NRC Research Press

CULTIVAR DESCRIPTION

Conquer red spring wheat

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Abstract: Conquer, an orange wheat blossom midge (*Sitodiplosis mosellana* Géhin) resistant hard red spring wheat (*Triticum aestivum* L.), combines good agronomic performance with good resistance to leaf rust, stem rust, stripe rust, and common bunt. Conquer had similar maturity, acceptable straw strength, and higher test weight as compared with check cultivars. Based on end-use quality analyses, Conquer has acceptable quality for 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.

Résumé : La variété de blé roux vitreux de printemps (*Triticum aestivum* L.) Conquer résiste à la cécidomyie du blé (*Sitodiplosis mosellana* Géhin) et allie une bonne performance agronomique à une bonne résistance à la rouille des feuilles, à la rouille de la tige, à la rouille jaune et à la carie. Conquer se compare aux variétés témoins pour la précocité. Sa paille est aussi robuste mais son poids spécifique est plus élevé. Les analyses en regard de l'usage final indiquent que la qualité du grain est suffisante pour qu'on classe Conquer dans la catégorie « blé roux de printemps Canada Prairie ». [Traduit par la Rédaction]

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

Introduction

Conquer is an orange wheat blossom midge (*Sitodiplosis mosellana* Géhin) resistant hard red spring wheat (*Triticum aestivum* L.) cultivar developed by Agriculture and Agri-Food Canada (AAFC), Cereal Research Centre (CRC), Winnipeg, Manitoba released in 2010. It was granted registration number 6784 by the Variety Registration Office, Canadian Food Inspection Agency on 28 June 2010. Conquer is adapted to western Canada and fits into the Canada Prairie Spring Red (CPSR) wheat market class.

Pedigree and Breeding Methodology

Conquer was developed from the cross HY639/99 EPWA-Mdg 61, which was made at the AAFC Cereal Research Centre (CRC) in 1999. The objective of this cross was to develop a high yielding, Canada Prairie Spring Red (CPSR) wheat cultivar with high grain protein concentration and adapted to the eastern prairies with resistance to orange wheat blossom midge (OWBM) and hessian fly. HY639 was developed from the cross HY617BSR*2//ND643/HY617, where HY617 was the source of common bunt, smut, and rust resistance and ND643

Received 28 March 2016. Accepted 16 May 2016.

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Abbreviations: CPS, Canada Prairie Spring; **DON**, deoxynivalenol; **FHB**, *Fusarium* head blight.

(Glupro) was the source of the high protein gene *Gpc-B1* (Mesfin et al. 1999); 99EPWA-Mdg 61 was an F_9 line developed from the cross HWAlpha/Monon where Monon, a soft red winter wheat line, was the source of OBWM and hessian fly resistances.

A modified pedigree breeding method was used to develop Conquer. Thirty-four F_1 seeds were planted in the greenhouse during the winter of 1999. The F_2 seeds derived from individual F_1 plants were space-planted in 1.2 m^2 4-row plots in an early generation disease nursery at Glenlea, MB in 2000. Prior to planting, the F_2 seeds were inoculated with common bunt [caused by *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 (caused by *Puccinia triticina* Eriks. = *P. recondita* Roberge ex Desmaz.) and stem rust (caused by *Puccinia graminis* Pers.: Pers. f. sp. *tritici* Eriks. & e. Henn.). The F_2 plants that were rust or bunt susceptible, tall or prone to lodging, or late maturing, were discarded. Seeds from 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 2000–2001. After eliminating leaf rust susceptible and (or) tall or weak strawed plants, 600 F_3 heads were selected from agronomically desirable plants. These heads were threshed individually, the seed was visually inspected, and the resulting 456 F_4 heads were planted as rows in an artificially inoculated common bunt, leaf, and stem rust nursery near Portage la Prairie, MB in 2001. Based on visual disease and midge resistance, plant type, grain yield, and kernel appearance, F_5 seed from 232 head rows was advanced to the next generation.

The F_5 generation was planted in one meter rows near Palmerston North, New Zealand (2001–2002). These lines were concurrently screened for bunt resistance in the AAFC-CRC greenhouses and for basic quality (protein content, kernel hardness, and whole grain SDS sedimentation volume) at the CRC Cereal Quality Lab. Based on bunt resistance and quality data plus agronomic performance and disease resistance in New Zealand, 10 F_5 rows were harvested and sent back to Canada. In 2002, these 10 F_6 lines were planted in single-replicate yield trials with alternating checks every tenth plot at Glenlea, Brandon and Portage la Prairie, MB, and in rust/common bunt disease nurseries planted at Glenlea and Portage la Prairie. Fifteen heads were randomly collected from each F_6 line and five heads from each line were advanced for further purification and selection in New Zealand. Forty-nine F_7 head rows were planted near Palmerston North, New Zealand in 2002–2003 and 20 lines were selected based on selection criteria similar to those in the F_4 generation. Using the same treatment design as the F_6 yield trial, these $F_{6:8}$ lines were planted in 2003 F_8 Yield Trials planted at Glenlea, Brandon and Saskatoon, SK. Six F_9 lines were advanced to the 2004 Eastern Prairie Wheat (EPW)'A1' trials, a replicated yield trial grown at five locations and in disease nurseries. Based on agronomic performance, disease resistance, and quality analysis, two F_{10} lines were advanced to EPW 'B' tests grown at seven locations in 2005. One entry, EPWB05-43, was advanced to the High Yield Wheat Cooperative (HYWC) Registration tests as HY682 in 2006–2008.

As part of the registration tests, artificially inoculated field nurseries were used to determine reactions to leaf rust and stem rust at AAFC-CRC, Winnipeg, 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) 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 (caused by *Puccinia striiformis* Westend) was recorded based on natural field infection in stripe rust nurseries near Lethbridge, AB (Randhawa et al. 2012). *Fusarium* head blight (caused by *Fusarium graminearum*) 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). 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). 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.

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

Analyses of variance were conducted 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 from those of the check cultivars. For end-use quality data there were no replicated observations within years, hence standard deviation of the means is reported.

Performance and Adaptation:

Based on 44 station years of testing in the 2006–2008 HYWC Registration test, the grain yield of Conquer was higher than 5701PR across all zones within western Canada (Table 1). Overall, Conquer yielded about 6% higher than 5701PR (NS) and the same as 5702PR.

Conquer was similar in maturity to 5701PR and 5702PR. Conquer had acceptable straw strength, was 9.4 cm taller ($P \leq 0.05$) than 5701PR and 6.0 cm taller ($P \leq 0.05$) than 5702PR. Conquer had higher test weight

Table 1. Least square means for grain yield and agronomic characteristics of Conquer compared with check cultivars in the High Yielding Wheat Co-operative Registration Trials, 2006–2008.

	Grain yield						Agronomics				
Lines	Zone 1	Zone 2	Zone 3	Zone 4	Mean	% of 5701PR	Maturity	Height	Lodging	Test Wt	Thousand Kernel Wt
5701PR	4516	4178	4821	6669	4633	100	97.8	81.7	2.2	75.2	37.0
5702PR	4702	4472	5266	6707	4921	106	97.6	85.1	2.0	74.1	36.3
Conquer	4556	4555	5140	7112	4897	106	98.4	91.1	3.1	77.0	37.4
LSD	510	370	721	1203	294		2.0	2.5	0.7	1.0	1.6
Site Years	13	15	13	3	44	44	46	48	20	41	41

Note: Zone 1 = Brandon, Glenlea, Indian Head, Rosebank, and Souris; Zone 2 = Beiseker, Kernen, Regina, Scott, Swift Current, Watrous; Zone 3 = Beaverlodge, Ellerslie, Lacombe, Melfort, Vermilion; Zone 4 = Lethbridge.

Table 2. Reaction of Conquer to various diseases[a] compared with check cultivars in the High Yielding Wheat Co-operative Registration Trials, 2006–2008.

	Leaf rust			Stem rust			Common bunt			Loose smut		
Line	2006	2007	2008	2006	2007	2008	2006	2007	2008	2006	2007	2008
5701PR	2 R	0 R	3 R	1 R	Tr R	5 R	R	3 VR	24 I	31 I	30 MR	37 I
5702PR	15 MR	2 R	3 R	10 I	Tr R	15 I	VR	3 VR	20 I	43 I	33 MR	26 MR
Conquer	20 MR	3 R	27 MR	1RMR	Tr R	5 R	VR	0 VR	0 VR	63 MS	18 MR	37 I

[a]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 3. Reaction to Leaf spot diseases, wheat midge, and stripe rust of Conquer compared with check cultivars in the High Yielding Wheat Co-operative Registration Trials.

	Leaf spot-glenlea[a]			Midge (S/R/U)[b]				Stripe rust[c]	
	2006	2007	2008	2006	2007	2008		2013	2014
5701PR	37 MS	5 I	3.2 R	15-21 S	11-25 S	23-7 S	5700PR	85S	75S
5702PR	15 R	10 MS	6.3 I	5-27 S	0-34 S	25-11 S	AAC Foray	15R	5R
Conquer	7 R	12 MS	3.5 R	30-2 R	27-15 Seg	24-0 R	Conquer	1R	1R

[a]Caused by main leaf spotting pathogens: P. tritici-repentis, P. nodorum, M. graminicola, and C. sativus.
[b]Wheat midge caused by *Sitodiplosis mosellana* (Géhin): S, susceptible; R, resistant; U, undamaged.
[c]Data was collected from 2013 and 2014 HYW Coop tests with different check cultivars.

Table 4. FHB reaction of Conquer compared with check cultivars in the High Yielding Wheat Co-operative Registration Trials, 2006–2008.

	Glenlea-FHB Index			Carman-FHB Index			Ottawa-FHB Index			DON-2007 (ppm)	
Line	2006	2007	2008	2006	2007	2008	2006	2007	2008	Glenlea	Carman
5701PR	64 S	32 MS	15 I	16 I	8 MR	28 I	75	29	35	4.1	4.8
5702PR	27 MR	25 I	16 MS	18 I	13 MR	31 I	52	29	38	3.3	3.8
Conquer	33 I	44 S	10 I	37 MS	41 MS	59 S	47	11	23	0.8	9.0

than both check cultivars. It had slightly heavier kernels than both 5701PR and 5702PR (Table 1).

Conquer was resistant to stem rust, stripe rust, common bunt, moderately resistant to the prevalent races of leaf rust found in western Canada, and had an intermediate reaction to loose smut (Tables 2 and 3). Conquer was moderately susceptible to *Fusarium* head blight, similar to the check cultivars (Table 4). Based on

three years of registration trial screening, Conquer was resistant to (undamaged) the wheat midge, conferred by the presence of the gene, *Sm1* (Table 3) and confirmed by the presence of the molecular marker (Thomas et al. 2005). End-use quality (milling and baking) assessment by the Canadian Grain Commission showed that Conquer had acceptable quality for the CPSR wheat class (Tables 5 and 6). Redefinition of the CPSR class to increase gluten strength will see Conquer reclassified into the newly created Canada Northern Hard Red (CNHR) class as of August 2018.

Other Characteristics

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

Seedling characteristics

Coleoptile colour: absent
Juvenile growth habit: semi erect
Seedling leaves: medium green, glabrous
Tillering capacity (at low densities): Moderately high

Adult plant characteristics

Growth habit: erect
Flag leaf: dark green, glabrous, pronounced waxy blade, short length and narrow width, leaf auricle with weak anthocyanin and pubescent margin
Flag leaf attitude: intermediate
Culm colour: glabrous

Spike characteristics

Shape: semi-clavate
Length: medium
Density: medium
Attitude: nodding
Colour: white
Awns: awned; shorter than spike

Spikelet characteristics

Glumes: white at maturity; medium length and width; glabrous; medium width square shoulder, short length beak with acute shape

Kernel characteristics

Type: hard, red in colour
Size: large, long, medium width; elliptical shape; rounded cheeks; medium length brush hairs, mid-deep crease depth
Embryo: broad elliptical

Maintenance and Distribution of Pedigreed Seed

Breeder seed was produced by collecting F_6-derived F_{11} random heads from a rogued increase of Conquer grown at Regina, SK in 2006 and growing about 250 heads as one meter long head F_{12} rows in isolation at Portage in 2007. Two hundred forty-three F_{13} single-plant progeny lines were grown as single 15 m rows at Indian Head,

Table 5. Grain and milling characteristics of Conquer compared with check cultivars in the High Yielding Wheat Co-operative Registration Trials, 2006–2008.

	Grain			Milling								
	Test wt	Kernel wt	Wheat protein	Flour protein	Protein loss	Falling number	Amylograph peak	Flour yield	Flour ash	Flour color	Starch Dmg	Particle size index
2006												
5701PR	78.7	38.2	13.4	12.5	0.9	360	780	74.8	0.42	80	6.8	57
5702PR	78.7	36.7	12.6	11.5	1.1	390	685	75.1	0.39	87	7.6	56
Conquer	80.7	38.6	13.3	12.5	0.8	395	775	74.9	0.37	83	6.0	58
2007												
5701PR	80.2	38.2	13.2	12.4	0.8	430	935	76.0	0.41	85	6.5	58
5702PR	78.9	37.3	13.2	12.2	1.0	425	815	76.0	0.40	85	7.1	56
Conquer	81.7	38.3	13.0	12.2	0.8	455	935	75.2	0.39	84	6.4	60
2008												
5701PR	80.8	46.0	13.9	13.0	0.9	440	735	75.6	0.38	86	6.6	57
5702PR	80.2	45.5	13.5	12.5	1.0	390	590	76.6	0.40	81	7.6	55
Conquer	81.0	47.0	14.3	13.8	0.5	420	620	76.5	0.38	78	5.9	58

Table 6. Baking characteristics of Conquer compared with check cultivars in the High Yielding Wheat Co-operative Registration Trials, 2006–2008.

	Farinograph				Remix baking							
	Absorption	Dough development time	Mixing tolerance index	Stability	Absorption	Peak time	Energy Whr kg^{-1}	Loaf volume	Loaf volume per unit Protein	Loaf appearance	Crumb structure	Color
2006												
5701PR	61.6	26.8	5.0	37.5	61	2.9	5.0	950	-	8.4	5.4	5.8
5702PR	60.7	13.0	10.0	25.5	60	3.4	5.6	790	-	8.5	5.7	5.8
Conquer	60.3	17.3	12.5	25.8	60	2.8	4.9	875	-	8.4	5.4	5.8
2007												
5701PR	61.5	23.5	5.0	40.0	62	2.6	4.7	945	76.2	8.8	5.5	5.8
5702PR	60.4	11.0	15.0	26.8	62	3.2	5.6	890	73.0	8.8	5.5	6.0
Conquer	61.0	16.8	10.0	41.3	63	2.6	4.5	860	70.5	8.5	6.0	6.1
2008												
5701PR	64.2	25.5	5.0	31.0	66	2.7	5.4	1045	80	8.8	4.0	5.8
5702PR	64.0	9.8	15.0	15.0	64	3.1	6.3	860	69	8.5	5.3	5.8
Conquer	63.6	9.5	15.0	19.0	66	2.4	4.8	915	66	8.5	5.0	5.9

SK in 2008. After discarding off type rows, 227 uniform breeder lines were bulked to produce breeder seed. The breeder seed of Conquer will be maintained by the AAFC Seed Increase Unit, Indian Head, SK S0G 2K0, Canada. Multiplication and distribution of the pedigreed seed will be handled by CANTERRA SEEDS, 201-1475 Chevrier Boulevard, Winnipeg, MB R3T 1Y7, Canada (http://canterra.com). To preserve the effectiveness of the *Sm1* gene, as detailed in the Midge Tolerant Wheat Stewardship Plan (www.midgetolerantwheat.ca), Certified Seed of Conquer will include a 10% interspersed susceptible wheat refuge of AAC Crusader and will be designated as Conquer VB (varietal blend).

Acknowledgements

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 (AAFC-CRC, Winnipeg) and N. Edwards (Grain Research Laboratory, Canadian Grain Commission, Winnipeg) for end-use suitability analysis; A. Brule-Babel and R. Larios (University of Manitoba) for assessing reaction to *Fusarium* head blight; D. Gaudet, B. Puchalski, and T. Despins (AAFC-LRC, Lethbridge) for assessing reaction to common bunt and stripe rust; and D. Gehl, (AAFC-Seed Increase Unit, Indian Head, SK) for production of Breeder Seed.

References

Fetch, T.G. 2005. Races of *Puccinia graminis* on wheat, barley, and oat in Canada, in 2002 and 2003. Can. J. Plant Pathol. **27**: 572–580. doi:10.1080/07060660509507258.

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 tritici* 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. Pages 93–102 in T. Ban, J.M. Lewis, and E.E. Phipps, eds. The global Fusarium initiative for international collaboration: a strategic planning workshop. CIMMYT, El Batàn, Mexico; March 14–17, 2006. Mexico, D.F.: CIMMYT; Cross-ref Publication No. 7.

McCallum, B.D., and Seto-Goh, P. 2006. Physiologic specialization of *Puccinia triticina*, the causal agent of wheat leaf, in Canada in 2004. Can. J. Plant Pathol. **28**: 566–576. doi:10.1080/07060660609507335.

Menzies, J.G., Knox, R.E., Nielsen, J., and Thomas, P.L. 2003. Virulence of Canadian isolates of Ustilago tritici: 1964-1998, and the use of the geometric rule in understanding host differential complexity. Can. J. Plant Pathol. **25**: 62–72. doi:10.1080/07060660309507050.

Mesfin, A., Frohberg, R.C., and Anderson, J.A. 1999. RFLP markers associated with high grain protein from *Triticum turgidum* L. var. *dicoccoides* introgressed into hard red spring wheat. Crop Sci. **39**: 508–513. doi:10.2135/cropsci1999.0011183X003900020035x.

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., Laroche, A., and Gaudet, D.A. 2012. Stripe rust resistance among western Canadian spring wheat and triticale varieties. Can. J. of 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.

Thomas, J., Fineberg, N., Penner, G., McCartney, C., Aung, T., Wise, I., and McCallum, B. 2005. Chromosome location and markers of *Sm1*: a gene of wheat that conditions antibiotic resistance to orange blossom wheat midge. Mol. Breed. **15**: 183–192. doi:10.1007/s11032-004-5041-2.