CULTIVAR

Registration of 'Vision 40' Wheat

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ABSTRACT

The potential exists to develop and market hard winter wheat (*Triticum aestivum* L.) in the eastern United States, where a majority of the mills, bakeries, and consumers reside. The primary objective of this study was to develop adapted and competitive hard winter wheat cultivars possessing high-value traits that offer the potential for new and expanded markets and greater profitability to wheat producers in the eastern United States. 'Vision 40' (Reg. No. CV-1063, PI 661154) hard red winter (HRW) wheat was derived from the cross 92PIN#109/92PAN1#33 and released by the Virginia Agricultural Experiment Station in March 2010. Vision 40 was developed with a modified bulk-breeding method and was tested as VA06HRW-66 in replicated yield trials in Virginia (2007–2009) and in the eastern region (2008– 2009). Vision 40 is a high-yielding, winter hardy, awned, semidwarf (*Rht2*) having mid- to late-season spike emergence and moderate resistance to diseases prevalent in the mid-Atlantic area with the exception of Fusarium head blight [caused by *Fusarium graminearum* (Schwabe)]. Vision 40 was the fourth highest yielding HRW wheat entry when averaged over 2 yr of the Uniform Bread Wheat Nursery grown at 11 test sites in 10 states in 2008 and 12 test sites in 9 states in 2009. In comparison with the hard wheat cultivar 'Lakin' (PI 617032), Vision 40 has acceptable end-use quality on the basis of flour yield (70.2 versus 70.3 g 100 g^{-1}), flour protein (9.5 versus 9.5 g 100 g^{-1}), flour water absorption (58.5 versus 59.1 g 100 g^{-1}), dough mixing tolerance (1.7 versus 2.3), pup-loaf volume (823 versus 803 cm^3), and crumb grain scores (3.6 versus 3.7).

'Vision 40' (Reg. No. CV-1063, PI 661154) is a widely adapted, winter-hardy, hard red winter (HRW) wheat (*Triticum aestivum* L.) that provides producers in the eastern United States with a high-yielding, high-value, specialty wheat cultivar. Vision 40 also purveys to millers and bakers in the eastern region a HRW wheat cultivar for the production of bread products. Producers can benefit from the differentially higher price paid for HRW versus soft red winter (SRW) wheat, and millers can benefit from lower grain transportation costs afforded by sourcing locally grown HRW wheat. Vision 40 was the fourth highest yielding HRW wheat entry averaged over 2 yr of the Uniform Bread Wheat Nursery grown at 11 test sites in 10 states in 2008 and 12 test sites in 9 states in 2009. Vision 40 has performed better than 'Vision 30' (PI 661153) in environments with greater winter stress.

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Abbreviations: AACC, American Association of Cereal Chemists; FHB, Fusarium head blight; HRW, hard red winter; KSU, Kansas State University; SRW, soft red winter.

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Methods

Parentage, Breeding History, and Line Selection

The HRW wheat cultivar Vision 40 was derived as an F_5 headrow from the cross 92PIN#109/92PAN1#33. The parentage of 92PIN#109 is Pioneer Brand '2163' (PI 601722)/W9523A. The parentage of 92PAN1#33 is W2424/'Siouxland' (PI 483469)//Pioneer Brand 2163. Both 92PIN#109 and 92PAN1#33 were developed, evaluated, and advanced within Pioneer Hi-Bred's former HRW wheat breeding program. Pioneer closed their wheat breeding station at Hutchinson, KS in 1990 and donated their HRW wheat breeding lines and germplasm to Kansas State University (KSU). Lines 92PIN#109 and 92PAN1#33 were evaluated in advanced yield trials at KSU in 1992 and subsequently were

distributed by Dr. R. G. Sears to cooperating breeding programs for testing and use in crossing.

The cross from which Vision 40 originated was made in spring 2000, and the F_1 generation was grown in the field as a single 1.2-m headrow in 2001 to produce F_2 seed. The population was advanced from the F_2 to F_4 generation with a modified bulk-breeding method. Wheat spikes were selected from the population in each segregating generation (F_2–F_3) on the basis of the absence of obvious disease, early maturity, short straw, and desirable head shape and size. Selected spikes were threshed in bulk, and the seed was planted in 20.9-m^2 blocks at Blacksburg and/or Warsaw, VA in the fall of each year. Spikes selected from the F_4 bulk where threshed individually and planted in separate 1.2-m headrows. Vision 40 was derived as a bulk of one of these F_5 headrows selected in 2005. The line was tested as entry 66 in nonreplicated observation yield tests at Blacksburg and Warsaw in 2006 and was designated VA06HRW-66.

Evaluation in Replicated Yield Trials

Vision 40 was evaluated as VA06HRW-66 in Virginia Tech's replicated bread-wheat variety trails from 2007 to 2009 and in replicated regional tests in the Uniform Bread Wheat Nursery in 10 states in 2008 and in 9 states in 2009 (http://www.ars.usda.gov/Main/docs.htm?docid=8419&page=2; verified 27 June 2011). These trials were conducted with randomized complete block designs with two to four replications, standard variety testing protocols, and recommended management practices that varied slightly from state to state. Plant traits were assessed visually (e.g., winter kill, straw strength, and disease resistance) and were rated on a scale from 0 (no visible symptoms) to 9 (severe symptoms) based on intensity and severity of the affected plant area.

All replicated yield tests in Virginia were conducted according to the small-grain production and management protocols recommended by Brann et al. (2000) with late season nitrogen applied to tests at Warsaw, VA according to Thomason et al. (2007). Conventional-till yield plots were planted at 22 seeds per 0.304 meter row were composed of six 2.74-m rows with 17.8 cm between rows at Painter, VA, and seven 2.74-m rows with 15.2 cm between rows at Warsaw, VA and Blacksburg, VA with harvest areas of 4.2 m^2 at all locations. Assessment of reaction to Fusarium head blight [FHB; caused by *Fusarium graminearum* (Schwabe)] was conducted in replicated inoculated and mist-irrigated nurseries according to the procedures described by Chen et al. (2006). Analysis of variance was conducted on data from individual locations and years and across locations and years with SAS version 9.2 (SAS Institute, Cary, NC). Mean comparisons of traits were made with a protected LSD ($P = 0.05$) test to identify significant differences among genotypes.

Grain subsamples (1000 g) were supplied to the USDA Hard Winter Wheat Quality Laboratory, Manhattan, KS for grain, flour, and milling and baking quality analysis. Single-kernel wheat characteristics were determined by the Single Kernel Characterization System (SKCS-Model 4100, Perten Instruments, Springfield, IL) according to American Association of Cereal Chemists (AACC) method 55-31 (AACC, 2000). Wheat and flour protein (% N × 5.7) were determined by a nitrogen determinator (Model FTP-528, Leco Corp., St. Joseph, MI) according to method 46-30 (AACC, 2000). Moisture and ash contents were determined by AACC methods 08-01 and 44-15A, respectively, (AACC, 2000). Wheat samples, tempered to constant moisture (16%), were milled on a Quadrumat Senior experimental mill (C.W. Brabender Co., Hackensack, NJ) according to AACC methods 26-10A and 26-50. Flour yield was determined as percent of straight grade flour. A mixogram for each flour sample (10 g, on a 14% moisture basis) was obtained with a 10-g Mixograph (National Mfg. Co., Lincoln, NE) with optimum water adsorption (Finney and Shogren, 1972). Mix time was visually determined from the mixogram. Mix time to peak dough development and mixing tolerance were determined by mixograph (method 54-40, AACC, 2000). Mixograph mix time was corrected based on protein content of flour. A straight-dough, 100-g pup-loaf bake test method was used to measure bread-making properties for crumb grain score and loaf volume (method 10-10B, AACC, 2000). Crumb grain of representative bread slices were graded from poor open grain (0) to outstanding closed grain (6).

Seed Purification and Increase

During fall 2007, 240 F_8 headrows of Vision 40 were planted in an isolation block and evaluated for purity and trueness of type. Of these 240 breeder seed headrows, 5 rows were removed and discarded on the basis of variability and lack of trueness to cultivar type. Variant headrows observed and discarded included 0.4% having plants with bronze-colored spikes at maturity, 0.8% having plants with blue-colored leaves, 0.4% having plants with a more erect growth habit, and 0.4% having plants with a more prostrate growth habit. The 235 remaining rows that were similar in phenotype and visually homogenous were harvested in bulk. The 29.5 kg of initial breeder seed was planted on 0.4 ha at the Foundation Seed Farm of the Virginia Crop Improvement Association during the fall of 2008 and produced 70 units (22.7 kg $unit^{-1}$) of foundation seed. In fall 2009, this seed was planted at the Foundation Seed Farm and produced 1300 units of seed that was distributed to seedsmen in fall 2010. Certification of foundation seed fields of Vision 40 identified plants that were 10–30 cm taller in 2009 (0.26%) and 2010 (0.07%). In 2010, 0.03% plants having bronze-colored spikes were also noted. Wheat cultivar Vision 40 has been observed to be uniform and stable in the F_8–F_{10} generations, during which breeder seed was developed, and in production of foundation seed in 2009 and 2010.

Characteristics

Botanical and Agronomic Characteristics

The juvenile plant growth of Vision 40 is semierect. At the boot stage, Vision 40 has recurved, nontwisted flag leaves. The coleoptiles are purple and the anthers are yellow. The stem internodes are hollow and peduncles are erect. Spikes of Vision 40 are creamy white at maturity, and the awned, recurved spikes are tapering. The glumes are pubescent, of

medium length, and white with wide, wanting shoulders and acuminate beaks. Green plants of Vision 40 contain a trace amount of anthocyanin in the stems at maturity. The hard red kernels are ovate in shape with rounded cheeks and a long brush. The phenol reaction is dark brown.

Spike emergence (days from 1 January) of Vision 40 (120–124 d) was similar to that of 'Culpeper' (PI 654422 PVPO) and 2–3 d later than 'Tribute' (PI 632689) (Tables 1–3). The average plant height of Vision 40 (89–94 cm) was similar to that of Culpeper and 5–8 cm greater than Tribute. Vision 40's lodging score (0–9, where 0 = erect to 9 = completely lodged) of Vision 40 (2.3–3.6) was similar to that of Tribute (3.1–3.8) and better than that of cultivars TAM 302 (PI 605910) at 5.6 and TAM 303 (4.8–5.7).

Field Performance

In Virginia, Vision 40's 3-yr average (2007–2009) grain yield (5120 kg ha^{-1}) was most similar to that of the recent HRW wheat releases 'Vision 10' and 'Vision 20' (4838 kg ha^{-1}) (Table 1). The average grain volume weight of Vision 40 (74.4 kg hL^{-1}) was most similar to that of 'TAM 110' (PI 595757), which was 75.4 kg hL^{-1} (Table 1). Vision 40 was evaluated for 2 yr in USDA-ARS Uniform Bread Wheat Nursery (Tables 2 and 3) and ranked fourth in 2008 and second in 2009 for yield among HRW wheat cultivars. In the 2008 nursery, Vision 40 was exceeded ($P \leq 0.05$) in yield only by the two SRW wheat check cultivars, but it had a similar yield as the two SRW wheat checks in 2009. In both years, the average grain volume weight of Vision 40 (74.3 and 71.8 kg hL^{-1}) was similar to that of TAM 303 (73.7 and 71.7 kg hL^{-1}). The winter hardiness of Vision 40 was very good, with average winter stress ratings (0–9, where 0 = no injury, 9 = complete kill) from 0.5 to 2 versus 1–4 for 'Jagger' (PI 593688) and 4.5–5.7 for 'AGS 2000' (PI 612956).

Disease and Insect Resistance

Reaction of Vision 40 to disease and insect pests (0–9, where 0 = immunity, 9 = very susceptible) has been evaluated over diverse environments (Tables 1–3). Vision 40 is resistant to *Barley yellow dwarf virus* (0.3–2.4) and *Wheat soilborne mosaic virus* (2.0). Vision 40 is moderately resistant to leaf rust (caused by *Puccinia triticina* Eriks.) (1.5–3.4),

Table 1. Three year (2007–2009) mean performance of Vision 40 hard red winter wheat in Virginia Tech tests in Virginia.†

Cultivar	Grain yield	Grain volume weight	Heading date	Plant height	Lodging	Disease resistance			
						Powdery mildew	Leaf rust	BYDV‡	FHB index§
	kg ha^{-1}	kg hL^{-1}	d after 1 Jan.	cm	0–9¶	0–9#			0–100
Tribute††	5792	78.8	121.2	83.3	3.4	1.9	1.0	1.1	8.1
Pioneer 26R15††	5778	73.0	123.0	88.9	2.3	0.6	0.8	1.9	3.7
Renwood 3260††	5536	76.6	120.2	87.1	3	0.2	1.1	1.2	8.7
Vision 30	5301	74.8	121.3	87.4	3.9	0.1	1.2	1.4	10.7
Vision 40	5120	74.4	123.7	89.2	3.6	2.4	1.5	2.4	31.2
Vision 20	4838	76.7	121.7	86.6	3.2	2.9	1.2	2.4	31.6
Vision 10	4838	73.2	125.0	84.6	3.2	3.0	2.7	2.5	14.2
Lakin	4663	76.7	123.9	90.4	2.6	3.8	3.6	2.1	11.9
Culpeper	4629	73.0	124.2	89.2	3.4	3.7	0.3	2.8	18.6
TAM 110	4609	75.4	119.9	89.2	4.9	1.1	4.2	2.2	4.1
Soissons	4576	71.3	126.1	80.0	1.8	0.4	3.9	1.4	14.2
TAM 302	4334	72.5	124.7	87.9	5.6	3.1	0.7	3.4	27.9
Karl 92	4025	75.8	120.7	84.6	2.8	1.4	4.1	3.5	21.8
Mean (*N* = 38)	5019	74.4	123.1	86.1	3	1.5	1.8	2.5	16.2
No. of site-years	7	7	6	6	4	7	4	4	2
CV (%)	8.8	1.8	0.7	3.8	42.8	87.6	92.7	39.6	77.2
LSD (0.05)	390	1.2	0.8	3.0	1.5	1.1	2	1.1	21.1

†Yield, grain volume weight, and powdery mildew data from Blacksburg (2007–2009), Warsaw, (2007–2009), and Painter (2009); heading date and height data from Blacksburg (2007–2009) and Warsaw (2007–09); data on *Barley yellow dwarf virus* from Blacksburg (2007–2009) and Warsaw (2007); lodging data from Blacksburg (2008, 2009) and Warsaw (2008, 2009); leaf rust data from Blacksburg (2008) and Warsaw (2007–2009); data on Fusarium head blight (FHB) index from the Blacksburg Scab Nursery (2008, 2009).

‡BYDV, *Barley yellow dwarf virus*.

§FHB index = % incidence × % severity ÷ 100.

¶0 = erect; 9 = completely lodged.

#0 = highly resistant; 9 = highly susceptible.

††Soft red winter wheat check cultivars.

Table 2. Mean performance of Vision 40 hard red winter wheat in the 2007–2008 USDA-ARS Uniform Bread Wheat Regional Nursery.

							Disease resistance								
							Stripe rust								
Cultivar	Grain yield	Grain volume weight	Head date	Plant height	Lodging	Winter stress	Infection type	Disease severity	Powdery mildew	Leaf rust	BYDV[†]	WSBMV[‡]	SB[§]	Kernel weight	Kernel diameter
	kg ha^{-1}	kg hL^{-1}	d after 1 Jan.	cm	0–9[¶]	0–9[#]	0–9[††]	%	0–9[‡‡]					mg	mm
Tribute[§§]	5711	78.0	120	86.4	3.1	3.5	8.0	40.0	0.0	1.0	3.7	3	5	31.10	2.29
AGS 2000[§§]	5550	75.1	118	94.0	2.5	4.5	7.5	15.0	1.7	0.9	3.3	4	7	36.22	2.46
Vision 30	4992	74.8	120	91.4	3.8	1.5	5.5	12.0	0.1	3.8	2.7	2	5	29.20	2.28
NuEast	4804	77.2	122	96.5	4.6	1.5	7.5	24.0	2.6	1.4	4.7	2	4	33.16	2.49
Vision 20	4730	76.5	120	88.9	2.8	1.0	2.0	1.0	4.5	2.6	3.7	3	7	26.92	2.13
Vision 40	4663	74.3	122	94.0	2.3	0.5	6.0	6.0	3.3	3.4	0.3	2	4	28.01	2.22
Vision 10	4636	73.3	124	86.4	4.4	0.5	2.0	1.0	3.6	3.4	3.7	4	5	29.74	2.26
TAM 303	4562	73.7	120	91.4	5.7	2.0	6.5	9.0	0.3	0.8	1.7	6	7	29.51	2.19
Endurance	4354	73.6	122	96.5	3.4	0.5	3.5	8.0	3.0	1.2	4.7	4	5	29.80	2.29
Deliver	4220	75.8	123	91.4	5.5	0.5	4.5	1.5	2.1	0.4	6.7	4	5	32.59	2.36
Jagger	4199	73.3	117	88.9	3.8	1.0	0.5	0.5	7.1	4.9	3.7	4	7	26.09	2.16
TAM 203	4186	72.9	120	88.9	4.0	1.0	1.0	2.0	6.3	0.0	5.3	4	6	28.89	2.25
Lakin	4092	76.2	122	96.5	2.6	0.5	7.0	24.5	5.3	4.7	5.0	4	5	28.10	2.19
Appalachian White	3991	73.9	126	94.0	6.0	1.0	1.0	1.0	3.5	2.7	5.7	2	2	28.15	2.27
Duster	3877	73.6	123	88.9	6.8	0.5	3.5	4.0	2.9	0.5	3.7	3	5	25.00	2.15
Jagalene	3669	75.4	121	91.4	2.2	0.5	2.5	1.0	8.1	5.0	4.3	4	6	28.43	2.29
Hondo	3413	75.0	127	94.0	4.7	1.0	6.0	4.5	0.7	4.3	5.0	3	4	27.57	2.20
Mean (*N* = 50)	4435	74.8	122	91.9	3.8	1.7	3.3	5.5	2.7	2.4	4.3	3	5	29.77	2.27
No. of locations	11	10	9	10	8	2	2	2	8	4	1	1	1	4	4
CV (%)	13.5	2.7	2	4.8	44	67	54	115	49	76	22.8	38	16	7.48	4.66
LSD (0.05)	501.9	1.8	2	3.9	1.7	2	4	13	1	3	1.3	2	2	3.11	0.15

[†]BYDV, *Barley yellow dwarf virus.*

[‡]WSBMV, *Wheat soilborne mosaic virus.*

[§]SB, Stagnospora blotch.

[¶]0 = erect; 9 = completely lodged.

[#]0 = no injury; 9 = complete kill.

[††]0 = immune; 9 = highly susceptible.

[‡‡]0 = highly resistant; 9 = highly susceptible.

[§§]Soft red winter wheat check cultivars.

Table 3. Mean performance of Vision 40 hard red winter wheat in the 2008–2009 USDA-ARS Uniform Bread Wheat Regional Nursery.

								Disease resistance								
								Stripe rust								
Cultivar	Yield	Grain volume weight	Head date	Plant height	Lodging	Winter stress	Winter survival	Infection type	Disease severity	Powdery mildew	Leaf rust	BYDV†	FHB‡	SB§	Kernel weight	Kernel diameter
	kg ha^{-1}	kg hL^{-1}	d after 1 Jan.	cm	0–9¶	0–9#	%	0–9††	%	0–9‡‡					mg	mm
Tribute§§	4690	76.6	117	86.4	3.8	4.0	100	3.0	45.0	5.5	1.0	2.9	2.3	5.0	29.81	2.28
Vision 30	4690	74.0	116	91.4	4.2	3.3	100	9.0	83.3	0.0	2.3	1.5	2.4	3.0	27.24	2.24
AGS 2000§§	4656	72.5	115	94.0	2.7	5.7	93	9.0	78.3	0.7	0.3	2.1	4.0	4.0	33.86	2.40
Vision 40	4482	71.8	120	91.4	3.5	2.0	100	4.5	36.7	3.6	1.8	0.3	7.0	5.0	26.91	2.21
Culpeper	4374	72.4	120	91.4	1.9	2.3	100		30.0	4.8	0.5	1.0	4.5	3.5	30.42	2.36
NuEast	4287	75.7	118	96.5	3.8	3.3	100	8.0	68.3	5.3	0.0	1.8	1.5	3.5	29.51	2.35
TAM 401	4058	73.1	114	88.9	5.2	4.0	100		10.0	4.9	0.2	3.5	2.3	4.5	27.00	2.15
Lakin	3924	74.0	118	91.4	3.3	2.0	100	9.0	66.7	5.7	6.0	2.5	3.8	4.5	28.31	2.24
Appalachian White	3857	73.9	124	94.0	3.6	1.7	100	2.0	7.5	3.3	0.5	2.7	2.9	1.5	27.72	2.29
TAM 303	3843	71.7	116	91.4	4.8	3.7	100	6.0	40.0	4.4	1.0	3.2	1.4	5.0	28.56	2.21
Jagger	3689	71.8	113	88.9	3.2	4.0	100	2.0	7.5	7.5	4.0	4.1	5.4	5.0	27.84	2.27
Jagalene	3474	70.4	117	88.9	1.7	2.7	100		10.0	7.6	4.2	2.8	5.4	5.5	28.50	2.34
Hondo	3420	74.2	123	94.0	3.1	2.3	100	8.0	88.3	4.0	2.7	3.4	0.9	3.5	26.82	2.20
Mace	2721	68.9	122	88.9	2.1	1.7	100		10.0	5.9	3.2	4.3	2.1	5.0	22.17	1.99
Mean (*N* = 50)	4027	72.5	118.8	90.9	2.8	3.3	97.4	6.2	37.5	2.9	1.6	2.8	3.4	4.2	29.41	2.31
No. of locations	12	11	8	10	6	3	2	2	3	4	2	5	2	2	9	9
CV (%)	11.9	4.6	2.2	4.9	45.5											
LSD (0.05)	383	2.8	2.5	3.9	1.4											

†BYDV, *Barley yellow dwarf virus.*

‡FHB, Fusarium head blight.

§SB, Stagnospora blotch.

¶0 = erect; 9 = completely lodged.

#0 = no injury; 9 = complete kill.

††0 = immune; 9 = highly susceptible.

‡‡0 = highly resistant; 9 = highly susceptible.

§§Soft red winter wheat check cultivars.

glume blotch [caused by *Stagonospora nodorum* (Berk.) Castellani & E.G. Germano] (4.0–5.0), and powdery mildew [caused by *Blumeria graminis* (DC) E.O. Speer] (2.4–3.6). Vision 40 is also moderately resistant to stripe rust (caused by *Puccinia striiformis* Westend.) based on average infection type (Line and Qayoum, 1992) ratings (0–9) from 4.5 to 6.0 and disease severity (0–100%) ratings from 6.0 to 36.7%. Vision 40 is susceptible to Fusarium head blight (FHB), having a visual rating of 7.0 and a 3-yr average (2007–2009) FHB index value of 31.2%. Therefore, growing Vision 40 in areas where high levels of FHB occur will require producers to be diligent in scouting fields and using fungicide management of FHB to produce sound grain free from mycotoxins. Reaction of Vision 40 to stem rust (caused by *Puccinia graminis* Pers.:Pers. f. sp. *tritici* Eriks. & E. Henn.), speckled leaf blotch (caused by *Septoria tritici* Roberge in Desmaz.), *Wheat spindle streak mosaic virus*, *Wheat streak mosaic virus*, and Hessian fly [*Mayetiola destructor* (Say)] is not known.

End-Use Quality

Independent milling- and baking-quality evaluations were conducted over three crop years (2008–2010) by the USDA-ARS Hard Winter Wheat Quality Lab in Manhattan, KS to evaluate grain hardness, milling characteristics, and bread-baking quality (Table 4). The average grain hardness score of Vision 40 (54.6) was most similar to that of 'Soissons' (PI 573744), which was 58.3. The straight-grade flour yields of Vision 40 (70.2 g 100 g^{-1}) were similar to those of Lakin (70.3 g 100 g^{-1}). Grain and flour protein concentrations of Vision 40 (10.5 and 9.5 g 100 g^{-1}) were similar to those of Lakin (10.9 and 9.5 g 100 g^{-1}). Vision 40 and Lakin had similar dough mixing tolerance (1.7 versus 2.3) and dough mixing times (2.13 versus 2.43 min). Vision 40 produced a 100-g pup loaf with an average loaf volume of 823 cm^3 compared with 803 cm^3 for Lakin.

Availability

The Foundation Seed Stocks Division of the Virginia Crop Improvement Association provided foundation seed of Vision 40 to seed producers during fall 2010. Marketing and distribution of Vision 40 will be handled by Virginia Identity Preserved Grains, LLC, West Point, VA. Recognized seed classes include Foundation and Certified. Application has been made for U.S. Plant Variety Protection for Vision 40. A seed sample has been deposited in the USDA-ARS National Center for Genetic Resources Preservation and will become available for distribution after expiration of its U.S. Plant Variety Protection. Small quantities of seed for research purposes may be obtained from the corresponding author for at least 5 yr after the date of this publication.

Acknowledgments and Disclaimer

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Table 4. Milling and baking quality of Vision 40 wheat in 2008– 2010 Virginia Tech tests conducted by the USDA-ARS Hard Winter Wheat Quality Laboratory, Manhattan, KS.

	Single-kernel hardness				Flour yield				Grain protein†				Flour protein†				Flour ash†			
Cultivar	2008	2009	2010	Mean	2008	2009	2010	Mean	2008	2009	2010	Mean	2008	2009	2010	Mean	2008	2009	2010	Mean
	0–100‡				g 100 g^{-1}															
Vision 30	52.6	65.4	70.0	62.7	71.8	67.8	70.1	69.9	11.6	11.4	12.3	11.8	10.5	10.3	11.4	10.7	0.417	0.427	0.370	0.405
Vision 40	43.0	59.8	61.0	54.6	70.7	68.4	71.6	70.2	10.1	10.0	11.4	10.5	9.1	8.8	10.5	9.5	0.432	0.442	0.419	0.431
Karl 92	51.8	68.2	62.6	60.9	70.8	63.9	72.1	68.9	12.0	12.8	12.7	12.5	10.7	10.9	11.4	11.0	0.447	0.402	0.393	0.414
Lakin	54.8	67.2	76.0	66.0	72.0	68.1	70.9	70.3	11.0	9.9	11.7	10.9	9.8	8.5	10.4	9.5	0.442	0.436	0.393	0.424
Soissons	45.8	62.3	66.7	58.3	74.6	71.4	72.4	72.8	10.3	11.1	11.7	11.0	9.4	10.2	10.5	10.0	0.446	0.433	0.421	0.434
Mean§	47.9	56.9	67.9	57.6	72.4	67.7	71.0	70.4	11.1	11.3	12.0	11.5	9.9	9.7	10.8	10.1	0.434	0.430	0.398	0.421
SD	9.9	19.4	15.3	14.9	1.2	2.0	1.0	1.4	0.6	0.9	0.5	0.7	0.5	0.9	0.6	0.6	0.0	0.0	0.0	0.0
CV (%)	20.8	34.1	22.5	25.8	1.7	2.9	1.5	2.0	5.5	8.2	4.0	5.9	4.9	8.8	5.6	6.4	5.6	7.3	6.9	6.6

	Flour water absorption				Dough mixing time				Dough mixing tolerance				Pup-loaf volume				Crumb grain score			
Cultivar	2008	2009	2010	Mean	2008	2009	2010	Mean	2008	2009	2010	Mean	2008	2009	2010	Mean	2008	2009	2010	Mean
	g 100 g^{-1}				min				0–6¶				cm^3				0–6#			
Vision 30	59.7	60.0	59.6	59.8	3.27	3.47	3.39	3.38	4	3	3	3.3	760	795	880	812	2.0	4.0	4.0	3.3
Vision 40	58.1	57.7	59.6	58.5	1.89	2.33	2.16	2.13	2	1	2	1.7	770	820	880	823	3.8	4.2	2.8	3.6
Karl 92	60.8	61.0	61.7	61.2	4.65	4.32	4.20	4.39	4	4	2	3.3	845	830	860	845	3.0	4.0	3.5	3.5
Lakin	59.7	57.0	60.7	59.1	2.56	1.80	2.92	2.43	3	2	2	2.3	810	750	850	803	4.0	3.0	4.0	3.7
Soissons	58.6	58.8	61.3	59.6	3.10	4.97	4.08	4.05	4	4	4	4.0	743	780	800	774	3.5	3.5	2.5	3.2
Mean§	59.3	58.8	60.2	59.4	2.9	2.9	3.1	2.9	3.2	2.7	2.5	2.8	783	797	845	809	2.9	3.4	3.2	3.2
SD	0.9	1.6	1.4	1.3	0.9	1.1	1.0	1.0	1.0	1.1	1.1	1.1	40.6	43.8	50.1	44.8	1.1	0.7	0.8	0.9
CV (%)	1.5	2.7	2.3	2.1	30.5	36.8	32.6	33.3	32.3	40.5	42.8	38.5	5.2	5.5	5.9	5.5	36.6	21.2	25.6	27.8

†Data adjusted to 14% moisture basis.

‡0 = very soft; 100 = very hard.

§Mean value of all entries evaluated in trial in 2008 (*N* = 25), 2009 (*N* = 32), and 2010 (*N* = 30).

¶0 = weak dough with poor mixing tolerance; 6 = strong dough with good mixing tolerance.

#0 = poor open grain; 6 = outstanding closed grain.