Title: BC Cranberry Variety Assessment 2022 Final Report

Prepared by: Renee Prasad, renee.prasad@ufv.ca

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Key Findings

- All varieties were late to bloom in 2022 compared to 2021. However, yield in 2022 was higher in 2021 for most varieties examined at the BC Cranberry Research Farm. The top three varieties in 2022 were Vasanna (560.35 barrels/acre), Demoranville (485.71 barrels/acre) and Haines (372.75 barrels/acre).
- Vasanna (437.87 barrels/acre) and Mullica Queen (371.60 barrels/acre) have the highest averages over the eight years of data collection.
- The cool start to the field season resulted in a disruption of phenology patterns observed in the past 4 years. The differences in upright development – from bud swell to fruit set were not as pronounced in 2022 between Mullica Queen and BG (normally the earliest varieties to start development, bloom etc.) and Haines (normally the slowest variety to develop) as have been observed in the past.
- Fruit colour development was delayed in 2022 compared to 2021 – Vasanna, BG, Mullica Queen and Pilgrim King had higher amounts of white fruit in late September 2022 compared to the previous year; only Mullica Queen and BG exceeded the 15% threshold. RS11 also had higher amounts of white fruit in late September in 2022 compared to 2021 but this is consistent with this variety being a candidate for late harvest. By October, all varieties were below the 15% threshold for white fruit.
- A small study examined the impact of fertilizer timing on Mullica Queen, BG, and Haines. Three split applications of fertilizer were applied either on a single date or based on when uprights had developed pin-head fruit. We observed no significant differences in either yield or runner production for plots treated with fertilizer all on the same date or based. We recommend these plots be monitored through to bloom in 2023, and that the trial be repeated.

Introduction: The purpose of the BC Cranberry Research Farm (BCCRF) is to support the long-term sustainability of the cranberry industry in BC. To achieve this purpose the performance of released and numbered cranberry varieties are examined yearly. The data collected at the BCCRF can be used by growers to compare performance of varieties, at a single site, and thus make decisions regarding varieties to invest in for their own farms. While yield is an obvious factor in selecting varieties, additional features such as fruit quality (firmness and colour) are also important. It is also important to understand differences in growth across varieties as this can impact management. Management steps in cranberries that are based on phenology include frost protection via irrigation, pesticide applications for fruit rot and fruitworm control, and application of fertilizer. The timing of these management steps could vary if phenology varies among varieties, as our previous data has shown. Lastly having a long-term data set is important when some years are unusual, as was the case for 2022 with a cool wet beginning to the field season and then prolonged hot-dry period through September (Table 1). The objectives of the 2022 field season at the BCCRF were to continue to collect yield and fruit quality data on released and select numbered varieties (Objective 1, 2 and 3); continue to observe phenology and field performance differences among several released varieties (Objective 4 and 5); and new for 2022 compare the impact of fertilizer timing for three varieties (Haines, Mullica Queen and BG) (Objective 6).

Table 1. Comparison of Growing Degree Days at Boundary Bay Airport (data are from farmwest.com)

	May 10	June 10	September 20
2021	880	1306	3123
2022	837	1257	3149

Objective 1 and 2 Yield Methods: 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 22 and prior to harvest on October 11. For Field 1, berries were collected from three square-foot samples. Berries were collected from Field 2 on September 22 and 23 and from either two square-foot samples/plot. In Field 2 there are two replicates for each variety in the different plantings, so a total of four square-foot samples/variety were used to determine average yields. We also collected berries from the Valley King and Pilgrim King plots in Field 2 on October 11. 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.

Objective 1 Results: All varieties from the Rutgers breeding program had higher yields in 2022 compared to 2021 (Table 2). The increases in yield ranged from 69 estimated barrels/acre to 246 estimated barrels/acre. The Valley Corp. varieties on the other hand had only small fluctuations in yield compared to 2021. All varieties having estimated yields over 300 barrels/acre, except for Welker (Table 2). The top three varieties in 2022 were Vasanna (560.35 barrels/acre), Demoranville (485.71 barrels/acre) and Haines (372.75 barrels/acre).

Table 2. Estimated marketable yields* (average barrels/acre) for 8 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	2022	Multi-Year Average
Crimson Queen (Field 1)	335.52	382.37	308.44	559.23	231.47	493.85	294.17	367.71	371.595
Mullica Queen (Field 1)	153.14	420.81	265.57	586.18	245.81	244.67	287.40	356.47	320.00
Demoranville (Field 1)	171.82	350.38	172.3	425.91	236.00	368.99	294.16	485.71	313.16
Welker (Field 1)	611.53	211.07	331.75	393.95	428.47	243.31	157.59	235.69	326.67
Haines (Field 1)	508.53	300.26	208.43	441.95	311.57	336.31	228.04	372.75	338.48
Vasanna (Field 1)	473.18	457.53	532.48	410.46	311.66	442.60	314.71	560.35	437.87
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	359.45	N/A
BG (Field 1)	115.79	330.09	203.59	378.13	171.83	380.72	325.41	348.02	281.70
Valley King (Field 2)	260.36	242.45	393.69	226.41	260.36	320.86	367.46#	345.57	292.81
Pilgrim King (Field 2)	141.63	180.74	214.61	186.50	141.63	265.59	325.97#	307.13	205.40

* 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"; 2019-2020 = ½", 2021-2022 = 12/32"
# Averages based on six samples

Objective 2 Results: For the varieties bred to be high yielding by the Rutgers breeding program RS20-30 continues to outperform the other varieties in the planting (Table 3). The 5-year average yield of 387 barrels/acre – over 100 barrels/acre more than Mullica Queen, Haines and Welker in that same planting (Table 3). Interestingly, these plots in Field 2 have had minimum fertilizer applications so it will be interesting to do foliar and soil nutrient analysis of these plots. Potentially, RS20-30 and some of the other varieties in this planting may be performing very well, despite reduced inputs. To determine which of these varieties may be candidates for larger scale plantings, we recommend collecting yield and phenology data for the five high yield varieties listed in Table 3 for 1 more year and comparing performance of these varieties in other areas of North America, if any.

For the varieties bred for fruit rot resistance RS64-9, 73-1, and 3-1 continue to yield over the 200 barrels/acre over the past 2 years (Table 4). Despite the cool wet spring conditions we continue to observe relatively low levels of fruit rot in these plots, well below the acceptable fruit rot thresholds. Also, because our fruit are all hand-harvested prior to any harvest procedures (flooding or beating) our measure of fruit rot would be conservative compared to levels observed on farms during normal harvest. One avenue for future research is to further examine methods to more accurately assess these varieties for fruit rot resistance.

Table 3. 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	2018*	2019*	2020*	2021*	2022*	5-Year Average
Stevens	128.59	123.06	179.56	356.5	231.99	203.94
Haines	149.07	203.75	166.35	454.79	294.09	253.61
Welker	267.15	204.62	242.78	449.38	198.07	272.4
Mullica Queen	190.79	192.95	272.6	349.22	378.86	276.884
CNJ04-20-30	442	252.75	415.64	390.68	431.67	386.548
CNJ04-1-31	270.51	189.63	287.25	504.65	Data missed	313.01
CNJ04-1-3	225.61	211.28	328.18	311.99	278.66	271.144
CNJ04-35-11	147.64	170.76	179.03	420.39	157.04	214.972
CNJ04-2-27	179.6	200.27	274.58	426.58	306.21	277.448

* 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"; 2019 and 2020 is ½"; 2021 and 2022 12/32". #average of two samples.

Table 4. 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*	2022*	4-year average	% Fruit rot (by berry number) 2022
Stevens (true)	94.06	140.73	283.92	265.42	196.0325	1%
CNJ04-64-9	95.19	179.82	224.52	243.83	185.84	0%
CNJ06-3-1	108.45	244.87	336.49	277.25	241.765	9.6%
CNJ05-73-1	129.77	193.33	233.63	291.07	211.95	0%

* Average barrels/acre estimate in all years is based on marketable weight – minimum size based on Ocean Spray Cranberries criteria. For 2019, 2020 the minimum size is ½"; 2021 and 2022 12/32".

Objective 3 Fruit Quality (analysis conducted by Ocean Spray Canada) Methods: To assess berry characteristics a 1kg sample of berries were harvested (by hand) and sent to the Ocean Spray Canada 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.

Objective 3 Results: In 2021 all varieties were below the 15% threshold for white fruit in September (Fig. 1a). In 2022 however we observed that three varieties – BG, Mullica Queen, and RS-11 – were all above 15% in September but not 2 weeks later for the October harvest (Fig. 1b). This comparison demonstrates that year to year fluctuations crop growth and environmental conditions have interesting impacts on the different varieties. For example, Demoranville, Haines, and Crimson Queen were all below the 15% white fruit threshold in September 2022. All varieties exceed the minimum firmness threshold for both the September and October harvests in 2022 (Fig. 2). It is important to remember that all fruit for quality assessment are hand-harvested. Grower practices during harvest may result in different firmness scores.

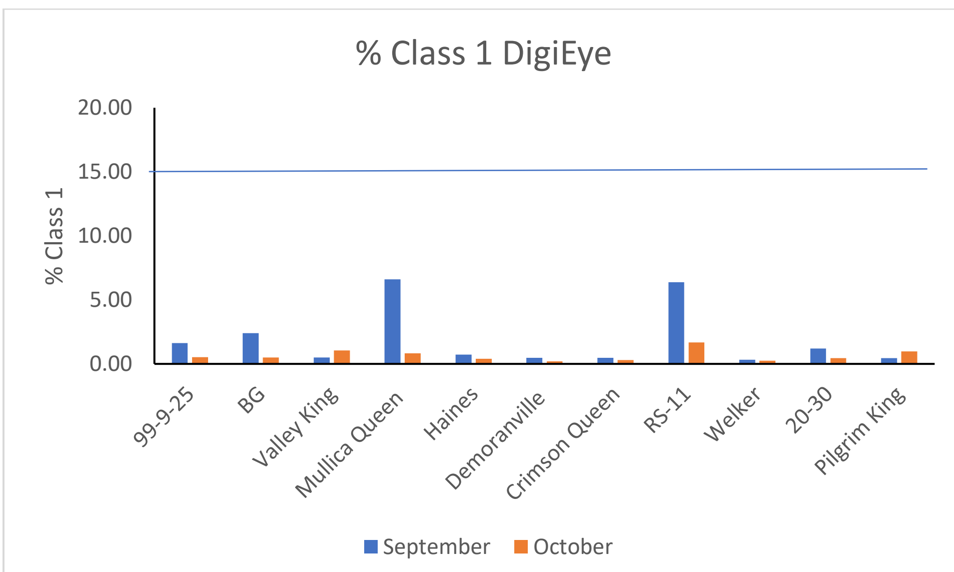

Figure 1a. Amount of class 1 (White fruit) harvested in September and October **2021** for 11 different cranberry varieties grown at the BC Cranberry Research Farm in Delta, BC. All fruit were hand harvested and data are courtesy of Ocean Spray Canada (Richmond, BC).

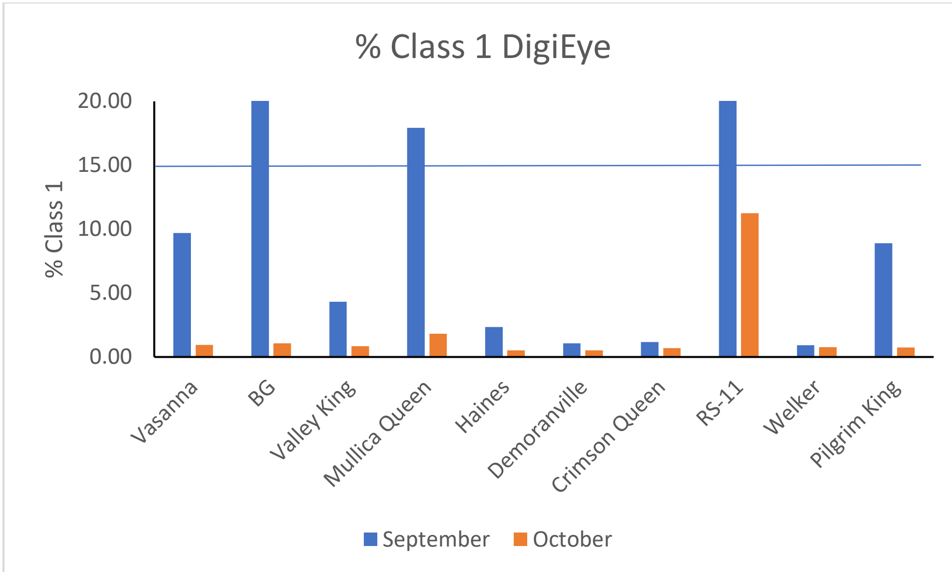

Figure 1b. Amount of class 1 (White fruit) harvested in September and October **2022** for 10 different cranberry varieties grown at the BC Cranberry Research Farm in Delta, BC. All fruit were hand harvested and data are courtesy of Ocean Spray Canada (Richmond, BC).

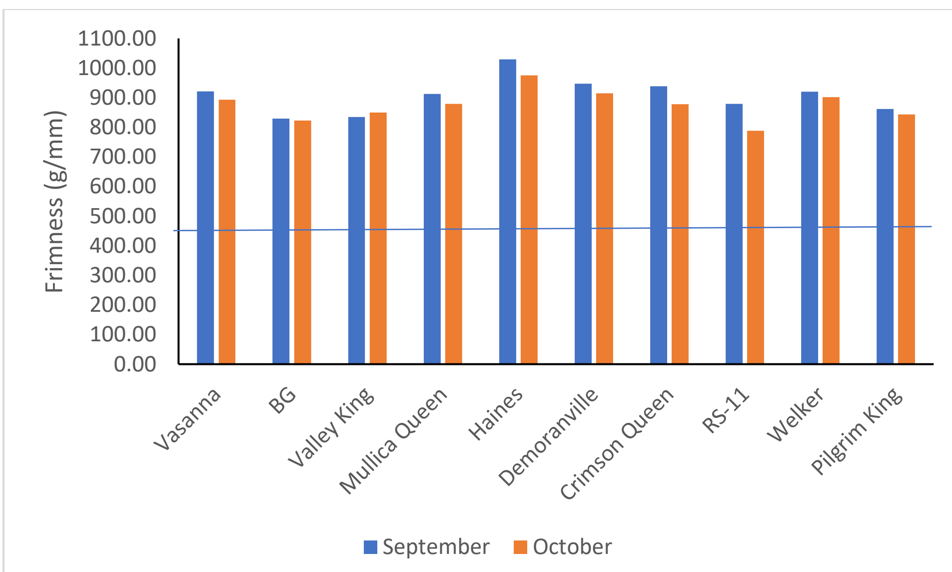

Figure 2. Firmness (g/mm) scores for fruit collected in September and October 2022, for cranberry varieties grown at the BC Cranberry Research Farm in Delta, BC. All fruit were hand harvested and all data are courtesy of Ocean Spray Canada (Richmond BC).

Objective 4 and 5 Bud and Bloom Phenology: 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. Bloom and out-of-bloom phenology was also calculated for 4 dates – June 30, July 5, July 12 and July 22. For these measurements we also stopped at three random locations per plot in Field 1 and for Valley King and Pilgrim King in the replicate 1 plots, in Field 2. At each of the three locations we then looked at 10 uprights and recorded the total number of unopen flower buds (pods), flowers, pinhead size fruit (green fruit with stigma still visible) and fruit. These counts were then used to calculate % bloom and % out-of-bloom using established formulae.

% Bloom =

$$\frac{\text{Total \# of flowers}}{\text{Total \# flowers and unopened flower pods}} \times 100\%$$

% Out-of-Bloom =

$$\frac{\text{Total \# of pinheads and berries}}{\text{Total \# pinheads, berries, flowers, and unopened flower pods}} \times 100\%$$

(Source: University of Maine - https://extension.umaine.edu/cranberries/grower-services/calculating-out-of-bloom/)

Results and Discussion: The early part of the 2022 field season was much cooler than 2021 (Table 1), as a consequence we observed that all phenology milestones were behind in 2022 compared to 2021. For example, by June 9 2021, all varieties except Haines were at hook (Stage 8 on Fig. 3a). In 2022, none of the varieties were at early hook (Stage 7) by June 14 (Fig. 3b). Interestingly, Haines continued the pattern of being one of the slowest to develop varieties in the early parts of the field season (April 12 to June 7) but the majority of uprights were at rough neck at the same time as all other varieties. Similarly, Haines had the least number of blooms and the slowest fruit development in early to mid-July, but by July 22 was at almost 100% out-of-bloom like the other varieties (Fig. 4). In 2021, Mullica Queen, Crimson Queen and Demoranville were all at over 90% out-of-bloom by July 12.

Our data indicate that there are relative differences in phenology among varieties (i.e., early and late varieties in terms of bud break and other important phenology milestones). However, assessing development for each variety each year is the only way to know for certain what development stage varieties are at and thus to adequately time important management such as frost protection, or fruit worm monitoring and control. Based on several years of data, it appears that growers with Haines planted along with other varieties should be the most aware of the differences in phenology timings.

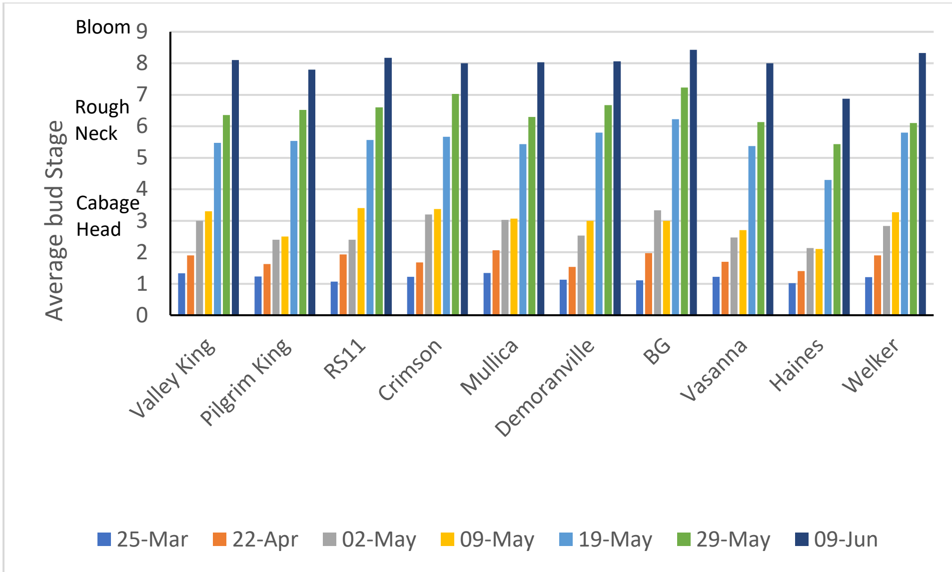

Figure 3a. Bud phenology of ten cranberry varieties grown at the BC Cranberry Research Farm, Delta BC in 2021. Bars represent the mean of 30 uprights/variety/sampling date. Bud stages are based on Figure 1 in Workmaster and Palta (2006).

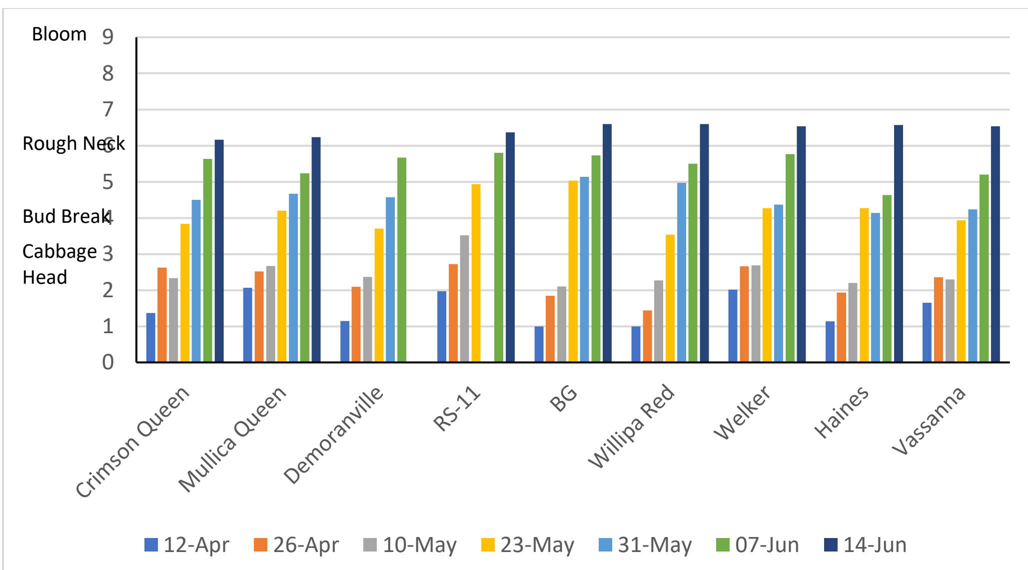

Figure 3b. Bud phenology of nine cranberry varieties grown at the BC Cranberry Research Farm, Delta BC in 2022. Bars represent the mean of 30 uprights/variety/sampling date. Bud stages are based on Figure 1 in Workmaster and Palta (2006).

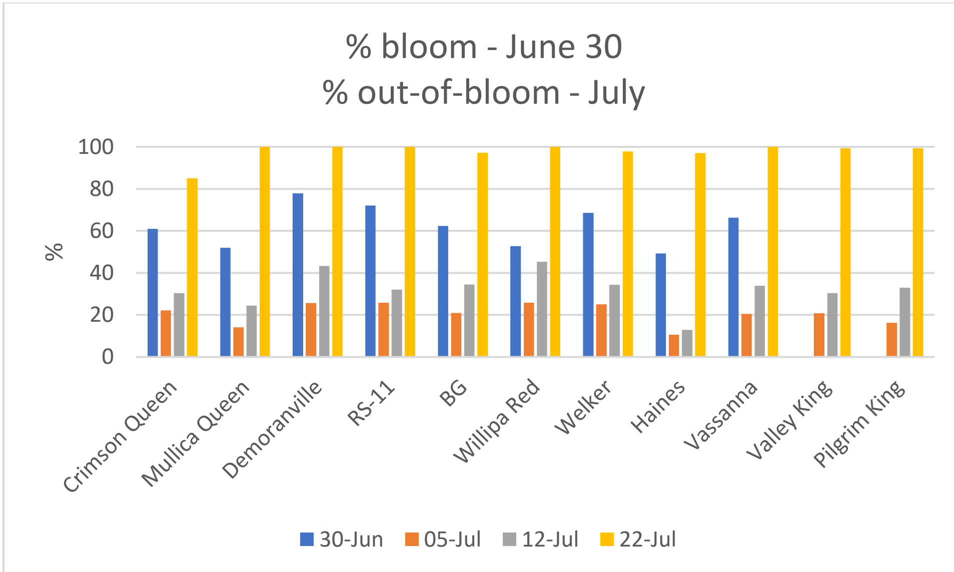

Figure 4. Comparison of bloom (June 30) and out-of-bloom status of 11 cranberry varieties grown at the BC cranberry research farm. Each bar is the mean of 30 uprights for each variety.

Objective 6 – Fertilizer timing trial (Miranda Elsby, Ocean Spray Canada, co-investigator)
Methods: To compare the impact of fertilizer application on the yield of different varieties we conducted a trial in three varieties – Haines, Mullica Queen, and BG. We selected these three varieties as previous years of phenology data show that Mullica Queen and BG to be the earliest varieties to develop (bud break to bloom) and that Haines to be consistently the latest variety to develop. For each variety we marked out four plots. Plots were 1.2 m X 1.5 m (4 feet X 5 feet) and were spaced at least 3 m apart. These plots were flagged and marked prior to fertilizer application to the rest of the field and were not fertilized when the grower fertilized the field. A fertilizer blend (9-17-26) was applied in three split applications starting when most of the fruit were in the pinhead stage. The amount of fertilizer applied for each application to each plot was 17g, 17g, and 14g. The first applications of fertilizer were applied to plots when most uprights were at the pinhead stage. This was on July 5 for Mullica Queen and BG and July 12 for Haines. Two subsequent applications were made 7 to 10 days apart from each other. Second and third applications were made on July 12 and 22 for Mullica Queen and BG, and on July 22 and 29 for Haines.
Berries were harvested from a single square-foot plot from the approximate middle of each plot on September 23, 2022. Control plots were taken from areas adjacent to our treated plots in areas where the grower applied fertilizer. Berries were assessed in a similar manner as for yield.

Results and Discussion: Estimated yields in BG and Haines trial plots were consisted with average yields for the whole plot of each variety in Field 1 (compare Table 2 with Fig. 5).

However, for Mullica Queen yields in trial plots were slightly higher than the whole plot averages (compare Table 2 with Fig. 5). But the values for Mullica Queen trial plots were within the range of sub-plots used to estimate yield (i.e., subplot 1 estimated yield was 420 barrels/acre, consistent with our trial plots). For all three varieties estimated yields were similar regardless of fertilizer timing (Treatment: $p=0.434$; Variety: $p=0.16$; Treatment X Variety: $p=0.417$). Fertilizer timing can also impact other aspects of growth including runner production, however we did not see any differences in runner production by September 22 in the plots (Table 5). Vegetative growth should continue to be monitored in these plots through 2023.

These early results suggest that for fertilizer application at least, the phenology difference of 1-week may not have a large impact on fertilizer uptake and yield. However, it is important to note that phenology differences between Haines and Mullica Queen/BG were not as pronounced in 2022 as they have been in previous years. Perhaps due to the cooler start to the field season. Thus, this work should be repeated over the course of two or three more field seasons. Nutrient analysis of Mullica Queen, BG, and Haines whole plots in Field 1 also shows that overall plots are below the lower thresholds for key nutrients by the end of August (Table 6). Further fertilizer trial work should examine foliar nutrient status before, during and at the end of August for plots.

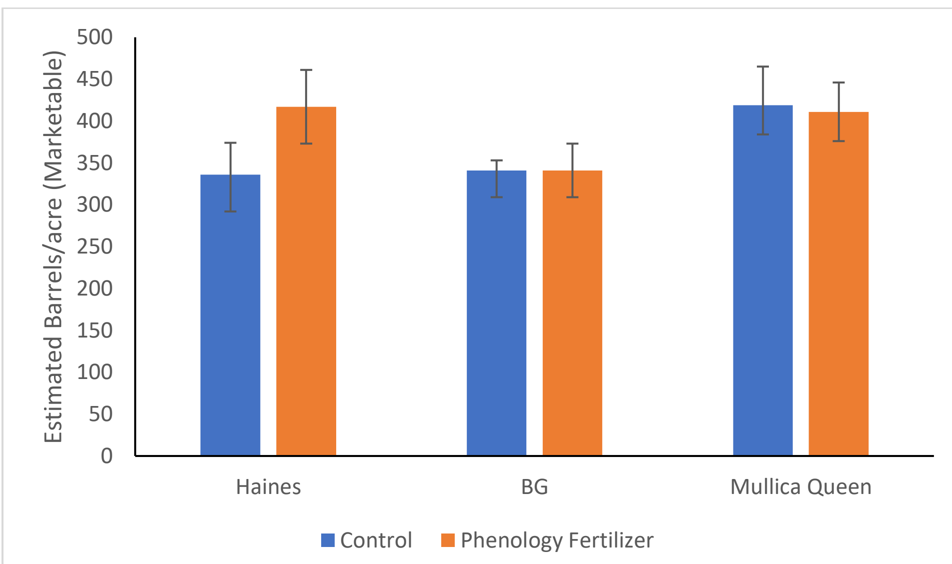

Figure 5. Estimated marketable yields of three varieties of cranberries fertilized using two different criteria for timing. Control treatments were fertilized on a set date and phenology treatments were fertilized when most uprights for the variety were at the pinhead stage. Bars represent the mean ± s.e. for four replicates/treatment.

Table 5. Average runner counts per 1-foot2 in Haines, Mullica Queen and BG plots treated with fertilizer either based on a single date or based on the phenology of individual plots.

	Haines	Mullica Queen	BG

Control	0.25	1.25	0.25
Penology	0.5	1.25	1.25

Table 6. Foliar nutrient concentrations for NPK in cranberry uprights collected on August 23, 2022, from Field 1 (same field as the fertilizer trial). Samples were analyzed by a commercial nutrient testing lab.

	Nitrogen	Phosphorous	Potassium
Mullica Queen	0.86	0.12	0.36
BG	0.74	0.11	0.38
Haines	0.82	0.10	0.37
Target Range	0.95-1.25%	0.14 – 0.20%	0.40-0.65%

Recommendations: The main function of the BCCRF is to provide a common site for evaluation of new varieties. The BCCRF can continue to serve this function by continuing to collect and assess fruit yield and quality data. Incorporating phenology and management should be the next steps, for promising varieties. The fertilizer trial should be repeated with a focus on BG, Mullica Queen, and Haines. Management considerations for higher yielding varieties, e.g., Vasanna, RS-11 and 20-30 should also be explored. For example, what is the impact on canopy and root health when yields are so consistently high.

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.

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