Registration of ‘Kelse’ Wheat


ABSTRACT

Hard red spring (HRS) wheat (Triticum aestivum L.) grain must have high grain protein concentration (GPC) to maximize market value. The objective of this research was to develop a HRS wheat cultivar with high GPC and durable resistance to stripe rust (Puccinia striiformis Westend f. sp. tritici), a major foliar fungal disease problem of spring wheat. ‘Kelse’ (Reg. No. CV-1035, PI 653842) HRS wheat was developed and released in July 2008 by the Agricultural Research Center of Washington State University. Kelse was tested under the experimental designations of WA007954, H0100092, and HR98036, which were assigned through progressive generations of advancement. Kelse is a semidwarf cultivar adapted to the intermediate-to-high rainfall (>380 mm average annual precipitation), nonirrigated wheat production regions of Washington State. Kelse was released based on its (i) resistance to the Hessian fly [Mayetiola destructor (Say)], (ii) high-temperature, adult-plant resistance (HTAP) to local races of stripe rust (infection type 0–3), (iii) high GPC, (iv) excellent bread-baking quality, and (v) high grain yield potential in the target production region. Kelse is the first HRS wheat cultivar adapted to the Pacific Northwest region of the United States with HTAP resistance to stripe rust. Based on molecular marker analysis, Kelse has the Lr34/Yr18 and Lr37/Yr17/Sr38 gene clusters for rust resistance. Kelse also has exceptionally high GPC compared with HRS cultivars currently in production.

G rain protein concentration (GPC) has a major impact on the end-use quality of bread products made with flour extracted from hard wheat (Triticum aestivum L.) grain; therefore, this trait is typically a high priority in wheat improvement efforts aimed at improving bread-making quality. Due to improved profit potential compared with soft white spring wheat, the acreage of hard red spring (HRS) wheat has increased dramatically in the Pacific Northwest region of the United States in recent years (Washington Agricultural Statistics Service, 2005–2008). The objective of this research was to develop a HRS wheat cultivar with high GPC, superior agronomic characteristics, and improved end-use quality attributes compared with other HRS cultivars currently in commercial production.

‘Kelse’ (Reg. No. CV-1035, PI 653842) HRS wheat was developed and released in July 2008 by the Agricultural Research Center of Washington State University. Kelse was named in honor of Kelsey L. Kidwell-Yonan, Dr. Kidwell’s beloved niece and treasured friend. Kelse was released as a replacement to ‘WestBred 926’ (proprietary cultivar from WestBred LLC, Bozeman, MT), ‘Hank’ (PI 613585; proprietary cultivar from WestBred LLC, Bozeman, MT), ‘Tara 2002’ (PI 617073; Kidwell et al., 2003b), and ‘Scarlet’ (PI 601814; Kidwell et al., 1999) based on its (i) resistance to the Hessian fly [Mayetiola destructor (Say)], (ii) high-temperature, adult-plant resistance (HTAP) to local races of stripe rust (Puccinia striiformis Westend f. sp. tritici), (iii) high GPC, (iv) excellent bread-baking quality, and (v) high grain yield potential in the intermediate-to-high rainfall (>380 mm average annual precipitation), nonirrigated wheat production regions in Washington State.

Methods

Kelse, tested under the experimental designations WA007954, H0100092, and HR98036, which were assigned through progressive generations of advancement, is an F14

headrow selection derived from the cross ‘WestBred 906R’ (PI 483455)/SD 2961 (PI 520542)/“Scholar” (PI 607557). WestBred 906R is an HRS variety derived from a facilitative male sterile recurrent selection released in 1981 by WestBred...
LLC, Bozeman, MT. SD 2961 is an unreleased HRS wheat breeding line developed by South Dakota State University in 1987 with the pedigree ‘Butte’ (Clt 17681) // ‘Olaf’ (Clt 15930) / MN 6792 (PI number not available). Scholar is an HRS wheat variety released in 1999 by Montana State University (Lanning et al., 2000), with the pedigree MT7746 (PI number not available) // ‘Lew’ (Clt 17429) // ‘Marberg’ (PI 518816). 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 F1 plants was used to establish a 3.6-m² F2 field plot in 1998. Approximately 100 heads were selected at random from individual F1 plants, and a 40-g subsample of the bulked seed was used to establish a single 7.2-m² F3 field plot in 1999. Single heads from approximately 150 F2 plants were selected at random and threshed individually to establish F3 generation headrow families in the field in 2000. F3 progeny were advanced at the Washington State University (WSU) Plant Growth/Wheat Research Facility on the WSU campus in Pullman, WA. F2 and F4 progeny were advanced in field nurseries at Pullman, WA, whereas F3 progeny were advanced at the Lind Dryland Experiment Station in Lind, WA.

Following selection among rows for general adaptation, resistance to stripe rust, plant height, and grain appearance, seed from all plants within each selected headrow was bulk harvested to obtain F3:12 seed for early generation quality assessment. A 15-g subsample of each selected head row was cyclone milled (UDY Corporation, Fort Collins, CO) using a 0.5-mm screen. Resulting whole wheat flour was evaluated for protein content and hardness using a Bran+Luebbe Infra-Alyzer 450 (Bran+Luebbe GmbH, Norderstedt, Germany). Selections with appropriate grain protein concentration and kernel hardness were evaluated for gluten strength using the sodium dodecyl-sulfate-sedimentation method (American Association of Cereal Chemists, 2000). Twenty-five headrow selections were grown in 7.4-m² plots in a nonreplicated field trial in Lind, WA, in 2001, and resulting grain was evaluated for grain yield, grain volume weight, grain protein concentration, disease resistances, and milling and baking quality. All subsequent years of field testing involved the same size headrow. All subsequent years of field testing involved the same size headrow. All subsequent years of field testing involved the same size headrow.

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Disease and Insect Resistance

In naturally infected field tests on the Whitlow Farm near Pullman, WA, and at Mt. Vernon, WA, from 2002 to 2005, 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 moderate resistance (IT 5) at Mt. Vernon, WA. 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 (*Puccinia striiformis* Westend f. sp. *striiformis*)-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 HTAP resistance to stripe rust, which has proven to be durable in other commercial spring wheat cultivars, such as ‘Louise’ (PI 634865; Kidwell et al., 2006). Kelse is the first HRS variety released in the Pacific Northwest region that is confirmed to have HTAP resistance to stripe rust.

Results of pedigree analysis indicate that Kelse may have inherited its stripe rust resistance from SD 2961 and subsequently from ‘Frontana’ (PI 500147; Singh and Rajaram, 1992). DNA marker cslLV34, which is linked to the *Lr34/Yr18* complex present in Frontana, was tested on Kelse (Lagudah et al., 2006). Results confirmed the presence of *Lr34/Yr18* in Kelse. Kelse also was analyzed using the primer pairs VENTRIUP-LN2, linked to the *Lr37/Yr17/Sr38* complex from *T. ventricosum* (Helguera et al., 2003). Results indicate that Kelse contains the *Lr37/Yr17/Sr38* genes for rust resistance. Data from the 2008 Western Regional Spring Wheat Nursery indicate that Kelse has a moderate resistance reaction to leaf rust, as well as to race TRTT of stem rust (USDA–ARS, 2009).

On the basis of results from 2 yr of controlled environment insect screening trials conducted at the University of Idaho in 2005 and 2006, Kelse is resistant (100%) to Hessian fly biotypes E, F, and GP. In 2005, Kelse was tested with the susceptible cultivar Alpowa (PI 566596) and the resistant cultivar Macon (PI 617072; Kidwell et al., 2003a) in a five replication trial with four plants per replicate. Kelse and Macon were 100% resistant, whereas Alpowa was 100% susceptible. In 2006, Kelse was tested with the susceptible cultivar Alturas (PI 620631; Souza et al., 2004) and the resistant cultivar UI Cataldo (PI 642361) in a replicated trial with five replicates, and four plants tested per replicate. Kelse and Cataldo were 100% resistant, whereas Alturas was 100% susceptible. 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 60 replicated field trials under fallow, rainfall, and irrigated conditions in Washington State from 2002 to 2008. In 12 trials conducted from 2002 to 2005 in low (<380 mm average annual precipitation), intermediate (380–460 mm average annual precipitation), and high precipitation zones (>460 mm average annual precipitation) and with irrigation, the average grain yield of Kelse, WestBred 926, and Scarlet were 3225, 3153, and 2755 kg ha⁻¹ respectively. Grain yield averages of Kelse and WestBred 926 did not differ significantly (*P < 0.05*) and were significantly 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 < 0.05*).

In 21 rainfed trials conducted from 2006 to 2008 in the semiarid region in Washington State, average grain yields of Kelse, WestBred 926, Tara 2002, and Hank were 2278, 2298, 2305, and 2331 kg ha⁻¹ respectively, and were statistically similar (*P < 0.05*). In 17 rainfed trials conducted from 2006 to 2008 in the intermediate rainfall zones in eastern Washington, the grain yield averages of Kelse, WestBred 926, Tara 2002, and Hank were 3682, 3615, 3675, and 3695 kg ha⁻¹ respectively, and were not significantly different (*P < 0.05*). In 10 replicated field trials conducted from 2006 to 2008 in eastern Washington in the high rainfall zones and under irrigation, the grain yield averages of Kelse, WestBred 926, Tara 2002, and Hank were 5160, 5274, 5362, and 5671 kg ha⁻¹ respectively. Grain yield averages of Kelse and WestBred 926 did not differ significantly but were significantly lower than those of Tara 2002 and Hank (*P < 0.05*).

In these same field trials, the average grain volume weight of Kelse (766 kg m⁻³) was significantly (*P < 0.05*) higher than WestBred 926 (755 kg m⁻³) and Hank (752 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, 44.4, 50.0, and 37.7 g, respectively. Thousand-kernel weight estimates were not replicated; therefore, statistical analysis was not conducted on these data.

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 baking qualities of Kelse were compared with WestBred 926, ‘Hollis’ (Kidwell et al., 2004), Tara 2002, and Scarlet. Grain protein concentration averages of Kelse (155 g kg⁻¹) were similar to those of both WestBred 926 and Hollis (149 g kg⁻¹), and were significantly (*P < 0.01*) higher than those of Tara 2002 (146 g kg⁻¹), and Scarlet (143 g kg⁻¹). Flour yields of Kelse (680 g kg⁻¹) were significantly (*P < 0.01*) lower than those of 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 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 WestBred 926 (1044 cm$^3$) and Scarlet (996 cm$^3$) when compared across production regions. All the above tests were conducted using approved AACC methods (American Association of Cereal Chemists, 2000).

In 2007, Kelse was evaluated by commercial millers and bakers in the Pacific Northwest Wheat Quality Council. These results indicate that Kelse had superior end-use quality attributes when compared with WestBred 926 in nearly every assessment category (data not shown). Out of the 28 wheat varieties tested, Kelse ranked third overall for superior end-use quality attributes, whereas WestBred 926 ranked 18th (Pacific Northwest Wheat Quality Council, 2008). All collaborators preferred the dough handling properties and baking quality of Kelse compared with WestBred 926, which were attributed to the superior protein quality of Kelse compared with 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 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.

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**References**


