CULTIVAR

Registration of 'Bill Brown' Wheat

Scott D. Haley,* Jerry J. Johnson, Frank B. Peairs, James S. Quick, John A. Stromberger, Joshua D. Butler, Hayley R. Miller, Emily E. Heaton, Jeff B. Rudolph, Bradford W. Seabourn, Guihua Bai, Yue Jin, James A. Kolmer, and Xianming Chen

ABSTRACT

'Bill Brown' (Reg. No. CV-133, PI 653260) hard red winter wheat (*Triticum aestivum* L.) was developed by the Colorado Agricultural Experiment Station and released in August 2007 through an exclusive marketing agreement with the Colorado Wheat Research Foundation. In addition to researchers at Colorado State University (CSU), USDA-ARS researchers at Manhattan, KS, St. Paul, MN, and Pullman, WA, participated in the development of Bill Brown. Bill Brown was selected from the cross 'Yumar'/'Arlin' made in 1997 at Fort Collins, CO. Bill Brown was selected as an $F_{5:6}$ line reselection in Yuma, AZ, in May 2003 and assigned experimental line number CO01385-A1. Bill Brown was released because of its superior grain yield under nonirrigated and irrigated production in eastern Colorado, high grain volume weight, resistance to leaf (*Puccinia triticina* Eriks.) and stripe rust (*P. striiformis* Westend.), and superior milling and bread baking quality. The name Bill Brown was chosen to honor the memory of former CSU Extension Plant Pathologist Dr. William M. Brown.

'Bill Brown' (Reg. No. CV-133, PI 653260) hard red winter wheat (*Triticum aestivum* L.) was developed by the Colorado Agricultural Experiment Station and released in August 2007 through an exclusive marketing agreement with the Colorado Wheat Research Foundation. In addition to researchers at Colorado State University (CSU), USDA-ARS researchers at Manhattan, KS, St. Paul, MN, and Pullman, WA, participated in the development of Bill Brown. Bill Brown was selected from the cross 'Yumar'/'Arlin' made in 1997 at Fort Collins, CO. Yumar (PI 605388) is a hard red winter wheat cultivar released by CSU in 1997 (Quick et al., 2001c) and Arlin (PI 564246) is a hard white winter wheat cultivar released by Kansas State University in 1992 (Sears et al., 1997a).

Bill Brown was selected in Yuma, AZ, in 2003 as an $F_{5:6}$ line reselection from experimental line CO01385, and assigned experimental line number CO01385-A1. Bill Brown has shown superior grain yield in both nonirrigated and irrigated production conditions in eastern Colorado. In addition to high grain yield, Bill Brown has shown high grain volume weight, resistance to leaf and stripe rust, and superior milling and bread baking quality. The name Bill Brown was chosen to honor the memory of former CSU Extension Plant Pathologist Dr. William M. Brown (deceased), who devoted his career to the improvement and management of diseases of wheat and other grain crops.

S.D. Haley, J.J. Johnson, J.S. Quick, J.A. Stromberger, J.D. Butler, H.R. Miller, and E.E. Heaton, Soil and Crop Sciences Dep., Colorado State Univ., Fort Collins, CO 80523; F.B. Peairs and J.B. Rudolph, Bioagricultural Sciences and Pest Management Dep., Colorado State Univ., Fort Collins, CO 80523; B.W. Seabourn, USDA-ARS, Grain Marketing and Production Research Center/Hard Winter Wheat Quality Lab., 1515 College Ave., Manhattan, KS 66502; G. Bai, USDA-ARS, Plant Science and Entomology Research Unit, Kansas State Univ., 4008 Throckmorton Hall, Manhattan, KS 66506; Y. Jin and J.A. Kolmer, USDA-ARS, Cereal Disease Lab., 1551 Lindig St., Univ. Minnesota, St. Paul, MN 55108; X. Chen, USDA-ARS, Wheat Genetics, Quality Physiology and Disease Research, Washington State Univ., Pullman, WA 99164. Registration by CSSA. Received 7 Mar. 2008. *Corresponding author (scott.haley@colostate.edu).

Abbreviations: AACC, American Association of Cereal Chemists; CSU, Colorado State University; IVPT, Irrigated Variety Performance Trial; NIR, near-infrared reflectance; RWA, Russian wheat aphid; SDS, sodium dodecyl sulfate; SRPN, Southern Regional Performance Nursery; UVPT, Uniform Variety Performance Trial.

Published in the Journal of Plant Registrations 2:218–223 (2008).
doi: 10.3198/jpr2008.03.0133crc

677 S. Segoe Rd., Madison, WI 53711 USA

Methods

Early Generation Population Development

Bill Brown was developed using a modified bulk breeding procedure. All early generation population and line development was done in the greenhouse or an irrigated field-testing location at Fort Collins, CO. The cross between the two parents, designated as cross population X971004, was made in the greenhouse in fall, 1997. The F_1 seed was harvested in January 1998 and immediately planted in a field nursery in mid-February 1998. Seed from the F_1 plants was harvested in bulk in July 1998 and planted in an unreplicated F_2 bulk nursery in September 1998. The F_2

bulk nursery was planted under furrow-irrigation in plots 7.9 m long with two rows, spaced 20 cm apart, planted on top of each of two beds spaced 76 cm apart (effective plot area 11.1 m^2). In July 1999, the F_2 population was harvested in bulk with a small-plot combine. A nonselected subsample of the grain was planted in September 2000 in an unreplicated F_3 bulk nursery with the same plot size as in the F_2. No among-cross selection was practiced. Of the group of 283 different F_3 populations, population X971004 was among a group of 146 populations that were selected in July 2000 (i.e., 52% among-cross selection intensity). Selected populations were advanced by random sampling of approximately 100 spikes harvested at maturity. Selection criteria for advancement included relative plant height and maturity and visual agronomic appearance of the bulk population at harvest. Selected spikes were threshed individually and planted in a furrow-irrigated headrow nursery in September 2000 in a paired-row arrangement 1 m long with 35 cm spacing between rows.

Line Selection and Evaluation

On the basis of visual appraisal of uniformity and agronomic appearance, experimental line CO01385 was selected from the headrow nursery as an $F_{3:4}$ line in July 2001. Between harvest and planting (August 2001), 5 g of grain from the selected headrow and approximately 630 other headrows were subjected to protein (American Association of Cereal Chemists [AACC] approved method 39-10, American Association of Cereal Chemists, 2000) and hardness (approved method 39-70A, American Association of Cereal Chemists, 2000) analysis via near-infrared reflectance (NIR) spectroscopy and a modified whole-meal sodium dodecyl sulfate (SDS) sedimentation method (Dick and Quick, 1983). Based on visual observation of grain properties (size, shriveling, and color) and values for NIR protein, NIR hardness, and SDS sedimentation, CO01385 and 520 other headrows were selected and planted in preliminary yield trials in September 2001. These trials were planted at five locations in Colorado in a single replication with 'Trego' (PI 612576; Martin et al., 2001) planted as a common check interspersed at regular intervals throughout the nursery (20% total check occurrence). Plots at each location were planted 3.7 m long, six rows wide, with 23 cm spacing between rows; all six rows were harvested (effective plot area, 5.1 m^2). During winter 2001–2002, lines advanced to preliminary yield trials were evaluated in standard greenhouse seedling screening tests (Nkongolo et al., 1989) for resistance to Biotype 1 Russian wheat aphid (RWA; *Diuraphis noxia* Kurdjumov) and dough mixing properties with the computerized Mixograph (AACC approved method 54-40A; American Association of Cereal Chemists, 2000). To account for spatial variation in the unreplicated trials, grain yield of unreplicated experimental lines was expressed using a moving means function (Clarke et al., 1994) and as a percentage of nearby check plots.

On the basis of grain yield and grain volume weight data from three locations, plant height (height from the soil surface to the tip of the spikes, excluding the awns), heading date (number of days to 50% heading from 1 January), RWA resistance, Mixograph mixing time and tolerance, and agronomic appearance, CO01385 and 89 other lines were subject to line reselection by random sampling 20 spikes from a plot growing at Fort Collins, CO. These reselections were grown in Yuma, AZ, during winter 2002–2003. Using visual observation, experimental line CO01385-A1 was selected in May 2003 as an $F_{5:6}$ line reselection from CO01385.

In September 2003, CO01385-A1 (Bill Brown) was planted in advanced yield trials at five locations in Colorado, along with five checks and 62 other line reselections made in Yuma. These trials were planted with two replications and the same plot size as the preliminary yield trials. On the basis of grain yield and grain volume weight from three locations, and other characteristics as described above, Bill Brown was selected and planted in the Uniform Variety Performance Trial (UVPT) and the Irrigated Variety Performance Trial (IVPT) in September 2004. The UVPT (nonirrigated) and IVPT are the official state variety trials for Colorado. For the UVPT, plots at each of 11 locations were replicated three times, with each plot 14 m long, six rows wide, and with 23 cm spacing between rows; all six rows were harvested (effective plot area 19.3 m^2). For the IVPT, plots at each of three locations were replicated three times, with each plot 7.9 m long, six rows wide, and with 18 cm spacing between rows; all six rows were harvested (effective plot area 8.5 m^2). During winter 2004–2005, remnant samples of grain were analyzed for milling and bread baking properties (using AACC approved methods; American Association of Cereal Chemists, 2000) in the CSU Wheat Quality Laboratory.

On the basis of grain yield and grain volume weight, and other screening data as described above, Bill Brown was tested in the UVPT and the IVPT for a second year in 2006. Bill Brown was also entered into the cooperative Hard Winter Wheat Southern Regional Performance Nursery (SRPN) in 2006. On the basis of grain yield and grain volume weight, and other screening data as described above, Bill Brown was retained for a third year of testing in the UVPT and IVPT and a second year of testing in the SRPN in 2007.

Seed Purification and Increase

Seed purification of Bill Brown began in the 2004 crop year using visual identification and manual removal of tall and red-chaffed off-types from bulk seed increases grown under irrigation. Seed harvested from the headrow selection in Yuma was planted in a strip plot (1.3 m wide, 7.9 m long) in fall 2003. During grain filling and again at harvest, strips were rogued to remove tall and red-chaffed variants. A subsample of seed harvested from these strips was grown in a longer strip plot (1.3 m wide, 44 m long) in 2005 and rogued as in 2004. In fall 2005, a subsample of seed from this strip was planted in a breeder seed ($F_{5:9}$) increase block (7.6 m wide, 185 m long) and rogued as in previous years. In 2007 Foundation seed was produced by planting all of the Breeder seed harvested in 2006 in a

4.1-ha seed increase block. The Foundation seed increase block ($F_{5:10}$) was rogued as in previous years.

Statistical Analyses

All statistical analyses were done using SAS-JMP Version 6.0.3 (SAS Institute, Cary, NC). Agronomic data (heading date, plant height, coleoptile length, straw strength) and end-use quality data were analyzed by the Student's paired *t* test procedure. Yield and grain volume weight data from the UVPT and IVPT were subjected to analysis of variance across locations within years and a combined analysis across location-years. Only entries common to the trials across all years were included. Within-year analyses were done according to a mixed model with environments and genotypes as fixed factors and replications within environments as random factors. Combined analyses were also done according to a mixed model with genotypes and location-year combinations as fixed factors and replications within location-year combinations as a random factor. Tukey's honestly significant difference test ($\alpha = 0.05$) was used to compare the least squares means for the genotype effects.

Characteristics

Agronomic and Botanical Description

Bill Brown is an awned, white-glumed, hard red winter wheat (Table 1). It has medium-early maturity, 141.5 d to heading from 1 January, 1.6 d later than 'Ripper' (PI 644222; Haley et al., 2007), 1.2 d earlier than 'Hatcher' (PI 632275; Haley et al., 2005), and 3.2 d earlier than 'Prowers 99' (PI 612420; Quick et al., 2001a). Plant height of Bill Brown is medium-short (60.1 cm), similar to Ripper (59.5 cm), 3.3 cm taller than Hatcher (56.8 cm), and 6.0 cm shorter than Prowers 99 (66.1 cm). Coleoptile length of Bill Brown (62.7 mm) is shorter than that of Hatcher (77.7 mm), Ripper (87.5 mm), and Prowers 99 (96.3 mm). Straw strength data for Bill Brown and the check cultivar Hatcher were only collected at a single, irrigated variety trial location. At this location, the straw strength of Bill Brown was good (3.3 score, 1 = erect to 9 = flat scale), numerically better than Hatcher (5.7 score), although this difference was not statistically significant ($P = 0.317$). No objective data are available for winter hardiness of Bill Brown, but field observations and field performance following extremely dry soil conditions during the winter in Colorado suggest that it is at least adequate for successful production in the central Great Plains region.

Bill Brown has a semierect juvenile plant growth habit with a green plant color at the boot stage and a coleoptile that lacks anthocyanin pigment. Flag leaves of Bill Brown are erect, not twisted, and show a waxy bloom at the boot stage. Bill Brown has mid-dense (laxidense), inclined, and tapering heads with white awns. Bill Brown has white, nonpubescent glumes that are medium length and medium width with oblique, narrow shoulders and narrow, acuminate beaks. Bill Brown has kernels that are ovate, red, and hard textured with a medium length noncollared brush, a rounded cheek, a narrow and shallow crease, a midsize germ, and a dark brown phenol reaction.

Bill Brown was observed to be uniform and stable during the last four generations of seed increase. When sexually reproduced, Bill Brown remains unchanged in its essential and distinctive characteristics. Variants are limited to (i) tall plants greater than two spike lengths above than the main canopy that occur at a frequency of fewer than 1 in 1000 plants and (ii) plants with brown glumes that occur at a frequency of fewer than 1 in 1000 plants. The variants in Bill Brown, as well as the typical plants in Bill Brown, are commercially acceptable.

Table 1. Agronomic data summary for hard red winter wheat cultivar Bill Brown and check cultivars tested in Colorado Variety Performance Trials (2005–2007).

Cultivar	Heading date	Height	Coleoptile length	Straw strength score†
	d from 1 Jan.	cm	mm	1–9
Bill Brown	141.5	60.1	62.7	3.3
Ripper	139.9 (0.053)‡	59.5 (0.541)	87.5 (0.001)	–
Hatcher	142.7 (0.096)	56.8 (0.006)	77.7 (0.025)	5.7 (0.317)
Prowers 99	144.7 (<0.001)	66.1 (<0.001)	96.3 (0.001)	–
Observations	10	53	6	3

†Lodging score: 1 = completely erect to 9 = completely flat at harvest.

‡*P* values (in parentheses) represent the significance of the comparison between Bill Brown and the respective check cultivar based on a Student's paired *t* test procedure (SAS-JMP version 6.0.3, SAS Institute, Cary, NC).

Disease and Insect Resistance

Bill Brown has been characterized for disease and insect resistance in Colorado and through cooperative evaluations of the USDA Regional Testing Program. Bill Brown is susceptible to stem rust (caused by *Puccinia graminis* Pers.:Pers f. sp. *tritici* Eriks. & E. Henn; races QFCS, QTHJ, RCRS, RKQQ, TPMK, TTTT, and TTKS) in field and greenhouse seeding tests. Greenhouse seedling evaluations with leaf rust (*P. triticina* Eriks.) suggest that Bill Brown is susceptible to most common leaf rust (races MCRK, THBJ, MJBJ, MHDS, KFBJ, TNRJ, MFPSC, and MLDSB), while a resistant reaction to race TGBG suggests that Bill Brown carries the *Lr14a* resistance gene. Under natural field infection with unknown leaf rust races in Colorado and western Kansas in 2007, Bill Brown was more resistant (1.2 score, 1 = resistant and 9 = susceptible, $n = 5$ evaluations) than Hatcher (6.4 score) and 'Jagalene' (PI 631376) (8.6 score), suggesting that its leaf rust resistance in field plots is most likely conditioned by resistance genes effective at the adult plant stage. In greenhouse screening tests, Bill Brown was resistant (infection type 0) to race PST-116 and intermediate (infection type 5) to race PST-100 of stripe rust (*P. striiformis* Westend.) at both the seedling and adult-plant stages. Bill Brown was susceptible (infection type 8) to races PST-17, PST-37, and PST-45 in seedling tests and intermediate (infection type 5) to race PST-17 in an adult-plant test. Under natural field infection with unknown stripe rust races in Colorado in 2005 and 2007, Bill Brown was moderately resistant (4.1 score; 1 = resistant and 9 = susceptible; $n = 13$ evaluations), similar to Hatcher

(3.6 score) and more resistant than Ripper (8.6 score). Bill Brown was susceptible to stripe rust in field tests in Washington in 2006 and 2007.

Cooperative evaluations through the USDA Regional Testing Program indicate that Bill Brown is moderately susceptible to wheat streak mosaic virus, susceptible to barley yellow dwarf virus, susceptible to the Great Plains Biotype of Hessian fly [*Mayetiola destructor* (Say)], and susceptible to greenbug Biotype E [*Schizaphis graminum* (Rondani)]. Bill Brown is resistant to Russian wheat aphid Biotype 1 and susceptible to Russian wheat aphid Biotype 2. Resistance to Russian wheat aphid Biotype 1 in Bill Brown is conditioned by the *Dn4* resistance gene from the Yumar parent.

Field Performance

Bill Brown was tested at 32 trial locations of the Colorado Dryland UVPT during 2005 (10 locations), 2006 (11 locations), and 2007 (11 locations) (Table 2). In the combined analysis across years, grain yield of Bill Brown was second highest in the trials, statistically similar to Hatcher, 'Bond CL' (PI 639924, Haley et al., 2006), Ripper, Keota (PI 648007), and 'Infinity CL' (PI 639922; Baenziger et al., 2006). In these analyses, Bill Brown also showed relatively high grain volume weight, slightly less than 'NuGrain' (PI 643090) and 'Danby' (PI 648010), but statistically similar to other cultivars known to have high grain volume weight, including Trego, Goodstreak (PI 632434, Baenziger et al., 2004), and Jagalene.

Bill Brown was tested at nine locations of the Colorado IVPT during 2005 (three locations), 2006 (three locations), and 2007 (three locations) (Table 3). In the combined analysis across years, grain yield of Bill Brown was the highest in the trials, statistically similar to Bond CL and 'TAM 111' (PI 631352, Lazar et al., 2004). Grain volume weight of Bill Brown in these trials was also high, statistically similar to NuGrain, Jagalene, Platte (PI 596297), TAM 111, and Hatcher.

Bill Brown was tested in the 2006 and 2007 SRPN. Across locations in the High Plains region, Bill Brown was the 10th highest yielding entry in the trial in 2006 (nine location mean yield 2410 kg ha^{-1}; 50 total entries) and the

Table 2. Grain yield and grain volume weight for hard red winter wheat cultivar Bill Brown and other cultivars tested in dryland (nonirrigated) Colorado Uniform Variety Performance Trials (2005–2007). Cultivars are ranked according to the average grain yield across environments.

	Grain yield				Grain volume wt.
Cultivar	2005	2006	2007	2005–2007 avg.	2005–2007 avg.
	kg ha^{-1}				g L^{-1}
Hatcher	2385 bc†	1786 ab	4075 a	2760 a	749 bcd
Bill Brown	2761 a	1814 ab	3654 bcd	2742 a	753 bc
Bond CL	2603 ab	1746 ab	3732 abcd	2696 ab	731 gh
Ripper	2595 ab	1868 a	3574 bcd	2682 abc	730 h
Keota	2252 cd	1811 ab	3761 abcd	2619 abcd	746 cde
Infinity CL	2082 def	1845 a	3781 abc	2584 abcde	739 defg
Above	2212 cde	1711 ab	3662 bcd	2538 bcdef	740 def
Jagger‡	2185 cde	1753 ab	3637 bcd	2536 bcdefg	738 efgh
Endurance‡	2045 def	1821 ab	3650 bcd	2520 bcdefg	750 bc
TAM 111	1950 efg	1631 ab	3852 ab	2494 cdefgh	749 bcd
Alliance‡	2148 cde	1766 ab	3531 bcde	2492 cdefgh	740 defg
Jagalene	2204 cde	1649 ab	3597 bcd	2492 cdefgh	751 bc
Yuma ‡	2053 def	1761 ab	3615 bcd	2489 cdefgh	737 efgh
Avalanche‡	2206 cde	1762 ab	3442 bcdef	2478 defgh	757 ab
Danby	2062 def	1694 ab	3636 bcd	2477 defgh	763 a
NuGrain	2165 cde	1636 ab	3549 bcde	2459 defghi	764 a
Prairie Red‡	2210 cde	1655 ab	3471 bcdef	2453 defghi	736 fgh
Ankor‡	1986 defg	1771 ab	3508 bcdef	2435 defghi	736 fgh
NuFrontier‡	2135 cde	1666 ab	3434 cdef	2420 efghi	751 bc
Akron‡	1819 fg	1732 ab	3454 bcdef	2351 fghi	739 defg
Goodstreak	2009 defg	1839 a	3145 ef	2341 ghi	753 bc
Trego	1750 g	1757 ab	3347 def	2302 hi	756 ab
Prowers 99	2088 def	1588 b	3113 f	2268 I	752 bc
Locations	10	11	11	32	30
Average	2170	1742	3575	2506	746
Model R^2	0.94	0.89	0.81	0.92	0.80

†Values within a column followed by the same letter are not significantly different at the $\alpha = 0.05$ probability level according to Tukey's honestly significant difference test.

‡Akron, PI 584504 (Quick et al., 1996); Alliance, PI 573096 (Baenziger et al., 1995); Ankor, PI 632275 (Haley et al., 2004); Avalanche, PI 620766 (Haley et al., 2003b); Endurance, PI 639233 (Carver et al., 2006); Jagger, PI 593688 (Sears et al., 1997b); NuFrontier, PI 619089; Prairie Red, PI 605390 (Quick et al., 2001b); Yuma, PI 605388.

Table 3. Grain yield and grain volume weight for hard red winter wheat cultivar Bill Brown and other cultivars tested in the Colorado Irrigated Variety Performance Trials (2005–2007). Cultivars are ranked according to the average grain yield across environments.

Cultivar	Grain yield				Grain volume wt.
	2005	2006	2007	2005–2007 avg.	2005–2007 avg.
	kg ha^{-1}				g L^{-1}
Bill Brown	6641 a[†]	5389 ab	6427 a	6152 a	773 a
Bond CL	6036 ab	5339 ab	6410 a	5928 ab	752 c
TAM 111	5862 ab	5700 a	5853 ab	5805 abc	771 a
Hatcher	6026 ab	4770 b	6009 ab	5602 bcd	768 ab
NuGrain	5911 ab	4848 b	5789 ab	5516 bcd	780 a
Yuma	5275 bcd	4841 b	6320 a	5479 bcd	757 bc
Jagalene	5705 ab	4800 b	5756 ab	5420 cd	774 a
Ankor	5497 bc	5019 ab	5395 b	5304 d	752 c
Platte	4613 cd	5422 ab	5425 b	5154 de	774 a
Prairie Red	4327 d	4786 b	5172 b	4762 e	751 c
Locations	3	3	3	9	9
Average	5589	5091	5856	5512	765
Model R^2	0.77	0.96	0.68	0.90	0.85

[†]Values within a column followed by the same letter are not significantly different at the $\alpha = 0.05$ probability level according to Tukey's honestly significant difference test.

Table 4. Milling and bread baking characteristics of hard red winter wheat cultivars Bill Brown, Ripper, Hatcher, and Above across multiple quality evaluations from the 2004, 2005, 2006, and 2007 crop seasons.

Trait	Comparisons	Bill Brown	Ripper	Hatcher	Above
SKCS[†] kernel weight (mg)	49	25.7	30.5*	29.8*	28.9*
SKCS kernel diameter (mm)	49	2.51	2.67	2.62*	2.62*
SKCS kernel hardness index (score)	49	74.0	62.1*	64.3*	68.8*
Wheat protein content (g kg^{-1})	42	137	142*	148 ns[‡]	138 ns
Wheat ash content (g kg^{-1})	42	15.3	15.2 ns	17.1 ns	15.6*
Flour extraction (g kg^{-1})	22	643	657*	656*	641 ns
Mixograph peak time (min)	28	4.59	3.34*	4.42 ns	2.82*
Mixograph peak width (%)	29	21.7	22.0 ns	21.2 ns	16.8*
Mixograph right width (%)	23	12.0	11.7 ns	15.0*	9.8*
Bake water absorption (g kg^{-1})	20	660	671*	656 ns	663 ns
Bake mix time (min)	20	3.96	3.16*	3.73 ns	2.34*
Loaf volume (L)	20	1.011	1.003 ns	0.999 ns	0.861*
Crumb color (score)[§]	20	3.50	3.55 ns	4.40*	2.80*
Crumb grain (score)[§]	20	3.40	3.65 ns	3.75 ns	1.50*

*Significance of the difference between Bill Brown and the indicated check cultivar based on a Student's paired *t* test procedure (SAS-JMP version 6.0.3, SAS Institute, Cary, NC) at the 0.05 probability level.

[†]SKCS, single kernel characterization system.

[‡]ns, not significant.

[§]Crumb color and crumb grain score scales: 6 = outstanding, 0 = unacceptable.

tenth highest entry in the trial in 2007 (10 location mean yield 3925 kg ha^{-1}; 50 total entries).

End-Use Quality

Milling and bread baking characteristics of Bill Brown were determined from multiple individual-location grain samples from the 2004, 2005, 2006, and 2007 seasons. 'Above' (Haley et al., 2003a), Hatcher, and Ripper were used as checks in these evaluations. Values for milling-related variables were generally acceptable for Bill Brown compared to the three check entries, all of which being known for generally superior hard winter wheat milling properties (Table 4). On the basis of single kernel characterization system analysis, Bill Brown had smaller kernel weight and kernel diameter than the checks with slightly harder kernel texture. Wheat ash and Quadrumat Senior flour extraction were comparable to the checks and generally within the range of acceptability for the domestic milling industry. Values for baking-related variables for Bill Brown were similar to Ripper and Hatcher (above-average baking quality checks) and generally superior to Above (below-average baking quality check) (Table 4). In Mixograph tests optimized for water absorption, Bill Brown had longer mixing time than Ripper and Above and greater curve width at peak and 2 min after peak (measures of dough strength and tolerance to dough overmixing) than Above.

In straight-dough pup loaf baking tests, Bill Brown had similar baking quality characteristics (i.e., bake mix time, loaf volume, crumb grain color and score) relative to Ripper and Hatcher, and superior to Above.

Availability

The Colorado Agricultural Experiment Station will maintain Breeder seed of Bill Brown. Multiplication and distribution rights of other classes of certified seed have been transferred from the Colorado Agricultural Experiment Station to the Colorado Wheat Research Foundation, 7100 S. Clinton St. Suite 120, Centennial, CO 80112. Bill Brown has been submitted for U.S. Plant Variety Protection under Public Law 91-577 with the Certification Only option. Recognized seed classes will include the Foundation, Registered, and Certified seed classes. A seed sample has been deposited in the USDA-ARS National Center for Genetic Resources Preservation, where it will become available for distribution after expiration of U.S. Plant Variety Protection. Small quantities of seed for research purposes may be obtained from the corresponding author for at least five years from the date of this publication. Seed distribution for research purposes will be done according to the provisions of the Wheat Worker's Code of Ethics (National Wheat Improvement Committee, 1995).

Acknowledgments

Bill Brown was developed with financial support from Colorado Agricultural Experiment Station Projects 795 and 646, the Colorado Wheat Administrative Committee, and the Colorado Wheat Research Foundation.

References

American Association of Cereal Chemists. 2000. Approved methods of the AACC. 10th ed. AACC, St. Paul, MN.

Baenziger, P.S., B. Beecher, R.A. Graybosch, D.D. Baltsenperger, L.A. Nelson, J.M. Krall, Y. Jin, J.E. Watkins, D.J. Lyon, A.R. Martin, M. Chen, and G. Bai. 2006. Registration of 'Infinity CL' wheat. Crop Sci. 46:975–979.

Baenziger, P.S., B. Beecher, R.A. Graybosch, D.D. Baltensperger, L.A. Nelson, J.M. Krall, D.V. McVey, J.E. Watkins, J.H. Hatchett, and M.-S. Chen. 2004. Registration of 'Goodstreak' wheat. Crop Sci. 44:1473–1474.

Baenziger, P.S., B. Moreno-Sevilla, C.J. Peterson, J.W. Schmidt, D.R. Shelton, D.D. Baltensperger, L.A. Nelson, D.V. McVey, J.E. Watkins, and J.H. Hatchett. 1995. Registration of 'Alliance' wheat. Crop Sci. 35:938.

Carver, B.F., E.L. Smith, R.M. Hunger, A.R. Klatt, J.T. Edwards, D.R. Porter, J. Verchot-Lubicz, P. Rayas-Duarte, G.-H. Bai, B.C. Martin, E.G. Krenzer, and B.W. Seabourn. 2006. Registration of 'Endurance' wheat. Crop Sci. 46:1816–1818.

Clarke, F.R., R.J. Baker, and R.M. DePauw. 1994. Moving mean and least-squares smoothing for analysis of grain-yield data. Crop Sci. 34:1479–1483.

Dick, J.W., and J.S. Quick. 1983. A modified screening-test for rapid estimation of gluten strength in early-generation durum wheat breeding lines. Cereal Chem. 60:315–318.

Haley, S.D., J.J. Johnson, F.B. Peairs, J.S. Quick, J.A. Stromberger, S.R. Clayshulte, J.D. Butler, J.B. Rudolph, B.W. Seabourn, G. Bai, Y. Jin, and J. Kolmer. 2007. Registration of 'Ripper' wheat. J. Plant Registrations 1:1–6.

Haley, S.D., J.J. Johnson, F.B. Peairs, J.S. Quick, P.H. Westra, J.A. Stromberger, S.R. Clayshulte, B.L. Clifford, J.B. Rudolph, A. Giura, B.W. Seabourn, O.K. Chung, Y. Jin, and J. Kolmer. 2006. Registration of 'Bond CL' wheat. Crop Sci. 46:993–994.

Haley, S.D., M.D. Lazar, J.S. Quick, J.J. Johnson, G.L. Peterson, J.A. Stromberger, S.R. Clayshulte, B.L. Clifford, T.A. Pester, S.J. Nissen, P.H. Westra, F.B. Peairs, and J.B. Rudolph. 2003a. Above winter wheat. Can. J. Plant Sci. 83:107–108.

Haley, S.D., J.S. Quick, J.J. Johnson, F.B. Peairs, J.A. Stromberger, S.R. Clayshulte, B.L. Clifford, J.B. Rudolph, O.K. Chung, and B.W. Seabourn. 2004. Registration of 'Ankor' wheat. Crop Sci. 44:1025–1026.

Haley, S.D., J.S. Quick, J.J. Johnson, F.B. Peairs, J.A. Stromberger, S.R. Clayshulte, B.L. Clifford, J.B. Rudolph, B.W. Seabourn, O.K. Chung, Y. Jin, and J. Kolmer. 2005. Registration of 'Hatcher' wheat. Crop Sci. 45:2654–2655.

Haley, S.D., J.S. Quick, T.J. Martin, J.J. Johnson, F.B. Peairs, J.A. Stromberger, S.R. Clayshulte, B.L. Clifford, and J.B. Rudolph. 2003b. Registration of 'Avalanche' wheat. Crop Sci. 43:432.

Lazar, M.D., W.D. Worrall, G.L. Peterson, A.K. Fritz, D. Marshall, L.R. Nelson, and L.W. Rooney. 2004. Registration of 'TAM 111' wheat. Crop Sci. 44:355.

Martin, T.J., R.G. Sears, D.L. Seifers, T.L. Harvey, M.D. Witt, A.J. Schlegel, P.J. McCluskey, and J.H. Hatchett. 2001. Registration of 'Trego' wheat. Crop Sci. 41:929.

National Wheat Improvement Committee. 1995. Wheat worker's code of ethics. Available at http://wheat.pw.usda.gov/ggpages/awn/41/awn41a2.html#report3 (verified 23 Apr. 2008). Annu. Wheat Newsl. 41.

Nkongolo, K.K., J.S. Quick, W.L. Meyer, and F.B. Peairs. 1989. Russian wheat aphid resistance of wheat, rye, and Triticale in greenhouse tests. Cereal Res. Commun. 17:227–232.

Quick, J.S., G.E. Ellis, R.M. Normann, J.R. Stromberger, J.F. Shanahan, and K. Lorenz. 1996. Registration of Akron wheat. Crop Sci. 36:211.

Quick, J.S., S.D. Haley, J.A. Stromberger, S. Clayshulte, B. Clifford, J.J. Johnson, F.B. Peairs, J.B. Rudolph, and K. Lorenz. 2001a. Registration of 'Prowers 99' wheat. Crop Sci. 41:929.

Quick, J.S., J.A. Stromberger, S. Clayshulte, B. Clifford, J.J. Johnson, F.B. Peairs, J.B. Rudolph, and K. Lorenz. 2001b. Registration of 'Prairie Red' wheat. Crop Sci. 41:1362–1363.

Quick, J.S., J.A. Stromberger, S. Clayshulte, B. Clifford, J.J. Johnson, F.B. Peairs, J.B. Rudolph, and K. Lorenz. 2001c. Registration of 'Yumar' wheat. Crop Sci. 41:1363.

Sears, R.G., T.J. Martin, T.S. Cox, O.K. Chung, S.P. Curran, W.F. Heer, and M.D. Witt. 1997a. Registration of 'Arlin' wheat. Crop Sci. 37:627.

Sears, R.G., J.M. Moffatt, T.J. Martin, T.S. Cox, R.K. Bequette, S.P. Curran, O.K. Chung, W.F. Heer, J.H. Long, and M.D. Witt. 1997b. Registration of 'Jagger' wheat. Crop Sci. 37:1010.