

Registration of 'Cowboy' Wheat

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ABSTRACT

'Cowboy' (Reg. No. CV-1095, PI 668564) hard red winter wheat (*Triticum aestivum* L.) was developed by the Colorado Agricultural Experiment Station and released cooperatively by Colorado State University (CSU) and the University of Wyoming (UWYO) in August 2011. In addition to researchers at CSU and UWYO, USDA-ARS researchers at Manhattan, KS, St. Paul, MN, and Pullman, WA, participated in its development. Cowboy was selected from the cross CO980829/'TAM 111' made in 2001 at Fort Collins, CO. TAM 111 (PI 631352) is a hard red winter wheat cultivar released by Texas A&M University in 2002. CO980829 is an experimental line from CSU with the pedigree 'Yuma' (PI 559720)/PI 372129//CO850034/3/4*Yuma/4/NEWS12. Cowboy was selected as an F_{3:4} line in July 2005 and assigned experimental line number CO050322. Cowboy was released because of its superior grain yield and adaptation under nonirrigated and irrigated production systems in Wyoming and its milling and baking quality characteristics.

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Methods

Cowboy was developed using a modified bulk-breeding method. All early-generation population and line development was done in the greenhouse or field-testing environments in Colorado. The cross, designated as population X011673, was made in the greenhouse in fall 2001. The F₁ seed was harvested in January 2002. Following vernalization for 8 wk at 2°C,

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Abbreviations: CSU, Colorado State University; GI, germination index; UWYO, University of Wyoming.

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seedlings were hand-transplanted in May 2002, to a field nursery in the San Luis Valley at Center, CO. The F₁ plants were hand-harvested in bulk in early September 2002, and the F₂ seed was immediately planted in an unreplicated field nursery at Fort Collins, CO, in late September 2002. In July 2003, the F₂ population was harvested in bulk with a small-plot combine. A subsample of the grain was sieved using a Ro-Tap Test Sieve Shaker (W.S. Tyler) to select larger kernels and then planted in September 2003 in an unreplicated F₃ field nursery under sprinkler irrigation at Fort Collins and under nonirrigated conditions at Akron, CO. In July 2004, population X011673 was subject to random sampling of approximately 200 spikes at maturity. Spikes were threshed individually and planted in a sprinkler-irrigated headrow nursery in September 2004. On the basis of visual observations of uniformity, agronomic appearance, and resistance to stripe rust (caused by *Puccinia striiformis* Westend. f. sp. *tritici* Eriks.), experimental line CO050322 was selected from the headrow nursery as an F_{3,4} line in July 2005.

Cowboy was evaluated in unreplicated preliminary yield trials in 2006, the CSU Advanced Yield Nursery in 2007, the CSU Elite Trial from 2008 to 2011, statewide nonirrigated and irrigated variety trials in Colorado from 2010 to 2011 and Wyoming from 2010 to 2012, the Regional Germplasm Observation Nursery from 2009 to 2011, and the Southern Regional Performance Nursery in 2010 and 2011. The CSU Advanced Yield Nursery and CSU Elite Trials were arranged in latinized row-column designs with two replications, and the state variety trials were arranged in randomized complete block designs with three (Colorado) or four to five (Wyoming) replications.

Seed purification of Cowboy began in the 2008 crop year using visual identification and manual removal of tall and red-chaffed off-types from bulk increases grown under irrigation at Fort Collins. These included a small strip increase (1.5 by 9.8 m) in 2008, a pre-breeder seed increase in 2009 (1.5 by 49 m), and a breeder seed increase in 2010 (1.5 by 189 m). The breeder seed harvested in 2010 was used to plant a 1.2-ha foundation seed increase in September 2011, for harvest in the 2012 crop season.

All statistical analyses were performed with SAS-JMP Pro Version 10.0.0 (SAS Institute). Agronomic, disease resistance, and end-use quality data were analyzed by the Student's paired *t* test. Yield and grain volume weight data from the CSU Elite Trial and statewide variety trials were subjected to combined analyses of variance across years and locations using a mixed model with genotypes as fixed factors and location-year combinations and replications within location-year combinations as random factors. Only entries common to the trials across all location-years were included. Tukey's honestly significant difference test ($\alpha = 0.05$) was used to compare the least squares means for the genotype effects.

Characteristics

General Description

Cowboy is an awned, white-glumed, hard red winter wheat. It has medium-late maturity, 153.8 d to heading from 1 January, which is 0.5 d later ($P < 0.05$; $n = 55$) than its sib selection 'Denali' (PI 664256; Haley et al., 2012), 2.5 d later

than 'Hatcher' (PI 638512; Haley et al., 2005), and 4.1 d later than 'Ripper' (PI 644222; Haley et al., 2007). Plant height of Cowboy is medium-tall (81.0 cm; $n = 117$), 2.3 cm shorter ($P < 0.05$) than Denali and 2.7 cm shorter than Hatcher and Ripper. The coleoptile length (evaluated according to Hakizimana et al., 2000) of Cowboy (65.4 mm; $n = 10$) is medium-short, longer ($P < 0.05$) than that of 'Bill Brown' (PI 653260; Haley et al., 2008) (60.9 mm), similar to ($P > 0.05$) that of Hatcher (69.2 mm), and shorter than ($P < 0.05$) that of Denali (72.1 mm) and Ripper (82.6 mm). Straw strength of Cowboy is moderate (4.1 score, $n = 23$; 1–9 scale, where 1 = erect to 9 = flat), less than ($P < 0.05$) that of Denali (3.0 score) and 'Thunder CL' (PI 655528; Haley et al., 2009) (1.7 score). Preharvest sprouting tolerance of Cowboy, assessed through determination of a germination index (GI; Mares et al., 2005) from field-grown samples, is very good (GI = 0.26; $n = 13$), greater ($P < 0.05$) than that of Denali (GI = 0.40), Hatcher (GI = 0.41), Ripper (GI = 0.41), Thunder CL (GI = 0.56), and 'TAM 112' (PI 643143) (GI = 0.66). No objective data are available for winterhardiness of Cowboy, but field observations and performance under dry soil conditions during recent winters in Colorado and Wyoming suggest that it is at least adequate for successful production in the central Great Plains region.

Disease and Insect Resistance

Cowboy has been characterized for disease and insect resistance in Colorado and through cooperative evaluations of the USDA Regional Testing Program. In greenhouse seedling evaluations at St. Paul, MN, Cowboy was susceptible to moderately susceptible to stem rust (caused by *Puccinia graminis* Pers.:Pers f. sp. *tritici* Eriks. & E. Henn) races QTHJC, TTTTF, and TTKSK, and resistant to moderately resistant to stem rust races MCCFC, QCCSM, QFCSC, RCRSC, RKQQC, SCCSC, and TPMKC. Field adult-plant evaluations showed that Cowboy was moderately susceptible to North American stem rust races at St. Paul and moderately resistant to Ug-99 and its derivatives at Njoro, Kenya. Greenhouse seedling evaluations with leaf rust (caused by *Puccinia triticina* Eriks.) have shown that Cowboy is susceptible to moderately susceptible to most common leaf rust races in the United States (KFBJ, MFPS, MHDS, MLDS, THBJ, and TMGJ). Cowboy is postulated to have the *Lr14a* resistance gene based on low infection types to race TDBG and may have additional seeding resistance genes based on low infection types to races KFBJ and TNRJ. Cowboy had moderate to high leaf rust severity levels in plots at Castroville, TX, in 2010 and 2011, indicating that it lacked effective leaf rust resistance to the current *P. triticina* population. The reaction of Cowboy to stripe rust appears to be very similar to that of its sister selection Denali (described in Haley et al., 2012). Field tests under natural infection at various locations in Washington State, greenhouse seedling tests with selected races at low temperatures (4–20°C), greenhouse adult-plant tests with selected races at high temperatures (10–30°C), artificially inoculated field evaluations at Rossville, KS, and field evaluations under natural infection in Colorado suggest that Cowboy has a combination of seedling (or all-stage) resistance and high-temperature adult-plant (HTAP) resistance to stripe rust.

Other evaluations in Colorado or through the USDA Regional Testing Program have shown that Cowboy is moderately susceptible to *Barley yellow dwarf virus* and susceptible to *Wheat soilborne mosaic virus*. The reaction of Cowboy to *Wheat streak mosaic virus* is not known, although it lacks the DNA markers associated with *Wsm1* (Qi et al., 2007) and *Wsm2* (Lu et al., 2012). Cowboy is heterogeneous for resistance to a collection of endemic biotypes of the Hessian fly [*Mayetiola destructor* (Say)] (Chen et al., 2009), susceptible to greenbug Biotype E [*Schizaphis graminum* (Rondani)], resistant to Russian wheat aphid (*Diuraphis noxia* Kurdjumov) Biotype 1, and susceptible to Russian wheat aphid Biotype 2.

Field Performance

In field trials in Colorado, grain yield of Cowboy was similar ($P > 0.05$) to its sister selection Denali (as described in Haley et al., 2012). These trials include the CSU Elite Trial (2009–2011; 29 trial locations), the Uniform Variety Performance Trial (2010–2011; 15 locations), and the Irrigated Variety Performance Trial (2010–2011; 6 locations). Significantly lower ($P < 0.05$) grain volume weight was observed for Cowboy relative to Denali in both in the CSU Elite Trial (777 vs. 782 kg m⁻³) and the Uniform Variety Performance Trial (768 vs. 785 kg m⁻³).

In the Wyoming nonirrigated state variety trial, grain yield of Cowboy (3291 kg ha⁻¹) was the highest among the entries in a combined analysis across years (2010–2012, 9 locations), similar to ($P > 0.05$) Denali (3056 kg ha⁻¹), and greater than ($P < 0.05$) all other entries tested, including ‘Settler CL’ (PI 653833; Baenziger et al., 2011) (2981 kg ha⁻¹), Hatcher (2925 kg ha⁻¹), Bill Brown (2917 kg ha⁻¹), ‘Robidoux’ (PI 659690; Baenziger et al., 2012) (2817 kg ha⁻¹), ‘Goodstreak’ (PI 632434, Baenziger et al., 2004) (2684 kg ha⁻¹), ‘Pronghorn’ (PI 593047, Baenziger et al., 1997) (2925 kg ha⁻¹), ‘Camelot’ (PI 653832; Baenziger et al., 2009) (2515 kg ha⁻¹), and ‘Buckskin’ (CItr 17263; Schmidt et al., 1976) (2463 kg ha⁻¹). In these trials, Cowboy had average grain volume weight (764 kg m⁻³), greater than ($P < 0.05$) Camelot (749 kg m⁻³) and similar to ($P > 0.05$) Goodstreak

(775 kg m⁻³), Pronghorn (774 kg m⁻³), Denali and Buckskin (772 kg m⁻³), Bill Brown (767 kg m⁻³), Settler CL (765 kg m⁻³), Hatcher (764 kg m⁻³), and Robidoux (762 kg m⁻³).

In the Wyoming irrigated state variety trial, grain yield of Cowboy (7879 kg ha⁻¹) was the highest among the entries in a combined analysis across years (2010–2012, 3 locations), similar to ($P > 0.05$) Denali (7700 kg ha⁻¹), Robidoux (7343 kg ha⁻¹), and ‘Freeman’ (PI 667038) (7284 kg ha⁻¹), and greater than ($P < 0.05$) all other entries tested, including Settler CL (2981 kg ha⁻¹), ‘Wesley’ (PI 605742; Peterson et al., 2001) (7151 kg ha⁻¹), Thunder CL (7088 kg ha⁻¹), and ‘Antelope’ (PI 633910; Graybosch et al., 2005) (6567 kg ha⁻¹). In these trials, Cowboy had above-average grain volume weight (773 kg m⁻³), similar to ($P > 0.05$) Thunder CL (784 kg m⁻³), Wesley (775 kg m⁻³), Denali (772 kg m⁻³), Antelope and Settler CL (770 kg m⁻³), and Freeman (763 kg m⁻³).

Cowboy was tested in the 2010 and 2011 Southern Regional Performance Nursery. Averaged across the hard winter wheat region, Cowboy was the third-highest-yielding entry in the trial in 2010 (3965 kg ha⁻¹; 48 total entries; 30 locations) and the fifth-highest-yielding entry in the trial in 2011 (3698 kg ha⁻¹; 34 total entries; 25 locations).

End-Use Quality

Milling and bread baking characteristics of Cowboy and common check entries were determined using approved methods of the American Association of Cereal Chemists (AACC, 2000) in the CSU Wheat Quality Laboratory. Multiple location-year samples from the 2008, 2009, and 2010 growing seasons were available to enable comparison between Cowboy and Hatcher, Ripper, and ‘Above’ (PI 631449; Haley et al., 2003) as check entries. The three check varieties have overall good milling properties while overall baking properties for Hatcher and Ripper are good and Above is poor. Values for milling-related variables were generally good for Cowboy, with kernel characteristics, grain protein concentration, and Brabender Quadrumat Senior (C.W. Brabender) flour extraction comparable to the check entries (Table 1). Values

Table 1. Milling, dough mixing, and bread baking characteristics of wheat cultivar Cowboy and check entries across multiple evaluations from the 2008, 2009, and 2010 growing seasons in Colorado.

Trait (unit of measurement)	Samples	Cowboy	Hatcher	Ripper	Above
SKCS kernel weight (mg)†	37	29.4	29.9 ns‡	31.1*	30.8*
SKCS kernel diameter (mm)	37	2.58	2.59 ns	2.67*	2.68*
SKCS kernel hardness (score)	37	67.8	68.6 ns	67.4 ns	72.0*
Grain protein (g kg ⁻¹)	33	133	130 ns	138*	130 ns
Grain ash (g kg ⁻¹)	33	14.9	14.8 ns	15.0 ns	15.2 ns
Flour extraction (g kg ⁻¹)	32	667	666 ns	669 ns	643*
Flour ash (g kg ⁻¹)	33	4.5	4.5 ns	4.7*	4.6 ns
Mixograph mixing time (min)	33	3.8	4.3*	3.3*	2.7*
Mixograph tolerance (0–6)§	32	2.8	3.8*	3.5*	2.2*
Bake mix time (min)	32	3.6	4.1*	3.2*	2.6*
Bake absorption (g kg ⁻¹)	32	629	631 ns	647*	620*
Loaf volume (L)	32	0.85	0.90*	0.87 ns	0.80*
Crumb grain (0–6)§	32	3.0	4.0*	2.9 ns	3.1 ns

* Significance of the difference between Cowboy and the check cultivar based on a Student’s paired *t* test procedure at the 0.05 probability level.

† SKCS, single kernel characterization system.

‡ ns, not significant.

§ Mixograph tolerance and crumb grain score scales: 6 = outstanding, 0 = unacceptable.

for baking-related variables of Cowboy were generally good, with values for mixograph mixing time, mixograph tolerance score, and loaf volume generally intermediate between the better-quality check Hatcher and the poorer-quality check Above (Table 1). DNA marker assays for high-molecular-weight subunits (Butow et al., 2004; Liu et al., 2008) have shown that Cowboy carries the 1 subunit (*Glu-A1a* allele) at the *Glu-A1* locus, the 7+8 subunits (*Glu-B1b* allele) at the *Glu-B1* locus, and the 2+12 subunits (*Glu-D1a* allele) at the *Glu-D1* locus. Cowboy does not carry either the T1BL-1RS or the T1AL-1RS translocation.

Availability

Breeder seed maintenance and multiplication and distribution rights of other classes of seed have been transferred from the Colorado Wheat Research Foundation to Crop Research Foundation of Wyoming, Inc., P.O. Box 1778, Laramie, WY 82073. Cowboy has been submitted for U.S. Plant Variety Protection (PVP) under Public Law 91-577 with the Certification Only option. Recognized seed classes will include the foundation, registered, and certified seed classes. Small quantities of seed for research purposes may be obtained from the corresponding author for at least 5 years from the date of publication. A seed sample has been deposited with the National Plant Germplasm System, where it will be available for distribution to interested researchers.

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