

Progress Report for 2016-17

Maryland Grains Producers Utilization Board

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

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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 2016-2017 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 the incorporation of value added traits geared towards the 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 was grown at the Virginia Crop Improvement Foundation seed farm in 2016-2017 season and a decision to submit this line for release will be made in spring 2018.

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 initiated development of pure lines using double-haploid techniques. Malt barley double-haploid lines are currently 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 were planted last fall (2017) and will be evaluated in a regional test this season (2017-2018). The remaining DH lines were planted in a preliminary test and will be evaluated at Blacksburg and Warsaw, VA. Pure lines possessing good agronomic characteristics and malt quality will be selected and advanced in yield tests in our program. Three other crosses 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 were used to produce DH Lines. These DH purelines were planted in headrows last fall (2017) at 2 locations (Blacksburg and Warsaw, VA) and will be evaluated this season (2017-2018).

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. Other breeding populations, derived from crosses with barley lines introduced from various programs including sources of FHB resistance and winter malting 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 four locations in 2017 are presented in Table 1. The best hulled barley experimental lines VA14B-79 (105 Bu/ac) yielded 6 Bu/ac more than Secretariat, 9 Bu/ac higher than Thoroughbred, 13 Bu/ac higher than Atlantic, and 14 Bu/ac better than the test average. Two other Virginia experimental lines (VA14B-63 and VA14B-74) ranked 2nd and 3rd, respectively in grain yield.

Two year (2016 and 2017) average performance data of hulled barley entries evaluated in the Virginia Tech State Barley Trial are shown in Table 2. The experimental line VA14B-79 in every case had the highest two-year average grain yield (100 Bu/ac) that was 2 Bu/ac higher than Secretariat, 10 bushel per acre higher than Thoroughbred and Atlantic, 18 bushel per acre higher than Callao, 21 bushel per acre higher than Price and 12 bushel per acre higher than overall test average. Two other Virginia experimental line VA14B-63 and VA14B-74, had grain yield that were 1 bushel per acre more than Secretariat, 9 bushel per acre higher than Thoroughbred and Atlantic (90 Bu/ac), and 12 bushel per acre higher than overall test average.

Agronomic performance data for Malt barley entries in the Winter Malt Barley Trials (WMBT) conducted at locations in Blacksburg and Warsaw, VA in 2017 are presented in Table 3. The winter barley variety Hirondeella was the highest yielding (101 Bu/ac) cultivar among 30 entries and yielded 8 bushel per acre higher than the winter barley check cultivar McGregor, 12 bushel per acre more than Wintmalt, 19 bushel per acre higher than Thoroughbred, 27 bushel per acre higher than Endeavor, 53 bushel per higher than Charles. Two other malt barley varieties Flavia and Calypso ranked 2nd and 3rd respectively in grain yield. The malt barley cultivar Violetta ranked 10th in average grain yield. In addition, these new malt barley (Flavia, Calypso and Violetta) cultivars also have better resistance (0 = no disease, and 9 = severe infection) to leaf rust (1, 2) than Thoroughbred and Charles (8 and 9 respectively). Meanwhile, data summary of performance based on entries in the WMBT conducted in inoculated and mist-irrigated FHB field test at Mount Holly, VA are presented in Table 3b; Violetta and Calypso expressed better resistance to FHB than the winter malt check cultivars McGregor, Thoroughbred, Wintmalt, and Charles. Violetta and Calypso had mean FHB values for incidence of (50.0 and 56.3%), severity (9.9 and 10.4%) and index (5.1 and 6.0%) respectively.

Agronomic performance data for entries in the Virginia Tech Winter Malt Barley Double haploid (DH) Preliminary test conducted at locations in Blacksburg and Warsaw, VA in 2017 are presented in Table 4. Average grain yield of Virginia malt experimental line VA16M-81 (99 Bu/ac) was similar to Flavia, 1 bushel per acre less than Thoroughbred, 1 bushel per acre higher than Endeavor (89 Bu/ac) and significantly higher than Charles (70 Bu/ac). VA16M-81 also had test weight (47.9 Lb/bu) that was 4

pounds heavier than Thoroughbred (44.0 Lb/bu), 2 pounds more than Endeavor (46.1 Lb/bu) and 9 pounds heavier than Charles. Two other Virginia malt barley DH lines VA16M-14DH12-83 and VA16M-14DH12-85 had average grain yield (96 Bu/ac) that were 5 bushel per acre lower than Thoroughbred, but 6 bushel per acre higher than Endeavor and significantly higher than Charles. These new malt barley results are encouraging and indicate that significant progress is being made by the breeding program in developing barley cultivars with high yield and improved disease resistance.

Summary of malt quality of entries in the 2015-2016 Winter Malt Barley DH Observation test at locations in Blacksburg and Warsaw, VA conducted by the USDA-ARS Cereal Crop Research Unit in Madison, WI are presented in Table 4a. The Virginia malt barley DH line VA16M-14DH12-81 (2R) had the highest average quality score (55). Malt quality traits and values for VA16M-14DH12-81 (2R) include malt extract value (81%), protein (14%), Diastatic Power (174 °ASBC), Beta glucan (209 ppm) and Fan (308 ppm). Another Virginia malt barley DH line VA16M-82 (2R) ranked 2nd in overall malt quality score (54), that was better than Endeavor, Wintmalt, Violetta, Flavia, Charles and Thoroughbred. Malt quality score for Violetta and Flavia were better than Charles 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, 2017 harvest.

	Yield	Test	Date	Mature	Plant	Leaf	Net	Powdery	
	(Bu/a @	Weight	Headed	Height	Lodging	Rust	Blotch	Mildew	Awns ¹
Barley Lines	48 lb/bu)	(Lb/bu)	(Julian)	(In)	(0-9)	(0-9)	(0-9)	(0-9)	
	(4)	(4)	(2)	(2)	(5)	(3)	(1)	(1)	
VA14B-79	105	41.8	104	33	3	3	3	0	SA
VA14B-63	103	43.1	105	33	3	3	4	1	SA
VA14B-74	100	42.1	106	34	3	3	3	0	SA
Secretariat	99	43.4	102	32	4	1	3	0	SA
VA15B-79	99	43.4	103	34	3	3	3	0	SA
VA14B-57	98	43.0	104	34	3	3	3	0	SA
Thoroughbred	96	41.0	107	33	3	8	7	5	LA
VA14B-78	96	42.9	102	34	3	3	3	1	SA
VA13B-25 LA	96	42.9	101	32	4	3	4	0	LA
VA14B-75	96	41.6	104	32	3	2	3	0	SA
VA15B-33	95	44.0	104	30	2	3	3	0	SA
VA15B-5	95	43.1	104	32	2	2	3	0	SA
VA12B-30	95	41.8	108	34	4	6	3	0	SA
VA15B-8	94	41.6	103	33	4	2	4	2	SA
VA12B-8 LA	94	41.2	105	36	3	6	7	1	LA
VA15B-78	94	45.1	105	35	3	5	4	0	SA
VA14B-59	94	41.4	103	32	3	3	2	0	SA
VA12B-41	93	42.1	105	34	4	3	3	0	SA
VA14B-73	93	42.5	103	34	3	3	3	0	SA
VA15B-89 (LA)	93	41.8	106	34	3	7	6	2	LA
VA11B-141 LA	93	43.9	105	36	3	4	4	0	LA
VA12B-56	93	41.2	101	30	3	6	4	0	SA
VA14BFHB-83	93	43.2	103	34	4	2	3	0	SA
Atlantic	92	41.5	101	31	3	6	4	1	SA
VA15B-98 (LA)	91	41.9	104	33	3	7	7	0	LA
VA11B-102 LA	91	40.7	106	35	3	3	3	0	LA
VA15B-65	91	41.5	101	34	4	6	4	0	SA
VA08B-95	90	41.6	102	33	5	3	3	8	SA
VA15B-60	90	41.9	101	30	3	6	5	0	SA
VA14B-71	88	43.4	103	33	4	3	3	0	SA
Flavia	87	43.3	111	26	2	4	5	1	2R,LA
VA15B-54	87	42.3	104	33	4	5	3	0	SA
Price	84	42.0	102	31	3	5	7	0	SA
VA15B-83 (LA)	84	42.0	101	33	5	6	5	0	LA
Violetta	84	44.0	107	29	2	3	4	1	2R, LA
Callao	82	40.2	101	29	6	5	4	0	SA
VA15B-67	82	41.1	102	33	4	6	3	0	SA
Nomini	75	39.9	101	39	3	6	1	0	AL
Barsoy	75	40.3	101	33	4	8	4	0	LA
Wysor	73	39.3	102	40	4	8	4	0	AL
VA92-42-46	69	40.2	103	39	3	1	8	0	AL
Average	91	42.1	104	33	3	4	4	1	
LSD (0.05)	6	0.6	1	1	1	1	1	1	
C.V.	9	1.9	1	4	37	23	26	156	

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. Two-year average summary of performance of hulled entries in the Virginia Tech Barley

	Yield	Test	Date	Mature	Plant	Leaf	Net	Powdery	BYD	Winter
	(Bu/a @	Weight	Headed	Height	Lodging	Rust	Blotch	Mildew	Virus ¹	Survival
Barley Lines	48 lb/bu)	(Lb/bu)	(Julian)	(In)	(0-9)	(0-9)	(0-9)	(0-9)	(0-9)	(%)
	(8)	(8)	(4)	(4)	(9)	(4)	(4)	(3)	(1)	(1)
VA14B-79	100	42.8	107.063	32	3	3	3	0	0	95
VA14B-63	99	43.5	108	33	3	3	2	0	0	94
VA14B-74	99	43.0	109.125	33	3	2	2	0	0	95
Secretariat	98	44.5	105.375	31	3	1	3	0	0	95
VA14B-57	96	44.0	106.813	33	3	3	2	0	0	94
VA14B-59	95	42.4	106.688	32	3	2	2	0	0	93
VA14B-75	94	42.6	106.938	32	3	2	2	0	0	96
VA14B-73	94	43.1	106.938	33	3	3	2	0	0	95
VA14B-78	93	43.5	105.313	33	3	3	3	0	0	96
VA12B-41	93	42.9	107.813	32	3	3	3	0	0	96
VA13B-25 LA	92	44.0	104.75	32	4	3	3	0	0	98
VA11B-102 LA	92	41.6	109.375	35	4	3	3	0	0	99
VA12B-30	92	42.5	110.438	33	3	5	3	0	0	97
VA12B-56	92	42.1	104.375	30	3	5	3	0	0	96
VA12B-8 LA	91	42.7	107.875	35	3	6	6	1	0	97
VA14BFHB-83	91	43.9	106.313	33	4	2	3	0	0	96
Thoroughbred	90	42.6	109.563	32	3	7	6	5	0	99
VA11B-141 LA	90	44.6	108.563	35	3	3	3	0	1	99
Atlantic	90	42.9	104.313	31	4	6	4	0	0	95
VA14B-71	89	44.2	106.438	33	4	2	2	0	0	98
VA08B-95	88	42.2	104.938	32	4	2	3	8	0	96
Callao	82	42.2	103.688	29	5	5	3	0	0	94
Price	79	43.2	105.25	31	3	5	7	1	0	95
Violetta	79	44.3	110.125	27	2	3	3	0	2	99
Barsoy	74	41.6	104.25	33	3	8	4	1	3	98
Nomini	74	39.4	104.188	37	3	6	3	0	0	98
Wysor	66	38.6	105.938	37	3	7	4	0	0	99
VA92-42-46	64	40.6	105.313	36	3	1	8	0	0	97
Average	88	42.7	106.634	33	3	4	3	1	0	96
LSD (0.05)	4	0.7	0.5197	1	1	1	1	1	1	3
C.V.	9	3.4	0.70087	4	36	24	29	105	234	2
Released cultivars are shown in bold print.										
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.										
The number in parentheses below column headings indicates the number of location-years on which data are based.										
1 BYD = Barley Yellow Dwarf Virus.										

Table 3. Summary of performance of eight commonly assessed traits at Blacksburg and Warsaw, VA locations in the Winter Malt Barley Trial, 2017 harvest season*

Line	Yield (Bu/A)	Test Weight (Lb/Bu)	Moist (%)	Heading Date (Julian)	Height (In)	Lodging (0-9)	Leaf Rust (0-9)	Early Height (In)
Hirondella	101	42.8	12	107	32	4	1	13
Flavia	98	46.0	12	110	27	2	2	9
Calypso	98	44.9	13	109	31	3	2	10
AC09/327/2 (Lyberac)	97	46.2	13	110	29	3	3	10
LGBB13-W102	96	44.8	12	110	29	3	1	9
McGregor	93	41.9	12	108	32	3	2	12
DH130910	91	46.5	13	110	31	5	1	11
Wintmalt	89	44.4	13	110	30	5	4	11
Puffin	88	46.7	12	110	29	3	2	10
Violetta	87	46.5	12	105	30	3	2	11
SU-Mateo	87	44.7	13	107	30	4	2	12
Mission	85	43.7	13	110	28	4	2	9
DH130939	83	44.8	12	101	28	4	6	12
Thoroughbred	82	43.3	12	102	32	2	8	15
06ARS617-25	75	42.0	13	105	26	4	4	16
Endeavor	74	44.3	13	104	29	3	5	19
06ARS633-3	69	38.8	13	105	27	4	7	14
MW12_4007-001	69	39.6	13	102	33	4	8	17
07ARS515-7	68	41.5	13	106	27	5	6	14
2WI14-7462	67	42.5	13	103	28	4	5	18
MW13_4159-012	67	39.0	12	104	33	4	7	12
DH130718	67	42.3	13	103	22	4	7	10
MW13_4107-010	66	39.2	13	102	33	3	7	16
2WI14-7581	65	42.1	13	100	26	3	8	22
DH130004	59	41.9	13	104	23	4	8	11
2WI14-7465	59	39.2	13	103	26	6	5	18
2WI14-7577	59	40.9	13	101	27	5	7	22
05ARS561-208	58	37.0	13	109	24	5	8	11
MW12_4028-007	55	39.1	13	98	25	7	8	15
Charles	48	34.7	13	102	26	7	9	14
Mean	77	42.4	13	105	28	4	5	13
CV	14	6.7	6	5	6	56	19	8
LSD	13	3.2	1	6	2	3	2	2
Varieties are ordered by descending yield averages.								
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 entries to FHB at Mt. Holly, VA in the Winter Malt Barley Trial, 2017 harvest season*

Line	Flower Date (Julian)	FHB Inc (%)	FHB Sev (%)	FHB Index (%)
Hirondella	105	85.0	20.3	17.0
Flavia	110	66.3	12.8	8.6
Calypso	106	56.3	10.4	6.0
AC09/327/2 (Lyberac)	109	77.5	11.6	9.1
LGBB13-W102	108	88.8	30.1	26.8
McGregor	105	83.8	24.8	20.9
DH130910	108	71.3	8.4	6.0
Wintmalt	108	71.3	11.2	8.2
Puffin	107	42.5	10.0	4.4
Violetta	103	50.0	9.9	5.1
SU-Mateo	106	47.5	9.1	4.3
Mission	108	58.8	8.8	5.3
DH130939	103	45.0	6.7	3.0
Thoroughbred	97	82.5	24.6	20.5
06ARS617-25	98	55.0	12.8	7.2
Endeavor	105	52.5	10.6	5.7
06ARS633-3	104	76.3	11.5	9.0
MW12_4007-001	104	62.5	9.4	6.0
07ARS515-7	103	67.5	9.2	6.3
2WI14-7462	97	57.5	13.8	8.2
MW13_4159-012	104	77.5	12.5	9.7
DH130718	102	71.3	14.2	9.7
MW13_4107-010	103	81.3	13.5	11.1
2WI14-7581	97	75.0	17.3	13.5
DH130004	105	65.0	10.1	6.7
2WI14-7465	100	70.0	17.4	12.3
2WI14-7577	95	87.5	22.1	19.7
05ARS561-208	110	61.3	10.0	6.2
MW12_4028-007	96	86.3	25.4	22.0
Charles	102	60.0	12.7	7.7
Mean	104	67.8	14.0	10.2
CV	1	13.8	24.6	33.7
LSD	2	13.1	4.8	4.8

¹Scab Incidence (%): Percentage of infected spikes among 10 randomly selected spikes.

²Scab Severity (%): Percentage of infected spikelets among 10 infected spikes.

³Scab Index: Incidence x Severity/100 (overall indicator of Scab resistance/suscebility level)

Table 4. Summary of performance of malt barley DH lines and check varieties in Virginia Tech Preliminary Winter Barley Trial (2016-2017) at Warsaw and Blacksburg, VA, 2017 harvest.

Line	Row Type	Yield	Moist	Test	Head	Height	Early	Lodging
		(Bu/A)	(%)	Weight	Date	(In)	Height	(0-9)
Locations*:		BB, WR	BB, WR	BB, WR	BB, WR	BB, WR	BB, WR	BB, WR
Thoroughbred	6	101	12.3	44.0	107	29	13	2
Flavia	2	99	12.7	46.7	111	24	9	1
VA16M-81 2R	2	99	12.7	47.9	108	30	12	1
Hirondella	6	98	12.6	44.6	110	26	10	1
SU-Mateo	2	97	12.8	46.0	110	27	10	1
VA16M-14DH12-83	6	96	12.7	42.0	107	30	11	4
VA16M-4DH12-85	6	96	12.7	44.4	106	32	13	2
KWS Scala	2	94	12.4	44.2	107	24	8	2
VA16M-14DH13-12	2	92	12.7	46.9	106	28	12	2
VA16M-14DH13-08	6	90	12.2	45.2	104	25	12	1
Violetta	2	90	12.7	46.5	108	23	9	1
Endeavor	2	89	13.8	46.1	107	26	17	1
VA16M-82 2R	2	87	13.2	48.4	105	31	18	2
VA16M-14DH12-71	6	87	12.5	43.7	102	25	13	2
VA16M-84 2R	2	87	12.7	48.7	106	31	14	1
VA16M-14DH13-06	6	86	12.2	44.6	103	30	16	2
VA16M-14DH12-69	6	85	12.4	45.6	102	25	10	3
VA16M-14DH12-84	6	85	13.6	42.3	102	26	22	2
VA16M-118 2R	2	84	13.0	46.7	106	31	18	1
VA16M-83 2R	2	83	13.0	48.6	105	33	13	1
VA16M-123 2R	2	83	13.4	48.0	105	28	20	3
VA16M-14DH12-94	2	83	14.5	47.0	113	34	14	1
VA16M-14DH12-72	2	82	13.0	48.9	108	29	18	3
VA16M-14DH13-10	6	82	12.8	49.0	112	31	13	1
VA16M-14DH12-86	6	82	12.4	47.3	103	29	14	1
VA16M-14DH12-74	6	82	12.8	47.3	101	25	12	3
VA16M-14DH12-75	6	82	12.0	45.5	100	26	22	1
VA16M-115 2R	2	81	13.3	49.2	104	26	21	1
VA16M-14DH12-81	2	80	12.2	46.7	103	30	13	2
VA16M-14DH13-00	6	79	14.2	44.4	102	28	21	2
VA16M-116 2R	2	79	13.0	47.4	111	30	18	3
VA16M-14DH12-90	2	78	13.5	46.6	112	31	12	4
VA16M-14DH12-92	2	75	13.2	46.7	106	30	12	4
VA16M-14DH12-67	6	72	12.3	45.3	98	18	17	1
Charles	2	70	12.5	38.5	104	22	11	2
VA16M-113 2R	2	68	13.2	47.8	105	31	18	4
Mean (n=39)		87	12.9	46.0	106	28	14	2
CV		10	8.0	1.9	6	8	8	97
LSD (0.05)		10	1.2	1.0	7	3	2	2
			16					
*BB, WR= Blacksburg and Warsaw								

Table 4a. Summary of Malt Quality of entries in the 2015-2016 VA DH Malt Barley Test at Blacksburg, VA: USDA_ARS Cereal Crop

Research Unit-Madison, Wisconsin															
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	Overall Rank
VA16M-14DH12-81	42.2	98.3	20.0	80.8	2.3	1.5	13.5	4.8	37.3	174.1	89.2	209.4	308.3	55.0	1
VA16M-82 2R	42.5	96.8	15.5	81.1	2.1	2.0	11.8	4.6	42.3	137.5	61.1	260.4	202.1	54.0	2
VA16M-118 2R	44.5	95.4	14.0	79.6	2.1	1.0	13.3	4.5	35.0	183.1	78.4	326.5	231.8	49.0	3
VA16M-14DH12-94	42.5	95.6	17.0	81.4	3.8	1.0	11.9	5.3	46.9	167.9	105.3	221.6	322.4	49.5	4
VA16M-14DH13-06	31.3	94.1	22.5	79.3	2.0	2.0	12.7	4.6	38.0	117.7	78.0	274.8	245.3	44.0	5
Endeavor	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	48.0	6
VA16M-81 2R	38.0	94.9	12.0	81.5	1.9	2.0	11.5	4.1	37.3	181.9	74.5	113.6	196.1	46.0	7
Wintmalt	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	43.5	8
VA16M-113 2R	42.9	94.0	15.0	79.1	1.9	1.0	13.6	4.4	33.5	124.9	63.0	435.7	208.2	43.0	9
VA16M-14DH13-00	32.8	78.2	17.5	80.7	3.0	2.0	13.1	5.7	44.5	93.2	99.1	260.2	307.9	44.0	10
VA16M-14DH12-85	32.2	82.7	18.0	79.0	2.1	1.0	12.2	4.4	38.4	196.4	115.1	357.3	255.2	43.5	11
Violetta	36.3	85.7	16.0	80.6	2.3	1.0	11.6	4.3	38.8	191.7	67.2	177.7	194.7	42.0	12
Flavia	34.1	84.1	16.0	79.9	2.7	1.5	12.3	4.2	36.4	182.8	63.5	180.8	198.6	42.5	13
VA16M-14DH12-92	39.2	92.7	16.0	80.1	3.6	1.0	13.9	5.4	40.5	140.8	95.5	146.1	330.9	41.5	14
VA16M-14DH13-12	38.9	93.6	17.5	80.9	2.8	1.5	12.8	5.2	44.4	117.9	101.6	216.9	291.5	42.5	15
VA16M-14DH13-10	30.3	80.9	31.0	78.9	2.2	1.5	11.9	4.1	35.8	154.3	57.9	439.6	181.8	40.5	17
VA16M-84 2R	41.8	91.0	16.0	79.8	2.0	2.0	12.5	4.4	37.5	133.7	63.1	344.0	173.8	41.0	20
VA16M-14DH12-90	35.4	91.7	18.5	78.2	2.2	1.0	12.8	4.3	35.9	109.0	69.8	419.4	214.8	39.5	21
VA16M-14DH12-83	25.8	60.4	14.0	78.5	2.5	1.0	11.8	4.5	40.6	171.9	112.4	179.8	264.4	37.5	24
VA16M-123 2R	37.0	88.6	11.0	79.0	3.1	1.0	13.7	4.8	34.9	101.0	77.8	286.2	306.3	32.0	25
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	38.0	26
VA16M-14DH12-71	27.4	86.4	13.5	77.9	2.5	2.0	12.6	4.5	37.4	118.6	96.7	365.4	258.0	36.0	29
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	34.5	31
VA16M-115 2R	37.3	92.8	16.0	78.1	2.0	1.5	13.7	4.5	34.7	125.4	74.5	488.4	202.5	36.0	33
VA16M-14DH13-08	29.4	92.2	11.5	76.4	2.3	1.0	12.9	4.0	32.8	178.8	58.3	589.5	169.4	33.5	34
VA16M-116 2R	37.2	90.5	19.5	77.9	1.7	1.0	11.9	3.8	33.2	148.9	74.0	439.3	192.8	33.5	35
VA16M-14DH12-86	30.2	91.1	20.5	77.1	1.8	1.0	12.8	4.3	34.8	162.2	59.5	565.6	174.3	33.5	37
VA16M-14DH12-84	26.8	69.0	14.0	77.6	2.3	1.0	12.3	4.6	38.8	159.8	70.3	443.2	176.7	35.0	38
Charles	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	33.5	39
VA16M-83 2R	42.4	90.3	15.5	79.7	2.3	2.0	12.3	4.3	36.3	134.7	60.9	307.9	171.1	35.0	40
VA16M-14DH12-75	27.9	83.8	11.5	78.9	2.3	2.0	14.5	4.3	29.8	134.7	93.4	248.4	277.5	30.0	41
Secretariat	29.8	86.5	7.5	76.7	2.6	1.5	11.9	3.7	33.2	83.4	48.8	655.3	183.6	27.5	43
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	29.0	45
VA16M-14DH12-72	37.8	91.2	18.0	79.0	1.7	1.0	12.1	4.2	36.4	92.1	59.3	613.6	142.0	29.5	46
Thoroughbred	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	28.5	49
VA16M-14DH12-69	27.3	83.3	22.0	77.0	1.9	1.5	13.1	4.1	33.0	178.9	45.0	620.3	160.9	27.5	52
VA16M-14DH12-74	37.6	93.7	19.5	78.2	1.4	1.0	14.4	4.0	29.7	94.0	49.5	592.0	162.8	23.0	59
VA16M-14DH12-67	24.17	74.05	11.00	77.49	2.07	2.00	14.11	4.19	30.26	109.65	54.91	359.22	191.23	20.50	60
Average	33.4	84.2	17.3	78.8	2.4	1.4	12.6	4.4	36.8	141.8	72.7	354.9	213.8	36.0	
Standard deviation	6.2	11.9	4.5	1.7	0.5	0.5	1.0	0.5	5.0	32.3	20.0	151.1	53.8	9.9	
Minimum	20.7	34.7	7	73.8	1.4	1	10.8	3.6	27.1	77.2	45	40.3	142	15.5	
Maximum	44.5	98.3	31	82.1	4	2.5	16	6.3	49.5	291.5	130.7	655.3	344.9	55	