

## Registration of 'Secretariat' Winter Barley

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### Abstract

'Secretariat' (Reg. No. CV-359, PI 673931) is a six-row hulled winter barley (*Hordeum vulgare* L.) developed by the Virginia Agricultural Experiment Station and released in May 2014. Secretariat, formerly designated VA08B-85, was derived from the cross VA00B-199/VA00B-259 and developed using a modified bulk breeding method. It was evaluated from 2012 to 2015 in the Virginia Official Variety Trials at five to six locations. Secretariat's average grain yield (5907 kg ha<sup>-1</sup>) was higher than the check cultivars 'Atlantic', 'Price', 'Callao', 'Nomini', and 'Wysor' and similar to 'Thoroughbred'. Average grain volume weight of Secretariat (61.1 kg hL<sup>-1</sup>) was similar to Thoroughbred, Atlantic, Price, and Callao and higher than Nomini and Wysor. Head emergence of Secretariat is 6 d earlier than the predominant cultivar Thoroughbred. Earlier maturity is a primary factor determining whether barley or wheat (*Triticum aestivum* L.) is used in double-cropping systems with soybean [*Glycine max* (Merr.) L.]. Grain of Secretariat produced an average starch concentration (56.9%) that was higher than Price and Callao, similar to Atlantic, but lower than Thoroughbred. Secretariat provides barley producers and end users in the eastern United States with a high-yielding, widely adapted, early-maturing winter barley cultivar that has good grain quality and is highly resistant to leaf rust (caused by *Puccinia hordei* G. Otth) and powdery mildew [caused by *Blumeria graminis* (DC.) E.O. Speer f. sp. *hordei* Em. Marchal].

'SECRETARIAT' (Reg. No. CV-359, PI 673931) is a widely adapted, high-yielding, short-awned, six-row, hulled winter feed barley (*Hordeum vulgare* L.) cultivar. It is early maturing and short in stature with good winter hardiness, good straw strength, and high grain volume weight. Winter barley is an integral component of double-cropping systems in the eastern United States due to its early maturity in comparison to wheat (*Triticum aestivum* L.) (Browning, 2011; Camper et al., 1972). Both wheat and barley allow producers to extend the time available for planting and harvesting these crops and reduce the buildup of crop-specific pathogens. Secretariat provides producers in the eastern United States with an early-maturing and high-yielding barley cultivar that is resistant to leaf rust (caused by *Puccinia hordei* G. Otth) and powdery mildew [caused by *Blumeria graminis* (DC.) E.O. Speer f. sp. *hordei* Em. Marchal]. Secretariat has expressed higher levels of resistance to leaf rust than the cultivars 'Atlantic' (PI 665041; Brooks et al., 2014), 'Price' (PI 632708; Brooks et al., 2005a), and 'Callao' (PI 592800; Price et al., 1996) and is more resistant than 'Thoroughbred' (PI 634933; Brooks et al., 2005b) to powdery mildew and leaf rust. In addition to good kernel physical characteristics, Secretariat has a mean starch concentration (56.9%) similar to Price and Callao and a protein concentration (9.8%) similar to Atlantic, Thoroughbred, Price, and Callao. The principal end use of Secretariat grain is as feed, but its kernel

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**Abbreviations:** DON, deoxynivalenol; FHB, Fusarium head blight; IT, infection type; UBWHN, Uniform Barley Winter Hardiness Nursery; UWBYN, Uniform Winter Barley Yield Nursery.

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quality and grain compositional traits also provide biofuel (ethanol and grain by-products) industries with a valuable feedstock (Hicks et al., 2011; Khatibi et al., 2011). As an alternative feed ingredient, barley may reduce costs and increase profitability for growers and end users in the eastern United States in comparison to corn (*Zea mays* L.) (Pork Checkoff Board, 2008).

The cultivar name Secretariat was chosen in celebration and recognition of the Virginia thoroughbred racehorse that, in 1973, became the first US Triple Crown Winner in 25 yr and of the cultivar's notable performance in one or more of the barley production regions in the mid-Atlantic region of the eastern United States. Secretariat provides barley producers in North Carolina, Maryland, Pennsylvania, and Virginia with a high-yielding, early-maturing cultivar with good grain quality and high levels of resistance to the prevalent diseases except for Fusarium head blight (caused by *Fusarium graminearum* Schwabe).

## Methods

### Parentage, Breeding History, and Line Selection

Secretariat winter barley was derived from the cross VA00B-199/VA00B-259. Parentage of VA00B-199 is CMB82A-520/VA91-44-611//‘Pamunkey’ (PI 583865)/3/‘Callao’ (PI 592800). The ancestry of VA00B-259 is CMB74A-333//VA90-44-90/VA90-42-22/3/VA92-42-46/4/Callao.

The cross from which Secretariat was derived was made in spring 2002, and the  $F_1$  was grown in the field as a single 1.2-m headrow in 2003 to produce  $F_2$  seed. The population was advanced from the  $F_2$  to  $F_4$  generation using a modified bulk breeding method. Barley spikes were selected from the population in each segregating generation ( $F_2$ – $F_3$ ) on the basis of absence of disease, early maturity, short straw, and desirable head type and size. Selected spikes were threshed in bulk, and the seed was planted in 20.9-m<sup>2</sup> blocks at Blacksburg and/or Warsaw, VA, during the fall of each year. Spikes selected from the  $F_4$  bulk were threshed individually using a Wintersteiger Hege 16 laboratory thresher (Wintersteiger AG, Austria) and planted in separate 1.2-m headrows at Warsaw. Secretariat was selected on basis of disease resistance, early maturity, lodging tolerance, and agronomic type as a bulk of one of these  $F_{4,5}$  headrows in 2007. It was tested as entry 85 in nonreplicated observation yield tests at Blacksburg and Warsaw in 2008.

### Evaluation in Replicated Yield Trials

Secretariat, tested as VA08B-85, was evaluated in the Virginia Official Variety Trials at five to six locations from 2012 to 2015 (Virginia Tech Cooperative Extension, 2012–2015). It was also evaluated in the regional USDA-ARS Uniform Winter Barley Yield Nursery (UWBYN) and the Uniform Barley Winter Hardiness Nursery (UBWHN) conducted across four to seven environments in each of 4 yr (2012–2015). Data for these nurseries are available at USDA-ARS (2012–2015). The UWBYN trials were conducted at one or two locations per state (Georgia, Maryland, North Carolina, Nebraska, Texas, and Virginia). These trials were conducted using randomized complete block designs with two to four replications. Each cooperator used standard variety testing protocols and management

practices recommended for their respective state. Plant traits assessed visually (e.g., straw strength) were rated using an ordinal scale from 0 (no visible symptoms) to 9 (severe symptoms).

All replicated yield tests in Virginia were conducted according to protocols for small-grain production and management as recommended by Brann et al. (2000). Conventional-till yield plots in the Virginia Official Variety Trial were composed of seven rows with 17.8 cm between rows at Blackstone, Holland, Orange, and Painter, VA, and seven rows with 15.2 cm between rows at Warsaw and Blacksburg. The harvested plot length was 2.74 m at all locations. Tests were planted at 28 seeds per 0.304 m of row.

### Statistical Analyses

Statistical analyses were performed either in SAS version 9.3 (SAS Institute, 2011) or Agrobase Generation II (ver. 16.2.1; Agronomix Software, 2004). Analysis of variance of agronomic performance data from the Virginia Official Variety Trial was conducted on data from individual locations and years and across locations and years, which is routinely performed in official variety trials, using PROC GLIMMIX available in SAS. Genotypes, locations, and years were treated as fixed effects, while replication was treated as a random effect. Mean comparison among traits were tested using Tukey's honestly significant difference test ( $P = 0.05$ ) to identify significant differences among genotypes. Analysis of variance for the UWBYN data was conducted by year with Agrobase Generation II, with genotypes and locations treated as fixed effects. Mean comparisons of traits using a protected LSD ( $P = 0.05$ ) test were made to identify significant differences among genotypes.

### Disease Ratings

In field experiments, disease severity was rated using an ordinal scale varying from 0 (no visible symptoms) to 9 (severe symptoms) that is used predominantly in breeding programs (Poland and Nelson, 2011). Assessment of reaction to Fusarium head blight (FHB) was conducted in replicated, inoculated, and mist-irrigated nurseries according to the procedures described by Chen et al. (2006). Twenty spikes per plot were evaluated for FHB incidence and severity. Reaction of seedlings to races 8 and 30 and two isolates (ND89-3 and 3757) of leaf rust and a field composite of powdery mildew was assessed in greenhouse experiments (Berger et al., 2012). Ten to 14 d after inoculation, primary and secondary leaves were rated using the 0-to-4 scale as described by Levine and Cherewick (1952), where infection types (IT) 0 to 2 denote resistance and 3 to 4 denote susceptibility.

### Grain Quality Traits

Analyses of grain quality samples from barley lines grown in the 2010 to 2012 crop seasons at Warsaw were conducted by the USDA-ARS Eastern Regional Research Center according to the procedures described in Griffey et al. (2010). Starch concentration of barley flour was assessed using AACC Approved Method 32-32 and AOAC Approved Method 46-30 (AACC International, 2000; AOAC International, 2000). Protein concentration of barley flour samples was determined in accordance with standard methods (Approved Method 990.03) (Approved Method 46-30) (AACC International,

2000; AOAC International, 2000). Barley  $\beta$ -glucan concentration was analyzed using ICC Standard Method 168 (ICC International, 2008). Fat concentration of the grain was estimated based on the procedure described by Moreau et al. (2003). Ash concentration was determined in accordance with standard methods (Approved Method 08-01) (AACC International, 2000). In all cases, the results are reported on a dry weight basis.

## Seed Purification and Increase

During fall 2011, 400 F<sub>4,9</sub> headrows of Secretariat were planted in an isolation block and evaluated for purity and trueness of type. Among these breeder seed headrows, 85 rows were discarded on the basis of poor vigor, disease susceptibility, and variability as well as lack of trueness to cultivar type. The 315 remaining rows that were similar in phenotype and visually homogenous were harvested in bulk, and this initial breeder seed (35 kg) was planted on a 0.30-ha increase strip sown at the Virginia Crop Improvement Association's Foundation Seed Farm at Mount Holly, VA, in fall 2012. This increase strip produced about 873 kg of initial foundation seed. This seed was sown on 4.1 ha at the Virginia Crop Improvement Association's Foundation Seed Farm during fall 2013 and produced approximately 17,673 kg of Secretariat foundation seed that was sold in fall 2014 as registered or certified seed.

## Characteristics

### Botanical and Agronomic Characteristics

Juvenile plant growth of Secretariat is semiprostrate, flag leaves are slightly waxy and upright at the booting stage, leaf sheaths and stems are slightly waxy, and anthocyanin is not present in leaves or stems. The stems have five nodes, closed collars, "slightly curved" peduncles, and an exertion of 0 to 3 cm above the base of the flag leaf blade. The six-row spikes of Secretariat are erect, dense, strap, and slightly waxy with no overlapping lateral kernels. The rachis is covered with short hairs. Glumes are midlong, with short hairs, and their awns are rough and less than equal to length of the glumes. The lemma

awn surfaces are rough and awns are short and less than equal to length of spike. The basal marking of the lemma is a depression. Rachilla hairs are short. Kernels are covered and short to midlong with a colorless aleurone and lacking hairs on the ventral furrow.

Data presented here (Tables 1 and 2) are means over years and locations from the 2012 to 2015 Virginia Official Variety Trials and the UWBYN (USDA-ARS, 2012–2015). In Virginia (Table 1), average spike emergence (days from 1 Jan.) of Secretariat (107 d) is similar to that of Price and 6 d earlier than Thoroughbred. In the UWBYN, spike emergence of Secretariat varied from 94 to 118 d (Table 2). Average plant height of Secretariat (81 cm) in Virginia is similar to that of Price, 6 cm taller than Callao, and 7 cm shorter than Thoroughbred, while plant height of Secretariat in the UWBYN varied from 76 to 86 cm. In Virginia, straw strength (on a 0–9 scale where 0 = no lodging, 9 = completely lodged) of Secretariat (4) is better than that of Callao (6), while it varied from 3 to 6 in the UWBYN. Winter hardiness for Secretariat in the UWBYN (Table 2) from 2013 to 2015 varied from 71 to 97% and was similar to that of Atlantic.

On the basis of data (Table 2) from 20 environments in the 2012 to 2015 UBWHN (USDA-ARS, 2012–2015), the mean winter hardiness (0–100% survival) of Secretariat varied from 42 to 74% compared with means from 44 to 88% for the check cultivar Kentucky 1 (CIho 6050). The 4-yr (2012–2015) average winter survival of Secretariat was 71.4% versus 79.3% for Tennessee Winter (PI 11193, CIho 257), 76.9% for Kentucky 1, and 53.5% for the winter-tender check cultivar Trebi (PI 537442, CIho 936; Wiebe, 1965). Complete data for UBWHN are available at USDA-ARS (2012–2015).

### Line Evaluation

In Virginia, the 4-yr (2012–2015) average grain yield of Secretariat (5907 kg ha<sup>-1</sup>) was similar to that of Thoroughbred but higher than those of the other barley cultivars (Atlantic, Price, Callao, and Nomini) currently grown in the mid-Atlantic and southeastern United States (Table 1). The average grain volume

**Table 1. Agronomic performance and disease reaction of winter barley cultivar Secretariat against six check cultivars in the Virginia Official Variety Trial, 2012–2015.**

Cultivar	Grain yield	Volume weight	Days to heading	Plant height	Straw strength	Leaf rust	Powdery mildew	Net blotch
	kg ha <sup>-1</sup>	kg hL <sup>-1</sup>	d	cm	0–9†		0–9‡	
Secretariat	5907	61.1	107	81	4.3	0.5	0.4	2.2
Thoroughbred	5723	60.5	113	88	3.4	6.0	4.4	2.7
Atlantic	5592	60.7	105	79	4.6	3.3	0.4	2.7
Price	5394	60.5	107	81	3.6	3.9	0.7	4.6
Callao	5061	60.3	105	75	6.1	3.5	0.4	2.5
Nomini	4883	57.1	106	96	2.4	3.9	0.4	0.9
Wysor	4705	56.0	108	96	3.5	5.7	0.2	3.4
Average (n = 7)	5321	60.0	107	83	4.0	3.8	1.0	2.7
HSD (0.05)§	323	1.8	0.8	2.6	0.6	0.8	0.7	1.4
CV (%)	11.7	6.8	0.4	13.1	0.4	0.4	0.4	0.5
Location-years	22	22	9	12	22	9	7	10

† 0 = no lodging; 9 = completely lodged.

‡ 0 = highly resistant; 9 = highly susceptible.

§ HSD, Tukey's honestly significant difference.

weight of Secretariat (61 kg hL<sup>-1</sup>) was higher than that of the check cultivars Nomini and Wysor (PI 501526; Starling et al., 1987). In the UWBYN (Table 2), mean grain yields of Secretariat varied from 5853 to 6472 kg ha<sup>-1</sup> and were similar to those of Atlantic and Thoroughbred in all years (2012–2015) and higher than Wysor and ‘Tambar 501’ (PI 620639; Marshall et al., 2003) in 2 (2012 and 2015) of 4 yr. Average grain volume weight of Secretariat varied from 61.3 to 62.3 kg hL<sup>-1</sup>, which was similar to that of Atlantic in all 4 yr, to that of Thoroughbred in 3

(2012, 2014, and 2015) of 4 yr, but higher than that of Wysor in all years.

## Disease Evaluation

In field trials, reaction of Secretariat to diseases (0 = no disease to 9 = severe infection) evaluated across diverse environments is presented in Tables 1 and 2. Secretariat is highly resistant to leaf rust and powdery mildew and resistant to net blotch (caused by *Pyrenophora teres* f. *teres* Smedeg.). On average, Secretariat

**Table 2. Agronomic performance of winter barley cultivar Secretariat and check cultivars evaluated in the Uniform Winter Barley Yield Nursery (UWBYN) and Uniform Barley Winter Hardiness Nursery (UBWHN) from 2012 to 2015.†**

Cultivar	Grain yield	Volume weight	Days to heading	Plant height	Straw strength	Leaf rust	Powdery mildew	Net blotch	Winter survival	Winter survival (UBWHN)
	kg ha <sup>-1</sup>	kg hL <sup>-1</sup>	d	cm	0–9‡	—————0–9§—————	—————0–9§—————	—————	%	%
<b>2012</b>										
Secretariat	6219	62.3	94	78	4.5	0.7	1.0	2.9	–	74.0
Atlantic	5800	62.6	93	80	5.2	3.0	0.2	2.4	–	68.0
Thoroughbred	6289	62.8	98	84	2.7	4.8	6.9	2.5	–	–
Wysor	5348	58.9	94	90	4.2	4.0	0.0	3.0	–	–
Tambar 501	5192	58.7	96	92	3.6	1.0	3.2	4.9	–	–
Grand mean (all lines)	5185	65.7	95	84	4.0	2.7	2.9	3.2	–	77.0
CV (%)	12.9	9.1	2.1	15.3	41.3	39.5	54.6	57.6	–	6.0
LSD (0.05)	591	4.3	1.9	4.2	1.6	1.8	2.8	3.2	–	9.4
No. of locations	7	6	6	7	6	2	2	2	–	6
<b>2013</b>										
Secretariat	5853	61.9	118	86	5.6	1.0	2.5	3.4	97	70
Atlantic	5671	60.6	117	84	4.9	5.5	1.4	5.2	97	70
Thoroughbred	5606	59.8	124	90	3.9	7.7	7.0	4.7	93	–
Wysor	5278	56.9	120	99	5.9	8.0	0.5	4.2	98	–
Tambar 501	5784	54.3	121	99	5.4	1.3	6.0	6.6	98	–
Grand mean (all lines)	5054	63.4	122	91	4.7	4.5	3.9	4.2	92	78
CV (%)	15.1	4.4	1.5	15.4	40.8	21.6	30.0	44.5	13.5	4.6
LSD (0.05)	594	1.8	2.2	4.6	1.7	1.7	2.0	2.6	21.6	7.7
No. of locations	9	8	4	8	7	2	2	3	2	4
<b>2014</b>										
Secretariat	6262	62.3	114	77	3.1	1.0	1.0	1.7	82	57
Atlantic	6348	60.7	113	78	4.0	6.0	0.3	2.2	75	57
Thoroughbred	5870	60.7	120	86	3.0	8.3	5.3	2.2	81	–
Wysor	5171	57.9	117	92	3.5	8.7	0.5	1.5	68	–
Tambar 501	5698	54.9	116	88	3.7	2.5	4.5	4.3	81	–
Grand mean (all lines)	5599	61.5	116	86	3.6	5.1	2.4	1.8	85	64
CV (%)	12.5	5.0	1.2	12.6	29.8	17.2	73.5	65.8	17.3	8.3
LSD (0.05)	619	2.1	1.6	4.1	1.0	1.2	2.2	1.0	20.2	11.1
No. of locations	7	7	4	6	6	2	2	2	4	5
<b>2015</b>										
Secretariat	6472	61.3	105	76	4.7	1.0	0.0	0.7	71	42.0
Atlantic	5719	58.2	104	72	5.2	7.3	0.0	1.5	67	–
Thoroughbred	6122	59.7	110	85	4.4	8.7	7.0	1.2	63	–
Wysor	5112	56.1	106	91	5.5	9.0	0.0	2.0	64	–
Tambar 501	5391	54.6	107	88	6.6	4.3	5.0	2.3	84	–
Grand mean (all lines)	5445	60.7	108	83	5.1	5.0	1.7	1.3	73	52.0
CV (%)	11.7	5.5	1.1	14.7	33.0	15.3	44.7	87.1	20.4	10.0
LSD (0.05)	757.9	3.1	1.4	5.6	2.0	1.1	1.0	1.1	20.6	11
No. of locations	4	4	4	4	4	1	1	2	3	5

† Complete data available at USDA-ARS, 2012–2015.

‡ 0 = no lodging; 9 = completely lodged.

§ 0 = highly resistant; 9 = highly susceptible.

had leaf rust ratings that varied from 0.7 to 1.0 compared with average scores of 4.0 to 9.0 for the susceptible cultivar Wysor, which has gene *Rph7*. Secretariat is highly resistant (0 to 2.5) to powdery mildew compared with Thoroughbred (5.3 to 7.0) and resistant to net blotch (0.7 to 3.4) compared with Tambar 501 (2.3 to 6.6) based on data from the UWBYN (Table 2). In inoculated and mist-irrigated FHB field tests, composed of replicated yield plots, Secretariat expressed moderate susceptibility to FHB and deoxynivalenol (DON) accumulation. The mean reactions of Secretariat to FHB evaluated at Mount Holly, VA, from 2013 through 2015 are shown in Table 3. Secretariat had mean FHB values for incidence of 88%, severity of 30%, index (0–100) of 29, DON concentration of 21 mg kg<sup>-1</sup> and fusarium damaged kernel of 37%. These FHB disease values are similar to those of cultivars Atlantic and Thoroughbred but significantly higher than that of the resistant cultivar Nomini.

In seedling leaf rust tests (data not presented), Secretariat was highly resistant to *P. hordei* isolate 3757 (IT = 0TrN), race 8 (IT = 0), and race 30 (IT = 0) but susceptible (IT = 3C) to isolate ND89-3 compared with average scores of 4 for the universal susceptible check cultivar Barsoy. The virulence/avirulence formulae for these *P. hordei* pathotypes include isolate 3757 (genes *Rph1.a, 2, 3.c, 4, 2+6, 7, 8, 9i, 10, 11/Rph5, 9.z, 14.ab* and *15.ad*), race 8 (*Rph 1.a, 4.d, 8.h, 10.o, 11.p/Rph 2, 3.c, 5.e, 6.f, 7, 9.i, 9.z, 13.x, 14.ab, 15.ad*), race 30 (*Rph 1.a, 2, 4.d, 6.f, 7, 8.h, 11.p/*

*Rph 3.c, 5, 9.i, 9.z, 10.o, 13.x, 14.ab, 15.ad*), and isolate ND89-3 (*Rph 1.a, 2, 4.d, 5.e, 6.f, 7.g, 8.h, 10.o, 11.p/Rph 3.c*). Seedlings of Secretariat also were highly resistant (IT = 0–1) to a *B. graminis* field composite of powdery mildew compared with those of Thoroughbred (IT = 3–4).

## End-Use Grain Quality

Barley grain quality samples from 2010 to 2012 crops (Table 4) were analyzed for starch, protein, β-glucan, ash, and crude fat concentration. Average starch concentration of Secretariat (56.9%) was similar to the check cultivars Atlantic, Price, and Callao but lower than that of Thoroughbred. Average protein concentration of Secretariat (9.8%) was similar to Atlantic, Price, and Thoroughbred. Average β-glucan concentration of Secretariat (4.7%) was similar to that of Atlantic, Price, Thoroughbred, and Callao. The ash concentration of Secretariat (2.5%) was similar to those of Atlantic, Price, and Callao but higher than Thoroughbred. The crude fiber content of Secretariat (1.6%) was similar to Price but lower than those of Atlantic, Thoroughbred and Callao.

## Availability

The Virginia Crop Improvement Association will be responsible for distribution of Secretariat foundation seed through the

**Table 3. Three-year average summary of reaction of entries in the Virginia Official Variety Trial to Fusarium head blight (FHB), 2013–2015 harvests.**

Cultivars	FHB incidence†	FHB severity‡	FHB index§	DON¶	FDK#
	%	%	0–100	mg kg <sup>-1</sup>	%
Secretariat	88	30	29	21	37
Atlantic	90	32	31	18	56
Nomini	74	16	15	11	46
Wysor	85	19	18	17	38
Callao	92	23	23	18	66
Thoroughbred	92	28	28	26	38
Price	92	32	32	25	40
Mean (n = 20)	88	26	25	18	49
LSD (0.05)	8.6	8.5	8.7	2.0	9.8
CV (%)	8.4	28.5	29.6	9.1	15.6

† FHB incidence = (number of infected spikes/total number of spikes) × 100.

‡ FHB severity = (number of infected spikelets/total number of spikelets) × 100.

§ FHB index = (% incidence × % Severity)/100.

¶ DON = deoxynivalenol content in harvested seed samples.

# FDK = percentage of fusarium damaged kernels in samples of 100 seeds.

**Table 4. Three-year (2010–2012 crops) summary of grain composition of Secretariat barley performed by the USDA-ARS.†**

Cultivar	Moisture ground sample	Starch	Protein	Beta Glucan	Ash	Crude fat
	%‡					
Secretariat	9.4	56.9	9.8	4.7	2.5	1.6
Atlantic	9.6	57.2	10.3	4.5	2.3	2.3
Thoroughbred	9.7	59.9	9.5	4.1	2.2	2.0
Price	9.2	55.2	10.3	4.4	2.5	1.8
Callao	9.3	55.5	11.0	4.6	2.3	2.0
Mean (n = 24)	9.8	60.5	11.0	4.5	2.1	1.9
LSD (0.05)	0.6	3.2	1.4	0.5	0.2	0.5
CV (%)	4.0	3.2	7.9	7.4	4.9	15.9

† Data provided by USDA-ARS Eastern Regional Eastern Regional Research Center, PA 19038.

‡ Percentage determined on a dry-weight basis.

Foundation Seed Farm at Mount Holly, VA. Small amounts of seed may be obtained from the corresponding author for research purposes. Secretariat has been deposited in the National Plant Germplasm System and will be available for distribution after 5 yr from the date of this publication.

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