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Registration of 'NE05548' (Husker Genetics Brand Panhandle) Hard Red Winter Wheat

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CULTIVAR

Registration of 'NE05548' (Husker Genetics Brand Panhandle) Hard Red Winter Wheat

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Abstract

Western Nebraska wheat producers and those in adjacent areas want taller wheat (*Triticum aestivum* L.) cultivars that retain their height under drought for better harvestability. 'NE05548' (Reg. No. CV-1117, PI 670462) hard red winter wheat was developed cooperatively by the Nebraska Agricultural Experiment Station and the USDA-ARS and released in January 2014 by the developing institutions. NE05548 was released primarily for its superior performance under rainfed conditions in western Nebraska and adjacent areas of the Great Plains and its tall plant stature. NE05548 was selected from the cross NE97426/NE98574 made in 1999 where the pedigree of NE97426 is 'Brigantina'/2*'Arapahoe' and the pedigree of NE98574 is CO850267/'Rawhide'. The F_1 generation was grown in the greenhouse in 2000, and the F_2 to F_3 generations were advanced using the bulk breeding method in the field at Mead, NE, in 2001 to 2002. In 2003, single F_3–derived F_4 head rows were grown for selection. There was no further selection thereafter. The $F_{3:5}$ was evaluated as a single four-row plot at Lincoln, NE, and a single row at Mead, NE, in 2004. In 2005, it was assigned the experimental line number NE05548. NE05548 was evaluated in replicated trials thereafter. It has excellent winter survival, acceptable disease reactions to many of the common diseases in its target area, and acceptable end-use quality for bread making.

NEBRASKA is climatically and geographically diverse (Peterson, 1992). Due to temporal and spatial rainfall and temperature variations, wheat (*Triticum aestivum* L.) cultivars with taller plant stature are preferred by some western Nebraska dryland wheat producers as a way to provide a wheat crop that is easily harvested when the crop becomes shorter in height due to drought. Popular wheat cultivars in this area included 'Scout 66' (Schmidt et al., 1971), 'Centurk' (Schmidt et al., 1973), 'Buckskin' (Schmidt et al., 1976) 'Centura' (Schmidt et al., 1985), 'Pronghorn' (Baenziger et al., 1997), and 'Goodstreak' (Baenziger et al., 2004), all of which are conventional height lines with no major semidwarfing genes. Providing higher-yielding, taller wheat cultivars remains a goal of the Nebraska Agricultural Experiment Station and the USDA-ARS cooperative wheat improvement team. Other major goals of the Nebraska Wheat Improvement team include the ability to survive the Nebraska winter, resistance to stem rust (caused by *Puccinia graminis* Pers.:Pers. f. sp. *tritici* Eriks & E. Henn.), and the capability of producing an acceptable loaf of bread (Baenziger et al., 2001).

'NE05548' (Reg. No. CV-1117, PI 670462) hard red winter wheat was tested under experimental line designation NE05548 and was developed and released in January 2014 cooperatively by the Nebraska Agricultural Experiment Station and the USDA-ARS for its tall plant height and adaptation in western NE. NE05548 will be marketed and sold as Husker Genetics Brand 'Panhandle'. The name *Panhandle* was chosen for the

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Abbreviations: NESVT, Nebraska State Variety Trial; NRPN, Northern Regional Performance Nursery.

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Panhandle of Nebraska, the region of Nebraska where this line is adapted and where taller wheat cultivars are still popular.

Methods

NE05548 was selected from the cross NE97426/NE98574 (made in 1999), where the pedigree of NE97426 is 'Brigantina'/2*'Arapahoe' (Baenziger et al., 1989) and the pedigree of NE98574 is CO850267/'Rawhide' (Baenziger et al., 1992). The F_1 generation was grown in the greenhouse over the winter of 1999–2000, and the F_2 to F_3 generations were advanced using the bulk breeding method in the field at University of Nebraska Agricultural Research Center near Mead, NE (hereafter referred to as Mead), in 2001 to 2002. Each F_2 bulk was planted in a 2.4-m-long four-row plot with 30 cm between rows at a seeding rate of 66 kg ha^{-1}. After a mild among-cross selection of <15% to remove very poor bulks, based on poor winter survival, disease susceptibility, extreme lateness, or lodging, F_3 bulks were planted in September 2002, in an unreplicated F_3 bulk nursery, each as a 5-m-long four-row plot that was with 30 cm between rows. Approximately 50% of the F_3 populations were visually selected on an estimate of winter survival, disease resistance, and general agronomic appearance based mainly on plant height, flowering date, straw strength, and visually estimated yield potential. Each selected population was advanced by randomly sampling approximately 100 spikes (heads) in July 2003, although especially meritorious bulks had a sample of 200 to 300 spikes selected. The bulk from which NE05548 was selected was considered meritorious, and 200 spikes were selected. Selected spikes were threshed individually and planted in a head row nursery in September 2003. Each head row selection was planted as a single 0.9-m row in a four-row set (e.g., four different head rows were planted in the set) with 30 cm between rows using a four-row drill. A total of nine head rows were selected from the population from which NE05548 was derived. Head rows were selected visually on the basis of uniformity, agronomic appearance, disease resistance to those present in the field, and on visual selection for good seed quality after harvest. Seed from the selected head rows was harvested and planted in a rainfed nursery at Mead as a single row 3 m long to measure winter survival, and at Lincoln, NE, in a single 2.4-m-long four-row plot with 30 cm between rows. An unreplicated nursery with replicated check cultivars was used. Selection in 2004 was based on the line surviving the winter, being resistant to stem rust, having agronomic merit (standability, grain yield, grain volume weight), and having acceptable end-use quality (Baenziger et al., 2001).

In fall 2004, NE05548 was planted as entry 548 (where entries run from 401 to 700) of the Nebraska preliminary yield trial at six locations (Mead, Lincoln, Clay Center, North Platte, Sidney, and Alliance) in an unreplicated nursery with replicated check cultivars. The experimental name combined the last two digits of the year it was entered and the entry number of the preliminary yield trial. Based on its performance in the preliminary yield trial, it was entered in the advanced yield trial using an incomplete block design with incomplete blocks of 5 entries nested in three blocks of 60 entries grown at Mead, Lincoln, Clay Center, North Platte, Sidney, and Alliance in 2006. In 2007, it was advanced to the elite yield trial using an incomplete block design with incomplete blocks of 5 entries nested in blocks of 60 entries and grown at seven locations in Nebraska (Mead, Lincoln, Clay Center, North Platte, McCook, Sidney, and Alliance) where it continued to be tested until its release. The trials had four blocks at Lincoln, two blocks at McCook, and three blocks at the remaining locations. Once the line was identified in 2005, the only selection thereafter was roguing to remove obvious off-types (usually lines that were taller than the majority of plants, awnless, or bronze chaff).

NE05548 was entered into the USDA-ARS coordinated Northern Regional Performance Nursery (NRPN; 2008 and 2009) (data at USDA-ARS, 2016) and in the Nebraska State Variety Trial (NESVT) from 2009 to 2013 (data available at Cropwatch, 2016). The NESVT was planted at 13 to 15 rainfed and two to three irrigated locations with three to six replications in Nebraska or combined with nearby locations in Wyoming. Normally, one to three locations are lost each year due to hail, freezes, drought, or severe disease incidence.

Lines were advanced based on winter survival (determined at Mead), resistance to stem rust and other foliar 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 1 January to when 50% of the emerged spikes had extruded anthers; straw strength 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). As tall wheat genotypes are needed for western Nebraska, tall wheat types may be selected even though they may yield lower than the best semidwarf wheat lines and cultivars.

Over the winter, all of the lines were evaluated in the greenhouse in Lincoln for their resistance to stem rust using race TPMKC or QFCSC (using methods described in Sidiqi et al., 2009) and at the USDA-ARS Cereal Disease Laboratory using races QFCSC, QTHJC, MCCFC, RCRSC, RKQQC, TPMKC, and TTTTF, in the greenhouse and a composite of races QFCSC, QTHJC, RCRSC, RKQQC, and TPMKC in the field at St. Paul, MN, for the advanced nursery (using methods described in Rouse et al., 2011). In addition, the lines were evaluated in the greenhouse at Lincoln and at the Cereal Disease Laboratory for leaf rust (caused by *P. triticina* Eriks) using methods described in Watkins et al. (2001) and Kolmer (2003) 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 *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). NE05548 was screened for its reaction to *Wheat streak mosaic virus* (and possibly *Triticum mosaic virus* and *High Plains virus*) by using a field screen that involved exposure to virus through natural fall infestations of wheat curl mites during 2008–09 through 2011–2012.

The lines were evaluated 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 1×10^5 spores mL^{-1} 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 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 hand-held bottle sprayer, and the spike was then covered with a transparent plastic bag for 7 d following inoculation. Fusarium head blight severity (%) was visually estimated 14 d after inoculation. In the field, natural infection, inoculated without irrigation, and inoculated with mist 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; Great Plains biotype) by the USDA-ARS Hard Winter Wheat Genetics Research Unit (using methods described in Chen et al., 2009). For end-use quality, the preliminary lines were evaluated using a Mixograph (National Manufacturing, Lincoln) and for protein concentration (Baenziger et al., 2001). The advanced lines were evaluated using composited grain samples from western Nebraska (locations other than Lincoln or Mead that were harvested for seed). Bread baking properties were evaluated by approved methods (AACC, 2000). Bake mixing time, water absorption, and external and internal grain and texture were recorded (AACC, 2000; Baenziger et al., 2001, 2008). Mineral concentration of NE05548 was measured by the procedures of Guttieri et al. (2015a,b).

Statistical Analyses

The elite and advanced breeding trials were analyzed annually using an incomplete block design within blocks (using Agrobase GEN II [Agronomix Software, Inc.]; Stroup et al., 1994). Occasionally, advanced and elite trials with three or more blocks were analyzed using the nearest neighbor procedure (NNA) of Agrobase GEN II (Stroup et al., 1994). Because Nebraska has three major wheat-producing regions (Peterson, 1992) and its irrigated trials are considered environmentally different from the rainfed trials, data were analyzed within a location or an irrigation treatment (irrigated or rainfed). Location means and ranks were examined, and lines were selected by having excellent performance within a location or irrigation treatment, across locations within a region, and all locations or irrigation treatments within a year based on the arithmetic mean of the adjusted means, or across locations, irrigation treatments, and years based on the arithmetic mean of the adjusted means. A truncated selection procedure was used as a risk avoidance strategy. Essentially, if a line performed well in 1 or 2 yr and then poorly in the next year, the line was discontinued because it might perform poorly in a producer's field. For summary data, however, we use the head-to-head cultivar (syn. variety) comparison of Agrobase GEN II, which allowed us to compare lines from different sets of trials to each other. Analyses of the NRPN data used SAS (SAS Institute Inc.) for a randomized complete block design within locations and across locations within a year. Entries tested in the NRPN were statistically analyzed only within years because many entries were tested for only 1 yr. For the NESVT, the trials were analyzed using SAS Mixed Model for a randomized complete block design with a row and column repeated statement with SP[POWA] to account for possible spatial effects within the block randomization restrictions. For NE05548, only the western Nebraska data were considered as its height is not desirable in the other two regions or under irrigation. Only entries common to the trials across years within a region in the NESVT (2009–2013) were analyzed using randomized complete block designs.

Characteristics

Agronomic and Botanical Description

The coleoptile color of NE05548 is white, and the juvenile growth habit is prostrate. The foliage is green with a waxy bloom on the leaf sheath, with little waxy bloom on the spike at anthesis and on the leaves. The leaves are glabrous. The flag leaf is erect and twisted at the boot stage. After heading, the canopy is moderately closed and erect to inclined. The spike is tapering, narrow, midlong, and middense. The glume is medium long and medium wide, and the glume shoulder is square to elevated. The beak is very long with an acuminate tip. The spike is predominantly inclined at maturity with some erect spikes. Kernels are red colored, hard textured, and mainly ovate in shape. The kernel has no collar and has a medium brush of medium length, rounded cheeks, midsize germ, and a narrow and shallow crease.

While considerable data are available from the breeding nurseries during line development, the majority of data presented here is from the head-to-head cultivar comparison for grain yield from the Nebraska elite trial (Table 1), the NRPN, and NESVT (Table 2) as the latter two have their complete reports readily available (USDA-ARS, 2016, and partial data available at Cropwatch, 2016; full data summary for NESVT-can be purchased at https://marketplace.unl.edu/extension/

Table 1. Head-to-head comparisons of NE05548 to six cultivars from trials in Nebraska from 2007 until 2013. Data on grain yield were from trials at up to seven rainfed locations (Mead, Lincoln, Clay Center, North Platte, McCook, Sidney, and Hemingford) each year; not every cultivar was grown in each year that NE05548 was grown (hence the different number of trials for the comparisons).

Cultivar	Trials	Grain yield of cultivar	Grain yield of NE05548	% of NE05548	Significance
	no.	kg hL^{-1}		%	
Camelot	64	3775	3738	101	NS†
Goodstreak	62	3700	3768	98	NS
Freeman	57	4234	3844	110	**
Overland	72	4067	3897	104	**
Settler CL	55	3966	3798	104	**
Wesley	72	3763	3897	97	**

** Significantly different at the $\alpha = 0.01$ probability level.

† NS, not significant.

ec103.html). For grain yield in Nebraska (Table 1), NE05548 was significantly lower yielding than 'Freeman' (NE06545, Baenziger et al., 2014), 'Overland' (NE01643, Baenziger et al., 2008), 'Settler CL' (NH03614CL, Baenziger et al., 2011), and 'Wesley' (Peterson et al., 2001). It was not significantly different from 'Camelot' (Baenziger et al., 2009) and Goodstreak. Of the comparison lines, only Goodstreak was a taller wheat, and it is the line that is the key comparison for cultivars of similar plant height (Table 2). Being taller wheat lines, both Goodstreak and NE05548 tend to be at a disadvantage in Nebraska except in the drier western part of Nebraska known as the Panhandle, where both lines did well (data not shown). These data are supported by the 2008 and 2009 USDA-ARS NRPN, where NE05548 ranked second and sixth, respectively, of the 31 and 25 entries tested regionwide in those years (data available at USDA-ARS, 2016). In the last 5 yr, it has been tested in western Nebraska in the Nebraska State Variety Trials across 20 environments (Table 2; partial data available at Cropwatch, 2016; full data summary can be purchased at https://marketplace.unl.edu/extension/ec103.html). NE05548 (3527 kg ha^{-1}) was not significantly higher yielding than the tall wheat cultivar Goodstreak (3393 kg ha^{-1}) but was significantly higher yielding than tall winter wheat cultivars Pronghorn (3165 kg ha^{-1}) and Buckskin (3111 kg ha^{-1}). It was similar in grain yield to Overland (3480 kg ha^{-1}), 'Robidoux' (3709 kg ha^{-1}; Baenziger et al., 2012), and Settler CL (3595 kg ha^{-1}). Based on these data, NE05548 is adapted to rainfed wheat production in western Nebraska and is the highest-yielding taller wheat. Per data from the NESVT, NE05548 is significantly shorter than Buckskin, not significantly shorter than Goodstreak and Pronghorn, and significantly taller than Robidoux, Settler CL, Camelot, and Wesley. NE05548 has a grain volume weight and grain protein concentration comparable to most wheat cultivars grown in western Nebraska (Table 2).

Disease and Insect Resistance

Data predominantly from the 2008 Southern and 2009 NRPN indicate that NE00548 is resistant to *Wheat soilborne mosaic virus*. It is resistant to highly resistant to stem rust in field nursery tests inoculated with a composite of stem rust races (RCRSC, QFCSC, QTHJC, RKQQC, and TPMKC) at St. Paul, MN (Table 3). It was susceptible to stem rust in Njoro, Kenya (where race TTKST predominates). In greenhouse seedling tests, it was resistant to races QFCSC, QTHJC, MCCFC, RCRSC, RKQQC, and TMPKC but susceptible to race TTTTF (data provided by Y. Jin at the USDA Cereal Disease Laboratory). NE05548 was postulated to carry *Sr6* and one additional gene (Zhang et al., 2014). The additional gene is likely *SrTmp*, which may be heterogeneous in this line. It was moderately resistant at St. Paul (5RMR) and moderately susceptible (10–20 MS/S at Castroville, TX) to leaf rust races of the Great Plains in 2008 and 2009. However, in 2012 and 2013 at Castroville,

Table 2. Grain yield, grain volume weight, grain protein concentration, and plant height for western Nebraska from 2009 to 2013 representing 20 location-years of data from rainfed environments.

Brand	Cultivar	Grain yield	Grain volume weight	Grain protein concentration	Plant height
		kg ha^{-1}	kg hL^{-1}	g kg^{-1}	cm
Husker Genetics	Robidoux	3709	76.6	108	74.9
Husker Genetics	Settler CL	3595	76.3	113	73.9
WESTBRED	Winterhawk	3575	77.0	110	74.2
—	NE05548	3527	75.3	116	80.3
Husker Genetics	Overland	3480	76.2	111	76.2
Husker Genetics	McGill	3480	75.6	110	75.7
PlainsGold	Hatcher	3474	76.2	110	70.1
—	Alliance	3467	75.6	109	75.2
—	NW03666	3400	76.1	112	73.9
—	Goodstreak	3393	76.9	112	82.8
—	Infinity CL	3393	76.7	113	76.5
NuPride	Camelot	3386	76.1	114	75.7
—	NE05496	3386	76.0	111	72.9
—	Arrowsmith	3306	75.6	115	80.3
—	Wesley	3245	75.3	115	70.1
—	Pronghorn	3165	77.0	115	84.3
—	Buckskin	3111	76.6	113	85.3
—	Millennium	3104	73.9	114	77.0
—	Scout 66	2795	76.3	116	85.3
—	Mace	2721	72.5	115	67.8
—	Turkey	2674	75.7	118	84.6
Mean†		3304	75.9	113	77.0
LSD‡ ($\alpha < 0.05$)		269	2.0	5	4.3

† 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.

‡ Least significant difference ($\alpha < 0.05$) was calculated from the analysis of variance using all of the values of the entries in the trial, including many experimental lines not shown in the table.

the line was rated fully susceptible. The line was postulated to carry *Lr14a* based on race specificity in the 2009 NRPN. However, it must have at least one additional undetermined seedling race-specific resistance gene for leaf rust. The field reaction to stripe rust ranged from resistant to susceptible in 2008 and 2009 NRPN data. Data from the Great Plains in 2011 and 2013 showed it to be moderately resistant. Based on greenhouse seedling and adult tests, NE05548 has at least one undetermined gene conferring seedling race-specific seedling resistance and at least one gene conferring race-specific adult plant resistance. It is moderately susceptible to Fusarium head blight (data from greenhouse and field observations in Nebraska) and moderately resistant for deoxynivalenol accumulation. NE05548 is moderately resistant to moderately susceptible to Hessian fly (Great Plains biotype; data provided by M.-S. Chen, USDA and Kansas State University). In different tests, it was classified as a resistant line to being a line in which 21% of the plants were resistant to the Hessian fly. It is susceptible to *Wheat streak mosaic virus* (data obtained from field screens in Nebraska) and the wheat stem sawfly (*Cephus cinctus* Norton; data from western Nebraska).

End-Use Quality

The milling and baking properties of NE05548 were determined for 6 yr by the Nebraska Wheat Quality Laboratory (Table 4). In these tests, Wesley, an excellent milling and baking wheat, was used for comparison. The average flour protein concentration of NE05548 (125 g protein kg flour^{-1}) was similar to Wesley (124 g protein kg flour^{-1}) for the corresponding years (also found in the NESVT; Table 2). The average flour extraction on the Buhler Laboratory Mill for NE05548 (747 g flour kg grain^{-1} was similar to Wesley (740 g flour kg grain^{-1}). The flour ash content (4.3 g kg flour^{-1}) was similar to Wesley (4.2 g kg flour^{-1}). Dough mixing properties of NE05548 were acceptable (mix time peak was 3.72 min and mix time tolerance was scored as 4.1 on a 1-to-7 scale where 7 is very tolerant) and similar to Wesley (mix time peak of 4.39 min and mix time tolerance scored as 4.6). Average Mixograph absorption (618 g H_2O kg flour^{-1}) was similar to Wesley (616 g H_2O kg flour^{-1}) for the corresponding years. The average loaf volume of NE05548 (0.822 L) was similar to Wesley (0.841 L). The scores for internal crumb grain and texture were both 3.7, not significantly different than Wesley (4.3 and 4.4, respectively). The overall end-use quality characteristic for NE05548 (scored as 3.8, where 3 is fair, 4, is good and 6 is excellent) was not significantly different than Wesley (4.4) and was similar to many commonly grown wheat cultivars. NE05548 should be acceptable to the milling and baking industries. After NE05548 was released, we discovered that it was a low Cd accumulating line when grown on high Cd soils (Guttieri et al., 2015a,b). Cadmium is a toxic heavy metal, and this line should be preferred in regions where soils high in Cd availability are found.

Seed Purification and Increase

Seed purification of NE05548 began in 2010 and continued through 2013 using visual identification and manual removal of variants (plants taller in height [5- 15 cm], awnless, or with bronze chaff) in bulk seed increases grown under rainfed conditions at Lincoln and Mead. NE05548 has been uniform and stable since 2010. Less than 0.5% of the plants were rogued from the breeder seed increase in 2010 to 2013. Up to 2% (20:1000) variant plants may be encountered in subsequent generations.

Availability

The Nebraska Foundation Seed Division, University of Nebraska-Lincoln, Lincoln, NE, has had foundation seed available under the marketing name Husker Genetics brand Panhandle to qualified certified seed enterprises since 2013. The seed classes are breeder, foundation, registered, and certified. Registered seed will be a nonsalable class. NE05548

Table 3. Seedling stem rust reaction scores of NE05548 hard red winter wheat and other check cultivars evaluated in the 2008 and 2009 Northern Regional Performance Nursery (NRPN)† at the USDA-ARS Cereal Disease Laboratory, St. Paul, MN, or in Kenya.‡

Nursery	Line/ selection	QFCS	QTHJ	MCCF	RCRS	RKQQ	TPMK	TTTT	Adult plant field response	
		06ND76C	75ND717C	59KS19	77ND82A	99KS76A-1	74MN1407	01MN89A-1–2	St. Paul	Kenya
2008 NRPN	Kharkof	S	–		S	S	S	S	20MS	1S
2008 NRPN	Antelope	0;/2	S		0/S	S	;3-	S	40S	40S
2008 NRPN	Wesley	;1	2		;1-	2/S	;1+	S/2	10S	70S
2008 NRPN	Jerry	;/S	S/0		S/2	S	;1	S/2	20 MS-S	50SMS
2008 NRPN	NE05548	0	2		;2	2	;1-	S	TR	80S
2009 NRPN	Kharkof	S/2	S	S	S	S	S	S		
2009 NRPN	Antelope	0	S	0;	0/;3	S	0;	S/;2		
2009 NRPN	Wesley	0;	S/2-	0;	;	S/;1	0;	1+3/2/S		
2009 NRPN	Jerry	;	2-/S	esc.§	;/2-	S/2	;	S/2-		
2009 NRPN	NE05548	0;	2	0;	;1-	2-	0;	S		

† Complete data set can be found at USDA-ARS (2016). Seedling infection type: 0 = immune response, no sign of infection, 1 = small uredinia surrounded by necrosis; 2 = small uredinia surrounded by chlorosis; 3 = moderate size uredinia without necrosis or chlorosis; 4 = large uredinia without necrosis or chlorosis; + = uredinia larger than normal;- = uredinia smaller than normal; semicolon (;) = hypersensitive chlorotic or necrotic flecks; S = seedlings with scores of 3 or higher.

‡ Adult plant infection response evaluation from a field stem rust nursery at St. Paul., MN, inoculated with a composite of races QFCSC, QTHJC, RCRSC, RKQQC, and TPMKC, and from Njoro, Kenya, with race TTKST being predominant, where TR = trace infection, MS = moderately susceptible, and S = susceptible.

§ esc. = escape (unscorable) due to plant growth and development.

Table 4. Comparison of NE05548 to Wesley from 2006 to 2013 for flour yield, bran score, mill score, flour protein content, flour protein content, flour ash content, Mixograph water absorption (water abs.), Mixograph mixing time (Mtime), Mixograph tolerance (Mtol), loaf volume (loaf vol.), and external appearance score (ext. score), crumb grain score, crumb texture score, and overall bake score 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 H_2O kg^{-1} flour basis.

Year	Milling			Protein in flour	Flour ash	Mixograph			Baking				
	Flour yield	Bran score†	Mill type score†			Water abs.	Mtime	MTol‡	Loaf vol.	Ext. score§	Crumb grain score§	Crumb texture score§	Overall§
	g kg^{-1}	1–5	1–5	g kg^{-1}			min	0–7	L	0–6			
						NE05548							
2006	732	3.5	3.5	136	4.30	600	3.55	5.0	0.800	4.0	4.0	4.0	4.0
2007	748	3.5	4.0	135	4.50	600	2.80	4.0	0.765	3.0	3.3	3.0	3.1
2009	756	3.5	3.5	137	4.20	600	2.43	2.5	0.773	3.5	3.3	3.3	3.3
2010	747	3.0	3.0	98	4.10	615	4.38	4.4	0.870	4.0	3.5	3.3	3.6
2011	769	3.5	4.5	112	4.50	635	3.88	3.8	0.828	4.3	4.0	4.0	4.1
2012	731	3.5	4.5	133	4.10	660	5.26	4.8	0.893	5.0	4.0	4.3	4.4
Mean	747.2	3.4	3.8	125.2	4.28	618.3	3.7	4.1	0.822	4.0	3.7	3.7	3.8
						Wesley							
2006	729	3.5	4.0	127	4.30	600	4.95	5.0	0.903	4.5	5.0	5.0	5.0
2007	733	3.5	2.5	139	4.30	600	3.55	4.3	0.800	4.0	4.8	5.0	4.8
2009	751	3.5	3.5	133	4.10	600	3.02	3.5	0.860	4.8	4.5	4.5	4.6
2010	741	3.5	4.5	107	4.00	623	4.93	4.9	0.870	4.3	4.3	4.5	4.3
2011	751	3.5	4.5	115	4.60	635	4.01	4.6	0.835	4.3	3.4	3.6	3.8
2012	734	4.0	4.5	123	3.90	640	5.85	5.4	0.775	3.8	3.8	3.8	3.8
Mean	739.8	3.6	3.9	124.0	4.20	616.3	4.4	4.6	0.841	4.3	4.3	4.4	4.4
LSD¶	17	0.3	1.0	19.0	0.30	30.0	1.4	1.1	0.067	0.7	0.7	0.8	0.7

† Scores on a 1-to-5 scale, with 5 = very good and 1 = very poor.

‡ Scores on a 0-to-7 scale, with 7 = very tolerant.

§ Scores on a 0-to-6 scale, with 6 = excellent.

¶ Least significant difference ($\alpha = 0.05$) for the mean values of NE05548 and Wesley.

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 Laboratory 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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