WASHINGTON AGRICULTURAL RESEARCH CENTER
WASHINGTON STATE UNIVERSITY
PULLMAN, WASHINGTON

Announces the Release of

**'KELSE'**

Hard Red Spring Wheat

## Introduction

'Kelse' (Reg. No._____; PI 653842) hard red spring (HRS) wheat (*Triticum aestivum* L.) was developed by the Agricultural Research Center of Washington State University in cooperation with the Agricultural Experiment Stations (AESs) of the University of Idaho and Oregon State University, and the United States Department of Agriculture-Agricultural Research Service (USDA-ARS). Kelse was named in honor of Kelsey L. Kidwell-Yonan, Dr. Kidwell's beloved niece. Kelse was released as a replacement to 'WestBred 926' (proprietary cultivar from WestBred LLC, Bozeman, MT), 'Hank' (proprietary cultivar from WestBred LLC, Bozeman, MT), 'Tara 2002' (Kidwell et al., 2003), and 'Scarlet' (Kidwell et al., 1999) based on its resistance to the Hessian fly [*Mayetiola destructor* (Say)], high-temperature, adult-plant resistance (HTAP) to local races of stripe rust (*Puccinia striiformis* Westend f. sp. *tritici)*, high grain protein content, superior baking quality, and grain yield potential in the intermediate to high rainfall (>380 mm of average annual precipitation), non-irrigated wheat production regions of Washington State.

## Methods

Kelse, tested under the experimental designations WA007954, H0100092, and HR98036, which were assigned through progressive generations of advancement, is a $F_{3:4}$ head row selection derived from the cross 'WestBred 906R' (PI 483455)/PI 520542//'Scholar' (PI 607557). WestBred 906R is a HRS variety derived from a male sterile facilitative recurrent selection released in 1981 by WestBred LLC, Bozeman, MT. PI 520542 is a HRS wheat variety developed by South Dakota State University in 1987 with the pedigree 'Butte'//'Olaf'/'MN 6792'. Scholar is a HRS wheat variety released in 1999 by Montana State University (Lanning et al., 2000), with the pedigree 'MT7746'/'Lew'//'Marberg'. The final cross for Kelse was completed in the greenhouse in Pullman, WA in 1997 and the following modified pedigree-bulk method was used to advance early generation progeny. Bulked seed (30 g) from $F_1$ plants was used to establish an $F_2$ field plot in 1998. Approximately 100 heads were selected at random from individual $F_2$ plants and a 40 g subsample of the bulked seed was used to establish a single $F_3$ field plot in 1999. Single heads from approximately 150 $F_3$ plants were threshed individually to establish $F_{3:4}$ head row families in the field in 2000. $F_1$ progeny were advanced at the WSU Plant Growth Facility on the Washington State University Campus in Pullman, WA. The $F_2$ and $F_4$ progeny were advanced in field nurseries at Pullman, WA, whereas $F_3$ progeny were advanced at the Lind Dryland Experiment Station in Lind, WA.

Following selection among rows for general adaptation, resistance to stripe rust (*Puccinia striiformis* Westend f. sp. *tritici)*, plant height, and grain appearance, seed from 30 to 50 plants within each selected head row was bulk harvested to obtain $F_{3:5}$ seed for early generation quality assessment. A 15 g subsample of each selected head row was UDY milled using a 0.5 mm screen. Flour produced was evaluated for protein content and hardness using a Bran+Luebbe InfraAlyzer 450. Selections with appropriate protein and hardness were then evaluated for gluten strength using the sodium dodecyl-sulfate-sedimentation method (AACC, 2000). Selections with high micro-sedimentation values were kept for grain yield assessment in replicated trials. Twenty-five head row selections from the original cross, designated as HR98036, were advanced to non-replicated testing at Lind, WA and grown in 7.4 $m^2$ plots in 2001 and evaluated for grain yield, test weight, grain protein content, disease resistance, and milling and baking quality. All subsequent years of testing were evaluated utilizing the same size plot area and data collection strategy using either a randomized complete block design (4 replications) (2002-2005) or a general alpha lattice design (3 replications) (2006-2007). Four of the original 25 selections were advanced to preliminary replicated, non-irrigated field trials in Pullman and Lind, WA in 2002. Two selections were

advanced to state replicated, non-irrigated trials in Pullman, Lind, Connell, and Dusty, WA in 2003. One line, designated H0100092, was selected to be tested on a regional basis and assigned the new identification number WA007954 in 2004. From 2004 to 2005, WA007954 was evaluated in the Tri-state Regional Nursery, which was established at 9 locations each year in Washington, Oregon and Idaho, in both rainfed and irrigated environments. In 2006, WA007954 was entered in the Washington State University Extension Uniform Cereal Variety Testing Spring Wheat Performance Trials and tested in 2006 and 2007 throughout eastern Washington at 18 and 16 locations, respectively. Since 2001, WA007954 was evaluated for end-use quality and disease resistance by the USDA-ARS Wheat Genetics, Quality, Physiology, and Disease Research Unit, Pullman, WA. WA007954 was evaluated by the Pacific Northwest Wheat Quality Council in 2007. Breeder seed of WA007954 (Kelse) was produced as a reselection, based on phenotypic uniformity, of 1400 $F_{3:11}$ head rows grown under irrigation in Othello, WA, in 2007. Selected head rows were bulked at harvest, resulting in the production of 573 kg of Breeder seed (Washington State Crop Improvement Association).

**Characteristics**

Kelse is an intermediate height, semidwarf plant with lax, tapering, erect curvature inflorescence with tan awns and glumes that are long in length, wide in width and have medium, oblique shoulders, and narrow, acuminate beaks. Kelse has oval kernels that are red, hard and vitreous. Seed of Kelse has a large germ with a medium depth crease, angular cheeks and a short, non-collared brush. Kelse lacks anthocyanin pigmentation in the coleoptile, displays a semi-erect juvenile plant growth habit, the flag leaf is green in color, recurved, twisted, and waxy at Feekes growth stage 10.0 (Large, 1954). The stem of Kelse has three nodes, lacks anthocyanin pigmentation, a waxy bloom is present, the last internode of the rachis is semi-solid, the auricle is pigmented, pubescence is absent, and the peduncle is erect with a length of 41 cm. Kelse headed [Day of year (DOY) 167] 3 days later than Hank (DOY 164), and 5 days later than WestBred 926 (DOY 162) and Tara 2002 (DOY 162). The average plant height of Kelse was 80 cm, which was significantly ($P$<0.1) taller than WestBred 926 (73 cm) and Hank (72 cm), and equal to Tara 2002 (80 cm). Lodging percentages of Kelse (<1%) when grown with irrigation were comparable to Hank (<1%), and lower than WestBred 926 (3-5 %) and Tara 2002 (15-20%) ($P$<0.1).

**Disease and Insect Resistance**

In greenhouse seedling tests conducted in 2006 and 2007 under low temperature cycles (diurnal temperatures gradually changing from 4 to 20°C; Chen and Line, 1992), Kelse was resistant (IT 2) to races PST-37, PST-45, and PST-100; intermediate (IT 5) to PST-17 and PST-43; but susceptible (IT 7-8) to PST 116 and PST-127. When adult plants were tested in the greenhouse at high-temperatures (diurnal temperature cycle gradually changing from 10 to 35°C; Chen and Line, 1995), Kelse was resistant (IT 0-3) to races PST-45, PST-100, and PST 116 and moderately resistant (IT 5) to PST-127. The contrasting reactions of seedlings compared to adult plants with races PST-116 and PST-127 indicate that Kelse has a moderate level of non-race-specific, high-temperature, adult-plant resistance (HTAP) to stripe rust, which has proven to be durable in other spring wheat varieties such as 'Louise' (Kidwell et al., 2006). In naturally infected field tests conducted by the USDA-ARS, Wheat Genetics, Quality, Physiology, and Disease Research Unit, Pullman, WA on the Whitlow farm near Pullman, WA and at Mt. Vernon, WA from 2002-2005 and on the Spillman Agronomy, Plant Pathology, and Whitlow farms near Pullman, WA in 2006 and 2007, and in breeding nurseries at multiple locations throughout eastern Washington from 2002 to 2007, Kelse displayed high levels of non-race-specific, HTAP resistance [infection type (IT) 0-3] at all locations in eastern Washington and moderately resistant (IT 5) at Mt. Vernon, WA. Kelse is the first HRS variety released in the region that is confirmed to HTAP resistance to stripe rust.

On the basis of results from two years of controlled environment insect screening trials conducted at the University of Idaho, Kelse is resistant (100%) to Hessian fly biotypes E, F and GP. On the basis of pedigree and natural field infestation ratings from Pullman, WA, Kelse is susceptible to the Russian wheat aphid [*Diuraphis noxia* (Mordvilko)].

**Agronomic Performance**

Kelse was evaluated in 45 replicated field trials under fallow, rainfed, and irrigated conditions in Washington State from 2002-2007. In 12 trials conducted from 2002 to 2005 in low (<380 mm average

annual precipitation), intermediate (380-460 mm average annual precipitation), high precipitation zones (>460 mm average annual precipitation) and with irrigation in Washington, the average grain yield of Kelse, WestBred 926, and Scarlet were 3225 kg $ha^{-1}$, 3153 kg $ha^{-1}$, and 2755 kg $ha^{-1}$, respectively. Grain yield of Kelse and WestBred 926 did not differ significantly and were significantly ($P$ <0.1) higher than grain yield averages of Scarlet. Average grain volume weight of Kelse (750 kg $m^{-3}$) was similar to WestBred 926 (744 kg $m^{-3}$) and significantly higher than the grain volume weight of Scarlet (736 kg $m^{-3}$) ($P$<0.1).

In 15 rainfed trials conducted from 2006 to 2007 in the low precipitation zones in Washington, average grain yield of Kelse, WestBred 926, Tara 2002, and Hank were 2419 kg $ha^{-1}$, 2486 kg $ha^{-1}$, 2492 kg $ha^{-1}$, and 2506 kg $ha^{-1}$, respectively and were not significantly different ($P$<0.1). In 11 rainfed trials conducted from 2006-2007 in the intermediate precipitation zones in Washington, the grain yield averages of Kelse, WestBred 926, Tara 2002, and Hank were 3790 kg $ha^{-1}$, 3937 kg $ha^{-1}$, 3917 kg $ha^{-1}$, and 3978 kg $ha^{-1}$, respectively. The average grain yield of Kelse and Tara 2002 did not differ significantly ($P$<0.1) but were lower than those of WestBred 926 and Hank. In seven tests conducted from 2006 to 2007 in the high precipitation zones and under irrigation in Washington, the grain yield averages of Kelse, WestBred 926, Tara 2002, and Hank were 5728 kg $ha^{-1}$, 6212 kg $ha^{-1}$, 6605 kg $ha^{-1}$, and 6618 kg $ha^{-1}$, respectively. Grain yield of WestBred 926, Tara 2002 and Hank were not significantly different from one another but were significantly higher than grain yield averages of Kelse ($P$ <0.1). In these same field trials, the average grain volume weight of Kelse (764 kg $m^{-3}$) was significantly higher than ($P$<0.1) WestBred 926 (754 kg $m^{-3}$) and Hank (750 kg $m^{-3}$) and equal to that of Tara 2002 (764 kg $m^{-3}$). Thousand-kernel weight averages of Kelse, WestBred 926, Tara 2002, and Hank were 38.3 g, 44.4 g, 50.0 g, and 37.7 g, respectively.

**End-Use Quality**

In tests conducted at the USDA-ARS Western Wheat Quality Laboratory in Pullman, WA using grain produced in 26 breeding and commercial variety testing trials in Washington from 2001 through 2007, the milling and backing qualities of Kelse were compared to WestBred 926, 'Hollis' (Kidwell et al., 2004), Tara 2002, and Scarlet. Grain protein content of Kelse (155 g $kg^{-1}$) was higher but statistically similar to both WestBred 926 and Hollis (149 g $kg^{-1}$), and significantly ($P$<0.01) higher than Tara 2002 (146 g $kg^{-1}$), and Scarlet (143 g $kg^{-1}$). Flour yield of Kelse (680 g $kg^{-1}$) was significantly ($P$<0.01) lower than WestBred 926 (692 g $kg^{-1}$), Hollis (701 g $kg^{-1}$), Tara 2002 (694 g $kg^{-1}$) and Scarlet (697 g $kg^{-1}$). Flour ash content for Kelse (4.5 g $kg^{-1}$) was similar to WestBred 926 (4.3 g $kg^{-1}$), and significantly ($P$< 0.01) higher than Tara 2002 (4.0 g $kg^{-1}$), Hollis (3.8 g $kg^{-1}$) and Scarlet (3.8 g $kg^{-1}$). Kelse had a lower average milling score (80.0) than WestBred 926 (82.1), Tara 2002 (84.0), Scarlet (85.3), and Hollis (85.7). Dough mixing time of Kelse (4.2 min) was similar to Scarlet (4.0 min) and WestBred 926 (4.1 min), slightly shorter than Hollis (4.5 min), and significantly ($P$< 0.01) shorter than Tara 2002 (6.1 min). Mixograph water absorption of Kelse (647 g $kg^{-1}$) was similar to that of WestBred 926 (642 g $kg^{-1}$) and Hollis (640 g $kg^{-1}$), but was significantly ($P$< 0.01) higher than Scarlet (639 g $kg^{-1}$) and Tara 2002 (637 g $kg^{-1}$). Average 100 g pup loaf volume for Kelse (1091 $cm^3$) was comparable to Tara 2002 (1084 $cm^3$) and Hollis (1085 $cm^3$), and significantly ($P$< 0.01) larger than that of West Bred 926 (1044 $cm^3$) and Scarlet (996 $cm^3$) when compared across production regions. All above tests were conducted using approved AACC methods (AACC, 2000).

In 2007, Kelse was evaluated by commercial millers and bakers in the Pacific Northwest Wheat Quality Council. Based on these results, Kelse had superior end-use quality attributes when compared to WestBred 926 in nearly every assessment category. Out of the 28 wheat varieties tested, Kelse ranked 3rd overall for superior end-use quality attributes, whereas WestBred 926 ranked 18$^{th}$ (date not shown). All collaborators preferred the dough handling properties and baking quality of Kelse compared to WestBred 926, which were attributed to the superior protein quality of Kelse compared to WestBred 926. The protein content, protein quality and baking quality attributes of Kelse overcame any concerns about milling quality and ash content from a commercial users' perspective.

**Availability**

Foundation seed of Kelse will be maintained by the Washington State Crop Improvement Association under supervision of the Department of Crop and Soil Sciences and the Washington State

University Agricultural Research Center. Small quantities may be obtained for research purposes by contacting the National Plant Germplasm System. U.S. Plant Variety Protection status for this cultivar is pending.

**References**

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

Chen, X.M. and R.F. Line. 1992. Identification of stripe rust resistance genes in wheat cultivars used to differentiate North American races of *Puccinia striiformis*. Phytopathology 82:1428–1434.

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.

Kidwell, K.K., G.B. Shelton, C.F. Morris, R.F. Line, B.C. Miller, M.A. Davis, and C. F. Konzak. 1999. Registration of 'Scarlet' wheat. Crop Sci. 39:1255.

Kidwell, K.K., G.B. Shelton, V.L. DeMacon, J.W. Burns, B.P. Carter, C.F. Morris, X. Chen, and J.H. Hatchett. 2003. Registration of 'Tara 2000' wheat. Crop Sci. 43:751-a.

Kidwell, K.K., G.B. Shelton, V.L. DeMacon, J.W. Burns, B.P. Carter, C.F. Morris, X.M. Chen, and N.A. Bosque-Pérez. 2004. Registration of 'Hollis' wheat. Crop Sci. 44:1871-1872.

Kidwell, K.K., G.B. Shelton, V.L. DeMacon, J.W. Burns, B.P. Carter, X.M. Chen, C.F. Morris, and N.A. Bosque Pérez. 2006. Registration of 'Louise' wheat. Crop Sci. 46:1384-1386.

Lanning, S.P., H.F. Bowman, D. Habernicht, G.R. Carlson, J.L. Eckhoff, G.D. Kushnak, R.N. Stougaard, D.M. Wichman, and L.E. Talbert. 2000. Registration of 'Scholar' wheat. Crop Sci. 40:861.

Large, E.C. 1954. Growth stages in cereals. Plant Pathol. 3:128–129.

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July 15, 2008

Date

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Mr. Ronald Whittum
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March 22, 2010

Dear Ron:

The purpose of this letter is to provide you with a supplemental description for the hard red spring wheat variety 'Kelse'. The variety description for Kelse should include a tolerance for white seed.

Kelse breeder seed was first produced in 2007. Initial seed purity tests (WSDA) of this breeder seed lot indicated that Kelse contained 0 white seed per pound. In 2008, two foundation seed lots were produced from the 2007 breeder seed lot and results indicated 0 white seed per pound, respectively (WSDA test). In 2009, one foundation seed lot was produced using the seed from the 2008 breeder seed lot and results indicated 9 white seed per pound.

Although the seed production of Kelse is in an early phase, and more sampling and testing will continue, it appears advisable at this point to include a variant description to allow distribution and certification.

In 2009 and 2010 both registered and certified class lots were submitted to the WSDA Seed Lab for normal germination and purity testing. Several of these lots showed a high percentage of variable red and white color making them unacceptable for certification. Upon further examination and PCR testing of the light colored seed they were found to be 99% Kelse Hard Red Spring. It was determined that the lots with a high percentages of the light colored seed were grown under irrigation and high fertility situations.

Kelse contains white seed that should be considered a variant within the variety. A white seed variant may occur in Kelse at a frequency of up to .10% (10 per 10,000 seed) in all classes of certified seed.

In some growing conditions (especially high fertility/irrigation), Kelse may contain a color variant that ranges from off white to the normal dark red of the variety. We believe this is related to established genetics of seed color in wheat, and these Kelse variants likely have only one gene for red seed color (of the three possible). These variants still maintain the hard seed

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characteristics of Kelse hard red spring wheat but with the color variant at a frequency of up to 1.0% (100 per 10,000 seed) in all classes of certified seed. Other variation from the original description of this variety should not be considered true-to-type.

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