CULTIVAR

Registration of 'Cataldo' Wheat

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ABSTRACT

'Cataldo' (Reg. No. CV-1033, PI 642361) is a soft white spring wheat (*Triticum aestivum* L.) developed by the Idaho Agricultural Experiment Station and released in spring 2007. Cataldo was tested under experimental numbers A02215S-B-1 and IDO642 and has the pedigree of IDO584/4*'Alturas'. IDO584 carries a new source of resistance to Hessian fly [*Mayetiola destructor* (Say)], the gene *H*25, originally derived from KS92WGRC 20. Cataldo was released for its novel Hessian fly resistance, conferred by the gene *H25*. The resistance was selected using molecular markers *Xgwm610* and *Xgwm397* associated with the *H25* gene, together with phenotypic testing. Cataldo was released to extend the range of the Alturas genetic background into rainfed production regions of northern Idaho and eastern Washington where Hessian fly is a consistent limitation to production. Cataldo is also earlier and shorter than Alturas and has high-temperature adult-plant resistance to stripe rust (*Puccinia striiformis* Westend. f. sp. *tritici* Eriks.) and end-use quality (cookie and Asian noodles) similar to Alturas.

'Cataldo' (Reg. No. CV-1033, PI 642361) is a soft white spring wheat (*Triticum aestivum* L.) developed by the Idaho Agricultural Experiment Station and released in 2007. Cataldo was selected from the backcross IDO584/4*'Alturas' and tested under experimental numbers A02215S-B-1 and IDO642. IDO584 is a donor parent that carries a new source of resistance to Hessian fly [*Mayetiola destructor* (Say)], the gene *H*25, originally derived from KS92WGRC 20. Alturas (PI 620631) is a soft white spring wheat cultivar released in 2002 (Souza et al., 2004). Cataldo was released for its novel Hessian fly resistance, conferred by the gene *H25*. The resistance was selected using molecular markers *Xgwm610* and *Xgwm397* associated with the *H25* gene (Guttieri et al., 2003; Wheeler, 2005), together with phenotypic testing. Cataldo, named for the oldest building in Idaho, the Cataldo Mission, is intended to extend the range of the Alturas genetic background into regions of northern Idaho and eastern Washington that have significant infestations of Hessian fly.

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Abbreviations: HTAP, high-temperature adult-plant; IT, infection type; UI, University of Idaho; WRSWSN, Western Regional Soft White Spring Nursery.

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Methods

Early Generation Population Development and Hessian Fly Resistance Screening

Cataldo, tested as ID0642 was derived from a backcross line, which was designated A02215S. It has the pedigree ID0584/4*Alturas. IDO584 is an advanced line derived from the cross IDO470*2/KS92WGRC20. IDO470 is a reselection of Idaho 377s (PI 591045, Souza et al., 1997), and KS92WGRC20 (PI 592732) is a germplasm release from the Wheat Genetics Resource Center at Kansas State University that carries the *H25* gene for resistance to Hessian fly (Sebasta et al., 1997). The recurrent parent, Alturas, is a soft white spring wheat cultivar released in 2002 that had excellent yield potential and good end-use quality but was susceptible to Hessian fly, limiting its usefulness in northern Idaho and eastern Washington, where Hessian fly is a major pest (Ratcliffe et al., 2000).

Cataldo was developed using a modified backcross breeding procedure. The initial cross was made in 2001 and advanced to the BC_3F_2 generation in 2002 in a greenhouse in Aberdeen, ID. Backcrossing was conducted and accompanied by selection for progeny carrying the *H25* gene using molecular

markers *Xgwm397* and *Xgwm610*. In each backcross, approximately 10 to 15 plants were characterized with the two markers. Plants with both marker alleles were then backcrossed to Alturas. After the third backcross, plants carrying the two markers were self-pollinated. The BC_3F_2 plants were evaluated again with molecular markers *Xgwm397* and *Xgwm610* and simultaneously for resistance to Hessian fly in replicated laboratory experiments at the University of Idaho (UI) Host Plant Resistance Laboratory at the Manis Entomological Facilities in Moscow, ID, using standard methods (Schotzko and Bosque-Pérez, 2002) with a laboratory colony established with flies collected from spring wheat in the summer of 1998 in Lewiston, ID. 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 resembles 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). Hessian fly resistance evaluation was conducted in a laboratory maintained at 21 ± 4ºC, and 16:8 h (light:dark) photoperiod. Plexiglass cages (51 by 50 by 51 cm) with nylon organdy-covered access panels on two sides of each cage were used for screening (Schotzko and Bosque-Pérez, 2002). Each cage contained 24 10-cm pots with four plants of the same genotype per pot, including pots planted to the susceptible check Alturas and the resistant check 'Hank' (PI 613585). Five replications were tested and pots were randomized within cages. Each cage was infested with five female and five male newly emerged flies when plants reached the two-leaf stage. Following insect infestation, humidity within cages was increased to over 90% to enhance insect establishment by placing plastic wrap over the nylon organdy of cages for 4 d. Humidity was then allowed to return to ambient levels (<50% relative humidity). A day after flies were released, plants were examined to determine if eggs were present and plant height was measured. Plants without eggs were considered escapes and were marked and not evaluated further. At 21 d after infestation, plant height was measured again and 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, while plants containing larvae or puparia were classified as susceptible (Schotzko and Bosque-Pérez, 2002).

Line Selection and Evaluation

Cataldo was selected on the basis of Hessian fly resistance and visual appraisal of uniformity and desirable agronomic traits resembling the recurrent parent Alturas. Seven $BC_3F_{2:3}$ plants from within A02215S were selected on the basis of the two markers *Xgwm397* and *Xgwm610* and resistant reaction to Hessian fly in a laboratory experiment in 2002. These lines were then planted using single-row plots (1.5 m) in 2003 and in an unreplicated observation yield trial in Aberdeen, ID, in 2004. One line, A02215S-B-1 was selected out of the seven lines and was designated as IDO642.

IDO642 was entered in UI Preliminary Yield trials in 2005 and evaluated under irrigation at Aberdeen, American Falls, Hazelton, and Tetonia, ID, and under rainfed conditions at Moscow, ID. It was then evaluated in UI Elite Yield trials from 2005 to 2007. The 2005 evaluation was conducted under irrigation at Aberdeen, American Falls, Hazelton, and Tetonia and under rainfed conditions at Moscow. The 2006 evaluation was conducted under irrigation at Aberdeen, Hazelton, and Tetonia and under rainfed conditions at Moscow, while the 2007 evaluation was conducted under irrigation at Aberdeen and rainfed conditions at Moscow. The preliminary and elite yield trials consisted of three replicated plots planted to a randomized complete block design. Each plot consisted of seven rows 4.3 m long and 1.5 m wide, with row spacing of 22 cm. The seeding rate was 2.47 and 1.98 million kernels ha^{-1} for irrigated and rainfed conditions, respectively. Alturas, 'Nick' (developed by Westbred LLC, Bozeman, MT), and 'Treasure' (PI 468962) were used as check cultivars.

IDO642 also was evaluated in the Western Regional Soft White Spring Nursery (WRSWSN) from 2005 to 2007. The WRSWSN was planted to five irrigated locations including Aberdeen, ID (2005–2007), Klamath Falls, OR (2005–2007), Davis, CA (2005–2006), Logan, UT (2005–2006), and Tulelake, CA (2005–2006). The nursery was planted in nine rainfed locations, including Bonners Ferry and Moscow, ID (2005–2007), Tetonia, ID (2005), Corvallis, OR (2005–2007), Bozeman, MT (2005–2006), Kalispell, MT (2006), Pendleton, OR (2005), Pullman, WA (2005–2007), and Waitsburg, WA (2006–2007). The WRSWSN is the primary, irrigated and rainfed regional variety trial for Idaho, Washington, and Oregon. Each location had three replications. Each plot consisted of seven rows 4.3 m long and 1.5 m wide, with row spacing of 22 cm. Alturas, 'Alpowa' (PI 566596), 'Louise' (PI 634865, Kidwell et al., 2006), and Nick were used as check cultivars.

Grain yield was measured in both the UI and WRSWSN trials. Grain volume weight and plant height were measured in most locations of both sets of trials, while days to heading was recorded in trials at UI research stations in Aberdeen, Tetonia, and Moscow. Lodging was recorded when significant lodging was present in the field.

Milling and baking quality were measured for composite grain samples harvested from Bonners Ferry and Moscow (2005–2006), and Aberdeen (2005–2007) and evaluated for heritable differences in milling and baking quality as previously described (Guttieri and Souza, 2003). Near-infrared analysis (Perten 8611, Perten Instruments, Springfield, IL) (AACC method 39-10) (American Association of Cereal Chemists, 2000) 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}. Sugar snap cookies were prepared and measured (AACC method 10-52) (American Association of Cereal Chemists, 2000). Solvent retention capacity of flour was measured using four water-based solvents according to the AACC method 56-11 (Gaines, 2000) with minor modifications as described previously (Guttieri et al., 2001a). Noodle quality was measured from a composite grain sample harvested in Aberdeen (2005–2006) using an Asian-style alkaline noodle. Alkaline noodles were prepared as described in Guttieri et al. (2001b). All quality analyses were conducted in the UI Wheat Quality Laboratory in Aberdeen.

Stripe Rust Evaluation

Cataldo was evaluated for resistance to stripe rust caused by *Puccinia striiformis* Westend. f. sp. *tritici* Eriks. in the field under natural infections and under controlled greenhouse conditions with selected races. It was tested in single-row plots (1.5 m long) in the WRSWSN in 2006 and 2007; and at three locations near Pullman, one location near Walla Walla (southeastern WA), one location near Lind (central WA), and one location near 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 (FS) 5–6 and 10.1–10.5 for most of locations when the susceptible check, 'Lemhi' (CItr 11415) had about 30% and greater than 80% severities at each growth stage, respectively. Stripe rust resistance also was evaluated at growth stage FS 10.1–11 at the Mount Vernon location when Lemhi had 40 to 100% severity depending upon year. Infection type (IT) data were recorded based on the 0 to 9 scale as described by Line and Qayoum (1992) and severity data were recorded as percentage of foliage infected.

In the greenhouse, 10 to 15 two-leaf stage seedlings of Cataldo were tested with each of races PST-17, PST-37, PST-43, PST-45, PST-100, PST-116, and PST-127 of *P. striiformis* f. sp. *tritici* at low temperatures (diurnal cycles gradually changing from 4 to 20°C). Inoculation, incubation, and note-taking were done using standard procedures (Chen and Line, 1992). Races tested collectively contain virulence genes known to occur in the United States. The races PST-100 and PST-116 were predominant in 2005, 2006, and/or 2007 in the Pacific Northwest (Chen, 2005; 2007; unpublished data). Infection types were recorded 20 to 22 d after inoculation. For adult-plant tests, races PST-100, PST-116, and PST-127 were used individually to inoculate adult plants at the growth stages FS 10–10.1. After incubation in a dew chamber at 10°C for 24 h, plants were grown in a growth chamber under controlled diurnal temperature cycles gradually changing from 10 to 35°C as described by Chen and Line (1995). For each race test, three plants were used and IT was recorded for each plant.

Seed Purification and Increase

Prebreeder seed of Cataldo originated from a composite of 100 head rows selected in Aberdeen, ID, in July 2005 on the basis of uniformity and similarity in appearance. The prebreeder seed was planted in Yuma, AZ, in fall 2005 to produce Breeder seed. In 2006 breeder seed was planted in Tetonia, ID, to produce Foundation seed. Cataldo is uniform for plant type without obvious phenotypic variants and has remained stable during four generations of evaluation, from 2003 to 2006.

Statistical Analysis

All statistical analyses were done using SAS Version 9.1 (SAS Institute, Cary, NC). Analysis of variance for grain yield, grain volume weight, days to heading, height, and lodging was performed across locations within years, and a combined analysis was performed across location-years using only entries common to all trials from 2005 to 2007. Within-year analyses were done according to a mixed model with location and genotypes as fixed factors and replications within location as random factors. Across-years analyses used a fixed model with location-years and genotypes as fixed factors. Data for end-use quality were measured at each location every year (2005–2007), and an average was taken over the 3-year/locations using the interaction for genotype with location-year as the error term for genotype effects. The LSD test ($\alpha = 0.05$) was used to compare the least squares means for the genotype effects for yield, agronomic, and quality traits.

Characteristics

Agronomic and Botanical Description

Cataldo is most similar in appearance to its recurrent parent Alturas. Cataldo has a nonpigmented and erect juvenile growth habit. It has a semidwarf plant type, shorter than Alturas, Louise, Alpowa, and Nick (Table 1). Cataldo has an awned, erect, lax head, which is white-chaffed at maturity. Seed of Cataldo is white and oval with a kernel type similar to Alturas.

Cataldo is an early- to intermediate-maturing spring wheat with earlier heading date (FS 10.5) than all check cultivars (Table 1). Cataldo is well adapted to the rain-fed production area of the Pacific Northwest, having similar grain yield to Louise, Alpowa, and Nick (Table 1).

Cataldo is distinguishable from Alturas using the polymerase chain reaction amplification products of the markers *Xgwm397* and *Xgwm610* for the Hessian fly resistance gene *H25* or by its phenotypic resistant response to Hessian fly either in the laboratory or field (Table 2).

Disease and Insect Resistance

Cataldo is resistant to Pacific Northwest U.S. populations of the Hessian fly (see Ratcliffe et al., 2000 for biotype descriptions) based on replicated laboratory evaluations. In a laboratory test in 2007, Cataldo had 0.0% infested plants, similar to the resistant donor parent IDO584, while susceptible Alturas had 100% infested plants (Table 2). In a marker-assisted evaluation test in 2007, 100% of Cataldo plants had resistant alleles of both markers, *Xgwm397* and *Xgwm610*, associated with the *H25* Hessian fly resistant gene (Table 2).

Cataldo has high-temperature adult-plant (HTAP) resistance to stripe rust. Except at Mt. Vernon, WA, Cataldo was resistant in all field tests with ITs 0 to 3 and severities 0 to 10%, similar to Alturas and Louise, while Lemhi, a susceptible check genotype, had IT 8 and 20 to 100% severities and Nick was either resistant (ITs 0–2) or susceptible (IT 8) depending on location and year. At Mt. Vernon, Cataldo was resistant to susceptible (ITs 2–8) in different nurseries in early growth stages (FS 5–6) but ranked resistant to moderately resistant (ITs 3–5) with low severities (10–30%) in late growth stages (FS 10.1–10.5), indicating HTAP resistance. When tested under controlled greenhouse conditions, Cataldo was susceptible in the seedling stage at low temperatures to races PST-17, PST-37, PST-43, PST-45, PST-100, PST-116, and PST-127 of *P. striiformis* f. sp. *tritici*. Under high temperatures, adult plants of Cataldo were resistant (ITs 1–3), similar to Alturas and Louise, while plants of Lemhi were susceptible (IT 8). Together with the field data, the results of greenhouse tests show that Cataldo has a good

Table 1. Agronomic performance of four wheat check cultivars and 'Cataldo' from the 2005 to 2007 Western Regional Soft White Spring Nursery. The complete data summaries can be found at http://www.ars.usda.gov/Services/docs.htm?docid=3712 (verified 22 May 2009).

Cultivar	Grain yield		Volume weight	Days to heading	Plant height
	Mean	Rank	Mean	Mean	Mean
	kg ha^{-1}		kg hL^{-1}	d from Jan. 1	cm
			2005		
Cataldo	4066	1	70.2	177	79
Alturas	4038	2	71.0	181	80
Nick	3868	5	71.3	178	76
Louise	3791	6	68.9	189	88
Alpowa	3703	7	70.2	184	83
Mean	3598		70.0	182	79
CV%	16.4		1.8	1	6
$LSD_{0.05}$	586		1.8	2	5
No. locations	8		4	5	8
			2006		
Cataldo	5037	7	70.9	169	73
Alturas	5214	2	73.1	174	76
Nick	4954	11	75.1	170	76
Louise	4934	12	73.3	173	85
Alpowa	5204	4	75.6	176	81
Mean	4913		73.5	174	79
CV%	8.9		2.1	1.5	4.9
$LSD_{0.05}$	430		1.6	3	3
No. locations	8		7	6	8
			2007		
Cataldo	4028	6	71.3	163	67
Alturas	4043	5	73.0	166	72
Nick	3830	10	75.0	165	74
Louise	4449	1	73.4	167	85
Alpowa	3902	9	74.1	170	76
Mean	4070		73.5	166	75
CV%	9.1		1.8	0.6	2.8
$LSD_{0.05}$	422		1.9	2	3
No. locations	6		4	3	4
			2005–2007		
Cataldo	4409	2	70.7	171	74
Alturas	4448	1	72.4	175	77
Nick	4252	5	74.0	172	76
Louise	4389	3	72.2	176	86
Alpowa	4303	4	73.7	178	80
Mean	4306		72.7	173	78
CV%	12.5		2.2	1	5
$LSD_{0.05}$	339		1.2	2	2
Location-years	22		15	14	20

Table 2. Phenotypic and marker-assisted evaluation of three parental wheat lines for resistance to Hessian fly in 2007.

Line	Hessian fly phenotype	No. plants tested	No. plants exhibiting a resistant reaction	Number of plants with target marker alleles		
				Xgwm 610 and *Xgwm 397*	*Xgwm610* only	*Xgwm397* only
Alturas	Susceptible	21	0	0	0	0
IDO584	Resistant (*H25*)	193	192	171	3	14
Cataldo	Resistant (*H25*)	19	19	19	0	0

level of HTAP resistance in combination with unspecified seedling resistance to stripe rust.

End-Use Quality

The overall end-use quality of Cataldo is similar to that of Alturas in both irrigated and rainfed locations. Cataldo also had better flour yield than Alpowa and better break flour yield than Nick in rainfed locations (Table 3). Cataldo had good noodle quality, similar to Alturas, and better noodle quality (Chinese raw noodle) than Louise, Alpowa, and Nick based on noodle color change between 0 and 24 h (*L** differential value) (Table 3). Cataldo had high lactic acid solvent retention capacity and low sucrose retention capacity, similar to Alturas and Louise (Table 3).

Availability

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

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Table 3. Quality characteristics of wheat cultivar Cataldo compared to four check cultivars from the 2005 to 2007 Western Regional Soft White Spring Nursery.

Cultivar	Alturas	Cataldo	Louise	Alpowa	Nick	Mean	CV%	$LSD_{0.05}$
Milling and baking quality from two rain-fed locations (Bonners Ferry and Moscow, ID) in 2005–2006								
Flour protein (g kg^{-1})	103.3	101.7	100.0	95.0	102.5	100.2	5.7	8.7
Flour yield (g kg^{-1})	638.3	620.0	626.7	597.5	632.5	626.1	2.5	24.2
Break flour yield (g kg^{-1})	401.7	391.7	416.7	427.5	367.5	404.1	6.6	41.2
Flour ash (g kg^{-1})	3.7	3.7	3.7	3.7	3.8	3.7	2.7	0.2
Cookie diam. (cm)	8.2	8.2	8.2	8.0	8.3	8.0	3.2	0.4
Alkaline noodle dough initial color *L0*, color in 24 hours *L24*, and color change *L** from one irrigated location (Aberdeen, ID) in 2005–2006								
L0	89	88	90	90	90	89	0.7	1.5
L24	81	80	80	78	76	79	1.9	3.5
ΔL^*	-8	-8	-10	-13	-13	-10	13.5	3.2
Flour solvent retention capacity from one irrigated location (Aberdeen, ID) in 2005 and 2007								
Lactic acid	112.6	118.8	112.7	120.4	99.5	107.0	5.7	16.7
Sodium carbonate	60.8	63.4	60.9	66.7	60.6	64.3	2.8	4.9
Sucrose	92.4	98.5	91.6	100.6	94.0	96.6	2.8	7.3
Water	49.0	50.3	47.0	49.5	48.3	49.7	1.6	2.1