

Registration of 'Pembroke 2014' Soft Red Winter Wheat

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Abstract

The Kentucky wheat (*Triticum aestivum* L.) crop is always at risk for Fusarium head blight (FHB) because of the prevalent grain crop rotation used by farmers. Corn (*Zea mays* L.) is followed by wheat, which is followed by double-crop soybean [*Glycine max* (L.) Merr.]. The wheat crop is planted directly into corn stubble that harbors the causal fungus for FHB, *Fusarium graminearum* Schwabe. Therefore, developing FHB-resistant winter wheat cultivars is a major goal of the wheat breeding program in Kentucky. 'Pembroke 2014' (Reg. No. CV-1113, PI 675564) is an early maturing, semidwarf soft red winter wheat cultivar developed and released in 2014 by the Kentucky Agricultural Experiment Station for the combination of resistance to FHB, high yield potential, excellent test weight, and resistance to lodging. Pembroke 2014 was developed from the cross '25R18'/KY92C-0010-17//KY96C-0767-1. 25R18 is a soft red winter wheat cultivar with FHB resistance that likely traces to 'Sumai 3' or one of its derivatives. KY92C-0010-17 is a breeding line derived from the cross T63/VA85-54-290. KY96C-0767-1 is derived from the cross '2552'/VA92-51-12. The cross was made in 2003, and Pembroke 2014 was initially selected from F_{4,5} headrows in 2008 using a modified bulk breeding method. Selected rows that gave rise to Pembroke 2014, tested as KY03C-1237-32, carried the resistance allele at a major FHB resistance quantitative trait locus, *Fhb1*. Pembroke 2014 was extensively tested in multilocation replicated yield trials, the Uniform Eastern Soft Red Winter Wheat Nursery, the Uniform Northern Scab Nursery, and the Kentucky Wheat Variety Trial.

Fusarium head blight (FHB) or head scab is a serious disease of wheat (*Triticum aestivum* L.) grown in Kentucky and the southern Corn Belt, where the crop is often planted with little or no tillage into corn (*Zea mays* L.) stubble. The causal agent for this disease, *Fusarium graminearum* Schwabe, persists in corn residue, putting the wheat crop at risk for FHB. Development of resistant cultivars is a key strategy for ameliorating the effects of this disease (McMullen et al., 2012). Hence, developing adapted FHB-resistant cultivars is a major goal of the Kentucky Agricultural Experiment Station.

'Pembroke 2014' (Reg. No. CV-1113, PI 675564) is a soft red winter wheat developed and released in 2014 by the Kentucky Agricultural Experiment Station for its grain yield potential, superior test weight, and resistance to FHB. Pembroke 2014, tested as KY03C-1237-32, was developed from the cross '25R18'/KY92C-0010-17//KY96C-0767-1. The primary donor of FHB resistance to the cross was the winter wheat cultivar 25R18, which was developed by Pioneer Hi-Bred International and has the pedigree 'WBGO195E2V'/'2510'//2510. WBGO195E2 has Type 2 FHB resistance derived from 'Sumai 3' (Tamburic-Iilincic et al., 2006). KY92C-0010-17 is a breeding line that traces back to the cross between two breeding lines T63 and VA85-54-290. The breeding line KY96C-0767-1 was derived from the single cross '2552'/VA92-51-12.

Before release, Pembroke 2014 was tested in multilocation replicated yield trials in the breeding program, the Uniform Northern Scab Nursery, the Kentucky Wheat Variety Trial, and the Uniform Eastern Soft Red Winter Wheat Nursery. The cultivar was named for the Pembroke silt loam soil series that is prevalent in the wheat-producing areas of Kentucky.

Methods

Population and Line Development

The three-way cross that gave rise to Pembroke 2014 (tested as KY03C-1237-32) was made in the greenhouse in Lexington,

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Abbreviations: DON, deoxynivalenol; FDK, *Fusarium*-damaged kernels; FHB, Fusarium head blight; MAS, marker-assisted selection; QTL, quantitative trait locus; SRWW, soft red winter wheat.

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Journal of Plant Registrations 10:41–46 (2016).
doi:10.3198/jpr2015.07.0045crc
Received 27 July 2015. Accepted 4 Oct. 2015.
Registration by CSSA.
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KY, in 2003. The F_1 generation was grown in a single row at Spindletop Farm in Lexington and harvested in bulk to produce F_2 seed. Individual heads were selected in the F_2 generation and threshed in bulk to generate an F_3 population. The same procedure was followed to generate the F_4 population, and then individual F_4 heads were selected, threshed into headrow trays and planted as $F_{4,5}$ headrows. Individual rows were harvested separately and planted as unreplicated $F_{4,6}$ preliminary trial entries in augmented design tests at Lexington and Schochoh, KY, in 2008.

Purification and Increase

One hundred eighty-nine $F_{6,7}$ headrows were grown in 2009 for purification and increase. One hundred three phenotypically selected rows were screened for the presence of the resistance alleles at the major scab resistance quantitative trait locus (QTL), *Fhb1* (which came from the parent 25R18), and were genotyped at the Eastern Regional Small Grain Genotyping laboratory in Raleigh, NC (for protocols, see USDA-ARS, 2010).

Seed from 66 selected rows was bulked and increased in 2010 at the University of Kentucky's Spindletop Farm. In fall 2011, approximately 20 bags of seed were transferred to Clements AG Supply of Springfield, KY, where the seed was planted on approximately 3.4 ha. Approximately 16.3 t of seed was produced and was distributed to four seed growers in Kentucky in fall 2012. In total, approximately 231.2 t of seed of Pembroke 2014 was produced in the 2013 harvest.

Statistical Analysis

All statistical analyses were done using SAS Program version 9.3 (SAS Institute, 2011). Analysis of variance was performed with a mixed model in which genotypes were treated as fixed effects and environments and replications within environments as random effects. Genotypic means were compared using a least significant difference (LSD) test ($P = 0.05$).

FHB Screening

Grain spawn applied at a rate of 12 g m^{-2} provided the inoculum (Agostinelli et al., 2012; Balut et al., 2013), which consisted of 27 isolates taken from scabby wheat seed collected from 2007 to 2010 at multiple locations across Kentucky. The FHB ratings, taken 21 to 24 d post-heading, were recorded on a 0-to-9 scale, where 0 represents 0 to 10% bleaching of spikelets within a plot and 9 signifies 90 to 100% of the spikelets in the plot are symptomatic. Detailed symptom readings included incidence (%), which is the proportion of 20 representative spikes that contained at least one bleached spikelet, and severity (%), which is the mean of the proportion of bleached spikelets of 10 spikes. The FHB index (%) is defined as incidence multiplied by severity and divided by 100.

Processing of scabby grain samples from the scab nursery to estimate *Fusarium*-damaged kernels (FDK) and for deoxynivalenol (DON) analysis was performed as previously described (Agostinelli et al., 2012; Balut et al., 2013). The DON analysis was performed at the University of Minnesota DON Testing Laboratory using gas chromatography with mass spectrometry (Mirocha et al., 1998; Fuentes et al., 2005).

Release Mechanism

Pembroke 2014 was released directly and licensed exclusively to the Kentucky Small Grain Growers Association (<http://www.kysmallgrains.org/>). Plant variety protection was not applied for. Foundation class seed was sold to growers who were then free to maintain their own seed supply or sell Pembroke 2014 in conformity with the Kentucky Seed Law.

Characteristics

Botanical Description

Juvenile growth of Pembroke 2014 is erect. Plant color at boot stage is green. Flag leaf at boot stage is erect and peduncle is without waxy bloom. Glume color is white with a rounded shoulder and acuminate beak. The spike is fully awned, mid-dense, and tapering. Kernels are ovate with rounded cheeks, a shallow crease, and a midsize brush.

Agronomic Performance

Pembroke 2014 was tested in multilocation replicated yield trials in Kentucky in 2009–2010 and in 2011 was entered in the regional Mason Dixon Nursery as well as the Kentucky Wheat Variety Trial, where it continues to be tested (Table 1; Bruening et al., 2012). Cultural practices used in the agronomic testing were those recommended for Kentucky wheat producers and described in Lee et al. (2009). Pembroke 2014 is short-statured, 6 cm shorter than the average of cultivars listed in Table 1. The heading date of Pembroke 2014 is equal to or earlier than that of the long-time early maturity check 'Clark' (Ohm et al., 1988) and approximately 8 d earlier than 'Truman' (McKendry et al., 2005).

Pembroke 2014 begins to grow rapidly in late winter/early spring, so growers are cautioned against planting it too early in the fall to minimize the risk of spring freeze damage. DNA marker data indicate that the cultivar has the insensitive allele at the *Ppd-D1* photoperiod locus, although it does not have the short vernalization allele at the *Vrn-A1* locus. This and all marker data reported herein may be confirmed at <http://www.ars.usda.gov/Main/docs.htm?docid=19523&page=1>.

Straw strength of Pembroke 2014 is exceptional, and thus there has been essentially no lodging in its testing history. Lodging during the period of testing reported in this article was minimal, although at one location in 2014, Woodford County, there was significant lodging. Pembroke 2014 showed zero lodging, while the lodging values for the other check cultivars across all trials at that location were as follows: 'Dinah', 20%; 'Pembroke 2008', 5%; Truman, 80%. Based on DNA marker data, Pembroke 2014 carries the *Rht-B1b* allele for reduced height. In the 2011–2014 Kentucky wheat variety trial, yield of Pembroke 2014 was similar to that of '25R32', another scab-resistant variety, but significantly greater than that of Truman, which is frequently used as a scab-resistant check in the eastern wheat region (Table 1). Pembroke 2014 was entered in the Uniform Eastern Soft Red Winter Wheat Nursery and tested at 26 locations in 2011–2012 and 2012–2013 (USDA-ARS, 2014). In an analysis of those entries common to both years of the test, Pembroke 2014 had an average yield of 4839 kg ha^{-1} , not significantly different from yields of the checks 'Bess' (4580 kg ha^{-1}), 'Branson' (4994 kg ha^{-1}) and MO080104 (4875 kg ha^{-1}), based

Table 1. Agronomic performance of Pembroke 2014 and other soft red winter wheat cultivars in Kentucky, 2011–2014.

Cultivar	Grain yield	Grain volume weight	Lodging	Height	Days to heading
	kg ha ⁻¹	kg hL ⁻¹	0–9†	cm	d after 1 Jan.
AgriMAXX 412	6272	73.8	2	99.0	125
AgriMAXX 413	6658	70.3	0	93.9	126
AgriMAXX 415	6343	74.3	0	96.5	127
BECK 113	6572	73.4	1	96.5	126
Bess	5972	73.8	2	101.6	126
Clark	5317	71.1	1	111.7	125
Delta Grow 7500	6331	71.0	0	93.9	128
Dyna-Gro 9042	6563	72.3	1	96.5	127
Dyna-Gro 9171	6672	70.3	0	93.9	126
KAS 5058	6346	74.6	2	104.1	127
KAS S1200	6689	70.4	0	93.9	126
Pembroke 2014	6232	73.6	0	88.9	125
25R32	6206	73.8	1	101.6	130
25R78	6369	71.4	0	96.52	126
26R20	5927	70.1	1	101.6	129
Progeny P 117	5962	71.5	3	101.6	123
Progeny P 185	6093	72.0	0	109.2	127
SC 1321	6645	69.9	0	93.9	126
SS 8700	6362	71.4	2	101.6	130
Terral TV8848	6608	71.9	2	99.06	127
Terral TV8861	6108	71.8	1	93.9	129
Truman	5821	73.6	2	109.2	133
Mean	6003	68.9	0.9	94.7	121.48
Location years	18	18	18	18	18
LSD (0.05)	402	2.1	3.4	2.6	1.8

† 0 = no lodging; 9 = > 90% lodged.

on least squares means from data collected across 21 locations over 2 yr (Table 2).

Disease Resistance

Pembroke 2014 was first entered in the Uniform Northern Scab Nursery in 2011 (US Wheat and Barley Scab Initiative, 2015), where it was in the low DON grouping based on the LSD (0.05) for the experiment. The cultivar has also been extensively tested in our mist-irrigated FHB nursery, where severe scab

epidemics are routinely generated. In the 2014 misted, inoculated nursery in Lexington, Pembroke 2014 appeared in numerous breeding line tests as a check, in addition to appearing as an entry in the Preliminary Uniform Northern Scab Nursery (Table 3). Over these 18 observations, Pembroke 2014 had an average FDK value of 15.5% versus 31.2% for the susceptible check 2555 and 10.4% for the resistant check KY02C-3005-25. Deoxynivalenol concentration of Pembroke 2014 (8.9 ppm) did not differ significantly from the most resistant check

Table 2. Agronomic performance of Pembroke 2014 and other entries common to the 2012 and 2013 Uniform Eastern Soft Red Winter Wheat Nursery.

Entry	Grain yield	Grain volume weight	Days to heading	Plant height
	kg ha ⁻¹	kg hL ⁻¹	d after 1 Jan.	cm
ARS07-0525	4506	74.3	119.1	80.8
Bess	4581	74.7	118.7	88.6
Branson	4991	73.2	117.6	81.8
DAS1003	4322	73.4	123.5	97.5
KY03C-1002-02	4909	74.1	116.7	79.2
MO080104	4875	76.0	117.8	87.9
NC08-23324	4379	75.1	116.6	78.5
OH08-180-48	5148	74.8	121.2	83.3
Pembroke 2014	4839	74.9	116.2	74.7
Shirley	4982	71.8	119.4	77.2
VA08MAS-369	4847	76.3	116.8	81.5
VA09W-73	4730	75.4	117.0	82.6
VA10W-21	4915	73.9	117.7	83.1
Mean	4430	69.1	109.8	76.9
LSD (0.05)	314.9	1.5	2.0	3.6

Table 3. Fusarium head blight (FHB) rating, *Fusarium*-damaged kernels (FDK), and deoxynivalenol (DON) concentrations in Pembroke 2014 and other scab nursery checks.

Entry†	FHB rating	FDK	DON
	0–9‡	%	ppm
2555 (S)	2.6	31.2	15.3
KY02C-3005-25 (MR)	2.6	10.3	7.2
Pembroke 2014	0.7	15.5	8.9
Ernie (MR)	1.2	28.1	13.6
Truman (MR)	2.2	12.3	12.6
LSD (0.05)	0.4	1.8	1.7

† S = susceptible; MR = moderately resistant.

‡ 0 = no spikelet blighted; 9 = >90% of spikelets blighted. Data presented are entry means based on 18 to 62 observations in the inoculated, mist-irrigated scab nursery, Lexington, KY, 2014.

KY02C-3005-05 (7.2 ppm), but it was significantly lower than that of Truman, which is a resistant check in the Uniform Northern Scab Nursery. Truman had an average DON value of 12.6 ppm, based on 22 observations in multiple tests included in the overall scab nursery (University of Kentucky College of Agriculture, 2015).

Pembroke 2014 was grown in the fungicide × variety trials at Spindletop Farm in 2013 and at both Spindletop Farm and the West Kentucky Research and Education Center at Princeton, KY, in 2014. The tests comprised 19 entries in 2013 and 18 entries in 2014, most of which were either widely grown wheat cultivars or advanced breeding lines. The plots were inoculated with 17.8 g m⁻² grain spawn spread close to the booting stage (Feekes 9). Prostaro (Bayer CropScience; prothioconazole {2-[2-(1-chlorocyclopropyl)-3-

(2-chlorophenyl)-2-hydroxypropyl]-1,2-dihydro-3H 1,2,4-triazole-3-thione} and tebuconazole {α-[2-(4-chlorophenyl)ethyl]-α-(1,1-dimethylethyl)-1H-1,2,4-triazole-1-ethanol}) was applied at anthesis (Feekes 10.5.1) at a rate of 0.475 L ha⁻¹, followed 24 h later with application of a conidial spray (100,000 spores mL⁻¹ at a rate of 10 mL m⁻²). Grain from the fungicide × variety trial was harvested with a small plot combine and subsequently cleaned using sieving and low airflow similar to scab nursery grain sample processing. Otherwise, FDK determination and sample preparation for DON analysis were similar to those used for material from the scab nursery (Agostinelli et al., 2012; Balut et al., 2013). In the fungicide × variety trials in 2013, DON concentration of Pembroke 2014 was not significantly higher than that of Truman in either the control or the fungicide treatments (Table 4). In 2014, when the test was grown at Lexington and Princeton, DON level of Pembroke 2014 was significantly lower than the mean DON level of the trial except for the control treatment at Princeton (Table 5). Pembroke 2014 has the resistance allele at the major QTL *Fhb1* (Liu et al., 2008; Agostinelli et al., 2012; Balut et al., 2013).

Pembroke 2014 has excellent adult plant resistance to powdery mildew [caused by *Erysiphe graminis* (DC.) f. sp. *tritici* Ém. Marchal; syn. *Blumeria graminis* (DC) E.O. Speer], as well as moderate resistance to prevalent races of stripe rust (caused by *Puccinia striiformis* Westend.). The cultivar is moderately susceptible to speckled leaf blotch (caused by *Septoria tritici* Roberge in Desmaz.) and moderately susceptible to leaf rust (caused by *Puccinia triticina* [= *P. recondita* Roberge ex Desmaz. f. sp. *tritici*]). Pembroke 2014 is susceptible to the prevalent races of stem rust (caused by *Puccinia graminis* Pers.:Pers. f. sp. *tritici*

Table 4. Fusarium head blight symptoms of Pembroke 2014 and other soft red winter wheat cultivars and breeding lines with and without fungicide treatment, Lexington, KY, 2013.

Entry	Control					Fungicide†				
	Rating	Incidence	Severity	Index	DON	Rating	Incidence	Severity	Index	DON
	0–9‡	%	%	%	ppm	0–9‡	%	%	%	ppm
AgriMAXX 413	3.0	60.0	60.0	27.7	2.9	0.3	10.0	21.4	2.1	0.7
BECK 135	1.3	45.0	45.0	18.6	2.9	0.2	10.0	26.0	2.8	1.0
Dyna-Gro 9042	2.3	55.8	55.8	30.8	4.6	0.5	15.0	30.0	5.3	1.3
Dyna-Gro Dinah	0.8	24.2	24.2	9.7	1.4	0.0	3.3	16.2	0.6	0.5
KAS S1100	2.7	76.7	76.7	33.0	3.3	0.3	26.7	20.6	5.2	1.4
KAS S1200	4.7	77.5	77.5	41.2	6.3	0.7	16.7	28.0	5.1	1.4
KY03C-1002-02	1.8	68.3	68.3	22.3	3.1	0.0	9.2	11.8	1.2	0.9
KY03C-1237-05	0.0	22.5	22.5	3.5	2.4	0.0	4.2	10.8	0.5	1.2
Pembroke 2014	3.7	61.7	61.7	29.2	2.6	0.0	10.8	19.3	2.0	0.5
KY03C-1237-39	3.0	59.2	59.2	33.2	2.8	0.0	6.7	31.8	2.2	1.0
KY04C-3006-33-14-3	1.7	37.5	37.5	21.7	2.4	0.2	3.3	26.0	1.0	0.9
Pembroke 2008	2.0	56.7	56.7	30.5	4.5	0.2	9.2	29.8	2.7	0.6
25R32	0.0	8.3	8.3	1.0	1.3	0.0	0.8	9.5	0.1	0.4
25R56	1.3	43.3	43.3	24.9	2.1	0.0	5.8	24.3	1.4	1.4
26R22	4.0	70.8	70.8	34.0	6.3	0.3	10.8	36.7	4.4	1.9
SS 8700	0.8	31.7	31.7	14.4	2.9	0.0	2.5	22.4	0.6	1.6
SYNGENTA W1104	1.0	36.7	36.7	12.5	3.6	0.0	10.0	17.9	2.0	2.1
Truman	0.0	0.8	0.8	0.1	1.1	0.0	0.8	6.5	0.0	0.3
USG 3251	1.3	39.2	39.2	14.1	3.1	0.2	10.0	21.5	2.2	1.6
Mean	1.8	46.3	38.9	20.0	3.1	0.1	8.3	20.0	1.9	1.1
LSD (0.05)	1.3	20.7	13.8	12.2	2.1	0.4	8.6	11.7	3.0	0.9

† Prostaro fungicide applied at Feekes growth stage 10.5.

‡ 0-to-9 scale, where 0 = 0–10% bleached spikelets; 9 = 90–100% bleached spikelets.

Table 5. Deoxynivalenol (DON) concentration and *Fusarium*-damaged kernels (FDK) of wheat cultivars and breeding lines with and without fungicide treatment, Lexington and Princeton, KY, 2014.

Entry	Lexington		Princeton		Lexington		Princeton	
	Control				Fungicide†			
	DON	FDK	DON	FDK	DON	FDK	DON	FDK
	ppm	%	ppm	%	ppm	%	ppm	%
ARMOR HAVOC	3.3	5.2	1.0	2.3	2.1	0.6	0.6	0.0
AgriMAXX 413	4.6	7.4	2.0	3.2	2.1	1.0	0.7	0.2
BECK 113	1.8	3.1	0.9	1.4	0.5	0.6	0.3	0.5
BECK 120	3.9	5.5	1.6	3.7	1.5	0.9	1.0	0.2
Dyna-Gro 9042	4.2	5.0	2.6	2.9	3.6	2.2	1.7	0.8
KY03C-1002-02	1.5	2.6	1.5	1.4	0.9	0.4	0.6	0.2
KY03C-1195-10-8-5	3.5	2.2	1.4	1.2	2.2	0.9	1.4	0.4
Pembroke 2014	1.4	1.5	0.8	1.0	1.0	0.7	0.3	0.3
KY06C-1003-139-16-5	2.4	3.9	0.7	2.3	1.1	0.4	0.8	0.4
Pembroke 2008	5.0	5.8	2.4	3.4	2.2	0.8	1.3	0.4
25R32	2.0	3.1	0.6	1.6	0.5	0.6	0.3	0.2
25R40	4.6	4.4	2.4	3.1	3.9	0.9	2.3	0.3
26R10	4.6	5.3	2.4	3.3	4.1	1.4	2.2	0.7
26R53	3.5	4.8	1.7	2.5	3.9	0.9	1.7	0.0
SC 1321	4.1	7.1	1.8	3.7	1.6	0.4	0.9	0.5
SS 8700	4.9	7.3	2.0	3.0	2.8	1.5	2.2	0.3
SYNGENTA SY 483	5.0	4.4	1.0	1.8	6.4	2.4	2.7	0.9
Truman	2.9	2.8	0.2	0.9	3.1	1.1	1.1	0.5
Mean	3.6	4.4	1.5	2.3	2.5	1.0	1.2	0.4
LSD (0.05)	1.8	2.2	1.0	0.9	1.1	0.9	0.7	0.4

† Prostaro fungicide applied at Feekes growth stage 10.5.

Eriks. & E. Henn.), for which it was screened at the seedling stage as an entry in the Uniform Eastern Soft Red Winter Wheat Nursery. Disease data from the 2012 harvest year of the Uniform Eastern Soft Red Winter Wheat Nursery is presented in Table 6. Only the entries common to the 2 yr in which Pembroke 2014 was entered in the test are presented; the full data sets from both years can be downloaded from USDA-ARS (2014). Pembroke 2014 is also susceptible to prevalent biotypes of Hessian fly [*Mayetiola destructor* (Say)].

Milling and Baking Quality

Milling and baking quality of Pembroke 2014, based on tests at the USDA Soft Wheat Quality Laboratory in Wooster, OH, is shown in Table 7. In these evaluations, Pembroke 2014 had higher than average grain volume weight and higher than average grain protein concentration (AACCC, 2000). Cookie diameter of Pembroke 2014 was similar to that of the check cultivar Bess (17.8 vs. 17.9 cm), as was flour yield (66.7 vs. 67.7%). Gluten strength as indicated by lactic acid retention capacity was high

Table 6. Disease reaction of Pembroke 2014 and other soft red winter wheat cultivars and breeding lines common to the 2012 and 2013 Uniform Eastern Soft Red Winter Wheat Nursery.

Entry	Powdery mildew†	Septoria leaf blotch	Stripe rust	Leaf rust	FHB index (MI)	FHB index (MO)	FHB index (ON)
	0–9	0–9	0–9	0–9	%	%	%
ARS07-0525	2.0	4.3	1.5	1.4	9.4	20.2	14.0
Bess	2.4	3.7	2.4	4.9	5.0	14.4	13.5
Branson	1.0	3.0	1.6	3.8	3.6	28.1	18.8
DAS1003	0.8	2.1	4.1	5.3	0.0	9.2	9.0
KY03C-1002-02	1.8	3.8	3.7	4.8	7.4	28.2	15.1
MO080104	0.9	4.0	1.7	4.3	0.0	10.3	12.0
NC08-23324	2.4	4.2	5.4	0.8	20.0	16.3	13.5
OH08-180-48	3.4	2.4	1.5	1.0	3.8	12.4	13.5
Pembroke 2014	0.6	4.1	2.1	5.3	3.0	7.0	13.5
Shirley	0.0	2.5	5.2	1.0	9.0	33.2	16.3
VA08MAS-369	1.0	2.2	1.0	1.6	6.5	20.0	18.0
VA09W-73	1.0	2.4	1.8	2.1	12.9	12.2	8.0
VA10W-21	2.1	3.0	6.8	3.3	0.0	16.7	7.8
Location mean	1.7	3.1	2.7	3.0	6.9	16.0	13.4

† Data presented from 2012 only, when most locations reported diseases on the same scale. Ratings for powdery mildew, septoria blotch, stripe rust and leaf rust are the average of all locations reporting on those diseases. Fusarium head blight (FHB) index ratings shown separately by the three locations where it was measured.

Table 7. Grain quality traits of Pembroke 2014 and other cultivars and breeding lines common to the 2012 and 2013 Uniform Eastern Soft Red Winter Wheat Nursery.

Entry	Grain volume weight	Whole grain protein	Whole grain hardness	Flour yield	Softness equivalent	Flour protein	Lactic acid SRC†	Sucrose SRC†	Cookie diameter
	kg hL ⁻¹	g kg ⁻¹	0–100	%	%	g kg ⁻¹	%	%	cm
Branson	78.0	106.1	27.2	70.0	57.1	83.1	117.6	98.3	18.0
Bess	78.5	103.6	27.3	67.7	49.6	85.3	97.8	103.5	17.9
Shirley	77.6	110.6	28.8	69.9	51.6	85.9	96.3	96.4	18.5
MO080104	79.7	104.1	33.0	66.9	53.6	83.0	121.5	107.6	17.6
NC08-23324	79.6	104.8	36.0	67.7	48.5	86.3	113.3	103.6	17.8
Pembroke 2014	78.8	111.6	31.0	66.7	51.2	88.6	123.7	105.8	17.8
KY03C-1002-02	78.6	84.7	39.8	70.4	47.4	89.0	112.4	105.3	17.7
VA08MAS-369	80.7	106.6	34.5	69.5	49.8	87.1	127.9	97.9	17.9
VA09W-73	79.9	106.4	37.4	68.1	53.1	82.7	108.4	93.8	18.2
VA10W-21	79.4	93.5	35.1	69.6	42.2	76.6	117.5	110.1	15.8
DAS1003	78.2	95.9	27.8	69.3	55.3	72.4	81.5	91.7	18.4
OH08-180-48	79.2	98.1	32.6	70.3	57.0	77.4	118.6	96.5	18.5
ARS07-0525	78.1	114.0	31.7	70.1	50.8	88.6	93.1	104.1	17.9
Mean	78.7	105.9	31.8	68.9	52.0	84.6	106.4	98.9	18.0

† SRC, solvent retention capacity. Data provided by USDA-ARS Soft Wheat Quality Laboratory, Wooster, OH.

(123.7%), compared with the 2 yr mean value of 106.4%. Statistical significance of these comparisons could not be assessed from the data provided by the quality laboratory. Based on marker data, Pembroke 2014 does not carry the 1RS translocation, has 5+10 high molecular weight glutenin subunits and carries the Bx7OE overexpressor allele associated with gluten strength.

Seed Availability

Breeder seed of Pembroke 2014 will be maintained by the University of Kentucky wheat breeding project; small quantities may be obtained from the corresponding author. Seed of Pembroke 2014 has been deposited at the USDA-ARS National Center for Genetic Resource Preservation, where it will be available upon publication.

Acknowledgments

We thank John Connelley and Carolyn Swanson for their excellent technical assistance. Pembroke 2014 was developed with financial support from the Kentucky Agricultural Experiment Station, the Kentucky Small Grains Promotion Council, the Triticeae Coordinated Agricultural Project grant #2011-68002-30029, funded by the USDA National Institute of Food and Agriculture and the USDA-ARS, under Agreement No. 59-0206-9-054, which is a cooperative project with the US 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.

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