Registration of 'NE01481' Wheat

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Registration of 'NE01481' (Husker Genetics Brand McGill) Hard Red Winter Wheat

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ABSTRACT

'NE01481' (Reg. No. _____, 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 using the bulk breeding method as an $F_{3:4}$ line in 1999, and in 2001 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 south western NE and that it is the first modern release from our program with resistance to wheat soilborne mosaic virus.

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Wheat soilborne mosaic virus in an increasing problem in southeastern and south central Nebraska where it continues to spread north and west. The most common methods of control are the use of resistant cultivars and late-planted susceptible cultivars have reduced infection by low temperature at planting (Myers et al., 1993). However, with recent warm fall weather, even late planted wheat has suffered considerable grain yield losses due to the disease. 'NE01481' (PI 659689) hard red winter wheat (*Triticum aestivum* L.) was tested under 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 south western NE and it's resistance to soilborne wheat mosaic virus, a major potential disease in this region.

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METHODS

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NE01481 was selected from the cross NE92458/Ike that was made in the 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 F_1 generation was grown in the greenhouse in 1996 and the F_2 to F_3 generations were advanced using a modified bulk breeding method in the field at Ithaca, NE in 1997 to 1998. The seeding rate was 66 kg ha^{-1}. The F_2 bulk was a single 4-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 upon poor winter

survival, though also on poor disease resistance, extreme lateness, or lodging), F_3 bulks were planted in September 1997, in an unreplicated F_3 bulk nursery, each as a 4-row plot that was 5 m long with 30 cm between rows. Approximately 50% of the F_3 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, though especially promising bulks had a sample of 200 to 300 spikes selected in July 1998. Selected spikes were threshed individually and planted in a head row nursery in September 1998. Head row selections were planted as a single row that was 0.9 m long with 30 cm between rows. Head rows were selected visually on the basis of uniformity and agronomic appearance. In 1999 to 2000, the line was evaluated as a single plot in an observation nursery. Harvested samples were evaluated for end use quality using the Mixograph and protein content (Baenziger et al., 2001b). In 2000 to 2001, the line eventually designated at NE01481 was grown at six locations in Nebraska. There was no further selection thereafter.

From fall 2001 onward, NE01481 was evaluated in replicated trials in Nebraska and the Great Plains (advanced trial, 2001-2002; elite trial, 2002-2010, USDA-ARS coordinated Southern Regional Performance Nursery [SRPN] in 2004-2005 [data at http://www.ars.usda.gov/Research/docs.htm?docid=11932], and in the Nebraska State Variety Trial [NESVT] from 2005-2010 [data available at http://cropwatch.unl.edu/web/varietytest/wheat]). The NESVT is planted at 13 to 15 rainfed and two to three irrigated locations in Nebraska or combined with locations in Wyoming that are near the Nebraska border. Normally one to three locations are lost yearly due to hail, freezes, drought, or severe disease.

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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 (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 after Jan. 1 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; 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 using race TPMK (using methods described in Sidiqi et al., 2009) and at the USDA-ARS Cereal Disease Laboratory using 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 (using methods described in Rouse et al., 2011). In addition, the lines were evaluated at the Cereal Disease Laboratory for leaf rust (caused by *P. triticina* Eriks) in the greenhouse (using methods described in Watkins et al., 2001; Kolmer et al., 2009) and in the field (data from the regional performance nurseries using naturally occurring isolates) for leaf rust and and stripe rust (caused by *P. striiformis* Westendorp f. sp. t*ritici*). For wheat soilborne mosaic virus, the lines were screened in the field at Lincoln and in the regional performance nurseries using naturally occurring strains (using methods described in Hunger et al., 1989).

The lines were evaluated in in the greenhouse for Fusarium head blight (incited by Fusarium *graminearum* Schwabe). Each spike was artificially inoculated with a spore suspension of an isolate of *F. graminearum* at 1 x 10^5 spores/ml at mid-anthesis using a hand-held bottle sprayer. To obtain the spore suspension, an isolate of *F. graminearum* obtained from a Nebraska wheat field was grown on potato dextrose agar (PDA) plates on a laboratory bench

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for three weeks. 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 x 10^5 spores/ml with distilled water. Approximately 2 ml of the spore suspension was applied to each spike with a hand-held bottle sprayer and the spike was then covered with a transparent plastic bag for 7 days following inoculation. FHB severity (%) was visually estimated 14 days after inoculation. In the field, natural infection, inoculated without irrigation, and inoculated with irrigation nurseries were used to evaluate the lines (using 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 (using methods described in Chen et al., 2009). For end-use quality, the advanced lines were evaluated using grain samples from western NE (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 mixtime, 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).

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Statistical Analyses

Data for NE01481 were derived from the elite and advanced breeding trials and analyzed using an incomplete block (incomplete block size = 5) design within blocks (block size = 60; using Agrobase GEN II; Agronomix Software, Inc. Winnipeg, Canada; Stroup et al., 1994). Occasionally, advanced and elite trials with three or more replications were analyzed using the nearest neighbor (NNA) procedure of Agrobase GEN II (Stroup et al., 1994). Because NE has three major wheat producing regions (Peterson, 1992), the data were analyzed within a location

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within region and rarely over 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 one or two years 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 one year. For the NESVT, the trials were analyzed using 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 using 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 to 2009) were analyzed using randomized complete block designs.

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CHARACTERISTICS

Agronomic and Botanical Description

NE01481 is an awned cultivar with tan glums that expresses a semi-dwarf (contains the *RhtB1b* allele [formerly *Rht1*]) stature. The coleoptile color 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

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

The coleoptile length of NE01481 (78 mm ± 1 mm) is similar to Husker Genetics Brand 'OverJand' (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 shorter than conventional height cultivars such as 'Goodstreak' (109 ± 1 mm; Baenziger et al., 2004) and 'Scout 66' (114 ± 1 mm; Schmidt et al., 1971).

While considerable data are 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) and the NESVT (Table 1; complete report available at http://varietytest.unl.edu/winterwheat.html). In the SRPN, NE01481 (3893 kg ha^{-1} in 2004; 3624 kg ha^{-1} in 2005) ranked 27 out of 50 in 2004 and 19 out of 48 in 2005 for grain yield. NE01481 compared favorably to 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 (74.5 kg hl^{-1}) had lower grain volume weight than Trego (77.0 kg hl^{-1}) and TAM 107 (75.0 kg hl^{-1}). Its maturity (132 d after Jan. 1) is later than Trego (131 d after Jan. 1) and TAM 107 (128 d after Jan. 1). NE01481 (81.5 cm) is a tall semi-dwarf wheat and is taller than Trego (74.0 cm) and TAM 107 (75.0 cm).

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

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Disease and Insect Resistance

Using data predominantly from the 2005 Southern Regional Performance Nursery, NE01481 is moderately resistant to moderately susceptible to stem rust (caused by *P. graminis Pers.: Pers. f. sp. tritici* Eriks & E. Henn.) in field nursery tests 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 wheat soilborne mosaic virus (data from 2004 and 2005 Southern Regional Performance Nursery). NE01481 was scored in Oklahoma in 2004 and 2005 (5 measurements) as 1.4 which was similar to the resistant cultivar Trego (2.0) and better than the susceptible cutlivars Kharkof (3.6), Scout 66 (3.8), and TAM107 (3.6; where a scale 1 = resistant to 4 = susceptible was used). In field trials in NE where cultivars were infected with wheat soilborne mosaic virus, Wesley and NE01481 were resistant (scored as 1). It is moderately resistant to moderately susceptible to leaf rust (caused by *P. triticina* Eriks), and moderately susceptible to susceptible to stripe rust

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(caused by *P. striiformis* Westendorp f. sp. t*ritici*). It is moderately resistant to moderately susceptible to Fusarium head blight (caused by *Fusarium graminearum* Schwabe, data from greenhouse and field observations in Nebraska). NE01481 is susceptible to Hessian fly (*Mayetiola destructor* Say). It is susceptible to wheat streak mosaic virus (field observations in NE).

End-Use Quality

The milling and baking properties of NE01481 were tested for seven years 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 at a 140 g H_2O 1000 g^{-1} flour basis. The average flour extraction on the Buhler Laboratory Mill for NE01481 (708 g kg^{-1}) was lower than Wesley (739 g kg^{-1}). The average wheat and flour protein concentration of NE01481 (142 and 125 g kg^{-1}) were slightly lower than 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 (Table 1). The flour ash content (4.59 g kg^{-1}) was higher than Wesley (4.43 g kg^{-1}). Dough mixing properties of NE01481 were acceptable (Mixograph mixtime peak was 3.4 min and mixtime tolerance was scored as 3.6) and were lower than Wesley (Mixograph mixtime peak of 4.7 minutes and mixtime tolerance scored as 4.5). Average baking absorption (602 H_2O g kg^{-1}) was lower than Wesley (611 H_2O g kg^{-1}) for the corresponding years. The average loaf volume of NE01481 (864 cm^3) was lower than 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 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)

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was lower than 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 using 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 2007-9. The rogued variant plants were taller in height (5 - 15 cm), awnless, or with 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 in 2010. The USDA will not have seed for distribution. The seed classes will be Breeder, Foundation, Registered, and Certified. Registered seed will be a nonsalable class. NE01481 will be 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.

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Table 1. Grain yield, test weight, grain protein content, lodging, and plant height by district (southeast, n=13; south central, n=5; west central, n=20; and west or panhandle, n=23) in Nebraska for rainfed environments grown from 2005 to 2009.

	Southeast					South Central				
Cultivar	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
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
L.S.D. 0.05 ‡	376	3.0	3	14	4	393	NS	4	17	4
Cultivar	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
L.S.D. 0.05	310	0.9	4	8	3	188	1.2	4		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 L.S.D. (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.

Table 2. Comparison of NE01481 to Wesley from 2002 to 2008 for flour yield, grain protein content, flour protein content, ash content, Mixograph mixing time, Mixograph tolerance, loaf volume, and external appearance, crumb grain and crumb texture (predictors of end-use quality) as determined by the Wheat Quality Laboratory at the University of Nebraska using composite samples from Clay Center, North Platte, Sidney, and Alliance, NE (Baenziger et al., 2001). All reported values were measured at a 140 g H_20 1000 g^{-1} flour basis.

Year	Flour Yield	Grain Protein	Flour Protein	Ash Content	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	External Appearance	Crumb Grain	Crumb Texture	Overall Bake
			(g kg^{-1})		(min)	(score†)	(cm^3)		(score‡)		
						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
L.S.D. 0.05§	15	10	7	.25	0.5	0.5	55	0.4	0.3	0.5	0.4

† Scores use a 0 to 7 scale with 7 being very tolerant (Baenziger et al., 2001).

‡ Scores use a 0 to 6 scale with 6 being excellent.

§ Least significant difference ($p < 0.05$) for the mean values of NE01481 and Wesley.

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