Progress Report for 2015-16

Virginia Small Grains Board

Improvement and Development of Barley for use in Feed, Malt, and Fuel

Wynse S. Brooks, Mark E. Vaughn, Subas Malla and Carl A. Griffey
Virginia Polytechnic Institute and State University

The Virginia Tech barley breeding program is devoted to the development of barley cultivars that will result in the restoration and expansion of barley production throughout the mid-Atlantic and southeastern U.S. We utilize the best available genetic and agronomic technologies to accomplish this objective.

The primary objective of this project is designed to assess the yield potential of elite barley lines to determine genetic factors contributing to improved yield potential in barley. The specific objectives of this project are: 1) to assess and improve yield potential and other desirable traits such as resistance to diseases (leaf rust, powdery mildew, net blotch and Fusarium Head Blight-FHB); 2) to develop barley cultivars that are superior to current high yielding cultivars Secretariat, Atlantic and Thoroughbred using both conventional and marker assisted breeding methods; and 3) to develop and deploy DNA markers associated with yield and its components.

The main activities and accomplishments of the Virginia Tech Barley Breeding Program during the 2015-2016 crop season are as follows. Our primary breeding efforts were focused on development and improvement of yield potential of winter barley cultivars and a major focus on incorporation of value added traits geared towards development of new markets. As a result, we have initiated population development and a series of field testing trials to develop superior winter malt barley cultivars that are widely adapted in Virginia and surrounding states. One elite hulled (VA11B-141) barley line is being considered as a potential release candidate. This elite barley line has improved grain yield potential across a broad range of production conditions and has excellent seed qualities. Breeder seed for this advanced line is being multiplied at the Virginia Crop Improvement Foundation seed farm and a decision to submit this line for release will be made in fall 2017.

Meanwhile, our current breeding strategy is to select and use superior germplasm from the Winter Malt Barley Trial (WMBT) as parents in crosses with elite material from our program. We will develop winter malt barley cultivars that are valuable to local producers and the malting and brewing industries. In the interim, cultivars from the WMBT possessing good agronomic characteristics and malt quality will be identified and evaluated in yield tests in our breeding program. If results are favorable, malt barley cultivars with superior malt quality, improved grain yield and excellent disease resistance will be recommended for production in the eastern U.S. In addition, to accelerate development of superior, widely adapted, high yielding winter barley cultivars, our breeding program in collaboration with Oregon State University has initiated development of pure lines using double-haploid techniques. Malt barley double-haploid lines are being evaluated from a cross made between the two- rowed winter malt barley cultivar Endeavor and an elite Virginia barley line (VA09B-34) having malting characteristics similar to ‘Thoroughbred’. An initial set (48) of these double haploid lines was planted in a preliminary test last fall (2016) and will be evaluated at two locations (Blacksburg and Warsaw) this season (2016-2017). The remaining DH lines were planted in an observation test and will also be evaluated at locations in Blacksburg and Warsaw, VA. Pure lines possessing good agronomic characteristics and malt quality will be selected and advanced in yield tests in our program. In spring of 2015, three crosses were made between Virginia varieties (Nomini and Secretariat) and superior malt

barley cultivars (Violetta, KWS Scala and Endeavor) from the WMBT for FHB resistance, superior malt quality and high yield and are being used to produce DH Lines.

Significant progress continues to be made in the development of high value winter barley lines. We will continue to evaluate new winter barley lines for potential release. We continue to make progress improving resistance to FHB in the program. We are using marker assisted selection for FHB resistance and have also initiated a Single Seed Decent (SSD) method to rapidly develop FHB mapping populations. Other breeding populations, derived from crosses with barley lines introduced from various programs including sources of FHB resistance and winter malt barley lines, are being advanced in the program. Many lines have improved yield, straw strength and grain plumpness and have better resistance to diseases (eg. leaf rust, powdery mildew, net blotch, and FHB).

Performance data for hulled barley entries in the Virginia Tech State Barley Trials conducted at six locations in 2016 are presented in Table 1. The best hulled barley experimental lines VA14B-59 (98 Bu/ac) yielded 2 Bu/ac more than Secretariat, 12 Bu/ac higher than Atlantic, 14 Bu/ac higher than Thoroughbred, and 13 Bu/ac better than the test average. Two other Virginia experimental lines (VA14B-74 and VA14B-79) ranked 2nd and 3rd, respectively in grain yield.

Three year (2014, 2015 and 2016) average performance data of hulled barley entries evaluated in the Virginia Tech State Barley Trial are shown in Table 2. The experimental line VA12B-8 had the highest two-year average grain yield (102 Bu/ac) that was similar to Secretariat, one bushel per acre higher than Thoroughbred, 6 bushel per acre higher than Atlantic, 10 bushel per acre higher than Price and 11 bushel per acre higher than overall test average. Another Virginia experimental line VA11B-102, had grain yield that was similar to Thoroughbred (101 Bu/ac), 5 bushels per acre higher than Atlantic, and significantly higher than overall test average. These results are encouraging and indicate that significant progress is being made by the breeding program in developing high yielding barley cultivars with improved disease resistance.

Agronomic performance data of yield and test weight of entries in the Winter Malt Barley Trials conducted at multiple locations (Virginia (VA), Maryland (MD), North Carolina (NC), and Georgia (GA) in 2016 are presented in Tables 3a. Mean grain yield of the winter malt barley cultivar Hirondella was the highest (81 Bu/ac) among 28 entries over all states (4) and yielded 5 bushel per acre higher than the winter barley check cultivar Thoroughbred (AMBA recommended), 16 bushel per acre higher than Endeavor, 31 bushel per acre more than Wintmalt, and 32 bushel per acre higher than Charles. Two other winter malt barley cultivars Calypso and 10/069/1 ranked 3rd and 4th respectively in grain. In Virginia, the average grain yield of the malt barley cultivar Hirondella (107 Bu/ac) was 7 bushel per acre higher than Thoroughbred, 32 bushel per acre higher than Endeavor, 41 bushel per acre higher than Wintmalt and 42 bushel per acre more than Charles. In Maryland, grain yield of Hirondella (114 Bu/ac) was similar to Wintmalt, 3 bushel per acre higher than Thoroughbred, 22 bushel per acre higher than Endeavor and 40 bushel per acre higher than Charles. In North Carolina, grain yield of Hirondella (90 Bu/ac) was higher than those of the check cultivars (Thoroughbred, McGregor, Endeavor, Strider, Wintmalt and Charles). However, in Georgia, the winter malt barley variety Hirondella ranked 8th in grain yield. Meanwhile, based on summary of seven commonly assessed agronomic traits presented in Table 3b; Hirondella also has better resistance (0 = no disease, and 9 = severe infection) to leaf rust (1) than the check cultivars Thoroughbred (5), McGregor (4), Endeavor (7), Strider (5), Wintmalt (4) and Charles (8) and better resistance to BYDV (1) than Thoroughbred, McGregor and Charles.

Summary of malt quality of entries in the 2015-2016 Winter Malt Barley Trials (WMBT) at locations in Blacksburg and Warsaw, VA conducted by the USDA-ARS Cereal Crop Research Unit in Madison, WI are presented in Table 4. The malt barley experimental line 10.086 had the highest average quality score (53). Malt quality traits and values for variety 10.086 include malt extract value (82%), protein (13%), Diastatic Power (154 °ASBC), Beta glucan (140 ppm) and Fan (250 ppm). Another malt barley experimental line 04ARS640-1 ranked 2nd in overall malt quality score that was similar to the malt barley check cultivar Endeavor (48), but better than Charles, Strider, McGregor, Thoroughbred and Wintmalt. Malt quality score for cultivar Hirondella (35) was higher than Charles, Strider, McGregor and Thoroughbred, but lower than Endeavor and Wintmalt. Our breeding program plans to continue to build on the data collected on these varieties and evaluate and select superior malt barley lines each year from the WMBT, in order to determine which lines are best suited to provide the yields and quality sought by craft maltsters and brewers in the eastern U.S.

Table 1. Summary of performance of barley entries in the Virginia Tech Barley Test, 2016 harvest.

Barley Lines	Yield (Bu/a @ 48 lb/bu)		Test Weight (Lb/bu)		Date Headed (Julian)		Height (In)		Lodging (0-9)		Leaf Rust (0-9)		Net Blotch (0-9)		Powdery Mildew (0-9)		Barley Yellow Dwarf Virus (0-9)		Winter Survival (%)		Awns[1]
	(4)		(4)		(2)		(2)		(4)		(1)		(3)		(2)		(1)		(1)		
VA14B-59	97.6	+	43.5		110		31		3		2	-	4	-	0		0		93	-	SA
VA14B-74	97.3	+	44.0		112	+	32		3		1	-	4	-	0		0		95		SA
VA14B-79	95.8	+	43.9		110		31		3		2		5		0		0		95		SA
Secretariat	95.6	+	45.8	+	108	-	30	-	3		1	-	6		0		0		95		SA
VA14B-57	94.7	+	45.0		110		32		3		4		5		0		0		94		SA
VA14B-73	94.3	+	43.7		111		32		2		2	-	3	-	0		0		95		SA
VA14B-63	94.1	+	44.0		111		32		3		3		4	-	0		0		94		SA
VA11B-102	92.9	+	42.5		113	+	35	+	4	+	4		5		0		0		99		LA
VA14B-75	92.7	+	43.5		110		31		3		2		4	-	0		0		96		SA
VA12B-41	92.3	+	43.8		110		31		3		2		5		0		0		96		SA
VA12B-56	90.9	+	43.2		108	-	30	-	3		3		5	-	0		0		96		SA
VA14B-78	90.8	+	44.1		109	-	32		3		3		6		0		0		96		SA
VA14B-71	90.4	+	45.1	+	110		33		3		2	-	4	-	0		0		98		SA
VA14BFHB-83	88.7		44.7		109		32		5	+	2	-	6		0		0		96		SA
VA13B-25	88.7		45.1	+	109	-	32		4	+	4		5	-	0		0		98		LA
VA12B-30	88.5		43.3		113	+	32		3		4		7		0		0		97		SA
VA12B-8	87.6		44.4		111	+	33		3		5	+	8	+	1		0		97		LA
Atlantic	87.5		44.4		107	-	31		4		5	+	8	+	0		0		95		SA
VA11B-141	87.1		45.4	+	112	+	35	+	3		3		5		0		1	+	99		LA
VA08B-95	87.0		42.8		108	-	31		3		2	-	5		8	+	0		96		SA
VA14B-66	86.6		43.1		111	+	32		3		2	-	5		0		0		94		SA
VA12B-129	86.4		43.6		113	+	34	+	3		3		8	+	0		0		99		LA
VA14B-116	86.4		43.8		113	+	31		2	-	5	+	4	-	0		0		96		SA
VA09B-34	84.5		46.0	+	107	-	31		3		2	-	6		2	+	0		98		LA
Thoroughbred	84.4		44.3		113	+	31		2		5	+	9	+	6	+	0		99		LA
Callao	82.7		44.7		107	-	29	-	5	+	5	+	6		0		0		94		SA
VA14B-36	81.1		43.3		109		30	-	2		4		5		0		4	+	98		LA
VA13B-48	80.4		44.8		112	+	33		3		3		3	-	0		1	+	97		LA
VA13B-15	79.3	-	43.4		112	+	35	+	3		2	-	6		0		0		94		LA
Violetta	73.7	-	44.5		114	+	25	-	2	-	2	-	5		0		2	+	99		LA
Price	73.5	-	44.5		108	-	30	-	3		6	+	9	+	1		0		95		SA
Barsoy	71.9	-	43.0		107	-	32		3		7	+	7	+	1		3	+	98		LA
Nomini	70.5	-	38.7	-	108	-	36	+	3		4		7	+	0		0		98		AL
Wysor	54.9	-	37.5	-	110		34	+	3		7	+	8	+	0		0		99		AL
VA92-42-46	52.8	-	41.1	-	108	-	34	+	3		1	-	9	+	0		0		97		AL
Average	85.3		43.7		110		32		3		3		6		1		0		96		
LSD (0.05)	5.2		1.4		1		1		1		1		1		1		1		3		
C.V.	7.9		4.2		1		5		39		26		13		114		156		2		

Released cultivars are shown in bold print.

The number in parentheses below column headings indicates the number of locations on which data are based.

Varieties are ordered by descending yield averages.

A plus or minus sign indicates a performance significantly above or below the test average.

The 0-9 ratings indicate a genotype's response to disease or lodging where 0 = highly resistant and 9 = highly susceptible.

[1] LA=long awned, SA=short awned, AL=awnletted or awnless.

Table 2. Three year average summary of performance of hulled entries in the Virginia Tech Barley Tests, 2014, 2015, and 2016 harvests.

Barley Lines	Yield (Bu/a @ 48 lb/bu)		Test Weight (Lb/bu)		Date Headed (Julian)		Height (In)		Lodging (0-9)		Leaf Rust (0-9)		Net Blotch (0-9)		Powdery Mildew (0-9)		Early Lodging (0-9)		Winter Survival (%)	
	(16)		(16)		(6)		(8)		(15)		(4)		(9)		(5)		(1)		(3)	
VA12B-8	102.2	+	47.4		115	+	35	+	3	-	5	+	3		1		1	-	96	
Secretariat	102.2	+	48.1	+	112	-	31	-	4	+	1	-	2		0	-	5		92	-
VA11B-102	101.0	+	46.0	-	116	+	36	+	4	+	3	-	1	-	0	-	2		97	+
Thoroughbred	100.8	+	47.7	+	118	+	34		3		6	+	4	+	4	+	3		96	
VA11B-141	98.5	+	48.7	+	115	+	36	+	3	-	2	-	2	-	0	-	2		95	
Atlantic	96.4	+	47.5	+	111	-	31	-	4	+	4	+	3		0	-	3		93	
VA08B-95	93.8		46.2		112	-	33	-	4	+	2	-	2	-	6	+	7	+	93	
Price	92.4		47.4		113	-	31	-	4		5	+	5	+	0	-	3		92	-
VA09B-34	92.0		49.3	+	111	-	33	-	3	-	1	-	2	-	1		2	-	96	
Callao	87.9		47.7	+	110	-	29	-	6	+	4		3		0	-	7	+	93	
Barsoy	86.7		47.2		112	-	34		4		7	+	3		1		2		94	
Violetta	85.5	-	47.4		119	+	30	-	2	-	1	-	2	-	0	-	0	-	96	
Nomini	77.0	-	43.5	-	111	-	37	+	3	-	5	+	2	-	0	-	3		96	
Wysor	70.6	-	42.6	-	113		37	+	3		7	+	3	+	0	-	4		98	+
VA92-42-46	70.2	-	44.6	-	113	-	37	+	3	-	1	-	6	+	0	-	4		93	
Average	90.5		46.7		113		34		4		4		3		1		3		95	
LSD (0.05)	4.0		0.7		0		1		0		1		1		0		2		2	
C.V.	11.4		4.0		1		5		32		22		40		73		36		3	

Released cultivars are shown in bold print.

The number in parentheses below column headings indicates the number of location-years on which data are based.

Varieties are ordered by descending yield averages.

A plus or minus sign indicates a performance significantly above or below the test average.

The 0-9 ratings indicate a genotype's response to disease or lodging where 0 = highly resistant and 9 = highly susceptible.

Table 3a. Summary of performance of yield and test weight at multiple locations in the Winter Malt Barley Trial (2015-16)*

Lines	Row Type	Mean Yield Across States	Mean Test Weight Across States	VA Yield (bu/a)	VA Test Weight (lb/bu)	MD Yield (bu/a)	MD Test Weight (lb/bu)	NC Yield (bu/a)	NC Test Weight (lb/bu)	GA Yield (bu/a)	GA Test Weight (lb/bu)
Hirondella (08/258/17)	6	81	44.2	107	42.6	114	46.4	90	46.6	59	39.8
Calypso	2	71	40.8	94	43.5	117	44.5	55	39.0	40	35.4
10/069/1	6	71	42.5	93	41.1	120	46.0	51	43.6	58	38.4
MW11S4029-002	6	70	43.7	75	40.6	75	41.8	76	48.4	95	42.7
MW12_4007-008	6	65	43.5	85	43.6	89	42.1	40	48.8	70	38.9
SU-Mateo	2	62	45.3	85	43.8	108	46.7	44	43.5	37	46.3
04ARS640-1	2	61	47.7	60	43.2	83	47.5	73	53.9	82	45.5
6W13-7145	6	56	42.2	55	38.9	96	44.0	37	45.0	64	38.5
MW12_4042-002	6	53	42.2	43	39.0	101	41.9	56	44.9	52	41.7
6W11-0003	6	53	42.6	57	36.6	97	43.0	63	45.1	17	na
MW11S4024-004	6	52	41.8	51	36.8	84	41.8	41	47.5	63	39.2
10.086	2	51	42.9	72	43.8	88	44.4	49	42.6	52	40.4
10.0777	2	51	43.6	67	42.2	83	42.9	64	44.7	50	43.5
DH130718	2	44	42.7	39	39.8	76	44.0	43	46.2	50	43.3
Vincenta	2	44	39.8	55	38.8	88	44.0	26	36.2	25	37.7
DH130004	2	43	43.5	44	40.9	69	47.1	33	42.2	52	43.9
Puffin	6	43	42.7	51	43.6	99	48.1	22	35.7	24	42.5
06ARS633-10	2	43	39.8	46	34.7	87	42.9	36	40.7	32	37.7
02Ab669	2	43	43.6	48	39.1	75	46.2	40	46.3	34	40.7
6W13-7041	6	40	38.3	51	37.3	88	45.2	8	29.2	16	na
6W11-0064	6	36	41.3	44	35.4	75	41.0	7	44.4	23	na
05ARS561-208	2	31	38.2	41	35.6	66	43.2	28	34.9	6	na
Charles (Check)	2	49	39.9	65	37.3	74	42.6	53	40.2	35	38.1
Strider (Check)	6	51	41.3	65	34.6	89	44.8	47	44.9	39	38.3
McGregor (Check)	6	68	44.2	96	40.8	106	44.6	68	46.2	43	45.2
Endeavor (Check)	2	65	47.0	75	42.6	92	47.2	80	50.8	62	46.1
Thoroughbred (Check)	6	76	44.4	100	44.9	111	47.1	69	44.9	71	41.9
Wintmalt (Check)	2	50	43.5	66	43.6	114	46.2	38	37.4	12	46.7
Average		**54**	**42.6**	**65**	**40.2**	**92**	**44.5**	**48**	**43.3**	**45**	**41.4**
Minimum		**31**	**38.2**	**39**	**34.6**	**66**	**41.0**	**7**	**29.2**	**6**	**35.4**
Maximum		**81**	**47.7**	**107**	**44.9**	**120**	**48.1**	**90**	**53.9**	**95**	**46.7**

*Data collected from locations for each trait as available. Traits presented are those with data available from multiple locations. Data were collected at the following locations: Virginia (VA), Maryland (MD), North Carolina (NC), and Georgia (GA).

Table 3b. Summary of performance of eight commonly assessed traits at multiple locations in the Winter Malt Barley Trial (2015-2016)*

Line	Head Date (Julian)	Height (In)	Lodge (0-9)	Powdery Mildew (0-9)	Leaf Rust (0-9)	Yellow Dwarf (0-9)	Net Blotch (0-9)	Winter Survival (%)
Hirondella (08/258/17)	96.6	28.6	1.7	0.0	1.0	0.6	3.4	84.5
Calypso	101.2	31.2	0.8	0.0	1.0	2.7	2.6	99.8
10/069/1	95.1	28.5	0.9	1.0	2.0	3.7	5.2	89.2
SU-Mateo	92.3	31.4	2.2	7.1	1.0	2.3	4.0	85.7
MW12_4007-008	97.6	29.8	0.8	1.5	1.0	4.8	2.6	90.2
MW11S4029-002	98.5	27.2	0.5	0.0	7.3	3.4	2.8	87.9
10.086	88.6	25.0	1.7	2.5	5.3	6.2	3.8	82.9
10.0777	94.9	31.4	1.0	4.8	5.7	5.8	3.7	85.0
04ARS640-1	98.8	33.1	0.9	3.5	4.0	4.8	3.7	87.7
6W11-0003	100.1	31.9	0.7	2.5	7.0	2.8	3.6	98.6
Vincenta	95.0	30.9	1.6	3.3	1.3	5.6	5.4	90.2
6W13-7145	82.2	22.2	1.3	3.4	5.3	4.4	3.5	88.2
6W13-7041	81.2	22.6	1.4	5.0	4.0	5.0	4.0	88.8
Puffin	88.4	22.9	1.0	4.5	1.0	6.5	4.3	80.0
MW11S4024-004	98.1	24.5	0.9	0.0	6.0	5.9	3.7	84.8
02Ab669	89.3	24.3	1.0	5.4	7.0	6.3	3.4	81.2
06ARS633-10	100.9	27.3	0.3	0.0	4.3	5.9	4.4	87.1
DH130004	97.8	25.3	0.9	0.0	4.3	6.6	4.3	85.6
6W11-0064	96.9	26.8	1.1	6.0	4.3	5.5	4.0	98.6
MW12_4042-002	104.5	30.8	0.5	0.3	6.3	6.1	3.8	85.2
05ARS561-208	100.2	28.2	1.4	4.9	6.3	6.1	2.0	87.0
DH130718	100.8	23.0	1.1	3.8	4.3	6.3	4.5	88.9
Charles (Check)	98.9	25.5	0.2	1.0	7.7	4.9	3.9	99.6
Strider (Check)	92.1	27.7	1.4	3.6	4.5	0.9	3.9	87.6
McGregor (Check)	94.3	26.1	1.2	0.3	3.7	4.5	2.9	86.8
Endeavor (Check)	96.3	27.1	1.9	2.7	6.7	1.0	4.1	87.8
Thoroughbred (Check)	91.5	21.4	3.2	0.0	5.3	4.2	5.4	85.4
Wintmalt (Check)	88.1	24.8	1.7	1.0	3.7	1.8	2.8	84.3
Average	**95.0**	**27.1**	**1.2**	**2.4**	**4.3**	**4.4**	**3.8**	**88.2**
Minimum	**81.2**	**21.4**	**0.2**	**0.0**	**1.0**	**0.6**	**2.0**	**80.0**
Maximum	**104.5**	**33.1**	**3.2**	**7.1**	**7.7**	**6.6**	**5.4**	**99.8**

*Data collected from locations for each trait as available. Traits presented are those with data available from multiple locations. Data were collected at the following locations: Virginia (VA), Maryland (MD), North Carolina (NC), and Georgia (GA).

Table 4. Summary of Malt Quality of entries in the 2015-2016 Uniform Winter Malt Barley Trial at Blacksburg, VA: USDA_ARS Cereal Crop Research Unit-Madison, Wisconson														
Variety or Selection	Kernel Weight (mg)	on 6/64" (%)	Barley Color (Agtron)	Malt Extract (%)	Wort Color	Wort Clarity	Barley Protein (%)	Wort Protein (%)	S/T (%)	DP (ASBC)	Alpha-Amylase (20 DU)	Beta-glucan (ppm)	FAN (ppm)	Quality score
10.086	30.5	85.5	17.0	82.1	2.7	1.0	12.7	4.9	40.9	154.0	96.4	139.8	249.5	53
04ARS640-1	28.3	79.1	13.0	80.9	2.5	2.0	12.2	5.7	49.3	175.5	101.5	150.7	264.3	48
6W13-7145	25.3	53.1	22.5	76.5	2.9	1.0	12.3	5.2	43.9	204.0	90.3	238.1	262.6	46
MW12_4007-008	37.4	85.5	19.5	80.3	2.5	1.0	11.7	4.3	38.8	182.1	52.8	192.7	183.2	45
02Ab669	24.9	54.5	17.0	78.9	3.2	1.0	12.6	5.8	48.9	188.6	127.9	90.2	286.7	44
10.0777	31.8	84.0	17.0	81.0	3.3	2.0	12.5	5.9	49.4	175.9	115.1	54.7	310.9	43
DH130004	31.9	79.2	10.5	80.0	3.6	2.0	14.7	6.1	41.8	209.0	99.4	103.8	336.7	43
6W11-0064	22.7	45.1	15.5	73.8	3.5	1.5	14.3	5.6	40.6	291.5	91.9	102.4	268.1	40
05ARS561-208	22.9	41.8	23.0	77.8	3.3	1.0	12.8	5.2	43.2	185.1	124.8	174.9	253.8	40
MW12_4042-002	23.3	55.2	21.0	79.0	2.9	1.0	13.6	6.2	47.2	198.4	119.1	177.6	325.1	39
Puffin	31.6	78.7	21.5	79.2	2.5	1.0	12.7	4.7	37.9	148.4	60.4	306.0	204.4	40
06ARS633-10	24.4	43.9	20.0	77.0	3.4	1.0	13.0	5.5	43.4	186.8	130.7	186.2	302.3	40
MW11S4029-002	24.7	50.7	24.0	79.1	2.6	1.0	11.7	4.9	42.5	199.4	77.5	296.4	227.8	38
Calypso	37.0	87.7	20.5	80.9	2.5	1.0	10.9	4.1	39.0	173.5	52.9	217.4	180.7	38
10/069/1	31.4	80.8	16.5	78.5	2.9	1.5	11.7	4.1	37.6	151.5	60.1	337.7	185.1	36
Vincenta	32.3	75.5	16.0	78.0	2.6	1.0	13.0	4.6	38.2	169.1	64.9	175.5	190.5	37
DH130718	29.5	70.0	7.5	78.7	4.0	2.0	14.2	5.7	42.1	146.9	108.4	40.3	344.9	33
Hirondella (08/258/17)	35.0	73.9	22.5	79.5	2.5	1.0	11.6	4.2	38.7	164.4	54.0	387.6	156.1	35
MW11S4024-004	23.1	52.3	17.5	75.0	3.1	1.0	13.8	5.4	39.9	229.1	88.4	205.1	247.5	34
6W11-0003	23.5	56.3	24.0	76.8	2.8	1.0	14.2	5.5	41.0	268.3	95.2	306.6	289.3	33
6W13-7041	27.0	59.4	30.5	76.6	2.7	1.0	13.5	4.6	34.9	173.1	75.8	304.2	192.3	31
SU-Mateo	33.0	84.0	19.5	78.9	2.9	2.0	11.6	4.0	36.8	160.2	56.4	312.6	150.9	29
Charles (Check)	26.7	78.3	18.0	80.2	3.2	2.0	12.2	5.6	47.3	153.5	112.2	167.0	278.3	34
Strider (Check)	23.9	34.7	28.5	74.5	3.4	2.5	12.9	4.2	35.0	101.0	59.1	429.4	169.8	16
McGregor (Check)	28.8	66.0	15.0	77.5	2.5	1.0	11.2	3.8	36.7	92.5	54.7	425.4	161.9	27
Endeavor (Check)	29.3	71.5	18.0	81.4	2.8	2.0	11.5	5.4	49.5	164.5	107.5	166.8	273.3	48
Thoroughbred (Check)	28.7	81.8	19.0	78.2	2.2	1.0	10.8	4.0	37.3	138.4	53.9	466.4	159.6	29
Wintmalt (Check)	33.6	84.2	23.5	79.6	2.9	1.5	12.1	4.4	38.6	178.1	65.4	153.2	192.9	44
Minima	**22.7**	**34.7**	**7.5**	**73.8**	**2.2**	**1.0**	**10.8**	**3.8**	**34.9**	**92.5**	**52.8**	**40.3**	**150.9**	**16**
Maxima	**37.4**	**87.7**	**30.5**	**82.1**	**4.0**	**2.5**	**14.7**	**6.2**	**50**	**291.5**	**130.7**	**466**	**345**	**53**
Means	**28.7**	**66.9**	**19.1**	**78.5**	**2.9**	**1.4**	**12.6**	**5.0**	**41.6**	**177.2**	**86.3**	**228.0**	**239.1**	**37**
Standard Deviations	**6.1**	**14.9**	**4.9**	**1.7**	**0.6**	**0.4**	**1.1**	**0.7**	**5.3**	**41.1**	**22.6**	**153.7**	**56.4**	**8.8**