	1.7	93	82.6	34.4	14.2
Carberry	4147	97.6	99.7	1.4	85	79.9	35.6	14.5
AAC Viewfield	4367	102.8	99.7	1.3	80	80.8	33.7	14.3
Zealand	4123	97.1	95.7	2.2	101	79.1	34.9	14.5
LSD (0.05)	452	—	1.5	0.9	4	1.1	2.0	0.5
CV (%)	7	—	1.5	19	4	1	3.8	3.3
No. of environments	37	—	34	30	37	38	38	38

Note: LSD, least significant difference ($p > 0.05$); CV, coefficient of variance.
[a]Percent of checks mean, excluding Katepwa.
[b]Katepwa used only as a historical check and was not used in calculating the means of the checks.

Description Form of the Variety Registration Office, Canadian Food Inspection Agency.

Performance

In 3 yr of testing in the WBWC Registration Test during 2013–2015, Zealand exhibited the same grain yield as Glenn and Carberry, but 5%–6% less grain yield than Unity and AAC Viewfield, although this difference was not significant ($p > 0.05$) (Table 1). Zealand matured 1–4 d earlier than the check cultivars and was 3–21 cm taller than all checks, but exhibited lodging resistance better than Unity and similar to the other checks (Table 1). The test weight of Zealand (79.1 kg hL^{-1}) was 0.8–3.5 kg hL^{-1} lower than the checks, while its seed mass was in the range of the check cultivars (Table 1).

The tall plant type, large leaves, and early maturity render Zealand suitable for organic or high weed environments (Mason et al. 2007). This is suggested by the fact that Zealand yielded 37% greater than the highest yielding CWRS check cultivar, CDC Osler, in one location–year with A-level testing at a certified organic farm prior to B-level testing (Table 2).

Table 2. Grain yield of Zealand versus checks in an advanced yield trial with 75 entries grown on a certified organic farm near Lamont, AB, in 2011.

Cultivar	Yield (kg ha^{-1})	Yield (% checks)[a]
AC Splendor	1598	102
Katepwa	1567	100
CDC Osler	1761	112
CDC Teal	1358	86
5701PR[b]	2608	166
Zealand	2405	153
Checks mean	1571	—
CV (%)	23	—
LSD (0.05)	676	—

Note: CV, coefficient of variance; LSD, least significant difference ($p > 0.05$).
[a]Percent of checks mean, excluding 5701PR.
[b]5701PR belongs to the Canada Prairie Spring Red wheat class.

Other Characteristics

Botanical description

At the seedling stage, Zealand has erect to semi-erect growth habit and has glabrous lower leaf blade and sheath. Zealand has medium to dark green flag leaves with glabrous blades and sheaths, and no waxiness on the flag leaf blade. The flag leaf of Zealand is wide, upright in attitude, lacks anthocyanin coloration of the auricles, and has glabrous to slightly pubescent auricle margins. Zealand has a hollow straight culm neck. Zealand has parallel-sided, medium dense spikes that are apically awnletted, erect, and white at maturity. The lower glume of Zealand has a rounded to square shoulder, is slightly pubescent, and has an acute beak. The lowest lemma beak of Zealand is straight. The chaff color of Zealand is white at maturity. The kernels of Zealand are hard, light to medium red, medium in size and width, elliptical with rounded to slightly angular cheeks. It has a medium kernel brush with medium-long to long brush hairs. The kernel crease is narrow and shallow. Zealand has a small germ that is oval in shape.

Disease resistance

During the 3 yr of testing, Zealand was rated as resistant (R) in 2 yr and moderately resistant (MR) in 1 yr to the prevalent races of leaf rust (Table 3). Its reaction to loose smut was MR in 2 yr and R in 1 yr, whereas its reaction to stripe rust was intermediate (I) in 1 yr and R in 2 yr (Table 3). Zealand showed variable reaction, ranging from moderately susceptible (MS) to R to stem rust and common bunt over 3 yr of testing (Table 3). Zealand was rated as I to leaf spots. Based on the visual rating index of FHB, Zealand was rated as susceptible (S) in one, MS in three, and I in two environments (Table 4). The deoxynivalenol values of Zealand were in the range of Glenn and Carberry or lower (Table 4).

Table 3. Reaction of Zealand to rusts, bunt, loose smut, and leaf spot in the Western Bread Wheat Cooperative Registration Test (2013–2015).

		Stem rust		Leaf rust		Stripe rust		Common bunt		Loose smut		Leaf spot			
												Melfort		Swift Current	
Year	Cultivar	Sev.[a]	Rating[b]	Sev.	Rating	Sev.	Rating	Avg.	Rating	% inf.[c]	Rating	Score	Rating	Score	Rating
2015	Katepwa	15	MR	73.3	S	70	S	11.5	MR	0.0	R	8.7	MS	—[d]	—
2014	Katepwa	1	R	73.3	S	65	S	10.8	MR	4.4	R	8.3	MS	7.0	I
2013	Katepwa	1	R	70.0	S	60	S	10.8	R	0.0	R	9.0	MS	7.5	I
2015	Unity	25	I	30.0	MR	50	S	0.0	R	0.0	R	9.5	S	—	—
2014	Unity	3	R	46.7	MS	75	S	2.0	R	29.3	MR	7.3	I	7.3	I
2013	Unity	20	I	21.7	MR	15	R	1.0	R	38.5	I	7.7	I	7.5	I
2015	Glenn	10	MR	11.7	MR	20	I	4.5	R	2.2	R	8.0	I	—	—
2014	Glenn	7	MR	10.0	R	50	S	25.0	MS	40.4	I	8.0	I	8.5	MS
2013	Glenn	1	R	25.0	MR	15	R	10.3	R	22.7	MR	7.0	I	8.5	MS
2015	Carberry	5	R	5.0	R	10	MR	0.0	R	0.0	R	10.7	S	—	—
2014	Carberry	15	MR	0.7	R	5	R	15.8	I	0.0	R	8.0	I	7.5	I
2013	Carberry	1	R	3.7	R	15	R	1.3	R	8.3	R	7.7	I	9.0	MS
2015	AAC Viewfield	10	MR	3.7	R	20	I	21.3	I	0.0	R	9.5	S	—	—
2014	AAC Viewfield	2	R	5.0	R	5	R	11.3	MR	25.5	MR	7.7	I	7.5	I
2013	AAC Viewfield	3	R	11.7	MR	10	R	3.5	R	75.0	MS	7.3	I	7.8	I
2015	Zealand	5/10	R/I	10.0	R	25	I	0.0	R	0.0	R	8.0	I	—	—
2014	Zealand	25/30	I/MS	7.0	R	1	R	20.8	I	14.3	MR	7.0	I	7.3	I
2013	Zealand	20	I	11.7	MR	15	R	33.0	MS	27.3	MR	7.0	I	7.5	I
Overall	Zealand	—	I	—	R	—	MR	—	MS	—	MR	—	I	—	I

[a]Severity.
[b]R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible.
[c]Percent infection.
[d]—, not available.

Table 4. Reaction of Zealand to *Fusarium* head blight in the Western Bread Wheat Cooperative Registration Test (2013–2015).

		Morden					Carmen				
Year	Cultivar	VRI[a]	VRI rating[b]	DON[c] (ppm)	ISD[d]	ISD rating	VRI	VRI rating	DON (ppm)	ISD	ISD rating
2015	Katepwa	52.0	I	30.4	21.1	I	25.9	I	10.5	8.5	—[e]
2014	Katepwa	60.3	S	28.1	20.0	R	12.6	MR	5.6	5.1	MR
2013	Katepwa	25.0	I	—	—	—	44.8	MS	—	—	—
2015	Unity	62.8	MS	43.1	29.0	MS	15.3	MR	7.0	6.0	—
2014	Unity	62.8	S	49.2	32.7	MR	21.2	I	16.0	11.5	MS
2013	Unity	20.3	I	—	—	—	39.1	I	—	—	—
2015	Glenn	55.0	MS	40.1	27.0	MS	11.0	MR	9.5	7.3	—
2014	Glenn	36.8	I	40.2	26.6	MR	6.2	MR	7.8	6.1	MR
2013	Glenn	9.7	MR	—	—	—	22.1	MR	—	—	—
2015	Carberry	44.3	I	24.4	17.4	I	15.7	MR	9.0	7.2	—
2014	Carberry	32.8	MR	40.5	26.7	MR	12.3	MR	10.0	7.8	I
2013	Carberry	16.7	I	—	—	—	20.8	MR	21.0	14.7	—
2015	AAC Viewfield	50.7	I	39.2	26.4	I	10.4	MR	17.0	11.9	—
2014	AAC Viewfield	32.2	MR	56.9	36.6	MR	23.2	I	12.5	9.7	I
2013	AAC Viewfield	14.7	I	—	—	—	34.0	I	—	—	—
2015	Zealand	64.0	MS	34.6	24.0	I	30.8	I	13.0	10.1	—
2014	Zealand	37.3	I	36.8	24.5	MR	42.6	MS	16.0	12.2	MS
2013	Zealand	29.3	MS	—	—	—	72.4	S	—	—	—

[a]VRI, visual rating index = $[(R_{1inc} \times R_{1sev})+(R_{2inc} \times R_{2sev})+(R_{3inc} \times R_{3sev})]/3$.
[b]R, resistant; MR, moderately resistant; I, intermediate; MS moderately susceptible; S susceptible.
[c]DON, deoxynivalenol.
[d]ISD, incidence + severity + DON = (0.2 × mean incidence + 0.2 × mean severity + 0.6 × mean DON).
[e]—, not available.

Table 5. Means of wheat and flour characteristics and milling performance parameters[a] for Zealand and checks from the Western Bread Wheat Cooperative Registration Test (2013–2015).

	Wheat and flour characteristics					Milling performance			
Cultivar	Grain protein (%)	Flour protein (%)	Protein loss (%)	Falling number (s)	Amylograph peak viscosity (BU)	Clean flour yield	Flour yield PB 0.50 ash	Flour ash (%)	Starch damage (mega-zeme)
AAC Viewfield	13.7	13.0	0.7	402	645	75.5	78.7	0.4	7.6
Carberry	14.1	13.2	0.9	387	540	75.4	79.2	0.4	7.6
Glenn	14.0	13.4	0.7	357	758	74.7	78.8	0.4	8.7
Unity (VB)	13.6	12.9	0.7	450	926	76.8	77.9	0.4	8.3
Zealand	13.9	13.3	0.6	423	510	76.0	78.3	0.4	7.2
Mean of checks	13.9	13.1	0.7	399	717	75.6	78.6	0.4	8.1
CV (%)	1.7	1.8	10.5	3	4.5	0.86	0.86	3.3	2.3
LSD ($P < 0.05$)[b]	0.4	0.4	0.1	19	47	1	1.1	0.02	0.3

Note: CV, coefficient of variance.

[a]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).

[b]LSD, least significant difference ($p > 0.05$); standard error of the difference between means × 1.96.

Table 6. Means of dough properties and baking quality parameters[a] for Zealand and checks from the Western Bread Wheat Cooperative Registration Test (2013–2015).

	Dough properties							Baking quality			
	Farinogram				Extensogram			Canadian short process[b]			
Cultivar	Absorption (%)	Dough development time (min)	Mixing tolerance index (BU)	Stability (min)	Area (cm^2)	R_{max} (BU)	Length (cm)	Absorption (%)	Mixing time (min)	Mixing energy (W h kg^{-1})	Loaf volume (cm^3 100 g^{-1})
AAC Viewfield	64.8	7.9	20.0	14.7	116	503	18.6	69.0	5.2	12.6	1020
Carberry	65.0	6.5	28.3	10.2	111	442	20.0	69.0	5.0	12.0	1030
Glenn	66.5	8.8	16.7	17.0	141	705	17.0	70.3	6.0	14.3	1055
Unity (VB)	65.2	5.1	27.5	7.5	91	395	18.0	68.7	4.3	10.5	1017
Zealand	65.5	5.9	20.0	10.5	110	475	19.0	70.0	4.3	9.6	1048
Mean of Checks	65.4	7.1	23.1	12.3	115	511	18.4	69.3	5.1	12.3	1031
CV (%)	0.86	19.6	19	20	6	3.7	3.4	0.9	4.1	3.3	1.7
LSD ($P < 0.05$)[c]	0.9	2.2	6.7	3.9	11	30	1.0	1.0	0.3	0.6	29

[a]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).

[b]Canadian short process (150 ppm ascorbic acid).

[c]LSD, least significant difference ($p > 0.05$); standard error of the difference between means × 1.96.

End-use quality

Three years of end-use quality evaluation (Tables 5 and 6) conducted by the Canadian Grain Commission, Grain Research Laboratory, indicated that Zealand is acceptable for all grades of the CWRS wheat class. The grain and flour protein of Zealand was similar to the check cultivars (Table 5). Protein loss on milling was significantly lower ($p < 0.05$) than Carberry, but similar to other checks. The falling number of Zealand was significantly ($p < 0.05$) higher than all checks except Unity (VB). Its amylograph peak viscosity was lower than all checks except Carberry. The clean flour yield of Zealand was significantly higher than Glenn and its starch damage was lower than all checks. Extensogram characteristics of Zealand are similar to AAC Viewfield and stronger than Carberry. The farinograph absorption of Zealand was lower than Glenn but similar to other checks, whereas its Canadian short process absorption was similar to Glenn but higher than other checks. The dough development time of Zealand was shorter than Glenn but similar to other checks. Its mixing tolerance index was similar to AAC Viewfield and Glenn but lower than Carberry and Unity (VB). The farinograph stability of Zealand was similar to Carberry and Unity (VB) but shorter than AAC Viewfield and Glenn. The Canadian short process mixing time of Zealand was similar to Unity (VB) but significantly shorter than the other checks, whereas its mixing energy was lower than all the checks. The loaf volume of Zealand was significantly higher than Unity (VB) but similar to the other checks.

Maintenance and Distribution of Pedigreed Seed

Breeder Seed of Zealand was created from 150 $F_{8:10}$ heads taken from the Parkland B test seed increase at Edmonton, AB, in 2011. These heads were planted as head-rows in Edmonton in 2014. Of these, 62 rows were discarded due to non-uniformity and (or) the presence of off-types and 88 (about 100–200 g of seed per row) were harvested separately. From each head-row, 25 g were planted into 15 m rows at Edmonton in 2015. Twenty-seven (27) rows were eliminated due to non-uniformity and (or) the presence of off-types. Sixty-one (61) rows were harvested and bulked as 100 kg of clean Breeder Seed. Breeder Seed of Zealand will be maintained by the University of Alberta's Cereal Breeding Program, Edmonton, AB, Canada.

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