Title: BC Cranberry Variety Assessment 2021 Progress Report

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Introduction:

The BC Cranberry Research Farm continues to provide opportunities to evaluate multiple different cranberry varieties under a single microclimate and production regime. Data collection efforts continue to focus on documenting differences in yield amongst recently released (Crimson Queen, Mullica Queen, Demoranville, BG), newly released (Valley King, Midnight series, Haines and Welker) and unreleased varieties (e.g., RS99-9-25, RS11). Yield however is only one characteristic of a cranberry variety that is important to understand. For example, in 2020 we observed differences in growth parameters such as bud (Fig. 1) and bloom (Fig. 2) phenology. Additional work from Harbut, Someya, Lavkulich, (2019) and Someya (2019) and Ocean Spray Canada (Elsby, 2019) have also shown the importance of understanding the health of the cranberry canopy and roots as this can contribute to long term production challenges. Someya (2019) has developed a "pull-test" to provide a quick assessment of root health. To our knowledge this type of work on cranberry canopy and root health has not been compared across varieties at a single site. Again, the BC Cranberry Research Farm provides an opportunity to evaluate canopy and rooting changes amongst several varieties of different planting age.

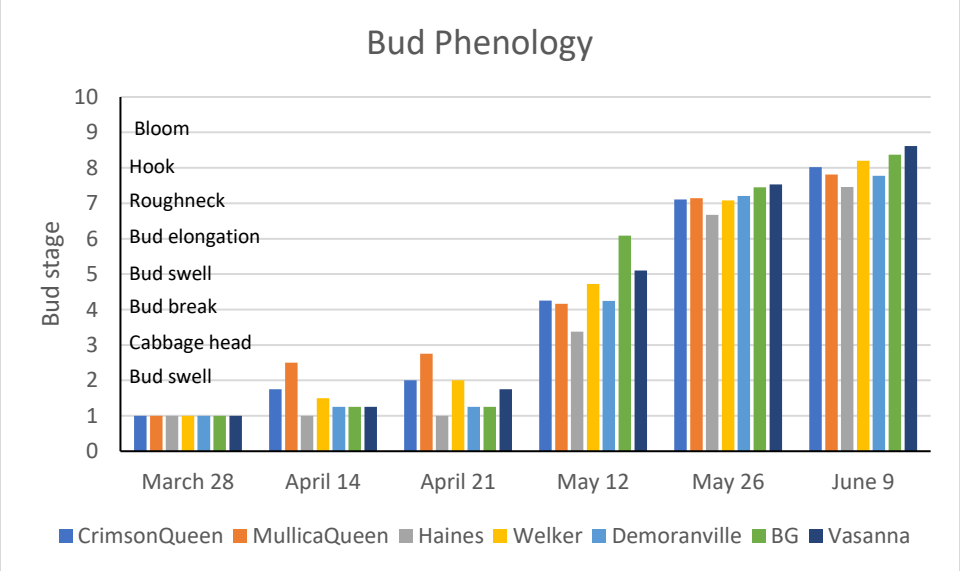

Figure 1. Bud phenology of seven cranberry varieties grown at the BC Cranberry Research Farm, Delta BC in 2020. Bars represent the mean of 30 uprights/variety/sampling date. Bud stages are based on Figure 1 in Workmaster and Palta (2006).

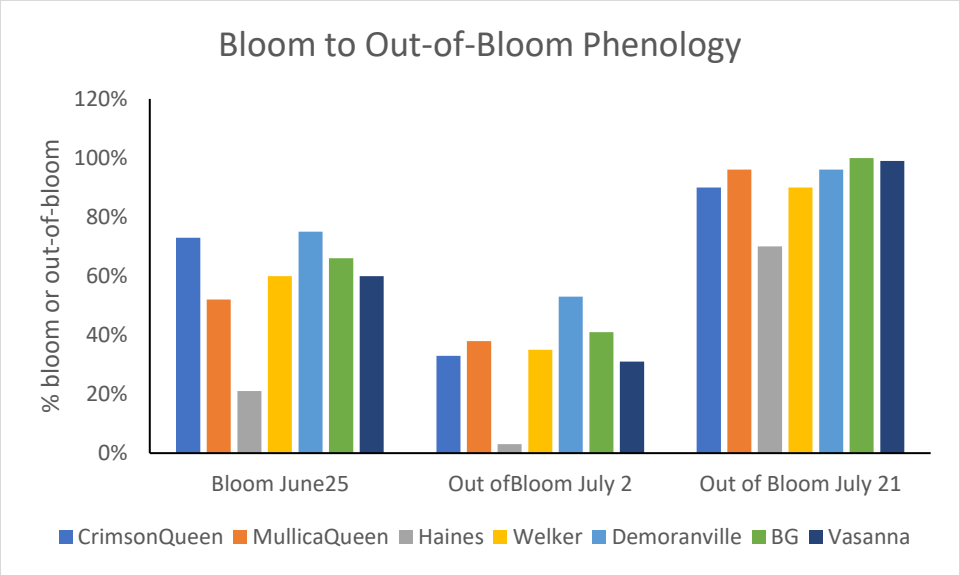

Figure 2. Comparison of bloom (June 25) and out-of-bloom status of seven cranberry varieties grown at the BC cranberry research farm during 2020. Each bar is the mean of 30 uprights for each variety.

The objectives of the 2021 varietal assessment at the BC Cranberry Research Farm were as follows:

- **Objective 1:** Collect yield data on released and numbered varieties from Rutgers and Valley Corporation planted in 2013: Crimson Queen, Mullica Queen, Demoranville, Haines, Welker, BG, Valley King, Pilgrim King, the newly released Vasanna (formerly RS99-25), and RS11.
- **Objective 2:** Collect yield data on numbered varieties from the Rutgers high yield breeding program, planted in 2015, and Rutgers fruit rot resistance lines, planted in 2016
- **Objective 3:** Compare fruit quality across certain varieties (analyses conducted by Ocean Spray Canada)
- **Objective 4:** Assess bud phenology across varieties over the early part of the spring (March to early June)
- **Objective 5:** Conduct a series of monthly pull-tests to assess root health for select varieties based on age of planting, and over the course of the field season
- **Objective 6:** Examine the impact of sanding on root health for Haines, Welker, and Mullica Queen via the pull-test

Methods:

Impact of COVID-19: COVID-19 did not impact our overall ability to complete the field work or the yield assessments for the BCCRF (Table 1). However, the flooding in November in the Sumas

Prairie, while not directly impacting the BC Cranberry Research Farm – did impact the project leads capacity to collect the post-harvest canopy assessment and delayed data entry.

Table 1. Status of varietal evaluation criteria for the BC Cranberry Research Farm

	2021	Status December 31, 2021
Pull-test – Monthly assessment of criteria developed by Someya (2019) and Elsby (2019)	Monthly May to September November (post harvest)	May to September completed November was not done
Bud Phenology	Bi-Weekly March to June	Completed
Yield	September and October	Completed
Fruit Quality (via Ocean Spray Lab)	October	Completed
Planting		To be done April 2022

In addition to the data collection described above, weekly pest monitoring is conducted from May to August. This is an important part of the BC Cranberry Research farm data collection.

Yield (Objective 1 and 2): We continue to harvest cranberries at the BCCRF using methods established in 2015 and used consistently for the past seven years. Specifically, yield data were collected following the protocols developed and reported on in previous reports (see 2016 Final Report). In Field 1, square-foot quadrats were placed randomly within the centre of the plot – within 2-m of the sprinkler line, ensuring that the location had 100% cranberry cover and no weeds. In Field 2, square-foot quadrats were placed randomly within the centre of the plot, 1-m from the edge. Berries were collected from Field 1 on two dates: September 21 and prior to harvest on October 6. For Field 1, berries were collected from three square-foot samples. Berries were collected from Field 2 on September 21 and 22 and from either two or three square-foot samples collected/plot. In Field 2 there are two replicates for each variety, so a total of four or six square-foot samples/variety were used to determine average yields. As in previous years we only collected a select number of varieties from the Rutgers and Valley Corporation 2013 plantings and from the Rutgers 2015 (high yield breeding lines) and 2016 (fruit rot resistance breeding lines) plantings in Field 2.

Fruit Characteristics (Objective 3): To assess berry characteristics a 1kg sample of berries was hand-harvested and sent to Ocean Spray fruit quality lab (Richmond, BC). To measure firmness a sample of berries is placed on the FirmTech machine which compresses individual berries by 1 mm and records the amount of gram force that was necessary to complete that compression – results are then presented in g/mm for the entire sample. Colour is measured using the DigiEye machine which converts images to coloured pixels and provides the % of berries in five different colour categories: Class 1 are the whitest fruit and Class 5 are the darkest red.

Phenology (Objective 4): Bud phenology data were collected on 11 varieties over the course of the growing season, every two to three weeks. Bud phenology was assessed by stopping at three random locations and determining the bud stage (using Fig. 1 from Workmaster and Palta, 2006) on 10 uprights/location. The average of the bud stage for the 30 uprights was then calculated for each variety on each date.

Root health ("Pull-Test") (Objective 5 and 6): The pull-test (see Soyema (2019) and Elsby (2019)) was conducted once a month from May to September on two sets of plots (Table 2). Data from the pull-test still needs to be converted to determine the root health index, as developed by Soyema (2019). Thanks to Ocean Spray Canada for sharing their data sheet which does the automatic conversion of pull heights to root volume under cranberry canopy. In each plot we did the pull-test at three different sites/plot on each date.

Table 2. Summary of questions and plots assessed using the pull-test (Soyema 2019).

Purpose	Field and Plots assessed
Impact of Planting Age on Root Health	Field 2 - Mullica Queen, Haines, and Welker – 2013 and 2015
Impact of Sanding on Root Health	Field 1 – Mullica Queen, Haines, and Welker – mowed and sanded strip (in 2018) versus central Control strip

Results and Discussion:

Objective 1 - Rutgers and Valley Corp. Variety Trials (2013 and 2018 Planting): The top five varieties in 2021 were Valley King, RS11 (2013 planting), Pilgrim King, BG, and Vasanna (Table 3). All five of these varieties had estimated marketable yields of over 300 barrels/acre. Crimson Queen, Haines and Welker all had lower yields in 2021 than 2020, while Mullica Queen yields were up slightly (Table 3). However, the 7-year average for these four varieties was over 300 barrels/acre. Several of the varieties are potentially exhibiting biennial bearing traits – yields alternating between relatively higher and lower values; these varieties are Crimson Queen, Demoranville, Haines, Vasanna, and BG. However, these observations need to be supported with additional years of data and results from other growing regions. All varieties in Field 1 had foliar nutrient levels (samples taken September 14, 2021) for NPK at or below the low end of the target range for each element (Table 4). Estimated marketable yields for RS11 from Field 1 (2018 planting) are much lower than the first harvest from the early harvests from Field 2 (2013 planting).

Table 3. Estimated marketable yields (average barrels/acre) for 7 years for select released and numbered varieties from the Rutgers and Valley Corp breeding programs planted in Field 1 and 2. Values are the mean of 3 samples, from Field 1, 4 samples from Field 2, unless otherwise noted. Data are from the late September harvest in each year

Variety (and Field)	2015	2016	2017	2018	2019*	2020*	2021	7-Year Average
Crimson Queen (Field 1)	335.52	382.37	308.44	559.23	231.47	493.85	294.17	372.15
Mullica Queen (Field 1)	153.14	420.81	265.57	586.18	245.81	244.67	287.40	314.80
Demoranville (Field 1)	171.82	350.38	172.3	425.91	236.00	368.99	294.16	288.51
Welker (Field 1)	611.53	211.07	331.75	393.95	428.47	243.31	157.59	339.67
Haines (Field 1)	508.53	300.26	208.43	441.95	311.57	336.31	228.04	333.58
Vasanna (Field 1)	473.18	457.53	532.48	410.46	311.66	442.60	314.71	420.37
RS-11 (Field 2)	459.82	394.43	302.20	378.7	334.31	423.20	344.75	376.77
RS-11 (Field 1 – Planted 2018)							214.54	N/A
BG (Field 1)	115.79	330.09	203.59	378.13	171.83	380.72	325.41	272.22
Valley King (Field 2)	260.36	242.45	393.69	226.41	260.36	320.86	367.46#	295.94
Pilgrim King (Field 2)	141.63	180.74	214.61	186.50	141.63	265.59	325.97#	208.10

* Average barrels/acre estimate in all years is based on marketable weight – minimum size based on Ocean Spray Cranberries criteria. Minimum size for 2015 to 2018 = 9/32”; 2019-2021 = ½”.

Averages based on 6 samples

Table 4. Foliar nutrient levels for varieties grown in Field 1. Foliar samples were collected on September 14, 2021, and data were analyzed by Element commercial lab (Surrey, BC) and September 10, 2020, data were analyzed by PSAI commercial lab (Richmond, BC).

	Macronutrient and target range for cranberries (as per Element lab report)			
Variety		**2021**		

	2020 % N 0.95-1.25	% N 0.95-1.25	2021 % P 0.14-0.20	2021 %K 0.4-0.65
Crimson Queen	0.8	0.82	0.10	0.43
Mullica Queen	0.8	0.81	0.096	0.36
Demoranville	0.7	0.74	0.085	0.35
Welker	0.64	0.92	0.11	0.32
Haines	0.7	0.84	0.098	0.33
Vasanna	0.83	0.96	0.098	0.35
RS-11 (Planted 2018)	No data	1.12	0.13	0.41
BG	No data	0.82	0.085	0.31

Objective 2 High Yield Variety Trial (2015 Planting): Seven varieties from the high yield lines developed by Rutgers were selected for further yield assessment in 2021, this was based on the performance of these varieties between 2018 to 2020 (Table 5). In 2021 estimated marketable yields of six of these seven varieties was over 300 barrels/acre (Table 5). It is recommended that the BC Cranberry Research Farm begin collecting more detailed data on this subset of varieties – for example bud phenology, bloom phenology, berry, and canopy/root (e.g., pull-test) characteristics.

Table 5. Estimated marketable yields (average barrels/acre) for 4 years for the 2015 planting of numbered varieties from the Rutgers breeding program for high yield (values are the mean of 4 samples (unless otherwise noted) from Field 2, and from the late September harvest in each year)

Variety (and Field)	2018	2019*	2020*	2021*	4-Year Average
Stevens	128.59	123.06	179.56	356.50	196.93
Haines	149.07	203.75	166.35	454.79	243.49
Welker	267.15	204.62	242.78	449.38	290.98
Mullica Queen	190.79	192.95	272.60	349.22	251.39
CNJ04-20-28	183.49	265.17	269.47	415.62#	239.38
CNJ04-20-30	442.00	252.75	415.64	390.68	375.27
CNJ04-1-31	270.51	189.63	287.25	504.65	313.01

CNJ04-1-3	225.61	211.28	328.18	311.99	269.27
CNJ04-35-11	147.64	170.76	179.03	420.39	229.46
CNJ04-2-27	179.60	200.27	274.58	426.58	270.26
CNJ04-21-30	133.39	169.00	135.40	296.80	183.65

* Average barrels/acre estimate in all years is based on marketable weight – minimum size based on Ocean Spray Cranberries criteria. Minimum size for 2018 = 9/32"; from 2019 is ½". #average of 2 samples.

Objective 2 Fruit Rot Resistant Variety Trial (2016 Planting): Fruit rot is not a significant issue for cranberry production in BC (M. Elsby personal communication 2022). Growers also have a toolbox of fungicides and previous research (e.g., Sabaratanam *et al*., 2014) have helped the industry understand the disease cycle of the various fruit rot pathogens. However, the current situation does not necessarily mean that fruit rot won't in the future be an issue. One of the predicted impacts of climate change on agriculture is increased pest and disease pressure (Gareau, Huang, and Gareau, 2018). Thus, data collection on these Rutgers varieties has long term value for the BC Cranberry industry. Additionally, other parts of North America struggle with fruit rot (Oudemans, Caruso and Stretch, 1998), so the data generated in BC can help cranberry growers in other areas. The top four performers based on estimated yields in 2020 were collected for yield in 2021. We observed estimated marketable yields of 100 to 336 barrels/acre for these varieties (Table 6). The variety CNJ06-3-1 is consistently the top performer (Table 6), but it also had relatively higher fruit rot levels in both 2020 and 2021 (Fig. 3). It is important to note, that while the fruit rot for this and the other varieties in this trial were lower than the 12% poor threshold established by Ocean Spray Canada, the berries for this trial are hand harvested. Additionally, fruit from the fruit rot resistant lines is characterized as having a waxy bloom. It is recommended that BC yield data in combination with fruit rot data from other regions (e.g., Massachusetts) be combined to determine which varieties should be examined in more detail in 2022 and beyond.

Table 6. Estimated marketable yields (average barrels/acre) for 3 years for numbered varieties from the Rutgers breeding program for Fruit Rot Resistance (values are the mean of 6 samples from 3 replicated plots planted in Field 2 in 2016)

Variety	2019*	2020*	2021	3-Year Average
Stevens (true)	94.06	140.73	283.92	172.90
CNJ05-80-2	21.89	104.68	135.11	87.22
CNJ04-64-9	95.19	179.82	224.52	166.51
CNJ06-3-1	108.45	244.87	336.49	229.94

CNJ05-73-1	129.77	193.33	233.63	185.58

* Average barrels/acre estimate in all years is based on marketable weight – minimum size based on Ocean Spray Cranberries criteria. For 2019, 2020 and 2021 the minimum size is ½".

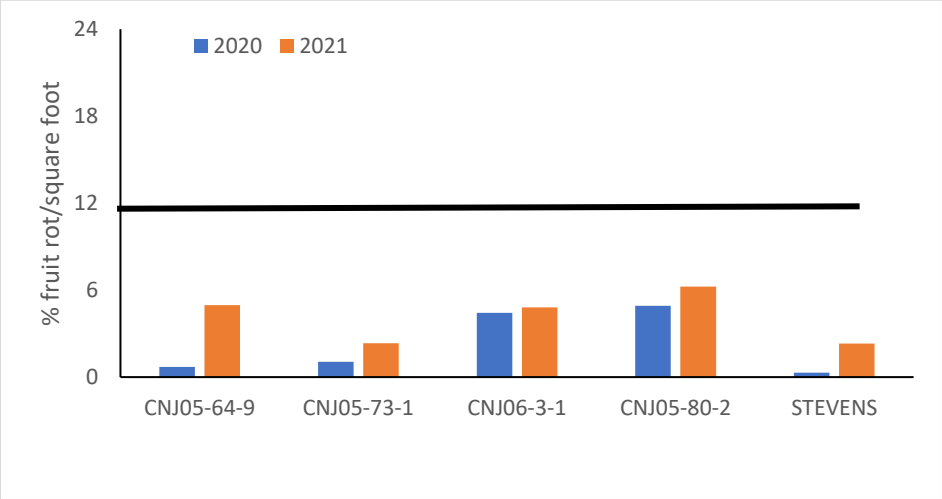

Figure 3. Comparison of fruit rot levels of four different fruit rot resistant lines. Averages are based on fruit rot levels of 6 samples of fruit, harvested from 3 plots from the 2015 planting in Field 2 at the BC Cranberry Research Farm. All fruit were hand harvested. The horizontal line represents the maximum amount of % poor (includes fruit rot, mechanical, or insect damaged fruit) that is accepted at Ocean Spray Canada receiving stations, based on flood harvested fruit.

Objective 3 Berry Characteristics (analysis conducted by Ocean Spray Canada): Analysis of berry characteristics indicate that the select varieties examined in 2021 continue to exceed Ocean Spray standards. For colour, fruit must not exceed 15% Class 1 (white) fruit; all fruit examined in both September and October 2021 were well below this threshold (Fig. 4). For firmness, the minimum value is 450 g/mm; again, all fruit examined in 2021 exceed this value as has been the case for the past three years (Fig. 5).

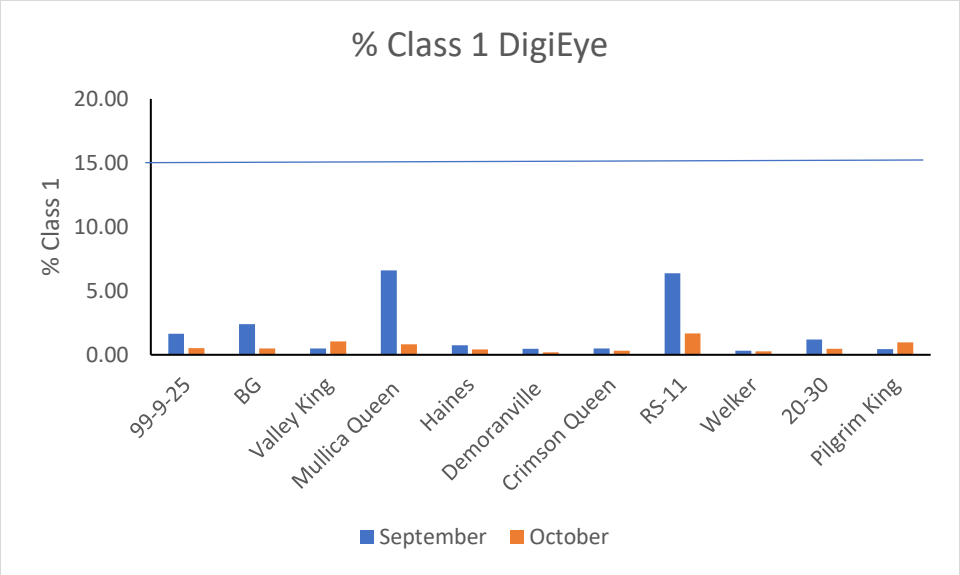

Figure 4. Amount of class 1 (White fruit) harvested in September and October 2021 for 11 different cranberry varieties grown at the BC Cranberry Research Farm in Delta, BC. All fruit were hand harvested and data are courtesy of Ocean Spray Canada (Richmond, BC).

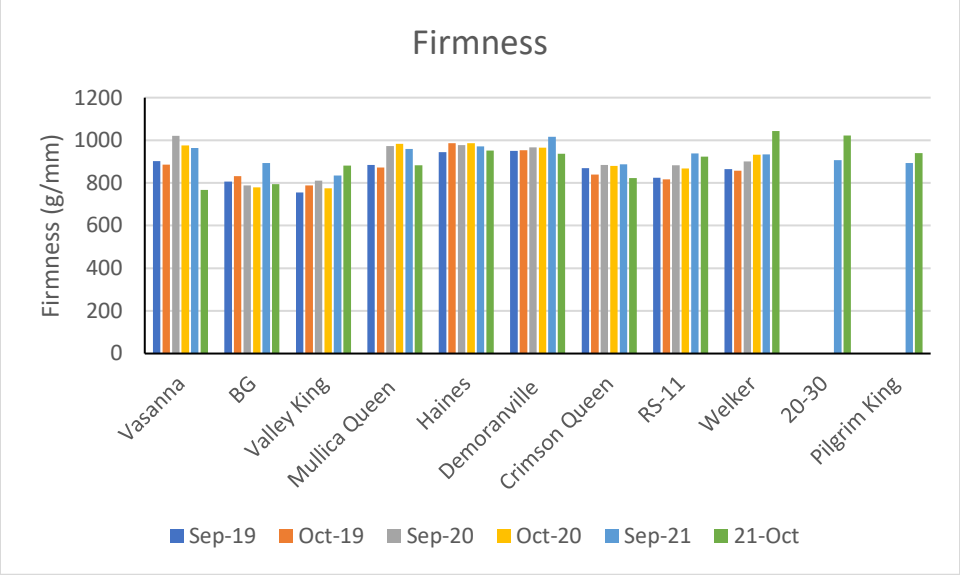

Figure 5. Firmness (g/mm) scores for fruit collected in September and October 2019 to 2021, for different released and pending cranberry varieties grown at the BC Cranberry Research Farm in Delta, BC. All fruit were hand harvested and all data are courtesy of Ocean Spray Canada (Richmond BC).

Objective 4 Bud Phenology of Select Varieties Regularly collecting phenology data on the development of buds (Fig. 6) and bloom (Fig. 7) continues to show that there are some important differences in the timing of phenology events among varieties. For example, in the early part of the season varieties like Mullica Queen, Valley King, RS11, BG and Welker are the first to break dormancy (Fig. 6 – March 25 and April 22 bars). Frost protection and application

of herbicides are examples of two management practices that are impacted by change in dormancy. Our data also continue to show that the variety Haines continues to be in generally slower in development. For example, by June 9 most varieties are ranging from early hook (stage 7) to bloom (stage 9) (Fig. 6). However, Haines are only approaching early hook. This delay carries through to bloom (Fig. 7) with Haines having the least amount of bloom by June 19 and the least amount of fruit development by end of June (Fig. 7). Management activities tied to bloom and out-of-bloom (start of pinhead fruit) include addition and removal of pollinators, the application of fungicides for fruit rot control, the application of nitrogen fertilizers and the application of insecticides on farms with fruit rot concerns.

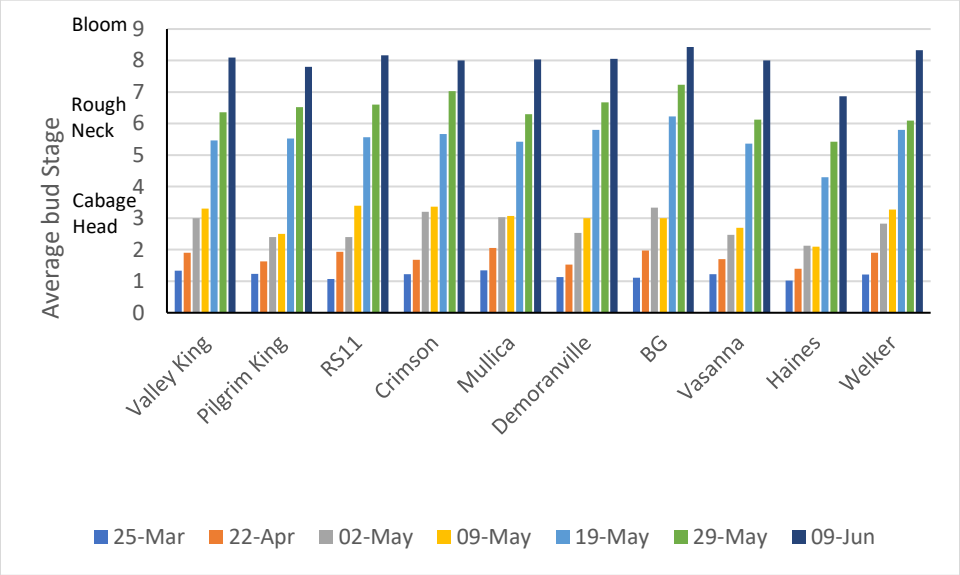

Figure 6. Bud phenology of ten cranberry varieties grown at the BC Cranberry Research Farm, Delta BC in 2021. Bars represent the mean of 30 uprights/variety/sampling date. Bud stages are based on Figure 1 in Workmaster and Palta (2006).

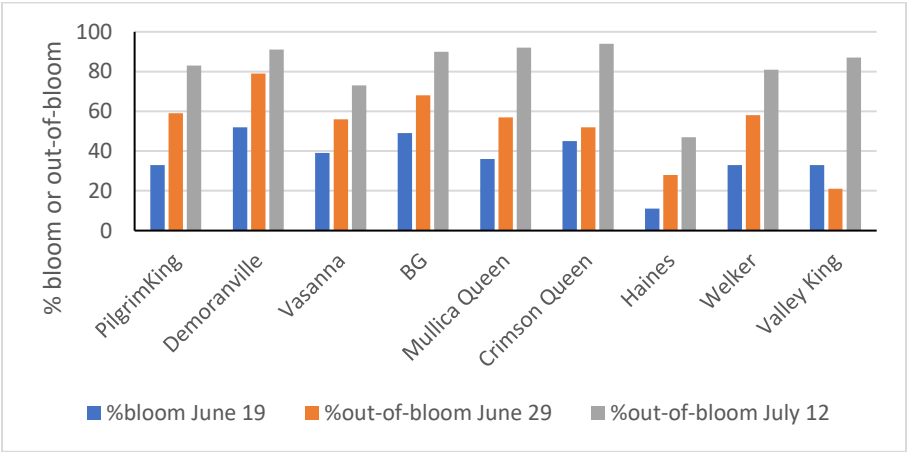

Figure 7. Comparison of bloom (June 19) and out-of-bloom status of nine cranberry varieties grown at the BC cranberry research farm. Each bar is the mean of 30 uprights for each variety.

Objective 5 and 6 Root Health Our raw pull-test results show that even a 2-year difference in planting (2013 versus 2015) results in differences in average pull-test scores for the canopy (Fig. 8). But when we converted the September score to root volume under canopy (as per Soyema 2019) we found that all three varieties and both planting dates scored as transitioning to decline (Table 7). Lastly, we examined the impact of sanding on root health by examining sanded and unsanded strips of Haines, Mullica Queen and Welker in Field 1. These plots were sanded in 2019. Our pull-test results do show differences in canopy heights, but as per the conversion to root volume there is no differences between sanded and unsanded areas in terms of root health score (Table 8). Because sanding and pruning are two important practices that BC cranberry growers use to manage the cranberry canopy, it is recommended that the impact of these two practices on the growth of the newer varieties should continue to be examined. To maximize efficiency, it is recommended that BG, Mullica Queen and Haines be the focus of future work as these three varieties are the most widely adapted locally.

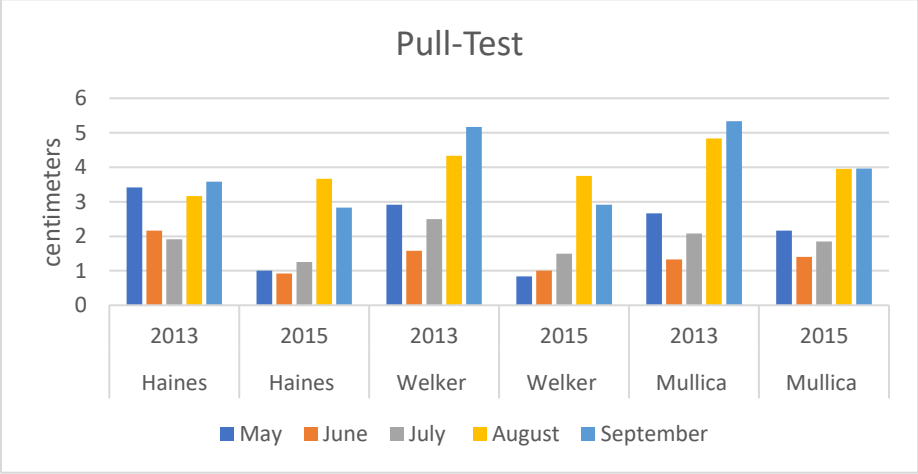

Figure 6. Comparison of above ground pull-test results for two different plantings (2013 and 2015) of Haines, Mullica Queen and Welker planted in Field 2 at the BC Cranberry Research Farm. Data are the raw average of six pull-test scores for each variety and planting date. The values are not converted into an index of root volume under canopy as per Soyema (2019) (see Table 7).

Table 7. Root health assessment using the Pull-Test scores (Soyema 2019) from September 2021

Variety	Year	Raw Pull-Test Heights (average of 3)	Natural log Height Pull	Root Health Score
Haines	2013	3.58	1.28	Transitioning to decline
Haines	2015	2.83	1.04	Transitioning to decline
Welker	2013	5.17	1.64	Transitioning to decline
Welker	2015	2.92	1.07	Transitioning to decline
Mullica	2013	5.33	1.67	Transitioning to decline

Mullica	2015	3.97	1.38	Transitioning to decline

Table 8. Effect of sanding on root health assessment using the Pull-Test scores (Soyema 2019) from September 2021

Variety	Sanding Treatment	Raw Pull-Test Heights (cm) (average of three)	Natural Log Pull Height (average of three)	Root Health Score
Haines	No Sand	4.33	1.46	Transitioning to decline
Haines	Sand	2.5	0.92	Transitioning to decline
Welker	No Sand	5.67	1.70	Transitioning to decline
Welker	Sand	2.67	0.96	Transitioning to decline
Mullica	No Sand	3.83	1.34	Transitioning to decline
Mullica	Sand	2.17	0.73	Transitioning to decline

Recommendations for 2022 (and beyond):

- **2013 plantings (Rutgers Varieties):** It is recommended that the BC Cranberry Research Farm consult with researchers and industry to develop a 5-year plan in terms of data collection and possible demonstration trials (e.g., fertilizer and continued canopy management practices) of the released and pending (i.e., RS11) varieties. For sanding and mowing effects it is recommended that the focus be on Mullica Queen, BG, and Haines.
- **2013 plantings (Valley Corporation Varieties)**
- **2015 plantings**: In addition to yield it is recommended that the BC Cranberry Research Farm begin collecting data on bud and bloom phenology, and berry and canopy characteristic on six varieties. These varieties are 20-28, 20-30, 1-3, 1-31, 35-11, and 2-27.
- **2016 plantings**: collaborate with Rutgers to identify which varieties based on yield in BC and fruit rot resistance in other regions should be studied further. Berry characteristics will be especially important for the fruit rot resistant variety assessment. Many of these berries have a waxy coat and the impact of this coat on marketability should be explored.
- **2022 plantings**: It is recommended that the BC Cranberry Research Farm consult with researchers and industry to develop the next steps in planting. Having multiple ages of

some of the more widely grown released varieties would be especially useful for being able to determine if long-term management for the different varieties should vary. For example, is the pruning and sanding schedule for all varieties the same or do some varieties need to be pruned/sanded earlier?

Literature Cited

Demoranville, C.J. 1998. *Frost protection guide for Massachusetts cranberry production*. University of Massachusetts Extension, Cranberry Experiment Station. 8pp. https://ag.umass.edu/sites/ag.umass.edu/files/fact-sheets/pdf/frost_protection.pdf (First Accessed March 2018)

Elsby, M. 2019. Cranberry canopy descriptors and assessments. Ocean Spray of Canada; Internal Document.

Gareau, B.J., Huang, X., Gareau, T.P. 2018. Social and ecological conditions of cranberry production and climate change attitudes in New England. *PLoS One* 13(2) doi: 10.1371/journal.pone.0207237

Harbut, R., Someya, T. and Lavkulich, L. 2019. Characterization of cranberry decline in British Columbia cranberry bed (Abstract Only). North American Cranberry Research and Extension Workers Conference. August 19-21, Vancouver, BC.

Oudemans, P.V., Caruso, F.L., and Stretch, A.W. 1998. Cranberry fruit rot in the Northeast: A complex disease. *Plant Disease* 82:1176-1184

Sabaratanam, S., Wood, B., Nabetani, K., Sweeney, M. 2014. Surveillance of cranberry fruit rot pathogens, their impact and grower education. Interim report. https://www.bccranberries.com/pdfs/researchreports/2014/4d2014_Sabaratnam_Interim_Research_Report.pdf

Someya, T. 2019. *Characterization of cranberry field decline syndrome in British Columbia*. Master of Science Thesis. University of British Columbia, Vancouver BC, 152pp.

Workmaster, B.A. and Palta, J.P. 2006. Shifts in bud and leaf hardiness during spring growth and development of the cranberry upright: Regrowth potential as an indicator of hardiness. *Journal American Society for Horticultural Science* 131(3):327-337