Registration of 'NE01643' Wheat

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ABSTRACT

'NE01643' (Reg. No. CV-1020, PI 647959) hard red winter wheat (*Triticum aestivum* L.) was developed cooperatively by the Nebraska Agricultural Experiment Station and the USDA-ARS and released in 2007 by the developing institutions and the South Dakota Agricultural Experiment Station. NE01643, the legal name for this cultivar, will be marketed under the name Husker Genetics Brand Overland in honor of the pioneers who crossed and stayed in the northern prairies. In addition to researchers at the releasing institutions, USDA-ARS researchers at Manhattan, KS, and St. Paul, MN, participated in the development of NE01643. NE01643 was selected from the cross 'Millennium' (PI 613099) sib/ND8974 that was made in 1995. The pedigree of ND8974 is 'Seward' (PI 508289)/'Archer'. Archer was developed by AgriPro Seeds Inc. and has the pedigree: 'Sonora 64' (CI 13930)/'Trapper' (CI 13999)/2/'Warrior' (CI13190)/3/'Centurk' (CI 15075). NE01643 was selected as an $F_{3:4}$ line (F_3-derived line in the F_4 generation) in 1999, and in 2001 was assigned experimental line number NE01643. NE01643 was released because of its superior grain-yield performance under non-irrigated production in Nebraska, South Dakota, and adjacent states.

'NE01643' (Reg. No. CV-1020, PI 647959) hard red winter wheat (*Triticum aestivum* L.) was tested under experimental line number NE01643 and was developed cooperatively by the Nebraska Agricultural Experiment Station and the USDA-ARS and released in March 2007 by the developing institutions and the South Dakota Agricultural Experiment Station. NE01643 will be marketed under the name 'Husker Genetics Brand Overland' in honor of the pioneers who crossed and stayed in the northern prairies. In addition to researchers at the releasing institutions, USDA-ARS researchers at Manhattan, KS, and St. Paul, MN, participated in the development of NE01643. NE01643 was released because of its superior grain yield performance under non-irrigated production in Nebraska, South Dakota, and adjacent states.

NE01643 was selected from the cross 'Millennium' (PI 613099, Baenziger et al., 2001a) sib/ND8974 that was made in 1995. The pedigree of ND8974 is 'Seward' (PI 508289, Cox et al., 1988)/'Archer'. Archer was developed by AgriPro Seeds Inc. (Berthoud, CO) and has the pedigree: 'Sonora 64' (CI 13930)/'Trapper' (CI 13999)/2/'Warrior' (CI13190)/3/'Centurk' (CI 15075).

Methods

Early Generation Population Development

NE01643 was developed using a bulk breeding procedure. The initial cross (made in spring of 1995) and F_1 plants were grown over the winter in the greenhouse and the F_2 seed was harvested in bulk in May 1996. The F_2 bulk generation was grown in an unreplicated breeding nursery at Mead, NE that was planted in September 1996 and harvested in July 1997 with a small plot combine. Each F_2 bulk was planted in a four-row plot with each row being 2.4 m long with 30 cm between rows. The seeding rate was 54 kg ha^{-1}. Eight hundred fifty F_2 bulks are planted and a mild culling selection of less than 5% is used to remove very poor bulks (usually based on poor winter survival, though also on poor disease resistance, extreme lateness, or lodging). Of the remaining F_2 populations (819), a non-selected subsample of the grain was planted in September 1997, in an unreplicated F_3 bulk nursery, as a 4-row plot that was 6.6 m long with 30 cm between rows. Of F_3 populations, approximately 50% were visually selected (401 actual selections) on the basis of winter survival, disease resistance, and general agronomic appearance (mainly plant height, flowering date, standability, and visually estimated yield potential). Each selected population was advanced by

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random sampling of approximately 100 spikes (as was the case for the population that contained NE01643, though especially meritorious bulks had a sample of 200 to 300 spikes selected) in July 1998. Selected spikes were threshed individually and planted in a headrow nursery in September 1998. Headrow selections were planted as a single row in a 4-row set that were 0.9 m long with 30 cm between rows.

Line Selection and Evaluation

Based on visual appraisal of uniformity and agronomic appearance, NE01643 was selected from the headrow nursery as an $F_{3:4}$ line in July, 1999. Eight lines were selected from the population. In August, 1999, before planting, all head row harvested seed was visually inspected for kernel plumpness and discoloration indicating diseased or stressed plant growth. Less than 5% of the harvested head rows were normally discarded, however, in this case two of the eight selections were discarded. In September, 1999, NE01643 and 1523 other head rows were advanced to an unreplicated observation nursery with replicated check cultivars 'Alliance' (PI 573096, Baenziger et al., 1995) planted in plots ending in 25, 'Arapahoe' (PI 518591, Baenziger et al., 1989) planted in plots ending in 50, 'Jagger' (PI 593688, Sears et al., 1997a) planted in plots ending in 75, and '2137' (PI 592444, Sears et al., 1997b) planted in plots ending in multiples of 100 The observation nursery was planted at Lincoln and Mead, NE. At Lincoln, each line was planted in a four-row plot with each row being 2.4 m long with 30 cm between rows. At Mead, each line was planted in a single row that was 2.4 m long with 30 cm between it and adjacent rows. 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. Four hundred twenty-seven experimental lines and 18 plots of the check cultivars were harvested in July, 2000, based on winter survival (determined at Mead, NE), resistance to stem rust and other diseases prevalent in the field, uniformity, and general agronomic appearance (mainly plant height measured from the soil surface to the tip of the spikes, excluding the awns; flowering date measured as the number of days to when 50% of the emerged spikes had extruded anthers), standability measured using a scale of 1 to 10 with 1 being little to 10% lodging and 10 being 100% lodged; and visually estimated grain-yield potential at maturity). At harvest, the center two rows of each selected four-row plot in Lincoln were cut using a two-row sickle bar cutter and threshed using a stationary thresher (to ensure pure seed). After harvest, the actual grain yield of the visually selected experimental lines were compared to the check cultivar grain-yield mean and specifically to those check cultivar plots closest to the harvested experimental line. The lowest grain yielding lines were discarded. For the remaining lines, 40 g of grain were tempered to a moisture content of 152 g H_2O kg^{-1} grain and milled in a Brabender Junior Laboratory mill (C.W. Brabender Instruments, Inc., South Hackensack, NJ). The flour was separated from the bran using a shaker (Strand, Minneapolis, MN) at 225 rpm for 90 s with a U.S. Standard Sieve No. 70 and weighed to estimate the flour yield per 40-g sample of grain. Flour protein content was determined by near-infrared reflectance (NIR) spectroscopy using flour samples from each plot following Method 39–70 (AACC, 2000). Flour mixing characteristics were evaluated on a 10 g flour sample using a Mixograph (National Manufacturing Co., Lincoln, NE) according to the Approved Method 54–40 (AACC, 2000) with a constant water absorption of 610 g H_2O kg^{-1} of flour. Mixograph mixing time (hereafter referred to as mixing time) was determined as the time in minutes required to reach peak dough resistance. Mixograph mixing tolerance (hereafter referred to as mixing tolerance) was rated based on the comparison against standard curves in the Nebraska Wheat Laboratory using a scale from low (0) to very high tolerance (7) with higher scores indicating greater tolerance of dough to overmixing using Approved Methods 54–40 (AACC, 2000; Baenziger et al., 2001b). Wheat lines with a mixing time of > 3 min and a mixing tolerance scores of > 3 are considered as having an acceptable end-use quality (Baenziger et al., 2001b), though year to year variation as seen in the check cultivar values can lead to selecting lines with lower mixing times and tolerance scores.

On the basis of high agronomic performance and acceptable end-use quality, 280 hard red winter wheat lines were planted in an unreplicated trial with replicated checks (Alliance, Millennium, 'Pronghorn' (PI 593047, Baenziger et al., 1997), 'Wesley' (PI 605742, Peterson et al., 2001), and 2137 planted every 100 plots at 20 plot intervals) and 30 hard white winter wheat lines (including 'Nuplains' [PI 612576] and 'Trego' [PI 612576, Martin et al., 2001] as checks) for a total of 330 plots. The hard red wheat lines were sorted on the basis of flowering date with those having the earliest flowering dates being first in the nursery. This trial was planted in September 2000 at six locations (Lincoln, Mead, Clay Center, Grant, Sidney, and Alliance, NE). Each line was planted in a four row plot with each row being 2.4 m long with 30 cm between rows and all four rows were harvested using a small plot combine with the exception of North Platte which was abandoned due to hail. Over the winter all of the lines were evaluated in the greenhouse for their resistance to stem rust using race TPMK. The lines were also evaluated at the USDA-ARS Cereal Disease Laboratory, St. Paul, MN for stem rust resistance. The name NE01643 was derived from this nursery as the line was harvested in 2001 (e.g., the 01) and it was entry 643 (the entries ranged from 401 to 730).

Based on grain yield, grain volume weight, plant height, flowering date, stem rust resistance, mixograph mixing time and tolerance, and agronomic appearance, NE01643 and 56 other lines (19% selection intensity) were selected and planted in advanced yield trials with three check cultivars (Alliance, Pronghorn, and Wesley) in September, 2001. These trials were planted in three replications at five locations (Lincoln, Mead, Clay Center, Sidney, and Alliance) and two replications at three locations (McCook, North Platte, and Grant) with the same plot size as the preliminary yield trials. The lines were evaluated for stem rust resistance in our greenhouses and at the USDA-ARS Cereal Disease Laboratory, and remnant grain samples from western NE (e.g., those harvested locations other than Lincoln or Mead which were harvested for seed) were composited and analyzed for milling and bread baking properties using 100 g pup loaves where the bake sample mixtime, water absorption, baked loaf volume, and external and internal grain and texture were measured (using AACC approved methods; AACC, 2000; Baenziger et al., 2001b). The lines were also evaluated for their resistance to Hessian fly (*Mayetiola destructor* Say) by the USDA-ARS-PSERU and Kansas State University.

Based on grain yield and other characteristics as described above, NE01643 and 17 other lines (30% selection intensity) were selected and planted in the Nebraska Intrastate Nursery (NIN) in

September, 2002 using plot methods similar to previous trials. The NIN is the elite rainfed (non-irrigated) trial for the breeding program and was planted with three replications at Mead, Clay Center, North Platte, Sidney and Alliance, and at Lincoln (four replications). Lines continue in this nursery until they are released or dropped from further consideration. Seed of the entries in the NIN are shared annually with South Dakota State University for testing to determine if any of the lines may have promise in South Dakota. The lines were evaluated for winter survival, agronomic performance, stem rust resistance, Hessian fly resistance, and bread making properties as previously described. Alliance was abandoned, but all other sites were harvested.

In September, 2003, NE01643 and nine lines (55% selection) continued testing in the NIN as described previously. All locations were harvested. NE01643 was also entered into the cooperative USDA-ARS Hard Winter Wheat Northern Regional Performance Nursery (NRPN).

In September, 2004, NE01643 and seven lines continued to be tested in the NIN (all locations were harvested and evaluated as described previously), the NRPN, and was entered into the Nebraska State Variety Trial (NESVT), the official, rainfed and irrigated state variety trial for NE. The number of replications in the NESVT varied from as low as three to as many as five harvested replications. The plot size (2.4 m by 1.2 m to three times that size) and row spacing (17.5 to 35 cm between rows) varied with the region of the state. The NESVT is usually planted at 13 to 15 rainfed and two to three irrigated locations in Nebraska or combined with close locations in Wyoming. Normally one to three locations are lost yearly due to hail, freezes, drought, or severe disease. NE01643 continued to be evaluated in the NIN and NESVT in 2005 and 2006 as described above.

Seed Purification and Increase

Seed purification of NE01643 began in the 2003 crop year using visual identification and manual removal of variants (primarily tall and red-chaffed off-types) from bulk seed increases grown under rainfed conditions at Lincoln, NE. Seed harvested from the advanced yield trials at Lincoln, NE in 2002 was planted in a short, unreplicated strip plot (1.2 m wide, 15 m long) in fall 2002. During grain filling and again at harvest, strips were rogued to remove tall, red-chaffed, and other variants. A subsample of seed harvested from these strips was planted in a longer strip plot (1.2 m wide, 45 m long) in fall 2003. This strip was rogued as in 2003. In fall 2004, a subsample of seed from this strip was planted at Mead, NE in a Breeder Seed ($F_{3:10}$) increase block (approximately 0.2 ha) and rogued as in previous years. In 2006, Foundation Seed was produced by planting all of the Breeder Seed harvested in 2005, in a five ha rainfed seed increase block at Mead, NE. The Foundation seed increase block ($F_{3:11}$) was rogued as in previous years. NE01643 has been uniform and stable since 2004. Less than 0.5% of the plants were rogued from the Breeder's seed increase in 2004. The rogued variant plants were taller in height (10–15 cm) or were awnless and/or with red chaff. Up to 1% (10:1000) variant plants may be encountered in subsequent generations. The Nebraska Crop Improvement Association and Mr. Roger Hammons provided technical assistance in describing the cultivar characteristics and accomplishing technology transfer.

Statistical Analyses

To analyze data during the development of NE01643, replicated trials with two replications were analyzed as randomized complete blocks and replicated trials with three or more replications were analyzed using the nearest neighbor (NNA) procedure of Agrobase 21 (Agronomix Software, Inc. Winnipeg, Canada; Stroup et al., 1994). Because NE has three major wheat producing regions (Peterson, 1992), the data were analyzed within a location within region and rarely over locations for the advanced and NIN trials. Location means and ranks were studied and lines were selected by having excellent performance within a location, across locations within a region, and all locations within a year based on the arithmetic mean of the NNA adjusted means, or across locations and years based on the arithmetic mean of the NNA adjusted means. A truncated selection procedure was used as a risk-avoidance strategy (basically if a line did well in one or two years and then poorly in the next year, the line was not continued because it might perform poorly in a producer's field). Analyses of the NRPN data used SAS (SAS Institute Inc., Cary, NC) for a randomized complete block design within locations and across locations within a year. Entries changed greatly between years in the NRPN making over year comparisons difficult. For the NESVT, the trials were analyzed using SAS using a row and column correction (PROC MIXED, SAS Institute Inc.) for each location and analyzed across years within a regions. Entries varied greatly across regions, hence analysis across regions and locations were not analyzed using SAS, but the arithmetic mean for lines in common were considered. Only entries common to the trials across years within a region in the NESVT (2004 to 2006) were analyzed using randomized complete block designs.

Characteristics

Agronomic and Botanical Description

While considerable data is available from the breeding nurseries during the line development, the majority of data presented here will be from the NESVT (Table 1) and NRPN (Table 2) as their complete reports are readily available [http://varietytest.unl.edu/winterwheat.html; (verified 19 Nov. 2007) http://www.ars.usda.gov/Research/docs.htm?docid=11932; respectively]. NE01643 is an awned, white-glumed, semi-dwarf (contains the *RhtB1b* [formerly *Rht1*]) cultivar. The mature plant height of NE01643 (84 cm) is 1 cm shorter than Millennium and 8 cm taller than Wesley (Table 1). NE01643 has good straw strength (5% lodged), similar to Wesley (3.7%), Millennium (3.9%), and Agripro Brand 'Jagalene' (Plant Variety Protection Office Certificate 200200160, 5.8%), and superior to 'Goodstreak' (PI 632434, Baenziger et al., 2004a; 15% lodged, Table 1) under rainfed conditions. In irrigated environments, NE01643 is similar to Jagalene, Wesley, and Millennium for lodging, and less than Wahoo (Table 1.) Other measurements of performance from comparison trials show that NE01643 is moderately late in flowering date (flowers 143 d after Jan.1, data from observations in NE), about 1 d later flowering than 'Wesley' and 0.5 d earlier than Millennium, respectively. Using data from the NRPN (Table 2), NE01643 is 2 d later than 'Nekota' (PI 584997, Haley et al., 1996) and 3 d earlier than Nuplains and 'Harding' (PI 608049, Haley et al., 2000) for heading. The winter hardiness of NE01643 (84%) is good to very good, similar to Nekota (84%),

Table 1. Grain yield, test weight, grain protein content, lodging, and plant height by district (the number of environments per district is in parentheses) in Nebraska for rainfed (39 environments) and irrigated trials (nine environments) grown from 2004 to 2006. The state averages for the rainfed trials are also included but were not statistically analyzed due to greatly different lines tested in the various state regional trials and the well recognized regional nature of adaptation within NE.

Cultivar	Southeast (9)					South Central (3)				
	Yield	Grain volume weight	Grain protein content	Lodging	Plant height	Yield	Grain volume weight	Grain protein content	Lodging	Plant height
	kg ha^{-1}	kg hl^{-1}	g kg^{-1}	%	cm	kg ha^{-1}	kg hl^{-1}	g kg^{-1}	%	cm
Antelope	3964	71.0	121	6.9	93.2	4388	68.5	135	10.7	88.1
Goodstreak	4233	74.5	125	16.1	103.9	4186	72.1	136	18.0	101.6
Harry	4206	67.7	115	4.2	89.4	3716	64.1	126	9.7	84.6
Infinity CL	4623	74.9	119	15.8	96.8	4616	70.5	128	12.7	93.2
Jagalene	4784	75.8	119	7.6	92.2	5059	72.8	126	8.3	88.1
Millennium	4347	73.4	120	2.7	97.0	4750	70.3	129	8.7	94.0
NE01643	4844	75.3	118	2.2	96.0	4925	70.0	129	8.7	92.2
Pronghorn	3695	71.3	123	43.4	101.9	3877	70.5	140	31.0	98.3
Scout66	3353	69.9	125	44.2	106.9	3474	70.7	135	25.0	99.8
Turkey	3138	67.4	125	36.9	104.1	3071	67.7	136	16.7	99.1
Wahoo	4018	68.9	118	11.0	95.5	4300	67.8	130	9.3	89.7
Wesley	4273	71.4	119	1.8	86.9	4703	67.3	127	7.7	85.6
Average all entries*	4230	72.6	120	11.3	95.2	4348	69.8	131	12.7	91.1
LSD 0.05%**	608	3.4	4	NS	4.4	665	2.0	6	14.2	4.9
	West Central (12)					Panhandle (15)				
Antelope	3212	73.6	131	2.5	72.6	2647	74.9	113	63.8	
Goodstreak	3393	75.8	131	10.4	88.9	2802	77.2	114	76.2	
Harry	3339	69.0	123	0.6	74.7	2963	73.0	107	67.1	
Infinity CL	3601	74.1	128	8.4	77.7	2835	75.4	114	68.1	
Jagalene	3487	75.9	132	1.6	73.7	2782	76.6	114	64.8	
Millennium	3467	74.9	129	0.3	80.0	2694	76.3	116	69.6	
NE01643	3628	74.8	128	3.0	78.5	2889	75.8	114	69.9	
Pronghorn	3245	75.3	130	22.8	86.9	2775	76.6	111	72.6	
Scout66	2882	75.8	131	47.9	89.7	2466	75.8	113	77.0	
Turkey	2708	74.0	135	28.8	88.4	2338	75.8	115	75.4	
Wahoo	3615	72.1	128	3.9	76.7	2714	73.9	112	67.3	
Wesley	3333	72.6	131	1.6	69.6	2567	73.2	123	60.7	
Average all entries*	3289	74.0	130	6.2	77.5	2701	75.4	110	67.8	
LSD 0.05%**	467	1.6	4	12.7	3.4	215	1.3	5	4.6	
	State (39)					Irrigated (9)				
Antelope	3553	72.0	125	6.7	79.4	6121	75.9	112	9.3	85.6
Goodstreak	3653	74.9	127	14.8	92.6					
Harry	3556	68.4	118	4.8	78.9					
Infinity CL	3919	73.7	122	12.3	83.9	5631	74.1	111	33.4	90.2
Jagalene	4028	75.3	123	5.8	79.7	6383	74.4	112	11.7	85.1
Millennium	3815	73.7	124	3.9	85.2	5738	74.9	111	20.1	93.0
NE01643	4072	74.0	122	4.6	84.1	6034	74.8	110	11.8	89.2
Pronghorn	3398	73.4	126	32.4	89.9					
Scout66	3044	73.0	126	39.0	93.3					
Turkey	2814	71.2	128	27.5	91.8					
Wahoo	3662	70.7	122	8.1	82.3	5631	70.5	113	37.2	89.7
Wesley	3719	71.1	125	3.7	75.7	6464	73.9	116	6.5	81.0
Average all entries*						6020	74.2	111.6	18.5	87.3
LSD 0.05%**						581	1.8	6	14.0	2.4

*This value is the average of all the values for the traits for the entries that were in the trial and includes values for many experimental lines not shown in the table.

**The LSD (least significant difference $p < 0.05$) was calculated from the analysis of variance using all of the values of the entries that were in the trial including many experimental lines not shown in the table.

and comparable to other winter wheat cultivars adapted and commonly grown in Nebraska and South Dakota.

The field appearance of NE01643 is most similar to Millennium. After heading, the canopy is open and erect to inclined. The flag leaf is erect and twisted (light to moderately) at the boot stage. The foliage is green to dark green with a light waxy bloom on the leaf sheath, but not on the leaves or spike at anthesis. The leaves are very lightly pubescent with very short hairs. The spike is tapering to oblong in shape, narrow, mid-long, and mid-dense. The glume is long and narrow, and the glume shoulder is narrow to midwide and rounded to square. The beak is short in length with an acuminate to acute tip. The spike is predominantly inclined at maturity with some spikes nodding. Kernels are red colored, hard textured, and mainly elliptical in shape. The kernel has no collar, a large brush of medium length, angular cheeks, large germ, and a mid-wide and mid-deep crease.

Table 2. Data on the agronomic performance of four check cultivars and NE01643 from the 2004 and 2005 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.

2004			Grain yield		Grain volume weight,	Days from 1/1 to heading	Plant height	Winter survival
	Entry	Line/selection	Kg ha^{-1}	Rank	Kg hl^{-1}	d	cm	0–100
	1	Kharkof	3577	40	77.1	159	94	70[†]
	2	Harding	4553	20	75.7	158	82	74
	3	Nuplains	4308	32	77.9	158	71	69
	4	Nekota	4021	35	75.7	153	74	71
	31	NE01643	5054	1	77.2	154	79	78
		Mean	4477		76	155	76	72
		CV	13					
		L.S.D. (0.05)	130					
2005								
	1	Kharkof	2881	31	74.7	161	104	96[‡]
	2	Harding	2776	32	74.4	161	101	97
	3	Nuplains	3420	27	72.5	160	77	86
	4	Nekota	3282	30	71.8	155	78	96
	17	NE01643	4342	1	74.0	158	83	90
		Mean	3741		72.7	158	83	88
		CV	12.8					
		LSD (0.05)	376					
2004–2005 Average								
		Kharkof	3229		75.9	160.4	99.5	83.4
		Harding	3665		75.0	159.4	91.5	85.1
		Nuplains	3864		75.2	159.3	73.9	77.2
		Nekota	3651		73.8	153.9	75.8	83.4
		NE01643	4698		75.6	156.1	81.1	84.1
		Mean	4109		74.3	156.6	79.7	79.9

[†]Data from 8 locations, using a scale where 100 is all of the plants in the plot survived the winter and 0 is where no plants in the plot survived the winter.

[‡]Data from 4 locations.

Disease and Insect Resistance

On the basis of seedling screening evaluations through the USDA Regional Testing Program, field evaluations in Nebraska and South Dakota, NE01643 is moderately susceptible to stem rust in field nursery tests inoculated with a composite of stem rust races (RCRS, QFCS, QTHJ, RKQQ, and TPMK) but resistant to the most prevalent race QFCS. NE01643 likely carries *SrTmp* and it is moderately resistant to race TTKS based on seedling tests. It is moderately resistant to leaf rust (caused by *P. triticina* Eriks), stripe rust (caused by *P. striiformis* Westendorp f. sp. *tritici,* data obtained from field observations in the Great Plains), and Hessian fly (*Mayetiola destructor* Say, using the Great Plains biotype). The rating scale of infection responses in these evaluations consisted of four classes: R (resistant), MR (moderately resistant), MS (moderately susceptible), and S (susceptible) determined primarily on the basis of the size of uredinia and total leaf coverage for leaf and stripe rust. NE01643 also is more tolerant to Fusarium head blight (caused by *Fusarium* spp., data obtained from misted screening nurseries in Kansas, Nebraska, and South Dakota) than many widely grown lines, which are generally very susceptible. It is susceptible to wheat soilborne mosaic virus, barley yellow dwarf virus, and wheat streak mosaic virus (data obtained from the Northern Regional Performance Nursery, 2004–2005 and field observations in NE).

Field Performance

In the NESVT, NE01643 was widely adapted and performed well throughout the state (Table 1) with the exception of irrigated wheat production systems where it performed near the average of the tested lines. Of the popular lines tested across the state, NE01643 was either the highest yielding line or not significantly different from the highest yielding line in each of the four rainfed regions of the NESVT. The state average rainfed yield of NE01643, 4072 kg ha^{-1} (39 environments from 2004 to 2006) was arithmetically greater (though not necessarily significantly greater) than the yields of other popular cultivars such as 'Antelope' (3553 kg ha^{-1}, PI 633910, Graybosch et al., 2005), Goodstreak (3653 kg ha^{-1},), 'Harry' (3556 kg ha^{-1}, PI 632435, Baenziger et al., 2004b), 'Infinity CL' (3919 kg ha^{-1}, PI 639922, Baenziger et al., 2006), Agripro Brand Jagalene (4028 kg ha^{-1}), Millennium (3815 kg ha^{-1}), 'Wahoo' (3662 kg ha^{-1}, PI 619098, Baenziger et al. (2002), and Wesley (3719 kg ha^{-1}) (Table 1). Though NE01643 has excellent grain yield in rainfed environments, its grain yield (6034 kg ha^{-1}) in irrigated environments is slightly above the test average (6020 kg ha^{-1}) and lower than popular irrigated wheat cultivars Wesley (6464 kg ha^{-1}) and Agripro Brand Jagalene (6383 kg ha^{-1}). The broad adaptation of NE01643 to the Northern Great Plains (Table 2) was evident in its performance in the NRPN where it was the highest yielding line in 2004 (out of 40 lines tested) and 2005 (out of 32 lines tested) NRPN trials. Compared to the check cultivars in the NRPN, NE01643 (4698 kg ha^{-1}) was

Table 3. Comparison of NE01643 to Millennium from 2001 to 2005 for flour yield, grain protein content, flour protein content, ash content, use of an oxidizing agents (KbrO3), bake mixing time, Mixograph mixing time, Mixograph tolerance, loaf volume, external appearance, crumb grain, and crumb texture (predictors of end-use quality) as determined by the Wheat Quality laboratory at the University of Nebraska (Baenziger et al., 2001). All reported values were measured at a 140 g H20 1000 g^{-1} flour basis.

Year	Flour yield	Protein wheat	Protein flour	Ash	Mg $KBrO_3$	Water absp.	Bake mix time	Mixograph mix time	Tolerance	Loaf volume	External	Crumb grain	Crumb texture
	g flour/ 100 g grain	g protein/ 100 g grain	g protein/ 100 g flour	g ash/ 100 g flour	Mg/kg flour	g water/ 100 g flour	Minutes	Minutes	(score)	Cm^3			
NE01643													
2001	70.7	15.6	14	0.436	0.75	63	4.3	3	2.7	840	Good-	Good	Good-
2002	70.6	14.5	13	0.448	0	62	4	2.6	2	835	Fair+	Good-	Fair+
2003	72.8	13.1	12.2	0.458	0	62	4.3	2.7	3	810	Fair	Fair	Fair
2004	70.9	15.1	13.8	0.442	0.75	63	4	2.3	2.3	850	Fair+	Fair+	Good-
2005	72.7	10.8	10	0.468	0	60	4.6	3.1	2.3	800	Fair-	Fair	Fair-
Mean	71.54	13.82	12.60	0.45	0.30	62.00	4.24	2.74	2.46	827			
St. err.	0.50	0.86	0.72	0.01	0.18	0.55	0.11	0.14	0.17	9.43			
Millennium													
2001	70.9	14.7	12.6	0.374	0	63	5.6	4.2	4	905	Vgood-	Good+	Good-
2002	70.3	14.9	13	0.464	0	62	5.3	4	3.3	940	Good	Good+	Good
2003	73.2	13.4	12.4	0.454	0	61	5.5	4	3.7	910	Good	Good-	Good-
2004	72.5	14.9	13.5	0.264	0.5	61	5	3.3	3.7	910	Good+	Good	Good+
2005	72.4	12.4	10.25	0.52	0	61	6	4.5	2.7	900	Fair+	Good	Good-
Mean	71.86	14.06	12.35	0.42	0.10	61.60	5.48	4.00	3.48	913			
St.err	0.54	0.50	0.56	0.04	0.10	0.40	0.17	0.20	0.22	7.00			

higher yielding than Nekota (3651 kg ha^{-1}) and Nuplains (3864 kg ha^{-1}). In addition to its excellent grain yield, NE01643 had relatively high grain volume weight (Tables 1 and 2) where it was above the average of every trial grouping and generally not significantly different from the line with the best grain volume weight.

As a moderately late maturing cultivar, NE01643 should be a replacement for 'Arapahoe', 'Culver' (PI 606726, Baenziger et al., 2000), and possibly Millennium and Wesley, though Millennium and Wesley have better disease and insect resistances and end-use quality than NE01643. NE01643 is genetically complementary (e.g., has different genetics/parentage) to Agripro Brand Jagalene, Goodstreak, Pronghorn, Wesley, and 2137. It is non-complementary (e.g., shares a common parent(s)) to Arapahoe, Culver, Millennium, Wahoo, and 'Niobrara' (PI 584996, Baenziger et al., 1996).

End-Use Quality

The milling and baking properties of NE01643 were determined for five years by the Nebraska Wheat Quality Laboratory (Table 3). In these tests, Millennium, an excellent milling and baking wheat, was used for comparison. All reported values were measured at a 140 g H_2O 1000 g^{-1} flour basis. The average wheat and flour protein content of NE01643 (138 and 126 g kg^{-1}) were similar to Millennium (141 and 124 g kg^{-1}) over all years. The slightly lower grain protein content was confirmed by the Nebraska cultivar performance trials where NE01643 had 122 g protein kg^{-1} compared to Millennium with a value of 124 g kg^{-1}. The average flour extraction on the Buhler Laboratory Mill for NE01643 (715 g kg^{-1}) was slightly lower than Millennium (719 g kg^{-1}). The flour ash content (0.45 g 100 g^{-1}) was higher than Millennium (0.42 g 100 g^{-1}). Dough mixing properties of NE01643 were acceptable, but would be considered weak (mixtime peak was 2.74 min and mixtime tolerance was scored as 2.5) which was weaker than Millennium (mixtime peak of 4.0 min and mixtime tolerance scored as 3.5). Average baking absorption (620 H_2O g kg^{-1}) was slightly higher than Millennium (616 H_2Og kg^{-1}) over all years. The average loaf volume of NE01643 (827 cm^3) was lower than Millennium (913 cm^3). The scores for the internal crumb grain and texture ranged from fair to good, which were poorer than Millennium which ranged from fair to very good). The overall end-use quality characteristics for NE01643 are adequate, but less than many commonly grown wheat cultivars and should be acceptable to the milling and baking industries.

Availability

The Nebraska Foundation Seed Division, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE 68583 had Foundation seed available to qualified certified seed enterprises in 2006. The U.S. Department of Agriculture will not have seed for distribution. The seed classes will be Breeder, Foundation, Registered, and Certified. The Registered seed class will be a nonsalable seed class. NE01643 will be submitted for

plant variety protection under P.L. 10577 with the certification option. A research and development fee will be assessed on all certified seed sales. Small quantities of seed for research purposes may be obtained from Dr. P. S. Baenziger and the Department of Agronomy and Horticulture, University of Nebraska-Lincoln for at least five years from the date of this release according to the provisions of the Wheat Worker's Code of Ethics (Annual Wheat Newsletter, 1995). A seed sample has been deposited in USDA-ARS National Center for Genetic Resources Preservation and in the USDA-ARS National Small Grains Collection, Aberdeen ID and seed is freely available to interested researchers.

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References

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

Annual Wheat Newsletter. 1995. Wheat worker's code of ethics [Online]. Available at http://wheat.pw.usda.gov/ggpages/awn/41/awn41a2.html#report3 (verified 19 Nov. 2007).

Baenziger, P.S., B. Beecher, R.A. Graybosch, D.D. Baltensperger, L.A. Nelson, J.M. Krall, D.V. McVey, J.E. Watkins, J.H. Hatchett, and M.-S. Chen. 2004a. Registration of 'Goodstreak' wheat. Crop Sci. 44:1473–1474.

Baenziger, P.S., B. Beecher, R.A. Graybosch, D.D. Baltensperger, L.A. Nelson, J.M. Krall, Y. Jin, J.E. Watkins, D.J. Lyon, A.R. Martin, M.-S. Chen, and G. Bai. 2006. Registration of 'Infinity CL' wheat. Crop Sci. 46:975–977.

Baenziger, P.S., B. Beecher, R.A. Graybosch, D.D. Baltensperger, L.A. Nelson, D.V. McVey, J.E. Watkins, J.H. Hatchett, and M.-S. Chen. 2004b. Registration of 'Harry' wheat. Crop Sci. 44:1474–1475.

Baenziger, P.S., B. Moreno-Sevilla, R.A. Graybosch, J.M. Krall, M.J. Shipman, R.W. Elmore, R.N. Klein, D.D. Baltensperger, L.A. Nelson, D.V. McVey, J.E. Watkins, and J.H. Hatchett. 2002. Registration of 'Wahoo' Wheat. Crop Sci. 48:1752–1753.

Baenziger, P.S., B. Moreno-Sevilla, C.J. Peterson, J.W. Schmidt, D.R. Shelton, D.D. Baltensperger, L.A. Nelson, D.V. McVey, J.E. Watkins, and J.H. Hatchett. 1995. Registration of 'Alliance' wheat. Crop Sci. 35:938.

Baenziger, P.S., B. Moreno-Sevilla, C.J. Peterson, J.W. Schmidt, D.R. Shelton, D.D. Baltensperger, L.A. Nelson, D.V. McVey, J.E. Watkins, J.H. Hatchett, and R.A. Graybosch. 1996. Registration of 'Niobrara' Wheat. Crop Sci. 36:803.

Baenziger, P.S., B. Moreno-Sevilla, C.J. Peterson, D.R. Shelton, D.D. Baltensperger, L.A. Nelson, D.V. McVey, J.E. Watkins, J.H. Hatchett, and J.W. Schmidt. 1997. Registration of 'Pronghorn' Wheat. Crop Sci. 37:1006.

Baenziger, P.S., B. Moreno-Sevilla, C.J. Peterson, D.R. Shelton, R.W. Elmore, R.N. Klein, D.D. Baltensperger, L.A. Nelson, D.V. McVey, J.E. Watkins, and J.H. Hatchett. 2000. Registration of 'Culver' Wheat. Crop Sci. 40:862–863.

Baenziger, P.S., B. Moreno-Sevilla, C.J. Peterson, D.R. Shelton, R.W. Elmore, P.T. Nordquist, R.N. Klein, D.D. Baltensperger, L.A. Nelson, D.V. McVey, J.E. Watkins, J.H. Hatchett, and G. Hein. 2001a. Registration of 'Millennium' Wheat. Crop Sci. 41:1367–1369.

Baenziger, P.S., J.W. Schmidt, C.J. Peterson, V.A. Johnson, P.J. Mattern, A.F. Dreier, D.V. McVey, and J.H. Hatchett. 1989. Registration of 'Arapahoe' wheat. Crop Sci. 29:832.

Baenziger, P.S., D.R. Shelton, M.J. Shipman, and R.A. Graybosch. 2001b. Breeding for end-use quality: Reflections on the Nebraska experience. Euphytica 119:95–100.

Cox, D.J., B.L. D'Appolonia, and J.D. Miller. 1988. Registration of 'Seward' wheat. Crop Sci. 28:378–379.

Graybosch, R.A., C.J. Peterson, P.S. Baenziger, L.A. Nelson, B.B. Beecher, D.D. Baltensperger, and J.M. Krall. 2005. Registration of 'Antelope' Hard White Winter Wheat. Crop Sci. 45:1661–1662.

Haley, S.D., J.L. Gellner, M.A.C. Langham, Y. Jin, S. Kalsbeck, C. Stymiest, J. Rickertsen, R. Little, B.E. Ruden, O.K. Chung, B.W. Seabourn, D.V. McVey, and J.H. Hatchett. 2000. Registration of 'Harding' wheat. Crop Sci. 40:1500.

Haley, S.D., B. Moreno-Sevilla, P.S. Baenziger, C.J. Peterson, J.W. Schmidt, D.R. Shelton, D.D. Baltensperger, L.A. Nelson, D.V. McVey, J.E. Watkins, J.H. Hatchett, and R.A. Graybosch. 1996. Registration of 'Nekota' Wheat. Crop Sci. 36:803–804.

Martin, T.J., R.G. Sears, D.L. Seifers, T.L. Harvey, M.D. Witt, A.J. Schlegel, P.J. McCluskey, and J.H. Hatchett. 2001. Registration of 'Trego' wheat. Crop Sci. 41:929.

Peterson, C.J. 1992. Similarities among test sites based on cultivar performance in the hard red winter wheat region. Crop Sci. 32:907–912.

Peterson, C.J., D.R. Shelton, P.S. Baenziger, D.D. Baltensperger, R.A. Graybosch, W.D. Worrall, L.A. Nelson, D.V. McVey, J.E. Watkins, and J. Krall. 2001. Registration of 'Wesley' Wheat. Crop Sci. 41:260–261.

Sears, R.G., J.M. Moffatt, T.J. Martin, T.S. Cox, R.K. Bequette, S.P. Curran, O.K. Chung, W.F. Heer, J.H. Long, and M.D. Witt. 1997a. Registration of 'Jagger' wheat. Crop Sci. 37:1010.

Sears, R.G., T.J. Martin, J.H. Hatchett, T.S. Cox, R.K. Bequette, S.P. Curran, O.K. Chung, W.F. Heer, J.H. Long, and M.D. Witt. 1997b. Registration of '2137' wheat. Crop Sci. 37:628.

Stroup, W.W., P.S. Baenziger, and D.K. Mulitze. 1994. A comparison of methods for removing spatial variation from wheat yield trials. Crop Sci. 34:62–66.