Registration of 'Denali' Wheat

Scott D. Haley,* Jerry J. Johnson, Frank B. Peairs, John A. Stromberger, Emily E. Hudson, Scott A. Seifert, Rebecca A. Kottke, Victoria A. Valdez, Jeff B. Rudolph, Terry J. Martin, Guihua Bai, Xianming Chen, Robert L. Bowden, Yue Jin, James A. Kolmer, Ming-Shun Chen, and Bradford W. Seabourn

ABSTRACT

'Denali' (Reg. No. CV-1075, PI 664256) hard red winter wheat (*Triticum aestivum* L.) was developed by the Colorado Agricultural Experiment Station and released cooperatively by Colorado State University (CSU) and Kansas State University (KSU) in August 2011 through a marketing agreement with the Colorado Wheat Research Foundation. In addition to researchers at CSU and KSU, USDA-ARS researchers at Manhattan, KS, St. Paul, MN, and Pullman, WA participated in its development. Denali was selected from the cross CO980829/'TAM 111' made in 2001 at Fort Collins, CO. CO980829 is an experimental line from CSU with the pedigree 'Yuma' (PI 559720)/PI 372129//CO850034/3/4*Yuma/4/NEWS12. TAM 111 (PI 631352) is a hard red winter wheat cultivar released by Texas A&M University in 2002. Denali was selected as an $F_{5:6}$ line in July 2007 and assigned experimental line number CO050303-2. Denali was released because of its superior grain yield under nonirrigated and irrigated production conditions in eastern Colorado, its grain volume weight, and its resistance to stripe rust (caused by *Puccinia striiformis* Westend. f. sp. *tritici* Eriks.).

'Denali' (Reg. No. CV-1075, PI 664256) hard red winter wheat (*Triticum aestivum* L.) was developed by the Colorado Agricultural Experiment Station and released cooperatively by Colorado State University (CSU) and Kansas State University (KSU) August 2011 through a marketing agreement with the Colorado Wheat Research Foundation. In addition to researchers at CSU and KSU, USDA-ARS researchers at Manhattan, KS, St. Paul, MN, and Pullman, WA participated in its development. Denali was selected from the cross CO980829/'TAM 111' made in 2001 at Fort Collins, CO. CO980829 is an experimental line from CSU with the pedigree 'Yuma' (PI 559720)/PI 372129//CO850034/3/4*Yuma/4/NEWS12). TAM 111 (PI 631352; Lazar et al., 2004) is a hard red winter wheat cultivar that was released by Texas A&M University in 2002. Denali was selected as an $F_{5:6}$ line in July 2007 and assigned experimental line number CO050303-2. Denali was released because of its superior grain yield under nonirrigated and irrigated production conditions in eastern Colorado, its grain volume weight, and its resistance to stripe rust (caused by *Puccinia striiformis* Westend. f. sp. *tritici* Eriks.).

Methods

Denali was developed using a modified bulk-breeding method. All early-generation population and line development was done in the greenhouse or at an irrigated field-testing location at Fort Collins, CO. The cross, designated as population X011673, was made in the greenhouse in fall 2001. The F_1 seed was harvested in January 2002. Following vernalization for 8 wk at 2°C, seedlings were hand transplanted in May 2002 to a field nursery in the San Luis Valley at Center, CO. The F_1 plants were hand harvested in bulk in early September 2002, and the F_2 seed was immediately planted in an unreplicated field nursery at Fort Collins, CO in late September 2002. In July 2003, the F_2 population was harvested in bulk with a small-plot combine. A subsample of the grain was sieved with a Ro-Tap Test Sieve Shaker (W.S. Tyler, Mentor, OH) to select the larger kernels, which were then planted in September 2003 in an unreplicated F_3 field nursery under sprinkler irrigation at Fort Collins, CO and under nonirrigated conditions at Akron, CO. In July 2004,

S.D. Haley, J.J. Johnson, J.A. Stromberger, E.E. Hudson, S.A. Seifert, R.A. Kottke, and V.A. Valdez, 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; T.J. Martin, Kansas State Univ., Agricultural Research Center-Hays, Hays, KS 67601-9228; G. Bai, R.L. Bowden, and M.-S. Chen, USDA-ARS, Hard Winter Wheat Genetics Research Unit, Kansas State Univ., 4008 Throckmorton Hall, Manhattan, KS 66506; X. Chen, USDA-ARS, Wheat Genetics, Quality, Physiology and Disease Research Unit, Washington State Univ., Pullman, WA 99164; Y. Jin and J.A. Kolmer, USDA-ARS, Cereal Disease Lab., Univ. Minnesota, 1551 Lindig St., St. Paul, MN 55108; B.W. Seabourn, USDA-ARS, Center for Grain and Animal Health Research, 1515 College Ave., Manhattan, KS 66502. Registration by CSSA. Received 22 Dec. 2011. *Corresponding author (scott.haley@colostate.edu).

Abbreviations: CSU, Colorado State University; GI, germination index; KSU, Kansas State University.

Published in the Journal of Plant Registrations 6:1–4 (2012).
doi: 10.3198/jpr2011.12.0675crc
Posted online 5 July 2012.

population X011673 was subjected to random sampling of approximately 200 spikes at maturity. The spikes were threshed individually and planted in a sprinkler-irrigated headrow nursery in September 2004. Based on visual observations of uniformity, agronomic appearance, and resistance to stripe rust, experimental line CO050303 was selected from the headrow nursery as an $F_{3:4}$ line in July 2005.

CO050303 was tested in unreplicated preliminary yield trials in 2006 and in the Advanced Yield Nursery in 2007. In July 2006, CO050303 was subject to reselection by random sampling of 40 spikes from a plot growing at Fort Collins, CO. These head selections were threshed individually and planted in a sprinkler-irrigated headrow nursery in fall 2006. Based on visual observations of uniformity and agronomic appearance, Denali was selected as an $F_{5:6}$ line in July 2007 and assigned experimental number CO050303-2.

Denali was evaluated in eastern Colorado in unreplicated preliminary yield trials in 2008, the CSU Elite Trial from 2009 to 2011, statewide nonirrigated and irrigated variety trials in 2010 and 2011, the Regional Germplasm Observation Nursery from 2009 to 2011, and the Southern Regional Performance Nursery in 2010 and 2011. The Advanced Yield Nursery and CSU Elite Trial were arranged in latinized row-column designs with two replications, and the state variety trials were arranged in latinized row-column designs with three replications. Seed purification of Denali began in the 2009 crop year using visual identification and manual removal of tall and red-chaffed off-types from a small strip increase (1.5 by 9.8 m) grown under irrigation at Fort Collins, CO. A subsample of grain harvested from the increase in 2009 was used to plant a large strip increase (1.5 by 189 m) for breeder-seed production in 2010. This increase was rogued as in 2009 and was used to plant a 2.0-ha foundation-seed increase near Fort Collins, CO in 2011. This increase was rogued as in previous years.

All statistical analyses were performed with SAS-JMP Pro Version 9.0.2 (SAS Institute, Cary, NC). Agronomic, disease resistance, and end-use quality data were analyzed by the Student's paired t test procedure. Yield and grain volume weight data from the CSU Elite Trial and statewide variety trials were subjected to combined analyses of variance 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

Denali is an awned, white-glumed, hard red winter wheat. Denali has medium-late maturity, 153.3 d to heading from 1 January, which is 1.8 d later ($P < 0.05$; $n = 59$) than 'Hatcher' (PI 638512; Haley et al., 2005) and 3.3 d later than 'Ripper' (PI 644222; Haley et al., 2007). Denali is medium-tall (83.3 cm; $n = 115$), 5.6 cm taller than ($P < 0.05$) Hatcher, and 6.1 cm taller than Ripper. Denali's coleoptile length (evaluated according to Hakizimana et al., 2000) (72.1 mm; $n = 10$) is similar to ($P > 0.05$) that of Hatcher (69.3 mm) and shorter than ($P < 0.05$) that of Ripper (83.3 mm). The straw strength of Denali is good (3.7 score, $n = 22$; on a 1–9 scale, where 1 = erect and 9 = flat), which is similar to ($P > 0.05$) that of Hatcher (4.2) and less than ($P < 0.05$) that of Ripper (2.6). Preharvest sprouting tolerance of Denali, assessed through determination of a germination index (GI; Mares et al., 2005) from field-grown samples, is moderate (GI = 0.40; $n = 11$) and is similar to ($P > 0.05$) that of Hatcher (GI = 0.43) and Ripper (GI = 0.42), and greater than ($P < 0.05$) that of 'Thunder CL' (PI 655528; Haley et al., 2009) (GI = 0.60) and 'TAM 112 (PI 643143) (GI = 0.66). No objective data are available for winter hardiness of Denali, but field observations and performance under dry soil conditions during recent winters in Colorado suggest that it is at least adequate for successful production in the central Great Plains region.

Disease and Insect Resistance

Denali 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, Denali was susceptible to moderately susceptible to stem rust 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 at St. Paul, MN and Njoro, Kenya, have confirmed that Denali is generally moderately resistant to North American races of stem rust and those found in Kenya (*Ug-99* and derivatives). Greenhouse seedling evaluations with leaf rust (caused by *Puccinia triticina* Eriks.) have shown that Denali is susceptible to most common leaf rust races in the United States (TMGJ, TDBG, MFPS, MHDS, 10US1-1 MLDS, TNRJ, 10US3-1 TFBJ, and KFBJ). In 2011 under natural field infection with unknown leaf rust races, Denali showed a susceptible reaction at both St. Paul, MN (50% severity, susceptible infection type) and Castroville, TX (80–100% severity, susceptible infection type). In greenhouse seedling evaluations under a low diurnal temperature cycle gradually changing from 4°C at 0200 h to 20°C at 1400 h (Chen and Line, 1995), Denali was resistant (infection types 2–3 on a scale of 0–9, where 0 = resistant and 9 = susceptible) to races PST-37 and PST-45 and susceptible (infection types 7–8) to races PST-100, PST-114, and PST-127 of stripe rust (Chen et al., 2010). In greenhouse adult-plant tests under a high diurnal temperature cycle gradually changing from 10°C at 0200 h to 30°C at 1400 h (Chen and Line, 1995; Chen, 2005), Denali was resistant (infection type 2) to races PST-100, PST-114, and PST-127. The standard low- and high-temperature profiles were used to simulate early- and late-season growing conditions and to distinguish usable high-temperature adult-plant resistance from all-stage resistance (also called seedling resistance; Chen, 2005). In artificially inoculated field tests at Rossville, KS in 2011, Denali showed a highly resistant reaction (infection type 1–2, 1–2% severity; $n = 3$), whereas the susceptible check KS89180B-2 had infection type 9 and 90–95% severity. Field observations of stripe rust severity at Laurel Springs, NC in 2011 were similar to those at Rossville, KS, whereas field observations at four locations in Washington suggested a higher degree of susceptibility to races in that region. Under natural field infection in Colorado in 2010, Denali was highly resistant (1.0 score on a scale of 1–9, where 1 = resistant and 9 = susceptible; $n = 15$) and more resistant ($P < 0.05$) than Hatcher (2.3) and Ripper (8.3). The susceptibility of seedlings at low temperatures to some races and resistance of adult-plants in greenhouse and field tests at higher temperatures suggest that Denali has a combination of seedling (or all-stage) resistance and very good high-temperature adult-plant resistance to stripe rust.

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

Field Performance

Denali was tested at 29 trial locations of the CSU Elite Trial during 2009 (12 locations), 2010 (9 locations), and 2011 (8 locations). In the combined analysis across years, grain yield of Denali was the second highest in the trial (4027 kg ha^{-1}), similar to ($P > 0.05$) that of 'Byrd' (PI 664257; Haley et al., 2012) (4344 kg ha^{-1}), Ripper (3987 kg ha^{-1}), 'Bill Brown' (PI 653260, Haley et al., 2008) (3945 kg ha^{-1}), TAM 112 (3851 kg ha^{-1}), and Hatcher (3773 kg ha^{-1}), and greater than ($P < 0.05$) that of Thunder CL (3579 kg ha^{-1}). In these trials, Denali had above-average grain volume weight (781 kg m^{-3}), which was similar to ($P > 0.05$) that of TAM 112 (782 kg m^{-3}), Byrd (777 kg m^{-3}), Bill Brown (774 kg m^{-3}), and Hatcher (770 kg m^{-3}), and greater than ($P < 0.05$) that of Thunder CL (761 kg m^{-3}) and Ripper (754 kg m^{-3}).

Denali was tested at 15 trial locations of the nonirrigated Colorado Uniform Variety Performance Trial during 2010 (9 locations) and 2011 (9 locations). In the combined analysis across years, the grain yield of Denali was the second highest in the trial (3973 kg ha^{-1}), similar to ($P > 0.05$) that of Byrd (4183 kg ha^{-1}), 'Settler CL'; (PI 653833; Baenziger et al., 2011) (3842 kg ha^{-1}), Hatcher (3789 kg ha^{-1}), Bill Brown (3754 kg ha^{-1}), and Ripper (3724 kg ha^{-1}), and greater than ($P < 0.05$) that of TAM 112 (3639 kg ha^{-1}). In these trials, Denali had above-average grain volume weight (785 kg m^{-3}), which was similar to ($P > 0.05$) that of TAM 112 (777 kg m^{-3}), Bill Brown (775 kg m^{-3}), and Hatcher (774 kg m^{-3}) and greater than ($P < 0.05$) that that of Settler CL (771 kg m^{-3}) and Ripper (754 kg m^{-3}).

Denali was tested at six trial locations of the Colorado Irrigated Variety Performance Trial (IVPT) during 2010 (three locations) and 2011 (three locations). In the combined analysis across years, the grain yield of Denali was the third highest in the trial (6581 kg ha^{-1}), similar ($P > 0.05$) to that of Byrd (6707 kg ha^{-1}), Settler CL (6707 kg ha^{-1}), Ripper (6514 kg ha^{-1}), and Hatcher (6224 kg ha^{-1}), and greater than ($P < 0.05$) that of Thunder CL (6044 kg ha^{-1}). In these trials, Denali had above-average grain volume weight (789 kg m^{-3}), which was similar to ($P > 0.05$) that of Byrd (796 kg m^{-3}), Thunder CL (784 kg m^{-3}), and Hatcher (782 kg m^{-3}) and greater than ($P < 0.05$) that of Ripper (769 kg m^{-3}).

Denali was tested in the 2010 and 2011 Southern Regional Performance Nursery. Averaged across the hard winter wheat region, Denali was the 5th-highest-yielding entry in the trial in 2010 (3908 kg ha^{-1}; 48 total entries; 30 locations) and the 13th-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 Denali and the common check entries were determined using the 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 Denali 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 Denali, with kernel characteristics, grain protein concentration, and flour extraction (with the Brabender Quadrumat Senior, C.W. Brabender, South Hackensack, NJ) comparable to those of the check entries (Table 1). Values for baking-

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

Trait (unit of measurement)	Samples	Denali	Hatcher	Ripper	Above
SKCS† kernel weight (mg)	28	31.0	30.1 ns	31.2 ns	30.9 ns
SKCS kernel diameter (mm)	28	2.62	2.62 ns	2.68*	2.67*
SKCS kernel hardness (units)	28	66.7	69.9*	68.7 ns	73.0*
Grain protein (g kg^{-1})	26	128	128 ns	135*	128 ns
Grain ash (g kg^{-1})	26	15.6	14.8*	14.8*	15.2*
Flour extraction (g kg^{-1})	23	679	674 ns	675 ns	648*
Flour ash (g kg^{-1})	25	4.5	4.4 ns	4.6*	4.6*
Mixograph peak time (min)	25	3.3	4.4*	3.2 ns	2.7 ns
Mixograph tolerance (score)‡	24	1.9	3.8*	3.1*	2.1 ns
Bake mix time (min)	24	3.0	4.2*	3.2 ns	2.6*
Bake water absorption (g kg^{-1})	24	617	627*	639*	615 ns
Loaf volume (L)	24	0.85	0.91*	0.89*	0.83 ns
Crumb grain (score)‡	24	2.8	3.8*	2.8 ns	3.4 ns

*Significance of the difference between Denali and the check cultivar based on a Student's paired *t* test procedure at the 0.05 probability level; ns, not significant.

†Single-kernel characterization system.

‡Scale for mixograph tolerance and crumb grain scores: 6 = outstanding, 0 = unacceptable.

related variables were generally similar for Denali and the lower baking-quality check Above, with reduced mixograph peak time, mixograph tolerance, bake water absorption, loaf volume, and crumb grain score compared with the higher-quality check Hatcher (Table 1). DNA marker assays for high molecular weight glutenin subunits (Butow et al., 2004; Liu et al., 2008) have shown that Denali 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. Denali does not carry either the T1BL-1RS or T1AL-1RS translocation.

Availability

The Colorado Agricultural Experiment Station will maintain breeder seed of Denali. 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, 4026 South Timberline Road, Suite 100, Fort Collins, CO, 80525. Denali 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. Small quantities of seed for research purposes may be obtained from the corresponding author for at least 5 yr from the date of publication. Seed of Denali has been deposited with the National Plant Germplasm System, where it will be available for distribution upon expiration of PVP, 20 yr after publication.

Acknowledgments

Research supported in part by the Colorado Wheat Administrative Committee and Wheat Research Foundation, USDA-CSREES Special Research Grants Nos. 2009-34205-19960, 2008-34205-19341, 2006-34205-17358, 2005-34205-16334, 2003-34205-13636, and the National Research Initiative of USDA's Cooperative State Research, Education and Extension Service CAP Grant No. 2006-55606-16629. Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture. USDA is an equal opportunity provider and employer.

References

American Association of Cereal Chemists. 2000. Approved methods of the AACC. 10th Ed. Am. Assoc. Cereal Chem., St. Paul, MN.

Baenziger, P.S., R.A. Graybosch, L.A. Nelson, T. Regassa, R.N. Klein, D.D. Baltensperger, D.K. Santra, A.M.H. Ibrahim, W. Berzonsky, J.M. Krall, L. Xu, S.N. Wegulo, M.L. Bernards, Y. Jin, J. Kolmer, J.H. Hatchett, M.-S. Chen, and G. Bai. 2011. Registration of 'NH03614 CL' wheat. J. Plant Reg. 5:75–80. doi:10.3198/jpr2010.02.0084crc

Butow, B.J., K.R. Gale, J. Ikea, A. Juhasz, Z. Bedo, L. Tamas, and M.C. Gianibelli. 2004. Dissemination of the highly expressed Bx7 glutenin sub-unit (*Glu-B1al* allele) in wheat as revealed by novel PCR markers and RP-HPLC. Theor. Appl. Genet. 109:1525–1535. doi:10.1007/s00122-004-1776-8

Chen, M.S., E. Echegaray, R.J. Whitworth, H. Wang, P.E. Sloderbeck, A. Knutson, K.L. Giles, and T.A. Royer. 2009. Virulence analysis of Hessian fly (*Mayetiola destructor*) populations from Texas, Oklahoma, and Kansas. J. Econ. Entomol. 102:774–780. doi:10.1603/029.102.0239

Chen, X.M. 2005. Epidemiology and control of stripe rust [*Puccinia striiformis* f. sp. *tritici*] on wheat. Can. J. Plant Pathol. 27:314–337. doi:10.1080/07060660509507230

Chen, X.M., and R.F. Line. 1995. Gene action in wheat cultivars for durable high-temperature adult-plant resistance and interactions with race-specific, seedling resistance to stripe rust caused by *Puccinia striiformis*. Phytopathology 85:567–572. doi:10.1094/Phyto-85-567

Chen, X.M., L. Penman, A.M. Wan, and P. Cheng. 2010. Virulence races of *Puccinia striiformis* f. sp. tritici in 2006 and 2007 and development of wheat stripe rust and distributions, dynamics, and evolutionary relationships of races from 2000 to 2007 in the United States. Can. J. Plant Pathol. 32:315–333. doi:10.1080/07060661.2010.499271

Hakizimana, F., S.D. Haley, and E.B. Turnipseed. 2000. Repeatability and genotype × environment interaction of coleoptile length measurements in winter wheat. Crop Sci. 40:1233–1237. doi:10.2135/cropsci2000.4051233x

Haley, S.D., J.J. Johnson, F.B. Peairs, J.S. Quick, J.A. Stromberger, J.D. Butler, H.R. Miller, E.E. Heaton, J.B. Rudolph, B.W. Seabourn, G. Bai, Y. Jin, J. Kolmer, and X. Chen. 2008. Registration of 'Bill Brown' wheat. J. Plant Reg. 2:218–223. doi:10.3198/jpr2008.03.0133crc

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 Reg. 1:1–6. doi:10.3198/jpr2006.10.0689crc

Haley, S.D., J.J. Johnson, F.B. Peairs, J.A. Stromberger, E.E. Hudson, S.A. Seifert, R.A. Kottke, V.A. Valdez, J.B. Rudolph, G. Bai, and X. Chen. R.L. Bowden, Y. Jin, J.A. Kolmer, M.-S. Chen, and B.W. Seabourn. 2012. Registration of 'Byrd' wheat. J. Plant Reg. 6:XXX–XXX. doi: 10.3198/jpr2011.12.0672crc

Haley, S.D., J.J. Johnson, P.H. Westra, F.B. Peairs, J.A. Stromberger, E.E. Heaton, S.A. Seifert, R.A. Kottke, J.B. Rudolph, G. Bai, R.L. Bowden, M.-S. Chen, X. Chen, Y. Jin, J.A. Kolmer, and B.W. Seabourn. 2009. Registration of 'Thunder CL' wheat. J. Plant Reg. 3:181–184. doi:10.3198/jpr2008.12.0727crc

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. 2003. 'Above' winter wheat. Can. J. Plant Sci. 83:107–108. doi:10.4141/P02-014

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. doi:10.2135/cropsci2005.0030

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. 44:355–356.

Liu, S., S. Chao, and J.A. Anderson. 2008. New DNA markers for high molecular weight glutenin subunits in wheat. Theor. Appl. Genet. 118:177–183. doi:10.1007/s00122-008-0886-0

Lu, H., R. Kottke, R. Devkota, P. St. Amand, A. Bernardo, G. Bai, P. Byrne, T.J. Martin, S.D. Haley, and J. Rudd. 2012. Consensus-mapping and identification of markers for marker-assisted selection of *Wsm2* in wheat. Crop Sci. 52:720–728.

Mares, D., K. Mrva, J. Cheong, K. Williams, B. Watson, E. Storlie, M. Sutherland, and Y. Zou. 2005. A QTL located on chromosome 4A associated with dormancy in white- and red-grained wheats of diverse origin. Theor. Appl. Genet. 111:1357–1364. doi:10.1007/s00122-005-0065-5

Qi, L.L., B. Friebe, P. Zhang, and B.S. Gill. 2007. Homoeologous recombination, chromosome engineering and crop improvement. Chromosome Res. 15:3–19. doi:10.1007/s10577-006-1108-8