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Registration of 'NE01481' Hard Red Winter Wheat

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Registration of 'NE01481' Hard Red Winter Wheat

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ABSTRACT

'NE01481' (Reg. No. CV-1061, PI 659689) hard red winter wheat (*Triticum aestivum* L.) was developed cooperatively by the Nebraska Agricultural Experiment Station and the USDA-ARS and released in April 2010. NE01481 will be marketed as Husker Genetics brand McGill. In addition to superior agronomic performance, Nebraska wheat growers would like to have increased resistance to *Wheat soilborne mosaic virus*. NE01481 was selected from the cross NE92458/'Ike' that was made in 1995. The pedigree of NE92458 is OK83201/'Redland' and the pedigree of OK83201, an experimental line developed by Oklahoma State University is 'Vona'/'Chisholm'/'Plainsman V'. NE01481 was selected with the bulk-breeding method as an F_{3,4} line in 1999, and in 2001 it was assigned experimental line number NE01481. NE01481 was released because of its superior grain yield in rainfed wheat production systems in southeastern, south central, and southwestern Nebraska and that it is the first modern release from our program with resistance to *Wheat soilborne mosaic virus*.

Wheat soilborne mosaic virus (SBWMV) in an increasing problem in southeastern and south central Nebraska, from where it continues to spread north and west. The most common methods of controlling the virus are the

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Abbreviations: FHB, Fusarium head blight; NESVT, Nebraska State Variety Trial; SRPN, Southern Regional Performance Nursery; SBWMV, *Wheat soilborne mosaic virus*.

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use of resistant cultivars and late-planted susceptible cultivars, which have reduced infection because of the low temperature at planting (Myers et al., 1993). However, with recent warm fall weather, even late-planted wheat has suffered considerable losses in grain yield due to the disease. 'NE01481' (Reg. No. CV-1061, PI 659689) hard red winter wheat (*Triticum aestivum* L.) was tested under the experimental line designation NE01481 and was developed cooperatively by the Nebraska Agricultural Experiment Station and the USDA-ARS and released in 2010. NE01481 will be marketed and sold as Husker Genetics brand McGill. The brand name McGill is in honor of the late Dr. David P. McGill, who was a legendary undergraduate teacher and professor of genetics at the University of Nebraska. NE01481 was released because of its superior grain yield in rainfed wheat production systems in southeastern, south central, and southwestern NE and its resistance to SBWMV, a major potential disease in this region.

Methods

NE01481 was selected from the cross NE92458/Ike that was made in spring 1995. The pedigree of NE92458 is OK83201/'Redland' (Schmidt et al., 1989), and the pedigree of OK83201, an experimental line developed by Oklahoma State University, is 'Vona' (Welsh et al., 1978)/'Chisholm' (Smith et al., 1985)/'Plainsman V' (PI 591702). The F₁ generation was grown in the greenhouse in 1996, and the F₂ and F₃ generations were advanced via a modified bulk-breeding method in the field at Ithaca, NE in 1997–1998. The seeding rate was 66 kg ha⁻¹. The F₂ bulk was a single four-row plot that was 2.4 m long with 30 cm between rows. After a mild culling selection of less than 15% to remove very poor bulks (usually based on poor winter

survival, but also on poor disease resistance, extreme lateness, or lodging), the F₃ bulks were planted in September 1997 in an unreplicated bulk nursery, each as a four-row plot that was 5 m long with 30 cm between rows. Approximately 50% of the F₃ populations were visually selected 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 randomly sampling approximately 100 spikes, although especially promising bulks had a sample of 200–300 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 that was 0.9 m long with 30 cm between rows. Headrows were selected visually on the basis of uniformity and agronomic appearance. In 1999–2000, the line was evaluated as a single plot in an observation nursery. Harvested samples were evaluated for end-use quality with the Mixograph (National Manufacturing Co., Lincoln, NE) and on the basis of protein content (Baenziger et al., 2001b). In 2000–2001, the line eventually designated as NE01481 was grown at six locations in Nebraska. There was no further selection.

From fall 2001 onward, NE01481 was evaluated in replicated trials in Nebraska and the Great Plains: (i) an advanced trial in 2001–2002; (ii) an elite trial in 2002–2010; (iii) the USDA-ARS-coordinated Southern Regional Performance Nursery (SRPN) in 2004–2005; and (iv) the Nebraska State Variety Trial (NESVT) from 2005 to 2010. The NESVT is planted annually at 13–15 rainfed and 2 or 3 irrigated locations in Nebraska or combined with locations in Wyoming that are near the Nebraska border. Normally 1–3 locations are lost yearly due to hail, freezes, drought, or severe disease.

The criteria for selection were good winter survival (determined at Ithaca, NE), resistance to stem rust (caused by *Puccinia graminis* Pers.:Pers. f. sp. *tritici* Eriks & E. Henn.) and other diseases prevalent in the field, uniformity, and general agronomic appearance. The traits for the latter included plant height (measured from the soil surface to the tip of the spikes, excluding the awns), flowering date (measured as the number of days after 1 January to when 50% of the emerged spikes had extruded anthers), standability (measured on a scale of 1 to 10, with 1 denoting little to 10% lodging, and 10, 100% lodging), grain yield, and grain volume weight. Over the winter, all of the lines were evaluated in the greenhouse in Lincoln, NE for their resistance to stem rust with race TPMK (with methods described in Sidiqi et al., 2009) and at the USDA-ARS Cereal Disease Laboratory with races TPMK, QCRS, RCRS, TTTT, and RKQQ in the greenhouse and a composite of races (RCRS, QR+FCS, QTHJ, RKQQ, and TPMK) in the field for the advanced nursery (with methods described in Rouse et al., 2011). In addition, the lines were evaluated at the Cereal Disease Laboratory for leaf rust (caused by *P. tritici* Eriks) in the greenhouse (methods described in Watkins et al., 2001 and Kolmer et al., 2009) and in the field (data from the regional performance nurseries using naturally occurring isolates) for leaf rust and stripe rust (caused by *P.*

striiformis Westendorp f. sp. *tritici*). For SBWMV, the lines were screened in the field at Lincoln and in the regional performance nurseries with naturally occurring strains (with methods described in Hunger et al., 1989).

The lines were evaluated in the greenhouse for Fusarium head blight (FHB; caused by *Fusarium graminearum* Schwabe). Each spike was artificially inoculated with a spore suspension of an isolate of *F. graminearum* at 1×10^5 spores mL⁻¹ at mid-anthesis by means of a handheld bottle sprayer. To obtain the spore suspension, an isolate of *F. graminearum* obtained from a Nebraska wheat field was grown on potato dextrose agar plates on a laboratory bench for 3 wk. Sterile distilled water (5 mL) was added to each plate and a rubber policeman was used to dislodge spores. The spore suspension was filtered through two layers of cheesecloth into a beaker and the concentration was adjusted to 1×10^5 spores mL⁻¹ with distilled water. Approximately 2 mL of the spore suspension was applied to each spike with a handheld bottle sprayer, and the spike was then covered with a transparent plastic bag for 7 d following inoculation. The severity (%) of FHB was visually estimated 14 d after inoculation. In the field, nurseries for natural infection, inoculation without irrigation, and inoculation with irrigation were used to evaluate the lines (with methods described in Wegulo et al., 2011). The lines were also evaluated for their resistance to Hessian fly [*Mayetiola destructor* (Say)] by the USDA-ARS Center for Grain and Animal Health Research (methods described in Chen et al., 2009). For end-use quality, the advanced lines were evaluated with grain samples from western Nebraska (e.g., those harvested locations other than Lincoln or Ithaca that were harvested for seed). The samples were composited and analyzed for milling and bread-baking properties using 100-g pup loaves, where the bake sample mix time, water absorption, baked-loaf volume, and external and internal grain and texture were measured by approved methods as previously described (AACC, 2000; Baenziger et al., 2001b; Baenziger et al., 2008).

Statistical Analyses

Data for NE01481 were derived from the elite and advanced breeding trials and analyzed with an incomplete block design (incomplete block size = 5) within blocks (block size = 60) with Agrobase GEN II (Agronomix Software, Winnipeg, Canada; Stroup et al., 1994). Occasionally, advanced and elite trials with three or more replications were analyzed with the nearest neighbor procedure of Agrobase GEN II (Stroup et al., 1994). Because Nebraska has three major wheat-producing regions (Peterson, 1992), the data were analyzed within a location within a region and rarely across locations for the advanced and elite trials. Location means and ranks were studied, and lines were selected for having excellent performance within a location, across locations within a region, and all locations within a year based on the arithmetic mean of the adjusted means or across locations and years based on the arithmetic mean of the adjusted means. A truncated selection procedure was used as a risk-avoidance strategy (basically if a line did well in 1 or 2 yr for grain yield, winter survival, disease

resistance, or end-use quality and then poorly in the next year's evaluations, the line was not continued because it might perform poorly in a producer's field). Analyses of the SRPN data used SAS (SAS Institute Inc., Cary, NC) for a randomized complete block design within locations and across locations within a year. The SRPN entries were analyzed and compared for statistical significance within years due to many entries being tested for only 1 yr. For the NESVT, the trials were analyzed with SAS and a row-and-column correction (PROC MIXED) for each location and analyzed across years within a region. Entries varied greatly across regions, hence analysis across regions and locations was not done with SAS, but the arithmetic means of lines in common were considered. Only entries common to the trials across years within a region in the NESVT (2005–2009) were analyzed with randomized complete block designs.

Characteristics

Agronomic and Botanical Description

NE01481 is an awned cultivar with tan glumes that expresses a semidwarf stature (it contains the *RhtB1b* allele [formerly *Rht1*]). The coleoptile of NE01481 is white and the juvenile growth habit is prostrate. The foliage is green with a light waxy bloom on the leaf sheath and spike at anthesis but not on the leaves. The flag leaf is recurved and not twisted at the boot stage. After heading, the canopy is moderately closed and inclined to nodding. The leaves

are glabrous. The spike is tapering, narrow, midlong, and middense. The glume is long and midwide, and the glume shoulder is square. The beak is moderately long with an acuminate tip. The spike is predominantly nodding at maturity with some spikes inclined. Kernels are red, hard textured, and mainly ovate in shape. The kernel has a small to nonexistent collar, a large, long brush, rounded cheeks, large germ, and a narrow and shallow crease.

The coleoptile length of NE01481 (78 mm ± 1 mm) is similar to that of Husker Genetics brand Overland ('NE01643', 79 ± 1 mm; Baenziger et al., 2008), 'Infinity CL' (83 ± 2 mm; Baenziger et al., 2006), and 'Wesley' (75 ± 1 mm; Peterson et al., 2001), but it is shorter than that of conventional height cultivars such as 'Goodstreak' (109 ± 1 mm; Baenziger et al., 2004) and 'Scout 66' (114 ± 1 mm; Schmidt et al., 1971).

Although considerable data were available from the breeding nurseries during line development, the majority of data presented here is from the SRPN (<http://www.ars.usda.gov/Research/docs.htm?docid=11932>; verified 28 July 2011) and the NESVT (Table 1; complete report available at <http://varietytest.unl.edu/winterwheat.html>; verified 28 July 2011). In the SRPN, NE01481 ranked 27 out of 50 in 2004 and 19 out of 48 in 2005 for grain yield (3893 kg ha⁻¹ in 2004; 3624 kg ha⁻¹ in 2005). NE01481 compared favorably with 'Trego', the highest-yielding check cultivar (3939 kg ha⁻¹ in 2004 and 3284 kg ha⁻¹ in 2005). In other measures of performance, NE01481 had lower grain volume weight (74.5 kg hL⁻¹) than Trego (77.0 kg hL⁻¹) and 'TAM 107'

Table 1. Agronomic traits by district in Nebraska for rainfed environments grown from 2005 to 2009.[†]

Cultivar	Yield kg ha ⁻¹	Grain volume weight kg hL ⁻¹	Grain protein content g kg ⁻¹	Lodging %	Plant height cm	Yield kg ha ⁻¹	Grain volume weight kg hL ⁻¹	Grain protein content g kg ⁻¹	Lodging %	Plant height cm
Southeast						South Central				
Camelot	4307	74.9	121	5	90	3480	68.7	132	15	95
Infinity CL	4461	75.9	118	9	89	3454	70.9	125	15	93
Millennium	4300	75.2	120	2	91	3830	71.3	128	7	96
NE01481 (McGill)	4596	74.8	115	4	90	3494	69.0	124	16	95
Overland	4730	76.1	120	1	86	4031	70.5	128	7	95
Scout 66	3151	72.3	124	26	99	2553	51.9	130	32	100
Wesley	3984	71.7	120	1	82	3830	67.4	126	7	88
Average all entries [‡]	4074	73.7	120	6	87	3449	66.7	128	13	93
LSD (0.05) [§]	376	3.0	3	14	4	393	NS	4	17	4
West Central						West				
Camelot	4199	75.2	121	8	89	3299	76.3	109		74
Infinity CL	4112	76.2	117	8	87	3326	76.6	110		74
Millennium	4179	76.8	120	4	91	3185	76.6	110		76
NE01481 (McGill)	4226	73.4	114	8	89	3171	76.3	107		74
Overland	4307	76.3	117	5	89	3346	76.8	107		75
Scout 66	3286	77.2	121	41	101	2889	76.7	109		85
Wesley	4065	74.0	119	6	79	3064	74.9	114		66
Average all entries [‡]	3966	75.4	118	10	88	3159	76.5	108		74
LSD (0.05) [§]	310	0.9	4	8	3	188	1.2	4		4

[†]Southeast, *n* = 13; south central, *n* = 5; west central, *n* = 20; west, *n* = 23.

[‡]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.

[§]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.

(75.0 kg hL⁻¹). Its maturity (132 d after 1 January) is later than that of Trego (131 d after 1 January) and TAM 107 (128 d after 1 January). NE01481 is a tall, semidwarf wheat (81.5 cm) and is taller than Trego (74.0 cm) and TAM 107 (75.0 cm).

In the NESVT (Table 1), NE01481 has performed well for grain yield across the diverse ecogeographic regions of Nebraska (Peterson, 1992); it was similar to Millennium (Baenziger et al., 2001a), Infinity CL, and 'Camelot' (Baenziger et al., 2009) and lower than Overland (NE01643) in one region and superior to Wesley in southeast Nebraska. The most important cultivar comparison for the intended use of NE01481 is Wesley, because they are the only cultivars with resistance to SBWMV in these trials. Based on our data, NE01481 has a similar or better grain-yield record than Wesley in every region. NE01481 and Wesley have similarly lower grain volume weights than some cultivars, and Wesley has a similar, but consistently lower, lodging score than NE01481. Wesley has a higher grain protein content and is shorter than NE01481 (Table 1).

Disease and Insect Resistance

Using data predominantly from the 2005 SRPN, NE01481 ranged from moderately resistant to moderately susceptible to stem rust in field nursery tests when inoculated with a composite of stem rust races (RCRS, QFCS, QTHJ, RKQQ, and TPMK). In greenhouse tests, it is resistant to races TPMK, QFCS, and RCRS but susceptible to races TTTT and RKQQ. NE01481 is resistant to SBWMV (data from 2004 and 2005 SRPN). On a scale of 1 to 4, where 1 = resistant,

and 4 = susceptible, NE01481 had a mean score in Oklahoma in 2004 and 2005 (five measurements) of 1.4, which was similar to that of the resistant cultivar Trego (2.0) and better than those of the susceptible cultivars Kharkof (3.6), Scout 66 (3.8), and TAM107 (3.6). In field trials in Nebraska in which cultivars were infected with SBWMV, Wesley and NE01481 were resistant (scores of 1). NE01481 ranges from moderately resistant to moderately susceptible to leaf rust and from moderately susceptible to susceptible to stripe rust. It ranges from moderately resistant to moderately susceptible to FHB (data from greenhouse and field observations in Nebraska). NE01481 is susceptible to Hessian fly and to *Wheat streak mosaic virus* (field observations in Nebraska).

End-Use Quality

The milling and baking properties of NE01481 were tested for 7 yr by the Nebraska Seed Quality Laboratory (Table 2). In these tests, Wesley, an excellent milling and baking wheat cultivar, was used for comparison. All reported values were measured on a 140 g H₂O kg⁻¹ flour basis. The average flour extraction on the Buhler Laboratory Mill (Buhler, Uzwil, Switzerland) for NE01481 (708 g kg⁻¹) was lower than for Wesley (739 g kg⁻¹). The average wheat and flour protein concentration of NE01481 (142 and 125 g kg⁻¹) were slightly lower than those of Wesley (143 and 130 g kg⁻¹) for the corresponding years. The lower grain protein content was confirmed by the NESVT where NE01481 and Wesley were tested (Table 1). The flour ash content (4.59 g kg⁻¹) was higher than that of Wesley (4.43 g kg⁻¹). Dough-mixing properties of NE01481 were acceptable (Mixograph mix-time

Table 2. Comparison of NE01481 to Wesley from 2002 to 2008 for characteristics as determined by the Wheat Quality Laboratory at the University of Nebraska.[†]

Year	Flour yield	Grain protein	Flour protein	Ash content	Mixograph		Loaf volume	External appearance	Crumb grain	Crumb texture	Overall bake
					Mix time	Tolerance					
	g kg ⁻¹				min	0–7 [‡]	cm ³	0–6 [§]			
NE01481											
2002	701	147	138	4.90	3.7	3.3	930	4.5	4.0	4.0	4.1
2003	719	127	125	4.86	3.5	4.0	930	4.0	4.0	3.5	3.7
2004	711	152	137	4.08	3.5	3.3	920	2.5	3.5	2.5	2.8
2005	719	112	105	4.80	6.5	3.0	945	3.5	3.5	3.5	3.5
2006	653	183	119	4.84	2.8	4.0	800	4.0	3.5	3.5	3.6
2007	719	139	132	4.49	2.5	3.0	750	3.5	4.0	4.0	4.0
2008	742	134	117	4.13	4.2	4.5	775	4.3	4.0	4.5	4.3
Mean	708	142	125	4.59	3.4	3.6	864	3.8	3.8	3.6	3.7
Wesley											
2002	733	153	146	4.56	5.0	5.7	1035	4.5	4.0	3.5	3.8
2003	740	135	134	4.34	5.3	4.3	1025	5.0	3.5	3.5	3.7
2004	744	145	138	3.64	5.2	4.0	1020	5.0	3.5	3.0	3.4
2005	731	126	116	4.54	5.0	3.7	965	4.5	4.0	4.0	4.1
2006	729	167	127	4.27	5.0	5.0	903	4.5	5.0	5.0	5.0
2007	733	140	139	4.33	3.6	4.3	800	4.0	4.8	5.0	4.8
2008	760	136	111	5.33	4.0	4.8	880	5.0	5.0	6.0	5.6
Mean	739	143	130	4.43	4.7	4.5	947	4.6	4.3	4.3	4.3
LSD (0.05)	15	10	7	.25	0.5	0.5	55	0.4	0.3	0.5	0.4

[†]Composite samples from Clay Center, North Platte, Sidney, and Alliance, NE (Baenziger et al., 2001b). All reported values were measured at a 140 g H₂O kg⁻¹ flour basis.

[‡]0 = weak; 7 = very tolerant (Baenziger et al., 2001b).

[§]0 = unacceptable; 6 = excellent.

peak was 3.4 min, and mix-time tolerance was scored as 3.6) and were lower than those of Wesley (Mixograph mix-time peak of 4.7 min and mix time tolerance scored as 4.5). The average baking absorption ($602 \text{ H}_2\text{O g kg}^{-1}$) was lower than that of Wesley ($611 \text{ H}_2\text{O g kg}^{-1}$) for the corresponding years. The average loaf volume of NE01481 (864 cm^3) was lower than that of Wesley (947 cm^3). The scores for the external loaf score, internal crumb grain, and texture ranged from 3.6 to 3.8 (where 6 is excellent and 4 is good), which was less than those for Wesley, which ranged from 4.3 to 4.5. The overall end-use quality characteristics for NE01481 (scored as 3.7, where 6 is excellent and 4 is good) was lower than for Wesley (4.3) but similar to many commonly grown wheat cultivars. NE01481 should be acceptable to the milling and baking industries.

Seed Purification and Increase

Seed purification of NE01481 began in 2003 and continued thereafter by means of visual identification and manual removal of variants (primarily tall, awnless, or red-chaffed off-types) from bulk-seed increases grown under rainfed conditions at Lincoln and Ithaca, NE. NE01481 has been uniform and stable since 2007. Less than 0.5% of the plants were rogued from the breeder's seed increase in 2007–2009. The rogued variant plants were taller (5–15 cm) or awnless or had red chaff. Up to 1% (10:1000) variant plants may be encountered in subsequent generations.

Availability

The Nebraska Foundation Seed Division, University of Nebraska-Lincoln, Lincoln, NE 68583 had foundation seed available under the marketing name Husker Genetics brand McGill to qualified certified seed enterprises beginning in 2010. The seed classes will be Breeder, Foundation, Registered, and Certified. Registered seed will be a non-salable class. NE01481 has been submitted for U.S. 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 5 yr from the date of this release. A seed sample has been deposited in the 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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