

### Registration of 'Protection' Wheat

'Protection' (Reg. no. CV-980, PI 639923) hard red winter wheat (*Triticum aestivum* L.) was developed by the Colorado Agricultural Experiment Station and released to seed producers in August 2004. Protection was released based on its tolerance to imazamox [2-[4,5-dihydro-4-methyl-4-(1-methyl-ethyl)-5-oxo-1H-imidazol-2-yl]-5-(methoxymethyl)-3-pyridinecarboxylic acid] herbicide, competitive yield with available imazamox-tolerant winter wheat cultivars, and improved bread baking quality relative to available imazamox-tolerant winter wheat cultivars.

Protection was derived from the cross 'Jagger'//TXGH12588-120\*4/FS2 made in 1997 at Center, CO. Jagger (PI 593688) is a hard red winter wheat cultivar released by Kansas State University in 1994 (Sears et al., 1997), and TXGH12588-120 is an unreleased sister selection of the hard red winter wheat cultivar TAM 110 (PI 595757; Lazar et al., 1997). The wheat germplasm line FS2 was developed by BASF Corporation (formerly American Cyanamid) using sodium azide-induced mutagenesis of the French wheat cultivar Fidel to obtain tolerance to the imidazolinone class of herbicides (Newhouse et al., 1992). An imazamox-tolerant BC<sub>3</sub>F<sub>2</sub> plant with the pedigree TXGH12588-120\*4/FS2 was used in the final cross with Jagger.

Vernalized F<sub>1</sub> seeds were increased in the greenhouse at Fort Collins, CO, during fall 1997. The F<sub>2</sub> population from this increase was space-planted at Center, CO, in summer 1998. A single seed harvested from an F<sub>2</sub> plant in early September 1998 was increased to the F<sub>3</sub> in the greenhouse at Fort Collins in fall 1998. Seed harvested from the F<sub>3</sub> plant was vernalized for 8 wk at 2°C in small plastic bags and hand-transplanted to the field at Center as hills in May 1999. Tolerance to imazamox herbicide of the F<sub>3,4</sub> line was determined by recording germination of 10 remnant seeds in petri dishes in the presence of an aqueous solution (50 µL L<sup>-1</sup>) of imazamox herbicide. Protection was selected as an F<sub>3,4</sub> line in September 1999 at Center and assigned experimental number CO991132. Protection was planted in an unreplicated observation plot at Fort Collins in fall 1999. In spring 2000, the observation trial was treated with imazamox herbicide (44.8 g a.i. ha<sup>-1</sup>) to confirm tolerance ratings from the petri dish germination assay. Protection was advanced from the observation trial in 2000 to replicated advanced yield trials in 2001 and replicated statewide variety trials from 2002 to 2004. Breeder seed of Protection was generated by selecting approximately 400 heads from an F<sub>2,10,03</sub> increase at Fort Collins in 2001 and growing these as headrows in Yuma, AZ, during winter 2001-2002. The F<sub>6,7</sub> headrows were treated with imazamox herbicide (44.8 g ai ha<sup>-1</sup>) in spring 2002 and rows with uniform appearance were composited. A bulk seed increase from the Breeder seed increase was grown in Yuma, AZ, in winter 2002-2003.

Protection is an awned, bronze-chaffed, early-maturing semidwarf hard red winter wheat. Protection is early maturing, 142 d to heading from 1 January ( $n = 6$  observations), similar to 'Above' (142 d; Haley et al., 2003) and Jagger (141 d). Plant height of Protection is medium-tall (73.7 cm;  $n = 15$  observations), taller than Above (66.0 cm) and Jagger (68.6 cm). Coleoptile length of Protection (88.0 mm,  $n = 6$  observations) is longer than Above (86.5 mm) and Jagger (80.1 mm). Shattering tolerance of Protection is average (4.7 score, 1 = no shatter to 9 = severe shatter,  $n = 4$  observations), slightly less than Above (3.5 score) and similar to Jagger (4.1 score). On the basis of field evaluations under natural infection in Colorado and cooperative evaluations through the USDA Regional Testing Program, Protection is moderately resistant to stem rust (caused by *Puccinia graminis* Pers.:Pers f. sp. *tritici* Eriks. & E. Henn.; composite of races QFCS, QTHJ, RCRS, TPMK, and TTTT),

susceptible to leaf rust (caused by *Puccinia triticina* Eriks.; composite of races MLRT, MFBP, TKBP, TDGT, and KBQT), resistant to stripe rust (caused by *Puccinia striiformis* f. sp. *tritici* Westend.; natural field infection), susceptible to *Wheat streak mosaic virus*, and heterogeneous for resistance to *Wheat soil-borne mosaic virus*. Protection is susceptible to the Great Plains biotype of Hessian fly [*Mayetiola destructor* (Say)] and susceptible to the Russian wheat aphid [*Diuraphis noxia* (Mordvilko)].

Protection was tested at 14 trial locations of the Colorado Dryland Uniform Variety Performance Trial (UVPT) in 2002 (three locations), 2003 (six locations), and 2004 (five locations). Grain yields of Protection (3097 kg ha<sup>-1</sup>) were lower than Above (3252 kg ha<sup>-1</sup>) and greater than 'AP502 CL' (3044 kg ha<sup>-1</sup>; Lazar et al., 2003), the only two cultivars in the trials with tolerance to imazamox. Compared with other available cultivars, Protection had lower grain yield than 'Ankor' (3138 kg ha<sup>-1</sup>; PI 632275), similar yield to 'Prairie Red' (3044 kg ha<sup>-1</sup>; PI 605390), and higher grain yield than Jagger (2916 kg ha<sup>-1</sup>). Average test weight for Protection (739 g L<sup>-1</sup>) in these trials was less than Above, Ankor, Prairie Red, and Jagger (749 g L<sup>-1</sup>) and less than AP502 CL (743 g L<sup>-1</sup>). Protection was tested at two trial locations of the Colorado Irrigated Variety Performance Trial (IVPT) in 2004. In these trials, Protection (7223 kg ha<sup>-1</sup>) had lower grain yield than 'Yuma' (7701 kg ha<sup>-1</sup>; PI 559720) and similar grain yield as Prairie Red (7228 kg ha<sup>-1</sup>). The straw strength of Protection in these trials was good (3.3 score, 1 = erect to 9 = flat,  $n = 3$  observations), less than Yuma (1.7 score) and Prairie Red (2.0 score) and better than Ankor (5.0 score).

Milling and bread baking characteristics of Protection were determined from multilocation composite grain samples from the Colorado UVPT in 2001 and 2002. The imazamox-tolerant cultivar Above was used as a check in these evaluations. Values for milling-related and baking-related variables of Protection were generally comparable to or superior to Above. Protection had lower grain volume weight (721 g L<sup>-1</sup>) than Above (735 g L<sup>-1</sup>); higher Single Kernel Characterization System (SKCS) kernel weight (29.1 mg kernel<sup>-1</sup>) than Above (27.9 mg kernel<sup>-1</sup>); higher SKCS kernel diameter (2.36 mm) than Above (2.16 mm); higher SKCS kernel hardness index (82.0 score) than Above (80.4 score); higher flour ash (4.9 g kg<sup>-1</sup>) than Above (4.3 g kg<sup>-1</sup>); and higher Quadromat Senior flour extraction (703 g kg<sup>-1</sup>) than Above (669 g kg<sup>-1</sup>). For baking-related variables, Protection (134 g kg<sup>-1</sup>) had higher grain protein content than Above (123 g kg<sup>-1</sup>); higher (637 g kg<sup>-1</sup>) mixograph water absorption than Above (618 g kg<sup>-1</sup>); higher (2.5 score; 0 = unacceptable to 6 = excellent scale) mixograph tolerance score than Above (1.0 score); similar (2.6 min) mixograph mixing time as Above (2.7 min); higher (619 g kg<sup>-1</sup>) bake water absorption than Above (605 g kg<sup>-1</sup>); similar (3.1 min) bake mixing time as Above (3.0 min); smaller (0.895 L) pup loaf volume than Above (0.930 L); and lower (2.3 score; 0 = unacceptable to 6 = excellent scale) pup loaf crumb grain score than Above (2.8 score).

Protection contains a patented herbicide tolerance trait owned by BASF Corp. that confers tolerance to imidazolinone herbicides, such as imazamox. Any use of Protection requires a Material Transfer Agreement (for research use only) or a Commercial License to the trait, as well as permission from the originator. Contact the corresponding author for all seed requests. The corresponding author will forward the request for seed to BASF Corporation. No seed will be distributed without written permission from both BASF and the Colorado State University for 20 yr from the date of release by Colorado State University (2004), at which time seed will also be available from the NPGS.

Breeder seed maintenance and multiplication and distribution rights of other classes of seed of Protection have been

transferred to AGSECO Inc., c/o Delange Seed, P.O. Box 7, Girard, KS 66743. Protection has been submitted for U.S. Plant Variety Protection under Public Law 91–577 with the certification only option.

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### Acknowledgments

Protection 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.

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doi:10.2135/cropsci2005.0032  
Published in *Crop Sci.* 46:995–996 (2006).