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CULTIVAR

Registration of 'Norden' Hard Red Spring Wheat

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Abstract

Grain yield, protein content, and straw strength are the three primary traits that growers consider when selecting wheat (*Triticum aestivum* L.) cultivars in the Red River Valley region of Minnesota and North Dakota. 'Norden' (Reg. No. CV-1136, PI 667104) was released by the University of Minnesota Agricultural Experiment Station in 2012 because it represented a unique combination of these traits, in addition to good resistance to leaf rust (*Puccinia triticina* Eriks.) and Fusarium head blight (FHB, caused primarily by *Fusarium graminearum* Schwabe). Norden is a midmaturity, semidwarf cultivar that was selected in part because it contains the *Lr34* gene for adult plant leaf rust resistance and the *Fhb1* quantitative trait locus for FHB resistance.

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'Norden' (Reg. No. CV-1136, PI 667104) hard red spring wheat (*Triticum aestivum* L.) was developed by the University of Minnesota Agricultural Experiment Station and released in 2012. Norden was released due to its grain yield, resistance to lodging, and leaf rust (*Puccinia triticina* Eriks.) resistance.

Norden is an F_4–derived selection from the three-way cross of 'Alsen'//'Parshall'/MN97665. Alsen (Frohberg et al., 2006) and Parshall (PI 613587) are both released cultivars from North Dakota State University and were selected as parents because of their adaptation to the region and good Fusarium head blight (FHB, caused primarily by *Fusarium graminearum* Schwabe) resistance. MN97665 has the pedigree ND674/MN92045. The pedigree of ND674 is 'Grandin' (PI 531005)*2/'Glupro' (PI 592759). The pedigree of MN92045 is ND626/MN86165. ND626 is an unreleased experimental line from North Dakota State University with the pedigree 'Len'//'Butte'*2/ND507/3/ND 593. MN86165 has the pedigree MN81135 (MN73110/MN7439)/MN80030 (MN7142/'Era'). Norden is named after the township of Norden, near Thief River Falls, MN. The name is also meant to convey its adaptation to more northern regions of the Northern Great Plains.

Methods

Early Generation Development

Seed from crosses of Alsen with multiple F_1 plants from the Parshall/MN97665 cross were designated 00X230 and made in

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Abbreviations: APR, adult plant resistance; DON, deoxynivalenol; FHB, Fusarium head blight; PVP, Plant Variety Protection; URHRSWN, uniform regional hard red spring wheat nursery; VSK, visually scabby kernels.

2000. The TC_1F_1 generation (crossed seeds) was grown in University of Minnesota greenhouses in St. Paul, MN, in 2001. Approximately 700 F_2 seed were grown in a St. Paul field in 2002. This field included inoculated spreader rows of wheat lines highly susceptible to leaf rust and stem rust (*Puccinia graminis* Pers.: Pers. f. sp. *tritici* Eriks. & E. Henn.). A single spike from 46 plants with appropriate maturity, plant height, and leaf and stem rust resistance were harvested. One seed from each of the 46 selected plants were advanced by single-seed descent in a New Zealand winter nursery. No selection was applied in the New Zealand nursery, and a single spike was harvested from 39 plants. In 2002, seed from the 39 plants were sown as F_4 headrows in St. Paul. Two of the thirty-nine rows were selected on the basis of appropriate plant height, maturity, and leaf and stem rust resistance. Both F_5 selections (each from a single spike from an F_4 row) were planted in a New Zealand winter nursery. Both selections were harvested in New Zealand, and one was designated MN03196 and grown in unreplicated F_6 preliminary yield trials at Crookston, Morris, and St. Paul, MN. These, and all subsequent yield trials, were sown in plots with a size of 4.5 to 5.5 m^2 and row spacing of 0.15 to 0.20 m. In 2004 and 2005, three-replication advanced yield trials were grown at the same three Minnesota locations. MN03196 was evaluated in the Minnesota Statewide Variety Trial at six or seven locations per year from 2006 to 2011. MN03196 was entered in the Uniform Regional Performance Nursery (URHRSWN) in 2007 and 2008 with sites in Minnesota, Montana, North Dakota, South Dakota, Wyoming, and Manitoba, Canada.

A sample of the harvested grain from two to three locations each year beginning in 2003 was milled and the flour was analyzed for mixing and bread-making properties (AACCI, 2000) at the USDA-ARS Spring Wheat Quality Laboratory in Fargo, ND. Preharvest sprouting was evaluated by harvesting 10 intact spikes at physiological maturity from each of two replicates grown at Crookston and St. Paul. Spikes were air dried for 5 d and stored at −20°C for 4 to 16 wk. Spikes were placed in a dew chamber (>90% relative humidity) at 22°C for 7 d and rated for degree of sprouting on a scale of 0 (no visible sprouting) to 9 (extensive sprouting over entire spike).

MN03196 was grown in inoculated, mist-irrigated FHB nurseries at Crookston, St. Paul, and/or Morris each year starting in 2003. The Crookston and Morris FHB nurseries used *F. graminearum*-colonized corn (*Zea mays* L.) kernel inoculum, and the St. Paul nursery was inoculated with a macroconidial suspension of *F. graminearum* following the methods of Fuentes et al. (2005). The FHB data collected included heading date, disease incidence and severity recorded 18 to 21 d after anthesis, 30-spike seed weight, visually scabby kernels (VSK), grain volume weight of the VSK sample using a 15.7-mL cylinder measuring 20 mm in diameter and 50 mm in height, and the deoxynivalenol (DON) content of mature seed (Fuentes et al., 2005).

MN03196 along with all other experimental lines at the preliminary yield trial stage or later were grown as single 1-m-long

Table 1. Performance of Norden and other hard red spring wheat cultivars in Minnesota, 2009 to 2011. Cultivars are sorted according to grain yield.

Cultivar	Grain yield	Grain volume weight	Grain protein	Days to heading	Plant height	Straw strength	Preharvest sprouting
	kg ha^{-1}	kg hL^{-1}	g kg^{-1}	d from planting	cm	0–9†	0–9‡
LCS Albany	5467	77.1	138.2	61.6	78.7	2.1	1.93
Faller	5121	76.6	144.4	59.6	83.2	2.4	1.83
Samson	5003	75.8	142.4	58.4	75.4	1.2	3.70
Jenna	4858	76.3	147.8	61.1	78.6	2.4	4.62
Knudson§	4799	77.2	143.6	58.6	78.8	2.4	1.53
Norden	4684	78.6	145.8	58.9	80.6	1.0	0.92
Vantage	4657	78.8	156.3	62.6	79.5	0.5	1.75
Sabin	4629	76.2	148.4	59.3	78.3	2.6	3.75
Barlow	4601	78.1	153.1	57.1	84.3	3.0	2.15
Select	4567	78.4	147.7	54.6	84.8	2.7	2.43
RB07	4560	76.7	148.6	57.1	79.4	2.7	1.30
Oklee	4471	77.8	150.4	55.8	80.5	3.0	2.47
Ada	4459	78.2	145.8	59.2	80.0	2.1	1.75
Brennan	4442	76.3	149.4	58.2	75.2	2.0	2.40
Briggs	4410	77.8	149.7	55.5	84.4	3.7	1.77
Rollag	4401	78.0	151.4	57.5	77.1	1.1	2.05
Tom	4377	76.8	147.7	57.6	82.2	3.1	1.27
Brick	4315	78.5	148.0	53.8	85.6	2.9	2.40
Kelby	4248	76.4	151.8	56.1	73.6	2.0	1.07
Glenn§	4228	79.7	153.9	55.9	86.0	1.5	0.90
Marshall§	4078	74.5	141.2	61.6	79.3	1.7	1.70
Mean	4589	77.3	147.9	58.1	80.3	2.2	2.08
LSD (0.05)	215	0.73	3.02	0.82	2.19	0.76	1.26
No. of environments	27	23	20	15	16	16	6

† 0 = no lodging, 9 = flat.

‡ 0 = no visible sprouting, 9 = extensive sprouting over entire spike.

§ Long-term check.

rows, 0.3 m apart, in an inoculated rust nursery in St. Paul beginning in 2003. This nursery contained a mixture of leaf- and stem-rust-susceptible spreader rows sown perpendicular to the experimental lines in every other alley. The alternate alleys were sown with winter wheat. Spreader rows were inoculated with prevalent leaf rust and stem rust races following the methods of Roelfs et al. (1992). MN03196 was tested for seedling reaction to leaf rust races KFBJ, MBRJ, MCDS, MFPS, MHDS, MJBJ, TCTD, TDBG, TGBG, THBJ, and TLGF following the methods of Oelke and Kolmer (2004) and stem rust races QFCSC, QTHJC, RCRSC, RKQQC, TPMKC, and TTTTF following the methods of Jin and Singh (2006). MN03196 was evaluated for reaction to stem rust race TTKSK (syn. Ug99) in the Kenya stem rust nursery in 2009 and 2011, as described in Jin et al. (2007).

Table 2. Performance of Norden and other hard red spring cultivars in the Uniform Regional Hard Red Spring Wheat Nursery, 2007 to 2008. Cultivars are sorted according to grain yield.

Cultivar†	Grain yield	Test weight	Protein	Heading	Height	Lodging
	kg ha^{-1}	kg hL^{-1}	g kg^{-1}	d after 1 June	cm	0–9†
			2007			
Brennan	3849.9	78.4	150.8	20.3	73.0	0.3
Velva	3806.8	76.1	148.6	23.1	83.2	0.4
LCS Albany	3750.3	76.8	142.4	25.3	77.3	0.0
Barlow	3721.3	78.3	151.0	19.7	84.9	1.0
Sabin	3701.7	77.3	149.9	22.5	79.4	1.3
Norden	3591.0	78.6	150.1	22.4	78.1	0.3
Select	3513.2	79.1	143.7	18.5	83.6	0.6
Verde‡	3497.6	76.2	145.2	23.6	78.5	0.8
2375‡	3178.3	76.8	144.3	21.3	80.6	2.1
Keene‡	2767.3	76.8	144.2	22.8	94.0	0.6
Chris‡	2124.8	74.9	151.2	23.8	96.7	4.3
Marquis‡	1949.3	74.6	145.6	24.9	98.3	2.6
Mean	3287.6	77.0	147.3	22.4	84.0	1.2
LSD (0.05)	307	0.9	5.9	0.8	2.8	1.0
No. of locations	12	12	9	12	12	4
			2008			
LCS Albany	4761.9	73.0	144.0	31.0	79.5	1.7
SY Soren	4515.3	75.0	151.9	29.0	75.0	0.5
Verde‡	4473.9	73.4	145.3	30.7	81.3	0.3
Velva	4442.6	74.5	149.0	29.9	85.2	0.9
Select	4412.4	76.4	146.7	25.8	87.2	1.1
2375‡	4314.0	75.1	146.3	29.1	88.1	2.5
Barlow	4300.0	76.3	151.6	27.8	88.6	1.8
Norden	4279.9	77.1	148.9	30.4	79.4	0.4
Keene‡	3750.9	74.9	148.4	30.0	99.4	2.4
Chris‡	3122.4	73.5	158.9	32.0	103.1	4.5
Marquis‡	3011.7	73.5	150.0	32.6	106.1	3.4
Mean	4125.9	74.8	149.2	29.8	88.4	1.8
LSD (0.05)	324	0.1	5.9	1.2	3.6	1.8
No. of locations	12	12	7	11	12	5
			2007–2008			
LCS Albany	4256	74.9	143.1	28.0	78.4	0.9
Velva	4125	75.3	148.8	26.4	84.2	0.7
Barlow	4011	77.3	151.3	23.6	86.7	1.5
Verde‡	3986	74.8	145.3	27.0	79.9	0.5
Select	3963	77.7	145.0	22.0	85.4	0.9
Norden	3935	77.8	149.6	26.2	78.8	0.4
2375‡	3746	75.9	145.2	25.0	84.4	2.3
Keene‡	3259	75.8	146.1	26.2	96.7	1.6
Chris‡	2624	74.2	154.6	27.8	99.9	4.4
Marquis‡	2480	74.1	147.5	28.6	102.2	3.0
Mean	3638.5	75.8	147.6	26.1	87.6	1.6
LSD (0.05)	211	0.8	4.2	0.7	2.3	1.1
No. of environments	24	24	16	23	24	9

† 0 = no lodging, 9 = flat.

‡ Long-term check.

Seed Purification and Increase

In 2005, 200 random heads were selected from a seed increase of MN03196 grown in St. Paul. A total of 140 headrows were grown at St. Paul from the 200 selected heads, and 14 rows were discarded because they had one or more taller spikes or were earlier heading. The remaining 126 selections were combine harvested in bulk and used to sow a seed increase in St. Paul in 2007. A total of 160 randomly selected heads, harvested from the 2007 St. Paul seed increase, were grown in St. Paul in 2008, and of these, two were discarded because they were different phenotypes. One or two heads from each of the remaining 158 rows were harvested. A sample of 160 headrows were grown at St. Paul in 2009, and 21 were discarded because either they were 1 d earlier or later heading than the majority of rows, or they contained plants that were >10 cm taller. The remaining 139 selections were combine harvested in bulk. A seed increase, using the bulk-harvested 2009 headrows, was grown in St. Paul in 2010. A total of 23 out of the ~10,000 plants grown were removed because they had one tiller 10 cm or more taller than other plants. A total of 47 kg of the resulting seed was sown near Brawley, CA, during the winter of 2010–2011 for further seed increase. A total of 2500 kg cleaned seed was produced from the California increase and further seed increase was arranged by the Minnesota Crop Improvement Association.

Statistical Analyses

All statistical analyses were done using JMP Pro 13.0.0 (SAS Institute, 2016). Data were subjected to ANOVA across environments with each location-year combination as a separate environment. A mixed model was used with genotypes as fixed factors and environments and replications within environments as random factors. The LSD test ($P = 0.05$) was used to compare means for the genotype effects.

Table 3. Performance of Norden and other hard red spring cultivars and checks in inoculated Fusarium head blight (FHB) nurseries, 2009 to 2011. Cultivars are sorted by the deoxynivalenol (DON) content of harvested grain.

Line†	Heading	FHB severity	30-spike seed weight	Grain volume weight	Visually scabby kernels	Deoxynivalenol
	d after 1 June	%	g		%	μg g^{-1}
Select	28.3	19.6	20.6	10.6	12.0	6.2
Alsen†	31.7	19.5	12.5	10.9	8.6	6.6
Rollag	31.8	20.8	18.7	11.0	8.3	6.7
Brick	27.4	18.3	19.6	10.8	8.9	6.7
Briggs	28.9	34.9	18.0	10.4	15.7	6.8
BacUp†	27.9	15.1	17.9	10.8	10.2	7.0
RB07	30.7	22.5	17.7	10.6	12.2	7.1
Blade	32.4	22.7	15.6	10.7	9.9	7.4
Albany	34.2	32.8	15.9	10.9	10.0	7.4
Sabin	32.5	24.7	18.2	10.6	9.3	7.7
Barlow	29.2	29.2	17.2	10.7	9.6	7.8
Glenn	29.2	14.8	17.3	11.3	9.3	7.9
Cromwell	32.7	37.7	15.6	10.5	11.1	7.9
Kelby	29.6	36.4	16.4	10.2	18.7	8.1
Breaker	31.9	20.7	15.7	11.1	12.3	8.3
Tom	31.9	24.2	19.2	10.5	12.3	8.6
Faller	32.7	21.4	21.0	10.8	10.0	9.3
Norden	31.4	39.8	16.5	10.8	10.5	9.7
Oklee	29.0	39.1	20.4	10.4	18.5	9.7
Vantage	35.3	31.8	17.4	11.1	11.0	10.0
Prosper	32.4	28.5	18.7	10.6	11.4	11.3
Knudson‡	31.7	28.7	17.8	10.4	22.1	11.3
Ada	32.2	36.5	15.4	10.4	18.5	12.1
Roblin§	28.1	79.4	10.1	9.5	56.3	12.6
Jenna	33.8	58.3	14.0	10.0	30.3	13.7
Brennan	31.8	55.7	14.4	9.9	25.9	13.8
MN00269§	35.9	80.2	5.9	8.3	35.6	14.9
Marshall‡	34.5	48.7	10.7	10.1	18.3	15.2
Samson	31.3	57.2	14.7	9.9	39.6	17.8
Wheaton§	33.1	84.0	6.5	8.6	62.5	18.3
Mean	31.5	36.1	16.0	10.4	18.3	9.9
LSD (0.05)	1.2	18.2	3.8	0.5	10.3	3.9
No. of environments	6	5	6	7	7	7

† Moderately resistant check.

‡ Long-term check.

§ Susceptible check.

Characteristics

Agronomic and Botanical Description

Norden has erect juvenile plant growth, a recurved flag leaf, white glumes with a rounded shoulder, and an acuminate beak. The spike is awned, middense, and tapering. The kernel is red and ovate in shape with rounded cheeks and a midnarrow, mid-deep crease. The brush on the kernel is not collared and is short in length. Norden is a midmaturity cultivar, averaging 58.9 d from planting to heading in Minnesota locations from 2009 to 2011 (Table 1). This is similar to 'Sabin' (Anderson et al., 2012). Norden has average plant height at 80.6 cm, measured from soil level to the tip of the spike, excluding awns (Table 1). This height is not significantly different than 'Oklee' (80.5 cm) (Anderson et al., 2005) or 'RB07' (79.4 cm) (Anderson et al., 2009). Norden has very good straw strength, with an average score of 1.0 on a 0-to-9 scale measured across 16 locations where differential lodging occurred from 2009 to 2011 (Table 1). This level of straw strength is significantly better than 15 of the 20 cultivars compared with Norden. In the 2007 and 2008 URHRSWN, the average lodging score of Norden over the nine locations in which lodging occurred was 0.4 (Table 2). This score was similar to the check 'Verde' (0.5) (Busch et al., 1996) and significantly ($P < 0.05$) lower than the checks '2375' (2.3, PI 601477), 'Marquis' (3.0, PI 90834), and 'Chris' (4.4; Heiner and Johnston, 1967).

Field Performance

In 27 Minnesota yield trials from 2009 to 2011, Norden's average grain yield was 4684 kg ha^{-1}, significantly higher than 9 of the 21 comparison cultivars, but significantly lower than three of them, namely 'LCS Albany' (5467 kg ha^{-1}, PI 658002), 'Faller' (5121 kg ha^{-1}; Mergoum et al., 2008), and 'Samson' (5003 kg ha^{-1}, PI 652923). Norden has significantly higher grain volume weight and straw strength than those three higher-yielding cultivars, in addition to significantly higher grain protein content (145.8 g kg^{-1}) than LCS Albany (138.2) and Samson (142.4). When evaluated in 24 environments in Minnesota, North Dakota, South Dakota, and Manitoba in the 2007 and 2008 URHRSWN, Norden had grain yield (3935 kg ha^{-1}) significantly higher than the checks 'Keene' (3259 kg ha^{-1}, PI 598224), Chris (2624 kg ha^{-1}) and Marquis (2480 kg ha^{-1}), but significantly lower than LCS Albany (4256 kg ha^{-1}) (Table 2).

Norden is rated as resistant to preharvest sprouting. In six tests conducted from 2009 to 2011, Norden had a preharvest sprouting rating of 0.92 compared with a mean of 2.08 for the 21 comparison cultivars. (Table 1).

Disease Resistance

Norden has been evaluated in FHB nurseries since 2003. It has moderate resistance to this disease and has been assigned a rating of 4 on a 1-to-9 scale in which 1 is immune and 9 is highly susceptible. Norden has a low level of VSK, average DON levels, but slightly higher than average disease severity under intense inoculum pressure (Table 3). Norden possesses the major FHB resistance quantitative trait locus *Fhb1* (Liu et al., 2008b).

Under field conditions, Norden is resistant to leaf rust and shows resistant infection types to races KFBJ, MBRJ, MCDS, MFPS, MHDS, MJBJ, TCTD, and TLGF but susceptible

Table 4. Leaf rust reaction of Norden and other hard red spring cultivars in seedling greenhouse tests and in the Uniform Regional Hard Red Spring Wheat Nursery, 2007 to 2008†.

	KFBJ		MBRJ	MCDS	MFPS		MHDS		MJBJ	TCTD	TDBG	TGBG	THBJ		TLGF	Morris	Crookston	St. Paul
Line	2007	2008	2007	2008	2007	2008	2007	2008	2007	2007	2008	2007	2007	2008	2008	2007	2007	2008
2375‡	0;§	3	3+	3+	3+	33+	3+	32+	32+	;2–	32	3+	3+	;22+	;2	40S	50MS	40MS
Barlow	;	;	0;	0;	0;	0;	0;	0;	0;	0;	;1	;2-	;2-	;2	;	TR-MR	TR	TR
Chris‡	32+	2+3	3+	3+	32+	3+	32+	3+	32+	3	3	3	3+	32+	;2	20MS	60MS	20MRMS
Keene§	;1–	;1–	0;	;	0;	0;	0	0;	0;	0;	2+n	;/2+3	;	2+;N	;	40S	70MS	70S
LCS Albany	3+	3+	;	;	3+	32;	;	;	3	0;	;	;1–	;	;	;	5MR-MS	10MR-MS	5RMR
Marquis	3+	3+	3+	3+	3+	4	3+	3+	3+	3+	;22+	3+;	3+	3+	32+	60S	80S	70S
Norden	;	;	;22+	;	;1+	;	;23	;	;2	0;	22+	32+	32+	23	;	5MR-MS	TR	10RMR
Select	;	;	2+/3	;	;	;	0;	;	;	;	;2–	;	;	;1–	;	10MS-S	TR	10RMR
Velva	;	;	0;	0;	0;	0;	0;	0;	0;	0;	;	;	;2–	;2–	;	R-MR	TR	10MRMS
Verde‡	;	;	;2–	;	12	;2–	32+	;22+	32+;	;	;1–	;12–	;2+	;	;	20MS	10MR	40MRMS

† Reaction of individual leaf rust races is based on seedlings.

‡ Long-term check.

§ Seedling infection types: 0 = immune response, no sign of infection; ; = hypersensitive chlorotic or necrotic flecks; 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. A range of infection types is indicated by more than one infection type, with the predominant type listed first. Infection types were described by Oelke and Kolmer (2004).

infection type to races TDBG, TGBG, and THBJ at a seedling plant stage (Table 4). According to the leaf rust survey conducted by the USDA-ARS, the most prevalent races in the US spring wheat region in 2010 were MLDSD (36.9% of samples), TDBJG (31.5%), and TFBGQ (6%). Therefore, it is likely that Norden contains adult plant resistance (APR) genes for leaf rust that are responsible for its high resistance, rated as a 2 on the 1-to-9 scale, under field conditions. Norden does contain one such APR gene, *Lr34*, according to the results of DNA marker testing (Lagudah et al., 2009). However, *Lr34* by itself does not provide highly effective resistance. In naturally infected sites, Norden has shown good resistance to stripe rust (*Puccinia striiformis* Westend. f. sp. *tritici* Eriks.).

Norden is highly resistant to the prevalent race QFCSC and other stem rust races that are important in North America (QTHJC, RCRSC, RKQQC, TPMKC, and TTTTF) at both the seedling and adult plant stages. Since the beginning of field evaluations of MN03196 in 2003, natural infection by stem rust on Norden has not been observed. Norden has shown moderately susceptible reactions to TTKSK (syn. Ug99) when evaluated in seedling screens in the greenhouse and in stem rust field nurseries in Kenya.

End-Use Quality

Norden has acceptable end-use quality, having all key parameters near the mean of the 21 comparison cultivars (Table 5). Norden's 1000-kernel weight (31.7 g), grain (136.6 g kg^{-1}) and flour (127.7 g kg^{-1}) protein content, and loaf volume (191.3 mL) are slightly below average, and its bake mix time (2.3 min.) and bake absorption (58.3 g kg^{-1}) are above average. Compared with the long-term quality check, 'Glenn' (Mergoum et al., 2006), Norden has poorer performance for all key measurements of end-use quality, but only the grain and flour protein content measurements are significantly ($P < 0.05$) poorer. Compared with the high-yielding but lower grain protein cultivar LCS Albany, Norden has significantly better 1000-kernel weight, grain and flour protein, and bake absorption. Norden contains the 2* and 5+10 subunits of the *Glu-A1* and *Glu-D1* loci, respectively (Liu et al., 2008a). These subunits have been positively correlated with bread-making quality (Payne, 1987).

Availability

The Minnesota Agricultural Experiment Station, St. Paul, MN 55108, will maintain breeder seed of Norden. Foundation seed will be produced and maintained by the Minnesota Crop Improvement Association, 1900 Hendon Ave., St. Paul, MN 55108. Norden has been approved for US Plant Variety Protection (PVP no. 201300125) with seed certification option. A seed sample has been deposited in the USDA-ARS National Center for Genetic Resources Preservation, where it will become available for distribution after expiration of the PVP in 2033. Small quantities of seed for research purposes may be obtained from the corresponding author for at least 5 yr from the date of this publication.

Table 5. Grain end-use quality of Norden and other hard red spring wheat cultivars grown in Minnesota, 2008 to 2010. Cultivars are sorted by loaf volume.

Cultivar†	1000-kernel weight	Grain protein	Flour protein	Bake mix	Bake absorption	Loaf volume
	g	g kg^{-1}‡		min.	g kg^{-1}	mL
Vantage	31.1	148.8	142.0	2.0	577.1	209.0
RB07	29.2	140.3	131.2	2.4	570.6	207.2
Glenn§	32.6	148.6	140.4	2.7	596.8	207.1
Barlow	33.9	145.3	137.3	2.1	589.8	201.9
Tom	37.3	140.9	129.3	2.1	564.8	197.7
Samson	32.5	135.8	125.3	2.4	564.4	197.4
Sabin	30.4	143.6	134.3	2.6	595.3	196.9
Oklee	33.8	143.7	133.7	1.8	554.2	195.9
Jenna	37.7	138.4	127.4	2.1	575.7	195.6
Faller	37.8	135.4	125.2	2.2	568.0	194.3
Brick	32.4	142.6	131.2	2.6	576.7	192.6
Briggs	34.8	145.3	133.8	1.6	575.2	192.4
Ada	34.4	138.1	128.7	2.0	576.6	191.8
Norden	31.7	136.6	127.7	2.3	583.1	191.3
Kelby	31.2	145.7	137.1	2.0	574.2	190.6
Knudson§	34.1	135.9	124.0	3.2	573.2	190.3
Select	33.3	141.9	131.0	2.5	580.8	188.8
Brennan	33.5	142.1	131.9	2.0	579.8	188.1
Marshall§	28.5	128.8	116.4	1.8	540.3	183.3
Rollag	33.8	142.7	134.3	1.7	588.4	182.3
LCS Albany	27.8	126.4	116.9	2.1	548.1	177.6
Mean	32.9	140.3	130.4	2.2	574.0	193.9
LSD (0.05)	2.7	9.0	10.0	0.5	21.0	18.3
No. of environments	9	9	9	9	9	9

† Cultivars are sorted by loaf volume.

‡ 12% moisture basis.

§ Long-term check.

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