WASHINGTON AGRICULTURAL RESEARCH CENTER
WASHINGTON STATE UNIVERSITY
PULLMAN, WASHINGTON

Announces the Release of

'WHIT'

Soft White Spring Wheat

Introduction

'Whit', soft white spring wheat (*Triticum aestivum* L.) (Reg. No._____, PI 653841), 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). Whit was named after Whitman County, WA, which is known for its high rainfall and excellent production conditions for soft white wheat. Whit was released as a replacement for 'Alpowa' (PI 566596) and 'Nick' (proprietary cultivar from WestBred LLC, Bozeman, MT) in non-irrigated wheat production systems in the intermediate to high rainfall (>380 mm of average annual precipitation) regions in Washington and Idaho 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*), short stature, early maturation, and high grain yield potential.

Methods

Whit, tested under the experimental designations WA008008, S0300100U, and SW2K067, which were assigned through progressive generations of advancement, is a $F_{3:4}$ head row selection derived from the cross 'Challis' (PI 600984)/5/'El Gaucho' (PI 352071)/'Sonora 64' (PI 342969)//'Spr Luke Mutant'/3/'Centennial' (PI 537303)/4/'Alpowa' (PI 566596). The final cross for White was completed in the greenhouse in Pullman, WA in 1999. Challis is a soft white spring line developed in 2002 by Western Plant Breeders Inc. with the pedigree of, 'Penawawa'/'Edwall'. El Gaucho is a wheat line developed in Argentina (Inst. Fitotecnico de Santa Catalina) in 1969 with a pedigree of 'Sinvalocho M.A.'/'Riccio' //'Lin Calel'. Sonora 64 was developed by INIFAP, CIFAP, Experimental Valle De Mexico in 1964 with the pedigree of 'Yaktana 54'//'Norin 10'/'Brevor'/3/2* 'Lerma Rojo 54'. Spr Luke Mutant is a derivative of the winter wheat 'Luke', which was developed by the Washington State Agric. Research Center in 1970 with a pedigree of, 'PI 178383'/2*'Burt'//'CItr 13438'. Centennial is a soft white spring wheat variety released by the Idaho Agric. Experiment Station in 1990 with the pedigree of, 'Cowbird sib'/'Sterling'. Alpowa is a soft white spring wheat variety released by Washington State University in 1994 with the pedigree of, 'Fielder'/'Potam 70'//'Walladay'/3/'Walladay'/ 'Potam 70'. The following modified pedigree-bulk breeding method was employed to advance early generation progeny. Bulked seed (30 g) from F_1 plants was used to establish an F_2 field plot (2000). Seed from approximately 100 heads selected at random from individual F_2 plants were bulked, and a 40 g subsample was used to establish a F_3 field plot (2001). Single heads of approximately 150 F_3 plants were threshed individually to establish $F_{3:4}$ head row families (2002). 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 were bulk harvested to obtain $F_{3:5}$ seed for early generation quality assessment. A 50 kernel subsample of each selected head row was analyzed for kernel hardness using a Perten Single Kernel Characterization System (SKCS) (AACC, 2000). Samples with acceptable soft white wheat kernel characteristics were retained, and evaluated for break and potential flour yield using a modified break flour mill (Micro-mill) designed for small samples (Seeborg and Barmore, 1957). Selections with high flour extraction rates were advanced to grain

yield assessment trials. Four head row selections were advanced to non-replicated testing at Pullman, WA and grown in 7.4 m^2 plots in 2003 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) (2004-2005) or a general alpha lattice design (3 replications) (2006-2007). Two of the original 4 selections were advanced to preliminary replicated yield trials in Pullman (high precipitation zone) and Moses Lake (irrigated), WA (2004), and state replicated trials at Pullman, Lind (low precipitation zone), Dusty (intermediate precipitation zone), Fairfield (high precipitation zone), and Moses Lake, WA (2005). One line, designated S0300100U, was selected to be tested on a regional basis and assigned a new identification number of WA008008 in 2006. From 2006 to 2007, WA008008 was evaluated in the Tri-state Regional Nursery, which was established at nine locations each year in Washington, Oregon and Idaho, in both rainfed and irrigated environments. Additionally, WA008008 was placed in the Washington State University Extension Uniform Cereal Variety Testing Program and tested in 2006 and 2007 at 18 and 16 locations, respectively, throughout eastern Washington. WA008008 also was evaluated in the 2007 Western Regional Nursery Trials. Since 2003, WA008008 has been evaluated for end-use quality and disease resistance by personnel form the USDA-ARS Wheat Genetics, Quality, Physiology, and Disease Research Unit, Pullman, WA. WA008008 was evaluated by the Pacific Northwest Wheat Quality Council in 2006. Breeder seed of WA008008 (Whit) was produced as a reselection, based on phenotypic uniformity, of 2100 $F_{3:9}$ head rows grown under irrigation in Othello, WA. Selected head rows were bulked at harvest, resulting in the production of 922 kg of Breeder seed.

Characteristics

Whit is an intermediate height, semidwarf soft white spring wheat. It has lax, tapering, erect inflorescence with tan awns and tan glumes that are long in length, medium in width, with wide, square shoulders and medium acuminate beaks. Whit has ovate kernels that are white, soft, and mottled. Seed of Whit has a midsize germ with a shallow crease, rounded cheeks, and a short, non-collared brush. Whit lacks anthocyanin pigmentation in the coleoptile, displays a semi-erect juvenile plant growth habit, and is green in color with recurved, twisted, waxy flag leaf at Feekes growth stage 10.0 (Large, 1954). The stem of Whit lacks anthocyanin pigmentation, a waxy bloom is absent, the last internode of the rachis is semi-solid, the auricle lacks pigmentation, pubescence is absent, and the peduncle is erect with a length of 32 cm. The heading date of Whit was one day earlier than 'Louise' (Kidwell et al., 2006), three to four days earlier than Alpowa, and one day later than Nick (Table 1). Whit was similar in height to Nick and 3 to 13 cm shorter than both Louise and Alpowa (Table 1). As precipitation levels increased, the height differential between Whit and Alpowa or Louise also increased.

Disease and Insect Resistance

Whit was tested in naturally infected field trials conducted by the USDA-ARS, Wheat Genetics, Quality, Physiology, and Disease Research Unit, Pullman, WA on the Whitlow farm near Pullman and Mt. Vernon in breeding nurseries from 2004 to 2006 and on the Spillman, Plant Pathology, and Whitlow farms near Pullman, WA in 2006 and 2007, and in various breeding nurseries throughout eastern Washington from 2004 and 2007. Whit was resistant [infection type (IT) 0-3] to moderately resistant (IT 5) in all tests, except that a susceptible reaction (IT 8) was recorded in the breeding nursery on Whitlow farm and in the varietal trial nursery on Spillman farm. However, the severities (15-20%) were low, which could be due to heterogeneity within the variety resulting in a few susceptible plants among the majority of resistant plants. When Whit was tested in the seedling stage in the greenhouse at low temperature cycles (diurnal temperatures gradually changing from 4 to 20° C; Chen and Line, 1992), it was highly resistant (IT 2) to races PST-17, PST-45, moderately resistant (IT 5) to PST-37 and PST-100, and susceptible (IT 8) to PST-43 and PST-116. These seedling reactions indicate that Whit has race-specific, all-stage resistance that is not effective against all of the predominant races currently in the region. However, when tested with race PST-116 in the greenhouse, Whit was susceptible (IT 8) at the seedling stage at the low temperatures but was resistant (IT 0) when tested at the adult-plant stage at high temperatures (diurnal temperature cycle gradually changing from 10 to 35°C; Chen

and Line, 1995). During the last three years testing when races PST-100 and PST-116 predominated in the region (data not shown), Whit displayed adult-plant resistance in the field. Field results were confirmed through greenhouse evaluations that indicated that Whit has non-race-specific, high-temperature, adult-plant (HTAP) resistance to stripe rust.

On the basis of results from controlled environment insect screening trials conducted at the University of Idaho from 2005 to 2008, White is resistant (95%) to Hessian fly biotypes E, F and GP. On the basis of pedigree and natural field infestation ratings from Pullman, WA, Whit is susceptible to the Russian wheat aphid [*Diuraphis noxia* (Mordvilko)].

Agronomic Performance

Whit was evaluated in 14 site-years in preliminary (two locations), state (five locations), tri-state (six locations), and western regional (one location) trials from 2004 through 2007 in low (<380 mm average annual precipitation), intermediate (380-460 mm average annual precipitation), high precipitation zones (>460 mm average annual precipitation), and under irrigation in Washington State. Averaged over the 14 site-years, Whit produced significantly higher grain yields than Louise and 'Alturas' (Souza et al., 2004), another partial waxy soft white wheat (Table 2). Average grain volume weight of Whit was similar to Louise and Alturas in these breeding trials (Table 2).

In 33 Washington State University Extension Uniform Cereal Variety Testing Spring Wheat Performance Trials conducted in 2006 and 2007, grain yields of Whit (2488 kg ha^{-1}) were similar to those of Alpowa (2556 kg ha^{-1}) but were less than those of Louise (2825 kg ha^{-1}) and Nick (2825 kg ha^{-1}) in the low precipitation zone. In the intermediate precipitation zone, Louise (4102 kg ha^{-1}), Alpowa (3901 kg ha^{-1}), and Nick (3901 kg ha^{-1}) produced significantly more grain than Whit (3699 kg ha^{-1}). Grain yields of Whit were similar to those of Alpowa and Nick in the high precipitation zone, whereas Louise produced significantly more grain than all three of these varieties in these trials (Table 2). Average grain volume weight of Whit was significantly higher than Louise, equal to Nick, and significantly lower than Alpowa in the high precipitation zone (Table 2). Under irrigation, Whit had the highest grain yield average of the four varieties; however, the co-variance of the 2006 trial was too high to discern differences among varieties with statistical confidence. The average grain volume weights of the four varieties were not statistically different from one another under irrigation (Table 2). Thousand-kernel weight averages of Whit, Louise, Nick, and Alpowa were 35.3 g, 45.8 g, 31.1 g, and 36.9 g, respectively.

End-Use Quality

The USDA-ARS Western Wheat Quality Laboratory in Pullman, WA assessed the end-use quality of Whit using grain produced in 26 breeding and commercial variety testing trials in Washington from 2004 through 2007. Louise, Alpowa, and Alturas were used as checks in these evaluations. Grain protein content of Whit (117 g kg^{-1}) was similar to Alpowa (112 g kg^{-1}) and Alturas (114 g kg^{-1}), and was significantly ($P<0.01$) greater than Louise (109 g kg^{-1}). Whit (41 g kg^{-1}) had significantly ($P<0.01$) higher flour ash content than Alpowa (37 g kg^{-1}), Alturas (40 g kg^{-1}), and Louise (37 g kg^{-1}). The milling score of Whit (85.1) was similar to Alpowa (84.4) but significantly ($P<0.01$) lower than Alturas (86.7) and Louise (87.6). Whit (551 g kg^{-1}) was similar to Alpowa (550 g kg^{-1}), Alturas (542 g kg^{-1}), and Louise (546 g kg^{-1}) for mixograph water absorption. The cookie diameter for Whit (9.4 cm) was significantly ($P<0.01$) larger than Alpowa (9.2 cm), similar to Alturas (9.5cm), and significantly ($P<0.01$) lower than Louise (9.6 cm). Limited data (n=3) indicate that Whit (1295 cm^3) was similar to Louise (1315 cm^3) for sponge cake volume. Flour swelling volume (23.9 ml g^{-1}) indicate that Whit is has partial waxy starch type. All above tests utilized approved AACC methods (AACC, 2000).

In 2006, Whit was evaluated by the Pacific Northwest Wheat Quality Council, where commercial millers and bakers concluded that Whit has acceptable milling, dough handling, and baking properties and is comparable to other soft white spring wheat cultivars that are currently in production in the Pacific Northwest (data not shown).

Availability

Foundation seed of Whit 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 of seed 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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