

Broadview hard red winter wheat

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Graf, R. J., Thomas, J. B., Gaudet, D. A., Laroche, A. and Beres, B. L. 2012. **Broadview hard red winter wheat**. Can. J. Plant Sci. **92**: 177–181. Broadview is a hard red winter wheat (*Triticum aestivum* L.) cultivar that is well adapted to the Canadian prairies. Compared with the check cultivars (CDC Falcon, CDC Harrier) in the Western Winter Wheat Cooperative registration trials, Broadview produced grain yield similar to CDC Falcon, the highest yielding check. In the eastern prairie rust area, it yielded 2% and 7% more grain than CDC Falcon and CDC Harrier, respectively. Broadview had good winter survival, early maturity, short straw, good lodging resistance and high test weight. It exhibited very good resistance to stem and leaf rust, and is believed to be the first winter wheat cultivar in North America to deploy the *Lr21* leaf rust resistance gene. Broadview is eligible for all grades of the Canada Western General Purpose wheat class.

Key words: *Triticum aestivum* L., wheat (winter), cultivar description, doubled haploid, cold tolerance, stem rust, leaf rust

Graf, R. J., Thomas, J. B., Gaudet, D. A., Laroche, A. et Beres, B. L. 2012. **Le blé de force roux d'hiver Broadview**. Can. J. Plant Sci. **92**: 177–181. Broadview est une variété de blé (*Triticum aestivum* L.) de force roux d'hiver bien adaptée aux Prairies canadiennes. Comparativement aux cultivars témoins (CDC Falcon, CDC Harrier) testés dans le cadre des essais coopératifs de l'Ouest, Broadview a un rendement grainier similaire à celui de CDC Falcon, le cultivar témoin donnant le plus haut rendement. Dans l'est des Prairies, où sévit la rouille, cette variété a produit respectivement 2 % et 7 % plus de grain que CDC Falcon et CDC Harrier. Broadview survit bien à l'hiver et parvient à maturité hâtivement. La variété se caractérise par une paille courte, une bonne résistance à la verse et un poids spécifique élevé. Il démontre une très bonne résistance à la rouille de la tige et des feuilles, et on croit qu'il s'agit du premier cultivar de blé d'hiver à exprimer le gène de résistance à la rouille *Lr21* en Amérique du Nord. Broadview est admissible à toutes les classes de la catégorie « blé à des fins générales de l'Ouest canadien ».

Mots clés: *Triticum aestivum* L., blé (d'hiver), description de cultivar, double haploïdie, tolérance au froid, rouille de la tige, rouille des feuilles

Broadview hard red winter wheat (*Triticum aestivum* L.) was developed at the Agriculture and Agri-Food Canada (AAFC), Lethbridge Research Centre (LRC), in Lethbridge, AB. Broadview received registration No. 6785 from the Variety Registration Office, Plant Production Division, Canadian Food Inspection Agency on 2010 Mar. 30. An application for Plant Breeders' Rights has been filed.

Broadview is well adapted to the Canadian prairies. Based on very good stem and leaf rust resistance, the name for this cultivar was chosen to signify the broader mandate of the AAFC, LRC breeding program into the eastern prairie region. It was also chosen to recognize the expanded market potential of western Canadian winter wheat, represented by the creation of the Canada Western General Purpose (CWGP) class in August 2008. Broadview was among the first winter

wheat cultivars recommended for this new wheat class, established to facilitate grain production from high yielding cultivars that are of benefit to the livestock and bio-fuel industries.

Pedigree and Breeding Method

Broadview hard red winter wheat was selected from the cross KS92WGRC15/CDC Kestrel//CDC Falcon made at the AAFC, LRC in Lethbridge. The final cross was made in 1997. KS92WGRC15 is a germplasm release from the Wheat Genetic and Genomic Resources Center at Kansas State University with the pedigree TAM200/KS86WGRC02//Karl. First believed to possess a new leaf rust resistance gene (*Lr40*) derived from *Triticum tauschii* (Coss.) Schmalh. (Cox et al. 1994), KS92 WGRC40 was later shown to carry an allele of *Lr21* (Huang et al. 2003). The *Lr21* gene was first transferred to hexaploid wheat and then identified at the AAFC Cereal Research Centre in the 1970s (Rowland and

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Abbreviations: AAFC, Agriculture and Agri-Food Canada; CWGP, Canada Western General Purpose; DH, doubled haploid; LRC, Lethbridge Research Centre

Kerber 1974). CDC Kestrel and CDC Falcon are both registered winter wheat cultivars developed at the University of Saskatchewan, Crop Development Centre, with the pedigrees Norstar*2/Vona and S86-808/Abilene, respectively (Fowler 1997, 1999a). CDC Kestrel and S86-808 were developed from the same cross.

Following multiplication of the F₁ seed, vernalized F₂ seedlings were screened for resistance to stem rust (*Puccinia graminis* Pers.: Pers. f.sp. *tritici* Eriks. & E. Henn.) and leaf rust (*P. triticina* Eriks.). Further culling of undesirable phenotypes resulted in 47 donor plants being used to generate 358 field-ready doubled haploid (DH) lines via the maize hybridization technique (Fedak et al. 1997). A total of 53 DH lines were produced from the specific F₂ plant from which Broadview was derived. Initial field row evaluation took place in 2002, in which selection was based on winter survival, plant vigour, straw strength, plant height, protein content and test weight. Stem and leaf rust resistance were assessed from 2003 to 2005 in an artificially inoculated nursery grown in collaboration with the University of Manitoba in Winnipeg, MB. Based on excellent rust resistance in 2003, a line designated LE1911 was evaluated in an irrigated, single replicate preliminary agronomic trial in Lethbridge in 2004. Promising results prompted advancement into replicated trials across western Canada in 2005. LE1911 was subsequently designated W425 and evaluated in the Western Winter Wheat Cooperative (WWWC) registration trials in 2006 and 2007. It was recommended for registration by the Prairie Registration Committee for Wheat, Rye and Triticale in February 2008. W425 continued as a third year entry in the 2008 registration trials to facilitate additional and uninterrupted data collection in the event that it was made a new check cultivar for the CWGP wheat class.

Evaluation of suitability for registration in the WWC trials was relative to CDC Falcon and CDC Harrier (Fowler 1999b), which were the designated CWGP check cultivars. Agronomic trials were grown in Alberta (Beaverlodge, Lethbridge "dry land", Lethbridge "irrigated", Lacombe, Vauxhall, Warner), Saskatchewan (Indian Head, Melfort, Saskatoon), and Manitoba (Brandon, Carman) through the collaborative efforts of AAFC, Alberta Agriculture and Rural Development, the University of Saskatchewan, and the University of Manitoba. Disease and pest resistance was assessed by AAFC, the University of Manitoba, and the agronomic trial collaborators when differential responses for various pathogens were observed. End-use quality analysis was not performed during registration testing, as the CWGP class does not have any defined end-use quality parameters. MINITAB was used for the combined mixed model statistical analysis, in which the effects of environment were considered random and genotypes were fixed (MINITAB Inc. 2007).

During registration testing, resistance to the major diseases of economic importance to winter wheat in both

the western and eastern prairies was assessed. Adult plant reactions to stem and leaf rust were determined in inoculated field nurseries conducted by the University of Manitoba in Winnipeg. The composite of stem rust races used for 1 or more years included: QTHST (C25), RHTSK (C20), RKQSR (C63), RTHJT (C57), TMRTF (C95), TMRTK (C10) and TPMKR (C53) (Roelfs and Martens 1988; Fetch 2005). Each year, the leaf rust races used for inoculation were a representative mixture found in western Canada during the previous field season (McCallum and Seto-Goh 2008, 2009; McCallum et al. 2010). Reaction to common bunt [*Tilletia tritici* (Bjerk.) G. Wint. in Rabenh. and *T. laevis* Kühn in Rabenh.] was estimated in a nursery conducted by AAFC, LRC staff by inoculating seed with a composite of races that included L1, L16, T1, T6, T13, and T19 (Hoffman and Metzger 1976; Gaudet and Puchalski 1989) and planting into cold soil in October. The reactions to powdery mildew [*Blumeria graminis* (DC.) E.O. Speer] and unspecified leaf spotting pathogens were recorded by trial collaborators at naturally infected test sites expressing differential symptoms.

Performance

Grain yield and other agronomic data for Broadview are reported from replicated tests over 3 yr (2006 to 2008) in the WWC registration trials. Based on 26 sites of grain yield data from across the Canadian prairies, Broadview produced 3% more than CDC Harrier and was similar in performance to CDC Falcon (Table 1). On a regional basis, Broadview was best adapted to Zone 4 (eastern prairie rust area), where it was 7% higher yielding than CDC Harrier and 2% higher yielding than CDC Falcon. In Zone 1 (southern Alberta) and Zone 2 (parkland), Broadview yielded similar to CDC Falcon; Zone 3 (semi-arid prairie) did not report reliable grain yield data during the three years of evaluation.

Broadview exhibited good winter survival, similar to both checks (Table 2). On average, Broadview headed at the same time as CDC Falcon and matured 0.6 d later, but was earlier to head (-3.2 d) and reach maturity (-1.8 d) than CDC Harrier. Broadview was intermediate in height to CDC Falcon (+5.8 cm) and CDC Harrier (-13.4 cm); straw strength, as indicated by the lodging score, was similar to CDC Harrier, but weaker than CDC Falcon.

The test weight of Broadview was similar to CDC Falcon and significantly higher than CDC Harrier (Table 3). Kernel mass was significantly larger than CDC Falcon and equal to that of CDC Harrier. Broadview had grain protein content and protein yield per hectare similar to CDC Falcon and higher than CDC Harrier.

Broadview exhibited resistance to both stem and leaf rust (Table 4). Based on the disease reactions and parentage, molecular marker analysis was performed and corroborated the presence of genes *Sr24/Lr24* and *Lr21* (A. Laroche, unpublished data). Broadview is

Table 1. Grain yield ($t\ ha^{-1}$) of Broadview compared with the check cultivars, based on data from the Western Winter Wheat Cooperative registration trials (2006–2008)

Cultivar	Grain yield							
	2006	2007	2008	Mean ^z	Zone 1 ^y	Zone 2	Zone 3	Zone 4
CDC Falcon	5.295	4.967	6.116	5.403	5.877	4.282	–	5.711
CDC Harrier	5.021	4.976	6.010	5.271	5.576	4.596	–	5.424
Broadview	5.161	5.136	6.120	5.410	5.835	4.281	–	5.812
LSD ($P \leq 0.05$) ^x	0.458	0.456	0.498	0.239	0.335	0.446	–	0.518
No. of tests	10	9	7	26	12	7	–	7

^zAll means are weighted by the number of tests.

^yZone 1: Southern Alberta sites (Lethbridge “dry land”, Lethbridge “irrigated”, Vauxhall, Warner).

Zone 2: Parkland sites (Beaverlodge, Lacombe, Melfort).

Zone 3: Semi-arid prairie site (Swift Current).

Zone 4: Eastern prairie rust hazard sites (Brandon, Carman, Indian Head, Saskatoon).

^xLeast significant difference includes variation from the genotype by environment interaction.

believed to be the first winter wheat cultivar in North America to deploy *Lr21*, which has been highly effective against leaf rust in spring wheat (McCallum and Seto-Goh 2010). In 2006, Broadview demonstrated intermediate resistance to stripe rust (*Puccinia striiformis* Westend.) based on natural infection in numerous trials during the Canadian prairie epidemic (McCallum et al. 2007). The reactions to powdery mildew infection and leaf spotting diseases were equal to, or better than, the checks. Broadview was very susceptible to common bunt and should be treated with effective fungicides prior to planting (Table 4).

The CWGP wheat class does not have any defined end-use quality parameters; thus, end-use quality analysis was not performed during registration testing. Internal AAFC evaluation had previously deemed Broadview unsuitable for the high quality Canada Western Red Winter (CWRW) wheat class based on low grain protein content, gluten strength and flour yield.

Other Characteristics

Seedling Characteristics

Anthocyanin colouration of coleoptile: absent (green).

Intensity of coleoptile anthocyanin colouration: absent.

Juvenile growth habit: prostrate.

Pubescence of lower leaf sheaths: very slight pubescence.
 Pubescence of lower leaf blades: glabrous.
 Colour of lower leaf blade: medium to dark green.
 Tillering capacity (at low densities): medium high.

Plant Characteristics at Booting

Growth habit: erect to semi-erect.
 Flag leaf colour: dark green.
 Pubescence of flag leaf blade: glabrous.
 Waxiness of lower side of flag leaf blade: pronounced.
 Waxy bloom of flag leaf sheath: strong.
 Pubescence of flag leaf sheath: glabrous.
 Flag leaf width: medium.
 Flag leaf length: medium.
 Frequency of plants with recurved/drooping flag leaves: high.
 Flag leaf attitude: drooping (recurved).
 Anthocyanin colouration of flag leaf auricles: weak.
 Pubescence of flag leaf auricle margins: slightly pubescent.

Plant Characteristics after Heading

Shape of culm neck: straight.
 Waxiness of culm upper internode: medium.
 Pubescence of culm upper internode: glabrous.
 Pubescence of rachis margins: slightly pubescent.
 Anthocyanin colouration of straw at maturity: absent.

Table 2. Agronomic performance of Broadview compared with the check cultivars, based on data from the Western Winter Wheat Cooperative registration trials (2006–2008)

Cultivar	Winter survival (%)	Heading ^z (d)	Maturity ^z (d)	Height (cm)	Lodging ^y (1–9)
CDC Falcon	91	169.2	208.4	75.8	2.5
CDC Harrier	92	172.4	210.8	95.0	3.0
Broadview	91	169.2	209.0	81.6	2.9
LSD ($P \leq 0.05$) ^x	3	0.6	1.0	2.0	0.4
No. of tests	14	20	20	22	14

^zDays to heading and maturity expressed as day of year.

^yLodging scale: 1 = all plants vertical, 9 = all plants horizontal.

^xLeast significant difference includes variation from the genotype by environment interaction.

Table 3. Seed characteristics of Broadview compared with the check cultivars, based on data from the Western Winter Wheat Cooperative registration trials (2006–2008)

Cultivar	Test weight (kg hL ⁻¹)	Kernel mass (mg)	Grain protein ^z (%)	Protein yield (kg ha ⁻¹)
CDC Falcon	79.3	29.6	11.1	606
CDC Harrier	77.2	31.1	10.7	578
Broadview	79.5	30.8	11.1	611
LSD ($P \leq 0.05$) ^y	0.5	0.9	0.4	32
No. of tests	24	24	24	24

^zGrain protein content determined using whole grain NIR analysis.

^yLeast significant difference includes variation from the genotype by environment interaction.

Pith in cross-section of straw: hollow.

Stem colour at maturity: yellow.

Spike Characteristics

Shape: tapering.

Attitude at maturity: inclined.

Density: medium.

Length: medium.

Waxy bloom: very weak.

Colour at maturity: white.

Awedness: awned.

Length of awns at tip of spike: shorter than spike.

Awn colour: yellow.

Awn attitude: intermediate to strongly spreading.

Supernumary spikelets: absent.

Hairiness of convex surface of apical rachis segment: absent or very sparse.

Lower Glume Characteristics

Width: medium.

Length: medium-long.

Pubescence: very slightly pubescent.

Shape of shoulder: very slightly sloping.

Shoulder width: narrow.

Shape of beak: slightly curved.

Beak length: medium.

Extent of internal hairs: absent to very sparse.

Colour at maturity: light tan.

Kernel Characteristics

Type: hard red.

Colour: medium red.

Size: medium to large.

Length: medium.

Width: medium.

Shape: elliptical.

Cheek shape: rounded.

Length of brush hairs: short to mid-long.

Size of brush: small to large.

Germ shape: oval.

Germ size: small to mid-size.

Crease width: mid-wide.

Crease depth: mid-deep.

Phenol reaction: brown.

Maintenance and Distribution of Breeder Seed

Breeder Seed production was initiated by planting approximately 1000 spaced plants for increase and selection in summer 2008. Following elimination of uncharacteristic plants, each plant was harvested individually and subsequently grown in Lethbridge under irrigation as small plant progeny plots in 2009. Inspection of the progeny plots by the CFIA, in cooperation with the Canadian Seed Growers' Association, took place in mid-summer 2009 after removing off-type and contaminated plots. Bulk harvest of the plots produced 645 kg of cleaned Breeder Seed. The AAFC Seed Increase Unit at Indian Head, SK, will maintain the Breeder Seed of Broadview. All other classes of seed will be multiplied and distributed by Canterra Seeds Ltd., 201–1475 Chevrier Blvd., Winnipeg, Manitoba, Canada R3T 1Y7.

Table 4. Disease reactions of Broadview compared with the check cultivars, based on data from the Western Winter Wheat Cooperative registration trials (2006–2008)

Cultivar	Year	Stem rust ^z	Leaf rust ^z	Stripe rust ^z	Common bunt ^z	Powdery mildew ^y	Leaf spots ^{yx}
CDC Falcon	2006	30 MR	5 MR	2.3	50 VS	4.5	5.3
	2007	5 R-MR	15 I	–	58 VS	3.3	5.4
	2008	5 R-MR	10 MR	–	58 VS	3.0	–
CDC Harrier	2006	30 I	15 MS-S	3.8	77 VS	3.5	4.1
	2007	5 R-MR	70 MS-S	–	70 VS	3.7	4.9
	2008	10 I	50 MS-S	–	82 VS	3.0	–
Broadview	2006	5 MR	1 R	5.2	61 VS	3.0	4.0
	2007	1 R	1 R	–	48 VS	3.0	3.1
	2008 ^w	1 R	tr R	–	29 S	2.3	–

^zPercent infection and type of reaction: tr=trace, R=resistant, MR=moderately resistant, I=intermediate, MS=moderately susceptible, S=susceptible, VS=very susceptible.

^yRated using a 1–9 scale: 1=disease free, 9=very severe symptoms.

^xSpecific leaf spotting pathogens were not determined.

^wDue to a seeding error in the registration trial nursery, the stem and leaf rust ratings reported are from a nearby inoculated nursery.

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