

Registration of 'Alice' Wheat

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ABSTRACT

'Alice' (Reg. No. CV-1023, PI 644223) hard white winter wheat (*Triticum aestivum* L.) was developed by the South Dakota Agricultural Experiment Station and released in 2006 to seed producers by the developing institution and the Nebraska Agricultural Experiment Station. Alice was selected from the cross 'Abilene' (PI 511307)/'Karl' (PI 527480) made in 1992 at Brookings, SD. Alice was selected as an F_{4.5} line (F₄-derived line in the F₅ generation) in 1997 and was assigned experimental line number SD97W609. Alice was released on the basis of its white grain color, earliness, excellent bread baking quality, good preharvest sprouting tolerance, and high yield performance in rainfed production systems in South Dakota and the northern Great Plains, including Nebraska. Alice was named to honor Alice Wright, administrative assistant for the South Dakota Wheat Commission for 23 yr.

'Alice' (Reg. No. CV-1023, PI 644223) hard white winter wheat (*Triticum aestivum* L.) was developed by the South Dakota Agricultural Experiment Station and coreleased by the South Dakota and Nebraska Agricultural Experiment Stations in August 2006. In addition to researchers at South Dakota State University, researchers at the University of Nebraska and the USDA-ARS at Man-

hattan, KS, and St. Paul, MN, participated in the testing of Alice. Alice was released on the basis of its white grain color, earliness, excellent bread baking quality, good preharvest sprouting tolerance, and high yield performance in rainfed production systems in South Dakota and the northern Great Plains, including Nebraska. Alice was named in honor of Alice Wright, administrative assistant for the South Dakota Wheat Commission for 23 yr.

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On the basis of its earliness, excellent grain yield, quality, and good preharvest sprouting tolerance, Alice should be a replacement for 'Trego' and 'Nuplains'. Alice is genetically complementary to 'Wendy', with better quality and preharvest sprouting tolerance.

Methods

Early Generation Population Development

Alice was developed using a modified bulk breeding method. The cross (coded X92103) was made in the greenhouse in fall 1992 in Brookings, SD, and the F₁ seed was planted in hills in the same greenhouse in spring 1993. Bulk F₂ populations, including X92103, were planted in September 1993 in a nonreplicated breeding nursery at Brookings and were harvested in August 1994. Each F₂ bulk was planted in a seven-row plot, with each row 4.0 m long with 20-cm spacing between rows. The F₂ was advanced to the F₃ generation as a bulk population using the same plot dimensions. Two hundred thirty-one different F₃ bulks were planted in nonreplicated breeding nurseries at the Central Crop and Soils Research Station in Highmore, SD, and under irrigation at the Dakota Lakes Research Farm near Pierre,

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Abbreviations: AYT, advanced yield trial; CPT, crop performance testing; NRPN, Northern Regional Performance Nursery; WSMV, wheat streak mosaic virus.

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SD, in September 1994 and were harvested in August 1995. Individual F₂ and F₃ plots were combine harvested in bulk without within-plot selection. Seed harvested from the F₃ bulk was visually sorted for white kernel color in 1995. The bulk population of selected white kernels was coded X92103W and was grown in the greenhouse in spring 1996. Single heads were harvested from this selected F₄ bulk and planted in the field as head rows in fall 1996. About 100 head rows representing population X92103 were planted at the Dakota Lakes Research Farm as single rows in a four-row set 0.9 m long with 20-cm spacing between rows.

Line Selection and Evaluation

Alice was selected on the basis of visual appraisal of uniformity and desirable agronomic traits from the head-row nursery as an F_{4.5} line in July 1997 and assigned experimental number SD97W609. In August 1997, before planting, all harvested head rows were visually inspected and selected on the basis of kernel plumpness and discoloration indicating diseased or stressed plant growth. Alice was planted in the South Dakota Early Yield Trial nursery planted at Brookings, Selby, and Winner, SD, in a single replication, with 'Arapahoe' (PI 518591; Baenziger et al., 1989) planted as a common check interspersed every 10 plots throughout the nursery. Plots at each location were planted 4.0 m long, seven rows wide, with 20-cm spacing between rows in September 1997. Over the winter, all of the lines were evaluated in the greenhouse for their resistance to stem rust (caused by *Puccinia graminis* Pers.:Pers. f. sp. *tritici* Eriks. & E. Henn.) using race TPMK. In August 1998, all seven rows of each plot at each location were cut using a seven-row sickle bar cutter and threshed using a stationary thresher (to ensure pure seed). Harvested seed was subjected to protein (approved method 39-10; AACC, 2000) analysis via near-infrared reflectance spectroscopy and a modified whole-meal sodium dodecyl sedimentation method for protein quality (Dick and Quick, 1983). Grain yield of nonreplicated experimental lines was calculated based on percentage of nearby check plots.

Twenty-six white experimental lines out of the early yield trial were selected for planting in the South Dakota Advanced Yield Trial (AYT) on the basis of grain yield, volume weight, protein concentration and protein quality, resistance to stem rust, leaf rust, and tan spot, uniformity, and general agronomic appearance. The AYT planted in 1998 was separated into hard red (45 entries) and hard white (35 entries) nurseries, each with three replications grown at Brookings, Highmore, Winner, Selby, Wall, and two environments in Pierre, SD.

Based on grain yield and grain volume weight, and other screening data as described above, Alice and four other lines were selected and planted in the South Dakota Crop Performance Testing (CPT) Variety Trial at 14 locations (Brookings, Watertown, Platte, Highmore, Selby, Winner, Wall, Pierre, Kennebec, Sturgis, Martin, Bison, Hays, and Oelrichs) in September 1999 using plot dimensions at the first eight locations similar to previous trials

(AYT and preliminary yield trials) but with four replications. Each plot at Kennebec, Sturgis, Martin, Bison, and Hays consisted of six rows 7.5 m long and 1.5 m wide, with 25-cm spacing between rows. The CPT trial is the official, dryland (nonirrigated) state variety trial for South Dakota. The 1999 CPT trial included 36 entries, consisting of 29 released cultivars and seven experimental lines (five from South Dakota and one each from Nebraska and Hybritech [Berthoud, CO]). During winter 1999–2000, remnant samples of grain were analyzed for milling and bread baking properties (using AACC approved methods; AACC, 2000) at the USDA-ARS Hard Winter Wheat Quality Laboratory in Manhattan, KS.

On the basis of grain yield and volume weight, and other screening data as described above, Alice and other experimental lines were retained for further testing in the CPT trials from 2001 to 2005, with remnant samples of grain analyzed for milling and baking properties as described above. Alice was also entered into the cooperative Hard Winter Wheat Northern Regional Performance Nursery (NRPN) in 2003 and 2004.

Days to heading was measured on all yield trials as the number of days from 1 January until 50% of the spikes emerged from the boot. Plant height was measured at maturity (in centimeters) as the average length of the stems from the soil level to the tip of the spike, excluding the awns. Winter survival was measured in 2001 at six South Dakota locations (Brookings, Britton, Selby, Highmore, Wall, and Pierre) as (spring stand/fall stand) × 100%. Preharvest sprouting tolerance was measured according to Wu and Carver (1999) using a total of nine observations and a scale of 1 to 9, where 1 = highly tolerant and 9 = highly susceptible. Polyphenol oxidase enzyme levels were measured following the assay of Anderson and Morris (2001). Resistance to stem rust of Alice and other lines included in the AYT, CPT, and NRPN was evaluated at the seedling stage using six races (QFCS, RCRS, QTHJ, RTQQ, TPMK, and TTTT) and at the adult plant stage using a composite of the first five races by the USDA Cereal Disease Laboratory, St. Paul, MN. Resistance to Great Plains biotype of Hessian fly [*Mayetiola destructor* (Say)] was assessed on all lines entered into the NRPN in 2003–2004 from seedling tests conducted at the Department of Entomology, USDA-ARS, Manhattan, KS. An artificially inoculated field nursery was used to evaluate tolerance of Alice and other lines in the CPT trials to wheat streak mosaic virus (WSMV) in Brookings, SD, between 2000 and 2005. Two inoculated and noninoculated rows of each entry were grown side by side and replicated three times for comparison. Data was obtained on yield losses, plant stunting, and disease severity due to WSMV. Severity was evaluated using a scale of 0 to 5, where 0 = no symptoms; 1 = very mild symptoms, isolated small light green areas of mosaic, no stunting; 2 = mild symptoms, small areas of light green or yellow mosaic, short streaks, mild stunting; 3 = moderate symptoms, predominant yellow mosaic, extensive streaks, moderate stunting; 4 = severe symptoms, severe yellow mosaic, some necrosis, severe stunting; and

5 = severe symptoms, extreme yellowing, necrosis, very severe stunting, and plant death.

Seed Purification and Increase

Breeder seed of Alice originated from a composite of 200 F_{10:11} head rows selected in May 2004 on the basis of visual uniformity and white kernel color purity. The rows, planted under irrigation in Yuma, AZ, were 0.9 m long with 30-cm spacing between rows. Breeder seed (F_{10:12}) was produced by planting the composite obtained from Yuma in a 0.5-ha rainfed seed increase block at Brookings in September 2004. This block was purified by manually removing variants (tall plants with bronze chaff and hard red seed). The Foundation seed block (F_{10:13}) was produced by planting Breeder seed into a 5-ha rainfed block at Brookings in September 2005. The Foundation seed block was rogued as in the previous year. Alice contained 0.05% tall plants with bronze chaff and hard red seed off-type and 0.28% tall plants with white seed variant in this Foundation seed block.

Statistical Analyses

All statistical analyses were done using SAS Version 9.1 (SAS Institute, Cary, NC). Yield and grain volume weight data from the CPT trials were subjected to analysis of variance across locations within years and a combined analysis across location-years. Only entries common to the trials across all years (2003–2005) were included. Within-year analyses were performed according to a mixed model with environments and genotypes as fixed factors and replications within environments as random factors. Across-year analyses were also performed according to a mixed model with genotypes and location-year combinations as fixed factors and replications within location-year combinations as random factors. The LSD test ($P = 0.05$) was used to compare the least squares means for the genotype effects.

Characteristics

Agronomic and Botanical Description

While considerable data is available from the breeding nurseries evaluated during line development, the majority of data presented here is from the CPT (Tables 1 and 3) and NRPN (Table 2) as their complete reports are readily available (<http://plantsci.sdstate.edu/triticum/variety%20perf.htm> and <http://www.ars.usda.gov/Research/docs.htm?docid=11932>, respectively).

Alice is an awned, white-glumed, early maturing, semidwarf hard white winter wheat. It has green foliage at anthesis. The spike is tapered, inclined, and mid-dense. The glume is wide with a medium length, wanting shoulder, and an acuminate tip. Kernels are white, hard textured, and elliptical in shape with a collarless short brush, rounded cheeks, and a shallow crease.

Alice was among the earliest maturing cultivars (149 d), 1 d later than Wendy (PI 638521; Ibrahim et al., 2006), 2 d earlier than 'Wesley' (PI 605742; Peterson et al., 2001), and 6 d earlier than 'Harding' (PI 608049; Haley et al., 2000) (Table 1). Plant height of Alice (70.9 cm) is slightly taller than Wendy (67.9 cm) and Wesley (69.3 cm) and 15 cm shorter than Harding (85.9 cm). Alice has good straw strength similar to Wendy. The winter survival of Alice, as tested at six South Dakota locations in the very cold winter of 2001 was fair (51%), similar to 'Rose' (51%; Cltr 17795; Wells et al., 1982) and 'Culver' (49%; PI 606726; Baenziger et al., 2000). No varietal differences for winter survival were observed from 2003 to 2006. Alice has a short coleoptile similar to Wesley and Trego (PI 612576; Martin et al., 2001) [70 mm, $n = 14$ observations; 117% of Wendy; 88% of 'Expedition' (PI 629060, Ibrahim et al., 2004); and 78% of Harding)]. Alice has good preharvest sprouting tolerance (1.8), similar to 'Crimson' (PI 601818; Haley et al., 1998a) (1.8) and better than Wendy (4.2) (Table 1).

Field Performance

Testing in the South Dakota CPT trials (39 environments from 2003 to 2005; Table 1) showed grain yield of Alice (3602 kg ha⁻¹) to be greater than Wendy (3557 kg ha⁻¹), Wesley (3553 kg ha⁻¹), Expedition (3532 kg ha⁻¹), Trego (3473 kg ha⁻¹), and Arapahoe (3508 kg ha⁻¹) and less than

Table 1. Grain yield, volume weight, days to heading, sprouting tolerance, plant height, and straw strength for 'Alice' and other cultivars tested in the South Dakota Crop Performance Variety Trial (2003–2005).

Cultivar	Grain yield kg ha ⁻¹	Volume weight kg hL ⁻¹	Days to heading d	Sprouting tolerance 1–9	Plant height cm	Straw strength 0–9
HWW[†]						
Alice	3602	75.6	148	1.8	71	1.9
Trego	3473	76.5	150	2.6	71	2.2
Wendy	3557	76.4	148	4.2	68	1.3
HRW[†]						
Alliance	3558	74.5	149	1.5	75	1.8
Arapahoe	3508	75.0	151	2.5	79	2.2
Crimson	3411	76.7	154	1.8	83	1.1
Darrell	3692	75.8	152	2.2	81	1.8
Expedition	3532	75.9	148	2.1	74	1.7
Harding	3541	75.8	154	2.3	86	1.6
Jagalene	3633	76.9	150	1.3	72	0.8
Jerry	3558	75.2	154	1.3	85	1.6
Millennium	3769	76.7	152	2.2	81	1.2
Nekota	3327	74.9	149	2.1	72	1.7
Tandem	3453	77.3	151	2.0	81	3.1
Wahoo	3719	73.5	151	1.5	77	2.3
Wesley	3553	73.6	150	2.1	69	0.9
Mean	3615	75.7	152	2.2	77	1.6
CV%	11.9	2.5	0.8	35.1	4.8	49.7
LSD (0.05)	99	0.4	0.4	1.3	1.2	0.6
Location-years	38	39	26	3	35	7

[†]HWW, hard white winter wheat; HRW, hard red winter wheat.

'Millennium' (PI 613009; Baenziger et al., 2001) (3769 kg ha⁻¹). Alice (75.6 kg hL⁻¹) had similar grain volume weight to Expedition (75.9 kg hL⁻¹), higher than Wesley (73.4 kg hL⁻¹), and lower than Millennium (76.7 kg hL⁻¹) and Trego (76.5 kg hL⁻¹).

Alice ranked 15th (out of 35 lines tested) and 26th (out of 40 lines tested) for grain yield in the NRPN in 2003 and 2004, respectively. Compared with the check cultivars in the NRPN (Table 2), Alice (4337 kg ha⁻¹) was higher yielding than 'Nekota' (4043 kg ha⁻¹; Haley et al., 1996) and Nuplains (4184 kg ha⁻¹; PI605741).

Disease and Insect Resistance

Alice was resistant to moderately resistant to stem rust races QFCS, RCRS, QTHJ, RTQQ, and TPMK and moderately susceptible to race TTTT in seedlings tests and moderately resistant to a composite of the first five races in adult plant tests. Seedling tests showed Alice to be susceptible to the Great Plains biotype of Hessian fly. Alice ranged from moderately susceptible to susceptible (50%

Table 2. Data on the agronomic performance of four check cultivars and 'Alice' from the 2003 and 2004 cooperative Hard Winter Wheat Northern Regional Performance Nursery. The complete data summaries can be found at <http://www.ars.usda.gov/Research/docs.htm?docid=11932>.

Line [†]	Grain yield		Volume weight mean	Days to heading mean	Plant height mean	Winter survival mean
	mean	rank				
	— kg ha ⁻¹ —		kg hL ⁻¹	d	cm	0–100
2003						
Kharkof	3209	35	76.7	164	110	88
Roughrider	3501	34	76.5	164	102	89
Nuplains	4059	28	76.9	163	80	75
Nekota	4066	27	75.2	159	81	77
Alice	4271	15	74.5	159	75	71
mean	4158		73.9	161	84	72
CV%	12.9					
LSD _{0.05}	365					
2004						
Kharkof	3577	40	77.1	159	94	70
Harding	4553	20	75.7	158	82	74
Nuplains	4308	32	77.9	158	71	69
Nekota	4021	35	75.7	153	74	71
Alice	4404	26	76.3	153	70	70
mean	4477		76	155	76	72
CV%	13					
LSD _{0.05}	130					
2003–2004						
Kharkof	3393		76.9	162	102	79
Nuplains	4184		77.4	161	75	72
Nekota	4043		75.5	156	78	74
Alice	4337		75.4	156	73	70
mean	4318		75	158	80	72

[†]With the exception of Alice, all cultivars compared in this table have red endosperm.

severity) to leaf rust (caused by *Puccinia triticina* Eriks.) under natural infection conditions in Brookings, SD in 2003 and 2004. Alice is moderately susceptible (moderate mosaic and/or moderate stunting) to wheat soilborne mosaic virus. Yield losses of Alice, Wendy, and Trego due to WSMV were 13.6, 20.1, and 29.0%. Plant stunting of Alice, Wendy, and Trego due to WSMV was 18.5, 7.7, and 20.9%. WSMV disease severity of Alice, Wendy, and Trego was 2.2, 2.4, and 2.0, respectively.

End-Use Quality

Both milling and baking quality scores of Alice were very good (Table 3). Relative to the check cultivars Wendy and Wesley, Alice had medium-sized kernels (28.9 vs. 27.5 and 29.7 mg, respectively). Flour extraction of Alice, Wendy, and Wesley was 674.1, 659.6, and 672.4 g kg⁻¹, respectively. Flour ash of Alice was lower (3.5 g kg⁻¹) than both Wendy (3.7 g kg⁻¹) and Wesley (3.8 g kg⁻¹). Flour protein of Alice (11.5%) was similar to Wendy (11.5%) and lower than Wesley (12.5%). In bread baking tests, flour water absorption and loaf volume of Alice (613.7 g kg⁻¹; 905.0 mL) were intermediate between Wendy (598.3 g kg⁻¹; 830.0 mL) and Wesley (631.3 g kg⁻¹; 931.7 mL). Alice had higher mixograph tolerance (4.3) than Wendy (1.0) but slightly lower than Wesley (5.0) (0 = unacceptable, 4 = acceptable, 6 = outstanding). Mixograph mix time for Alice (4.8 min) was intermediate between Wendy (3.2 min) and Wesley (7.0 min). Bread baking quality of Alice was better than all hard winter experimental lines and checks, including 'Tandem' (PI 601817; Haley et al., 1998b), entered in the 2004 Wheat Quality Council tests. Alice has moderate grain polyphenol oxidase levels (4.0), similar to Trego (4.1), higher than Wendy (3.4), but lower than 'NuFrontier' (5) (on a 1–5 scale; lower is better).

Table 3. Milling and baking characteristics of 'Alice', 'Wendy', and 'Wesley' obtained from a composite of four locations tested between 2003 and 2005.

Characteristic	Alice Wendy Wesley			Mean	CV%	LSD _{0.05}
	Hard	Hard	Hard			
Class	Hard	Hard	Hard			
Kernel size (mm)	2.2	2.1	2.2	2.2	6.0	0.3
Kernel weight (mg)	28.9	27.5	29.7	28.7	6.6	4.3
SKCS kernel hardness (score) [†]	59.6	66.1	61.6	62.4	7.1	10.0
Flour extraction (g kg ⁻¹)	674.1	659.6	672.4	668.7	1.4	21.0
Flour ash (g kg ⁻¹)	3.4	3.7	3.8	3.6	1.6	0.1
Flour protein, percent (12% moisture basis)	11.5	11.5	12.5	11.8	4.9	1.3
Flour water absorption (g kg ⁻¹)	613.7	598.3	631.3	614.4	1.0	14.5
Loaf volume (cm ³)	905.0	830.0	931.7	888.9	4.3	87.0
Mixograph tolerance (0–6 scale)	4.3	1.0	5.0	3.4	11.1	1.0
Bake mix time (min)	4.8	3.2	7.0	5.0	12.5	1.5
Crumb grain score (0–6 scale)	3.9	2.7	4.4	3.7	15.0	1.3

[†]SKCS, single-kernel characterization system.

Availability

The South Dakota Foundation Seed Stocks Division (Plant Science Department, South Dakota State University, Brookings, SD) had Foundation seed of Alice available to seed producers for planting during fall 2007. Seed classes are Breeder, Foundation, Registered, and Certified. Alice has been submitted for U.S. Plant Variety Protection under P.L. 910577 with the certification option. Small quantities of seed for research purposes may be obtained from the corresponding author for at least five years from the date of this publication.

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