NEBRASKA AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF NEBRASKA-LINCOLN
DEPARTMENT OF AGRONOMY AND HORTICULTURE

and

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
WASHINGTON, D. C.

RELEASE OF NE10589 HARD RED WINTER WHEAT

NE10589 is a hard red winter wheat (*Triticum aestivum* L.) cultivar developed cooperatively by the Nebraska Agricultural Experiment Station and the USDA-ARS and released in 2015 by the developing institutions. It was released primarily for its superior adaptation to rainfed wheat production systems throughout Nebraska and in adjacent wheat producing states. NE10589 will be marketed as Husker Genetics Brand 'Ruth' Hard Red Winter Wheat. It was named in honor of our greenhouse manager who was a huge aid to the breeding program and who died far too young. NE10589 genetically is a semi-dwarf wheat, containing the RhtB1b allele (formerly known as Rht1).

NE10589 was selected from the cross 'OK98697'/'Jagalene'//'Camelot' where the pedigree of OK98697 is 'TAM 200'/'HBB313E'//'2158'. The final cross was made in 2004. The F_1 generation was grown in the Yuma, AZ in 2005 and the F_2 to F_3 generations were advanced using the bulk breeding method in the field at Mead, NE in 2006 to 2007. In 2008, single F_3-derived F_4 rows were planted for selection at Lincoln, NE. There was no further selection other than to remove off-types thereafter. The $F_{3:5}$ was evaluated as a single four row plot at Lincoln, NE and a single row at Mead, NE in 2009. NE10589 was identified in 2010 as the experimental line, NE10589, and selected for further testing. This line seems to be very broadly adapted and was selected using both phenotypic and genomic selection.

NE10589 was evaluated in Nebraska replicated yield nurseries starting in 2010, in the USDA-ARS coordinated Northern Regional Performance Nursery in 2013 and 2014, in the Southern Regional Performance Nursery in 2014, and in the University of Nebraska Fall Sown Wheat Performance Trials in 2014 to 2015. In the Nebraska Intrastate Nursery (2012 to 2015, Table 1), NE10589 performed extremely well across Nebraska in head-to-head comparisons for grain yield with the currently popularly available wheat cultivars. These data are supported by the 2013 and 2014 USDA-ARS Northern Regional Performance Nursery where NE10589 ranked 9th and 2nd region-wide of the 37 and 40 entries tested in those years (data available at http://www.ars.usda.gov/Research/docs.htm?docid=11932). For a more northern adapted wheat cultivar, it also performed well in the 2014 Southern Regional Performance Nursery where it ranked 19th of the 40 lines tested in that year. In the last two years it has been tested in the Nebraska State Variety Trials across 25 environments (Table 2, full data available at http://cropwatch.unl.edu/web/varietytest/wheat). NE10589 (3436 kg/ha) had higher grain yield than all currently popular winter wheat cultivars that were tested state-wide (e.g. Overland,3275

kg/ha; Freeman,3214 kg/ha; and Wesley, 2947 kg/ha). Based upon these data, NE10589 is adapted to all rainfed wheat production in NE.

Other measurements of performance from comparison trials indicate that NE10589 is moderately late in maturity (147.2 d after Jan.1, data from 7 observations in eastern NE) which is very similar to Overland (147.9 d after Jan.1) and two days later than Freeman (145.4 d after Jan.1) and one day later than Settler CL (146.1 d after Jan.1). NE10589 is a semi-dwarf wheat cultivar and contains the *RhtB1b* (formerly *Rht1*,). The mature plant height of NE10589 is similar to Robidoux, but shorter than Camelot, Goodstreak, Panhandle, and Overland. NE10589 is taller than Wesley, Settler CL, and Freeman (Table 1). NE10589 has moderate straw strength for a semi-dwarf wheat with little lodging reported in the years it has been tested. The winter hardiness of NE10589 is good and comparable to other winter wheat cultivars grown in Nebraska.

NE10589 is resistant to *Soilborne wheat mosaic virus* in field nurseries in Nebraska It is moderately resistant to stem rust (caused by *Puccinia graminis Pers.: Pers. f. sp. tritici* Eriks & E. Henn.) in field nursery tests at St. Paul, MN and to stripe rust (caused by *P. striiformis* Westendorp f. sp. *tritici*) ,in field nurseries in Nebraska. In greenhouse seedling tests, it is resistant or segregating for resistance to stem rust races QFCSC, QTHJC, MCCFC, RCRSC, RKQQC, and TMPKC, but susceptible to race TTTTF. It is moderately susceptible to susceptible for leaf rust (caused by *P. triticina* Eriks,) data obtained from field observations in the Great Plains). By molecular markers, it is believed to carry the Lr37/Sr38/Yr17 translocation. NE10589 is moderately susceptible to Fusarium head blight (caused by *Fusarium graminearum*, data from greenhouse and field observations in Nebraska and Kansas) and moderately susceptible to DON accumulation. NE10589 is moderately resistant to moderately susceptible to Hessian fly (*Mayetiola destructor* Say,), but its reaction can be quite variable among greenhouse seedling tests. It is susceptible to *Barley yellow dwarf virus*, and *Wheat streak mosaic virus* (data obtained from the USDA-ARS Noirthern Regional Performance Nursery and field observations in NE).

NE10589 has high grain volume weight (Tables 1 and 2), which is similar to most high grain volume weight wheats and higher than Panhandle and Wesley winter wheat, both of which are considered to be lower grain volume weight cultivars. The milling and baking properties of NE10589 were determined for four years by the Nebraska Wheat Quality Laboratory (Table 3). In these tests, Wesley, an excellent milling and baking wheat and Overland, a poorer baking wheat, were used for comparison. The average flour protein content of NE10589 (11.6%) was lower than Wesley (113.1%) and similar to Overland for the corresponding years. The result was confirmed with data from the Nebraska State Variety Trial (Table 2). The average flour extraction on the Buhler Laboratory Mill for NE10589 (72.3%) was lower than Wesley, but higher than Overland (Table3). The flour ash content (0.43%) was higher than Wesley and similar to Overland. Dough mixing properties of NE10589 were acceptable (mixtime peak was 4.72 minutes and mixtime tolerance was scored as 4.3 on a one to 7 scale where 7 is very tolerant) and weaker than Wesley, but stronger than Overland. Average baking absorption (63.5%) was lower than Wesley and similar to Overland for the corresponding years. The average loaf volume of NE10589 (865 cm^3) was lower than Wesley and higher than Overland. The scores for the external appearance, internal crumb grain and texture were 4.3, 3.8 and 3.8, respectively, which were lower than Wesley, but higher than Overland. The overall end-use quality characteristics for NE10589 (scored as 4.0, where 3 is fair, 4 is good and 7 is excellent)

was lower than Wesley, but higher than Overland and similar to many commonly grown wheat cultivars. NE10589 should be acceptable to the milling and baking industries.

In positioning NE10589, based on performance data to date, it should be well adapted to most rainfed wheat production systems throughout Nebraska and in adjacent areas of the Great Plains. NE10589 is not recommended for irrigated wheat production due to its not having similar straw strength and comparable yield potential to the best available irrigated wheat cultivars (data not shown). Where adapted, NE10589 should be a replacement for Overland (under rainfed production). NE10589 is genetically complementary to virtually all wheat cultivars grown in Nebraska with the exception of Camelot and Jagalene.

NE10589 is an awned, tan-glumed cultivar. Its field appearance is most similar to Wesley, but can be easily separated from Wesley because Wesley has bronze chaff. After heading, the canopy is moderately closed and erect to inclined. The flag leaf is recurved and twisted at the boot stage. 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 glaborous. The spike is tapering, narrow, and lax. The glume is short and wide, and the glume shoulder is square to elevated. The beak has an acuminate tip. The spike is predominantly inclined at maturity with some recurved spikes. Kernels are red colored, hard textured, and mainly ovate in shape. The kernel has no collar, a medium brush of short length, rounded cheeks, midsize germ, and a narrow and shallow crease.

NE10589 has been uniform and stable since 2013. Less than 0.5 % of the plants were rogued from the Breeder's seed increase in 2013-15. The rogued variant plants were taller in height (5 - 15 cm) or were awnless and/or had red chaff. Up to 1% (10:1000) variant plants may be encountered in subsequent generations. The Nebraska Foundation Seed Division, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE 68583 will have foundation seed available to qualified certified seed enterprises in 2016 with the first sale of certified seed in 2016. The U.S. Department of Agriculture will not have commercial seed for distribution. The seed classes will be Breeder, Foundation, Registered, and Certified. NE10589 will be submitted for plant variety protection under P.L. 10577 with the certification option. A 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 years from the date of this release. In addition, a seed sample has been deposited in the USDA-ARS National Small Grains Collection, Aberdeen, ID, and this seed is freely available to interested researchers.

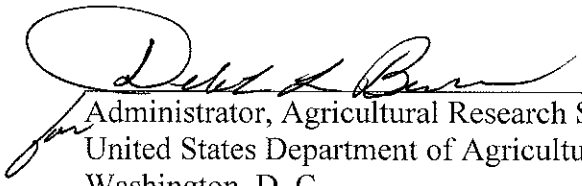
NE10589 was developed with partial financial support from the Nebraska Agricultural Experiment Station and the Nebraska Wheat Development, Utilization, and Marketing Board. Partial funding for P.S. Baenziger is from Hatch project NEB-22-328, USDA- IFAFS competitive grant 2001-04462, USDA, NRICGP 00-353000-9266, 2004-35300-1470, and 2007-51300-0375, USDA, CSREES NRICAP grant number 2006-55606-16629, USDA OREI 2007-51300-03785, AFRI/2011-68002-30029, the CERES Trust Organic Research Initiative, and USDA under Agreement No. 59-0790-4-092 which is a cooperative project with the U.S. Wheat & Barley Scab Initiative. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the USDA. Cooperative investigations of the Nebraska Agric. Res. Div., Univ. of Nebraska, and USDA-ARS.

Development team: P. S. Baenziger (breeder-inventor), R. A. Graybosch, D. Rose, M. Guttieri, Lan Xu, S. Wegulo, T. Regassa, D. Santra, G Kruger, G. Hergert, R. Klein, Y. Jin, J. Kolmer, Ming-Shun Chen, Guihua Bai, J. Poland, A. Lorenz, I. Salah, G. Hein, and J. Bradshaw.

Approval

Director, Nebraska Agricultural Experiment Station

12/1/15
date



Administrator, Agricultural Research Service
United States Department of Agriculture
Washington, D. C.

12/21/15
date

Table 1. Head to head comparisons of NE10589 to popularly grown or new cultivars from trials in Nebraska beginning in 2012 until 2015. Data on grain yield, grain volume weight, and plant height were from trials at up to eight rainfed locations (Mead, Lincoln, Clay Center, North Platte, McCook, Grant, Sidney, and Alliance) in Nebraska in each year (total environments in the comparison is N) and not every cultivar was grown in the same trial across the state.

Line	Grain Yield (kg/ha)				Grain Volume Weight (kg/hl)				Height (cm)			
	N	Line	NE10589		N	Line	NE10589		N	Line	NE10589	
Camelot	22	3951	4399	**	12	72.9	73.6	ns	17	94.1	88.9	**
Goodstreak	31	3374	3950	**	14	73.0	73.2	ns	24	104.0	90.7	**
McGill	17	4074	4431	**	8	76.0	77.4	ns	13	92.8	88.7	**
Panhandle	26	3263	3885	**	10	74.2	76.1	**	20	101.4	90.9	**
Freeman	26	3674	3885	**	10	74.1	76.1	ns	20	87.5	90.9	**
Robidoux	26	3639	3885	**	10	76.6	76.1	ns	20	90.9	90.9	**
Overland	31	3706	3950	**	14	73.8	73.2	ns	24	93.0	90.7	**
Settler CL	26	3339	3885	**	10	76.9	76.1	ns	20	85.7	90.9	**
Wesley	31	3325	3950	**	14	71.6	73.2	**	24	85.2	90.7	**

** Significantly different at the P=0.01 probability level.

Table 2. Grain yield by region and averaged across the state, and state average for grain volume weight, grain protein content, and plant height for Nebraska from 2014 to 2015 representing 25 location-years of data from rainfed environments.

		South-east	South Central	West Central	West	State Avg.	State Avg.	State Avg.	State Avg.
Brand	**Variety**	**Grain Yield (kg/ha)**	**Grain Yield (kg/ha)**	**Grain Yield (kg/ha)**	**Grain Yield (kg/ha)**	**Grain Yield (kg/ha)**	**Bushel Weight (kg/hl**	**Grain Protein (%)**	**Plant Height (cm)**
		Two year averages							
Husker Genetics	Freeman	3709	2721	3695	2567	3214	72.4	13.5	78.5
-----	Mattern	3104	3024	3480	2466	2988	71.0	14.9	84.2
-----	NE10589	3816	3494	3924	2735	3436	74.0	13.6	82.6
Husker Genetics	Overland	3648	3292	3635	2701	3275	74.5	13.8	84.0
----	Scout 66	3104	1982	2876	1935	2520	72.8	14.5	97.5
----	Turkey	3071	1982	2829	1975	2512	72.6	15.1	96.1
----	Wesley	3192	2553	3662	2237	2947	71.3	14.5	75.2
Average of all entries†		3410	2672	3568	2374	3028	72.2	14.2	82.3
L.S.D. at 5%‡		739	739	739	336				

† 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 3. Comparison of NE10589 to Wesley and Overland from 2011 to 2014 for flour yield, bran score, mill type scores, flour protein content, ash content, Mixograph water absorption (water abs.), Mixograph mixing time (MTime), Mixograph tolerance (MTol.), loaf volume, and external appearance (Ext. score), crumb grain score, crumb texture score, and overall baking score (Overall) 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_20 1000 g^{-1} flour basis.

Line	Year	Milling			Protein	Flour	Mixograph (14%mb)			Baking (14% mb)				
		Flour Yield, %	Bran Score†	Mill Type Score†	in Flour, %	Ash%	Water Abs, %	Mtime, min	MTol.‡	Loaf Vol. mL	Ext. Score§	Crumb Grain Score§	Crumb Texture Score§	Overall§
NE10589														
	2011	74.4	4.0	3.5	11.2	0.460	63.0	4.22	4.1	793	3.8	3.5	3.8	3.7
	2012	71.7	3.5	0.5	11.4	0.426	63.5	5.16	4.4	785	3.5	3.0	3.0	3.2
	2013	70.9	3.5	1.5	11.4	0.422	62.5	4.30	4.7	916	5.0	4.4	4.5	4.6
	2014	72.4	3.5	2.5	12.5	0.396	65.0	5.22	4.1	968	5.0	4.3	4.0	4.4
Mean		***72.3a****	***3.6a***	***2.0b***	***11.6b***	***0.426a***	***63.5a***	***4.72a***	***4.30a***	***865a***	***4.3a***	***3.8a***	***3.8b***	***4.0b***
WESLEY														
	2011	75.1	3.5	4.5	11.6	0.464	63.5	4.01	4.6	835	4.3	3.4	3.6	3.8
	2012	73.4	4.0	4.5	12.3	0.386	64.0	5.85	5.4	775	3.8	3.8	3.8	3.8
	2013	70.8	3.5	3.5	14.6	0.390	64.5	4.35	4.9	950	5.4	4.5	5.1	5.0
	2014	74.3	3.5	4.5	13.9	0.395	68.0	5.31	4.9	968	5.0	4.8	5.0	4.9
Mean		***73.4a***	***3.6a***	***4.3a***	***13.1a***	***0.409a***	***65.0a***	***4.88a***	***5.0a***	***882a***	***4.6a***	***4.1a***	***4.4a***	***4.4a***
Overland														
	2011	74.5	3.5	4.5	10.3	0.446	63.5	3.52	2.8	788	3.3	2.3	2.3	2.6
	2012	71.8	3.5	4.5	11.6	0.448	63.0	3.18	3.9	790	4.0	2.8	2.5	3.1
	2013	61.5			12.2	0.443	64.5	2.91	2.8	889	4.9	3.5	3.5	4.0
	2014	72.6	3.5	4.5	11.6	0.382	63.5	4.51	4.1	934	4.8	3.4	3.1	3.8
Mean		***70.1a***	***3.5a***	***4.5a***	***11.4b***	***0.430a***	***63.6a***	***3.53b***	***3.40b***	***850a***	***4.2a***	***3.0b***	***2.8c***	***3.3c***

† Scores use a 1 to 5 scale with 5 being very good and 1 being very poor

‡ Scores use a 0 to 7 scale with 7 being very tolerant.

§ Scores use a 0 to 6 scale with 6 being excellent

* Means followed by the same letter are not significantly different at the p=0.05 level.