CULTIVAR

Registration of 'UI Winchester' Wheat

J. Chen,* E. J. Souza, N. A. Bosque-Pérez, M. J. Guttieri, K. L. O'Brien, J. M. Windes, S. O. Guy, B. D. Brown, X. M. Chen, and R. S. Zemetra

ABSTRACT

'UI Winchester' (Reg. No. CV-1049, PI 642362) hard red spring wheat *(Triticum aestivum* L.) was developed by the Idaho Agricultural Experiment Station and released in July 2009. UI Winchester was developed using the bulk-pedigree selection method and was released for its improved resistance to stripe rust (caused by *Puccinia striiformis* Westend. f. sp. *tritici* Eriks.) combined with its resistance to Hessian fly [*Mayetiola destructor* (Say)] and for its comparable or better yield and end-use quality performance compared with the three widely adapted hard red spring wheat cultivars 'Jefferson' (PI 603040), 'Jerome' (PI 632712), and 'WestBred 936'. UI Winchester is named after the town of Winchester, Idaho. It was tested under experimental numbers A9356S and IDO578 and has the pedigree 'WestBred 926'/WA7702. UI Winchester is adapted to both irrigated and rainfed conditions, but it is better adapted to the rainfed production systems of the intermountain zone of the western United States.

Pyramiding resistance to stripe rust (caused by *Puccinia striiformis* Westend f. sp. *tritici* Eriks.) and to Hessian fly [*Mayetiola destructor* (Say)] is a major effort for the breeding programs in the Pacific Northwest of the United States. 'UI Winchester' (Reg. No. CV-1049, PI 642362) was released for its improved stripe-rust resistance combined with resistance to Hessian fly and for its comparable or better yield and end-use quality performance compared with the three widely adapted hard red spring wheat cultivars 'Jefferson' (PI 603040), 'Jerome' (PI 632712), and 'WestBred 936'. UI Winchester, named after the town of Winchester, ID, was tested under the experimental numbers A9356S and IDO578 and has the pedigree of 'WestBred 926'/WA7702. WestBred 926 is a hard red spring wheat with a proprietary pedigree that was developed by WestBred, LLC (Bozeman, MT). WA7702 is a hard red spring breeding line developed by Washington State University with the pedigree NDM01/NK751. UI Winchester is adapted to both irrigated and rainfed conditions, but it is better adapted to the rainfed production systems of the intermountain zone of the western United States. Seed of UI Winchester will be maintained by the University of Idaho (UI) Foundation Seed Program. Plant Variety Protection will not be sought for UI Winchester, and seed will be distributed to all interested parties.

J. Chen, K.L. O'Brien, and J.M. Windes, Univ. of Idaho, Aberdeen Research and Extension Center, 1693 S 2700 W, Aberdeen, ID 83210; N.A. Bosque-Pérez and R.S. Zemetra, Univ. of Idaho, Dep. of Plant, Soil and Entomological Sciences, P.O. Box 442339, Moscow, ID 83844-2339; E.J. Souza, USDA-ARS, Soft Wheat Quality Lab., 1680 Madison Ave., Wooster, OH 44691; M.J. Guttieri, Horticulture and Crop Science Dep., Ohio State Univ., 1680 Madison Ave., Wooster, OH 44691; S.O. Guy, Washington State Univ., Dep. of Crop and Soil Science, P.O. Box 646420, Pullman, WA 99164-6420; B.D. Brown, Univ. of Idaho, Parma Research and Extension Center, 29603 U of I Lane, Parma, ID 83660; X.M. Chen, USDA-ARS, 361 Johnson Hall, Washington State Univ., Pullman, WA 99164-6430. Research was funded by the Idaho Wheat Commission and the Idaho Agricultural Experiment Station Hatch Projects. Registration by CSSA. Received 19 Sept. 2009. *Corresponding author (jchen@uidaho.edu).

Abbreviations: UI, University of Idaho; UIEYT, University of Idaho Elite Yield Trials; WRHSWN, Western Regional Hard Spring Wheat Nursery.

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Methods

Pedigree and Breeding History

UI Winchester was derived from the cross WestBred 926/WA7702 and designated A9356S. WestBred 926 is a hard red spring wheat with a proprietary pedigree that was developed by WestBred, LLC (Bozeman, MT). WA7702 is a hard red spring breeding line developed by Washington State University with the pedigree NDM01/NK751. The A9356S cross was made at Aberdeen, ID in 1992, and F_1 seeds were planted in the field in 1993. The F_2 and F_3 generations were advanced as bulks in 1994 and 1995, respectively. In 1996, the F_4 bulk was planted at Aberdeen and 100 heads from short-stature plants were selected. Approximately 45 $F_{4:5}$ headrows were seeded in the field at Aberdeen in 1997. Headrows were selected and harvested based on uniformity, short stature, and resistance to stripe rust natural field infection. Among the headrows selected in 1997, one $F_{4:6}$ line, designated A9356S-2, was advanced to unreplicated yield trials at Aberdeen in 1998 and to replicated yield trials at

Aberdeen and Hazelton in 1999, 2000, and 2001. In 2002, A9356S-2 was designated IDO578.

Line Selection and Evaluation

IDO578 was first evaluated in the Idaho-Oregon-Washington Tristate Spring Wheat Nursery in 2002 and subsequently evaluated in the Western Regional Hard Spring Wheat Nursery (WRHSWN) in 2003. IDO578 was evaluated in the University of Idaho Elite Yield Trials (UIEYT) under irrigation at Aberdeen, Hazelton, and Tetonia, ID and under rainfed conditions at Tetonia and Moscow, ID from 2004 to 2008. IDO578 was evaluated in UI Variety Yield Trials under rainfed conditions at Soda Springs, ID from 2006 to 2008 and under irrigation at Rupert, Idaho Falls, Ashton, and Aberdeen, ID in 2008. Data presented in this paper were only from the UIEYT.

The UIEYT consisted of three replicated plots planted in a randomized complete block design. Each plot consisted of seven rows, 3.05 m long, 1.5 m wide, and 0.25 m apart. The seeding rate was 2.47 and 1.98 million kernels per hectare for irrigated and rainfed conditions, respectively. The cultivars Jefferson, Jerome, and WestBred 936 (WPB936) were used as checks.

Grain yield and volume weight, days to heading (50% of heads in the plot completely visible), and plant height (the distance from the ground to the top of spike, excluding awn) were measured in four of the five locations, while lodging (rated from 0 to 9, where 0 = no lodging, and 9 = 100% plants lodged) was recorded when significant lodging was present in the field.

Milling and baking quality were measured for composite grain samples harvested from two irrigated locations—Aberdeen (2005–2007) and Hazelton (2005) —and from one rainfed location, Tetonia (2005), ID. Milling and baking quality were evaluated as previously described (Guttieri and Souza, 2003). Near-infrared analysis (Perten 8611, Perten Instruments, Springfield, IL; American Association of Cereal Chemists [2000, method 39–10]) was used to determine flour protein concentration with values calibrated by combustion analysis of total nitrogen content (LECO Model FP-428, LECO Corp., St. Joseph, MO) and corrected to 120 g kg^{-1}. The single-kernel characterization system (SKCS-4100, Perten Instruments, Springfield, IL) was used to estimate the mean kernel weight and diameter based on a 100-kernel option setup on the machine. Quality analyses were conducted in the UI Wheat Quality Laboratory in Aberdeen, ID. Specific alleles for glutenin and purodindoline loci were determined using markers and related protocols published in http://maswheat.ucdavis.edu/protocols/index.htm (verified 1 June 2010).

Evaluation of Stripe Rust Resistance

UI Winchester was evaluated for resistance to stripe rust under natural field infections in 2007 and 2008. Stripe rust races prevalent at these locations during those years included PST-114 (virulent on Lemhi, Heines VII, Moro, Produra, Yamhill, Stephens, Lee, Fielder, Tres, Express, AvSYr8NIL, AvSYr9NIL, Clement, and Compair) and PST-116 (virulent on same lines as PST-114 plus Paha) with a low frequency of PST-138 (virulent on Hyak [*Yr17* and *YrTye*]) in 2008 (Carter et al., 2009). UI Winchester was tested in single-row plots (1.5 m long) in the WRHSWN in two locations at Pullman and one at Mount Vernon, WA. The nurseries were planted in late March to late April, depending on location and year. Stripe rust resistance was evaluated twice at the Feekes growth stages 5–6 and 10.1–10.5 when the susceptible check 'Lemhi' (CItr 11415) had about 30% and greater than 80% severities at each growth stage, respectively. Infection type was recorded based on the 0–9 scale as described by Line and Qayoum (1992), and severity was recorded as the percentage of foliage infected.

Evaluation of Resistance to Hessian Fly

The resistance of IDO578 to Hessian fly was evaluated in 2000 in a replicated laboratory experiment at the University of Idaho Host Plant Resistance Laboratory at the Manis Entomological Facilities in Moscow, ID. The screening method utilized was as described by Schotzko and Bosque-Pérez (2002). A laboratory colony established with flies collected from spring wheat in the summer of 1998 in Lewiston, ID was used for screening. Biotypes 'GP', 'E', 'F', and 'G' constituted 83% of the Hessian fly populations near Lewiston, ID (Ratcliffe et al., 2000). The laboratory colony had similar frequencies of these biotypes and resembled the biotype variation present in the field (Schotzko and Bosque-Pérez, 2002) in northern Idaho and eastern Washington. Insects were reared on the Hessian fly–susceptible wheat cultivar 'Centennial' (PI 537303). The evaluation of resistance to Hessian fly was conducted in a laboratory maintained at 21 ± 4°C and with a photo period of 16:8 h (light:dark). Plexiglas cages (51 cm × 50 cm × 51cm) with nylon-organdy-covered access panels on two sides of each cage were used for screening (Schotzko and Bosque-Pérez, 2002). Each cage contained twenty-four 10-cm pots with four plants of the same genotype per pot. WPB936 was used as a susceptible check, while 'Hank' (PI 613585) and WestBred 926 (WPB926) were used as the resistant checks. Five replicates were used and the pots were randomized within cages. Each cage was infested with five female and five male newly emerged flies when the plants reached the two-leaf stage. Following insect infestation, plastic wrap was placed over the nylon organdy of the cages for 4 d to raise the humidity in the cages to more than 90% so as to enhance insect establishment. Afterward, the relative humidity was then allowed to return to ambient levels (<50%). A day after the flies were released, the plants were examined to determine if eggs were present, and the plant height was measured. Plants without eggs were considered escapes and were marked and not evaluated further. Twenty-one days after infestation, the plant height was measured again, and the plants were dissected to count the number of larvae and puparia per plant. A plant was classified as resistant if it contained no larvae or puparia and suffered no stunting, whereas plants containing larvae or puparia were classified as susceptible (Schotzko and Bosque-Pérez, 2002).

Statistical Analysis

Data were analyzed using SAS Version 9.1 (SAS Institute, Gary, NC). Analysis of variance for grain yield and volume weight, days to heading, plant height, lodging, quality traits, and resistance to stripe rust were performed across location-years using only entries common among the trials. The LSD test ($\alpha = 0.05$) was used to determine the significance of a mean difference of two genotypes for the traits evaluated.

Seed Purification and Increase

In 2004, approximately 200 heads of IDO578 were selected and planted in single row plots at Aberdeen in 2005. Around 150 headrows with uniform height, days to heading, and head type were harvested and planted in single-row plots in 2006 in Pullman, WA for evaluation of stripe rust resistance. At the same time, the seeds of each harvested headrow were planted in four-row plots (3.05 m long and 1.5 m wide) in Tetonia, ID for seed increase. Headrow plots in Tetonia with superior resistance to stripe rust were selected and harvested based on the stripe rust data from Pullman. The harvested headrows were bulked to form prebreeder seed, which was planted in 2007 in Tetonia to produce breeder seed for the cultivar UI Winchester. UI Winchester is uniform for plant type without obvious phenotypic variants and has remained stable during seven generations of evaluation from 1998 to 2004.

Characteristics

Botanical and Agronomic Characteristics

UI Winchester has dark green foliage with recurved and twisted flag leaves and nonpigmented auricles and anthers. The head of UI Winchester is awned, middense, and white-chaffed at maturity. Seed of UI Winchester is red, intermediate in size, elongated, and hard. The mean kernel weight was 34.4 mg for UI Winchester compared with 44.5 mg for WPB936, 41.5 mg for Jefferson, and 45.8 mg for Jerome. Kernel diameter for UI Winchester was 2.46 versus 2.88 mm for WPB936, 2.78 mm for Jefferson, and 2.87 mm for Jerome.

UI Winchester has a nonpigmented coleoptile and an erect seedling growth habit. It is a semidwarf cultivar, with an average plant height of 78 cm compared to 74 cm for WPB936, 78 cm for the semidwarf cultivar Jerome, and 82 cm for the tall semidwarf cultivar Jefferson based on 15 UIEYT (Table 1). The heading date of UI Winchester is 1 to 2 d later than that of the check cultivars (Table 1). However, UI Winchester has a short grain-filling period; therefore, it matures earlier than the three check cultivars (J. Whitmore, personal communication, 2009).

UI Winchester was not significantly different from the check cultivars for grain yield and volume weight under both irrigated and rainfed conditions; however, it yielded better in rainfed than in the irrigated conditions (Table 1). UI Winchester produced a higher yield (2918.7 kg ha^{-1}) than the check cultivars Jefferson (2690.0 kg ha^{-1}), Jerome (2508.4 kg ha^{-1}), and WPB936 (2508.4 kg ha^{-1}) under rainfed conditions.

End-Use Quality

There were no significant differences between UI Winchester and the check cultivars (Jefferson, Jerome, WPB936) in end-use quality under both rainfed and irrigated conditions except for flour yield (Table 2). The flour yield of UI Winchester was significantly lower than that for Jefferson under irrigation and lower than those for the check cultivars under rainfed conditions. UI Winchester has *Glu1Bx7* (581 bp) and *PinB-D1*null alleles that can be used to differentiate it from Jerome, Jefferson, and WPB936 (data not shown).

Disease and Insect Reactions

UI Winchester has improved stripe rust resistance compared to Jerome and WPB936 based on the infection type evaluated in 2 yr of field trials (2007–2008) in two locations at Pullman and one at Mount Vernon, WA (Table 3). UI Winchester also had the lowest mean stripe-rust severity (18%) compared to the three widely grown hard red spring cultivars—WPB936 (36%), Jerome (25%), and Jefferson (28%)—and the known stripe-rust-susceptible check, Lemhi (65%) (Table 3). UI Winchester is resistant to Pacific Northwest populations of the Hessian fly. The identity of the gene(s) conferring resistance is unknown, but UI Winchester probably inherited the resistance from its WPB926 parent (Souza et al., 2005). In replicated evaluations using a laboratory colony of Hessian fly, UI Winchester had 100% resistant plants, which was similar to the resistant check Hank (100%) and WPB926 (95%), from which Winchester

Table 1. Grain yield, volume weight, days to heading, and plant height for UI Winchester compared with the three check cultivars in the UIEYT grown in three irrigated (IR; Aberdeen, Hazelton, and Tetonia) and two rainfed (RF; Tetonia and Moscow) locations in 2005–2007.

	Grain yield		Volume weight		Days to heading		Plant height	
Cultivar	IR	RF	IR	RF	IR	RF	IR	RF
	kg ha^{-1}		kg hl^{-1}		d		cm	
UI Winchester	6964.6	2918.7	75.1	71.5	178.0	185.0	89.2	66.0
Jefferson	7118.5	2690.0	75.6	72.0	176.9	183.0	94.2	69.9
Jerome	7200.8	2508.4	74.3	71.5	176.1	181.5	88.6	67.3
WPB936	6468.6	2508.4	72.8	71.4	176.9	180.5	85.1	63.5
Mean	6938.1	2656.4	74.5	71.6	177.0	182.5	89.3	66.7
$LDS_{0.05}$	701.1	692.3	1.7	1.5	2.0	4.7	5.1	2.9
CV (%)	7.0	11.4	1.6	1.0	0.5	0.7	3.9	1.8

Table 2. Mean flour protein content, flour yield, mixograph tolerance, and baking volume for UI Winchester compared with the three check cultivars in the UIEYTs grown in two irrigated (IR) locations, Aberdeen (2005–07) and Hazelton (2005), and one rainfed (RF) location, Tetonia (2005).

	Flour protein		Flour yield		Mix tolerance		Baking volume	
Cultivar	IR	RF	IR	RF	IR	RF	IR	RF
	g kg^{-1}		g kg^{-1}		degree		cm^3	
UI Winchester	133	131	679	655	72.0	74.0	1188	1450
Jefferson	126	128	714	677	75.3	73.0	1200	1450
Jerome	125	123	689	683	70.5	73.0	1221	1325
WPB936	132	133	689	669	73.7	63.0	1254	1450
Mean	129	129	693	671	72.9	70.8	1216	1419
$LSD_{0.05}$	12	na†	1.7	na	4.5	na	83	na
CV (%)	8.3	na	2.1	na	5.1	na	6	na

†na, not applicable.

derived its Hessian fly resistance. In the same test, the susceptible check WPB936 had resistant plants (Table 4).

Availability

Seed of UI Winchester will be maintained by the UI Foundation Seed Program, 3793 North 3600 East, Kimberly ID 83341. Plant Variety Protection will not be sought for UI Winchester and seed will be distributed to all interested parties.

Table 3. Mean stripe rust infection type and severity for UI Winchester compared with the three check cultivars in the UIEYTS grown in two locations at Pullman and one at Mt. Vernon, WA in 2007 and 2008.

Cultivar	Infection type	Severity
	0–9†	%
UI Winchester	4	18
Jefferson	5	28
Jerome	7	25
WPB936	7	36
Lemhi	8	65
Mean	6	34
$LSD_{0.05}$	2	26

†Infection type described by Line and Qayoum (1992): 0 = no visible signs or symptom, 1 = necrotic and/or chlorotic flecks; no sporulation, 2 = necrotic and/or chlorotic blotches or stripes; no sporulation, 3 = necrotic and/or chlorotic blotches or stripes; trace sporulation, 4 = necrotic and/or chlorotic blotches or stripes; light sporulation, 5 = necrotic and/or chlorotic blotches or stripes; intermediate sporulation, 6 = necrotic and/or chlorotic blotches or stripes; moderate sporulation, 7 = necrotic and/or chlorotic blotches or stripes; abundant sporulation, 8 = chlorosis behind sporulating area; abundant sporulation, 9 = No necrosis or chlorosis;abundant sporulation.

Table 4. Hessian fly resistance for UI Winchester compared to three hard red spring wheat cultivars in a laboratory experiment in Moscow, ID in 2000.

Line	No. plants tested	No. resistant plants	No. susceptible plants	% resistant plants
UI Winchester	20	20	0	100
WPB926	19	18	1	95
Hank	18	18	0	100
WPB936	17	0	17	0

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References

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

Carter, A.H., X.M. Chen, K. Garland-Campbell, and K. Kidwell. 2009. Identifying QTL for high-temperature adult-plant resistance to stripe rust (*Puccinia striiformis* f. sp. *tritici*) in the spring wheat (*Triticum aestivum* L.) cultivar 'Louise'. Theor. Appl. Genet. 119:1119–1128.

Guttieri, M.J., and E. Souza. 2003. Sources of variation in the solvent retention capacity test of wheat flour. Crop Sci. 43:1628–1633.

Line, R.F., and A. Qayoum. 1992. Virulence, aggressiveness, evolution, and distribution of races of Puccinia striiformis (the cause of stripe rust of wheat) in North America, 1968–87. USDA-ARS Tech. Bull. No. 1788, USDA-ARS, Washington, DC.

Ratcliffe, R.H., S.E. Cambron, K.L. Flanders, N.A. Bosque-Pérez, S.L. Clement, and H.W. Ohm. 2000. Biotype composition of Hessian fly (Diptera: Cecidomyiidae) populations from the southeastern, mid-western, and northwestern United States and virulence to resistance genes in wheat. J. Econ. Entomol. 93:1319–1328.

Schotzko, D.J., and N.A. Bosque-Pérez. 2002. Relationship between Hessian fly infestation density and early seedling growth of resistant and susceptible wheat. J. Agric. Urban Entomol. 19:95–107.

Souza, J., N.A. Bosque-Pérez, M.J. Guttieri, D.J. Schotzko, S.O. Guy, B. Brown, and R. Zemetra. 2005. Registration of Jerome wheat. Crop Sci. 45:1161–1162.