**BC Cranberry Marketing Commission**
**BC Cranberry Growers**

# Characterization of Cranberry Decline in British Columbia Cranberry Beds

# Interim Report

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BC Cranberry Growers

## Research Project Objectives:

1. Detailed characterization of cranberry beds to evaluate correlations between cranberry field decline symptoms and soil and plant characteristics

    a. Validation of soil diagnostic tools to identify the correlation between soil decomposition, oxygen/redox potential and cranberry field decline
    b. Collection of plant growth data to determine the impact of canopy architecture and carbohydrate status of cranberries

2. Conduct field trials to evaluate management techniques on beds affected by Cranberry Field Decline
    a. Evaluate management practices to remediate cranberry beds affected by cranberry field decline
    b. Evaluate current management practices of in order to formulate appropriate recommendation for management practices

## Determining Study Beds and Assigning the Objective(s)

Currently, there are 8 beds from 5 farms that have been assigned with objective(s) as shown in **Table 1**. The study area within each bed was carefully selected, with the strong consideration of the 2015 season results.

**Table 1**: List of Beds (ID) and assigned objectives

| *Objectives* | | *Bed ID* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G | H | J |
| *1a* | Soil Characteristics | | ✓ | ✓ | ✓ | ✓ | | | | |
| *1b* | Plant Characteristic | | ✓ | ✓ | ✓ | ✓ | | | | |
| | Carbohydrate Analysis | ✓ | ✓ | ✓ | ✓ | | | | | |
| *2a* | Management Trial | | | | | | ✓ | ✓ | ✓ | |
| *2b* | Renovation Trial | | | | | | | | | ✓ |
| *2c* | Management Evaluation | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

**OBJECTIVE 1: DETAILED CHARACTERIZATION OF CRANBERRY BEDS TO EVALUATE CORRELATIONS BETWEEN CRANBERRY FIELD DECLINE SYMPTOMS AND SOIL AND PLANT CHARACTERISTICS**

**OBJECTIVE 1A. VALIDATION OF SOIL DIAGNOSTIC TOOLS TO IDENTIFY THE CORRELATION BETWEEN SOIL DECOMPOSITION, OXYGEN/REDOX POTENTIAL AND CRANBERRY FIELD DECLINE**

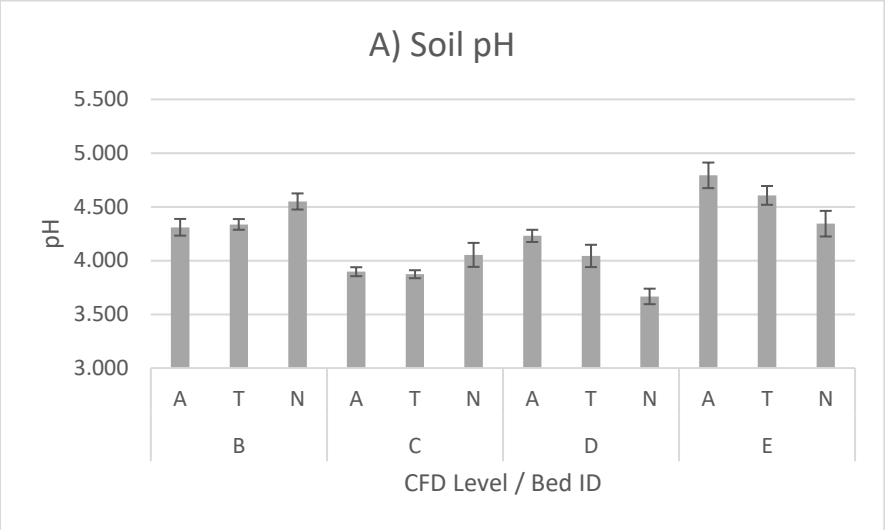
## Methods

Soil Chemistry

- Soil core samples (ϕ=2cm x 15cm) were taken from affected (A), transition (T), and non-symptomatic (N) areas in each of the study beds (Fig. 1).
- Each sample was tested for pH, ROP, and EC with a portable soil chemistry meter (CDS107: Omega Engineering Inc.) (Figure 2).
- *Sample Size*: 36 samples (3 replication x 3 treatment x 4 beds)
- *Sampling Frequency*: once

**Figure 1**(left): Soil core in the probe sampled in one of the beds.
**Figure 2**(right): Soil chemistry meter and sensor measuring pH and Redox potential of a sample.

**Results**


A) Soil pH
5.500
5.000
4.500
4.000
3.500
3.000
pH
A T N A T N A T N A T N
B C D E
CFD Level / Bed ID

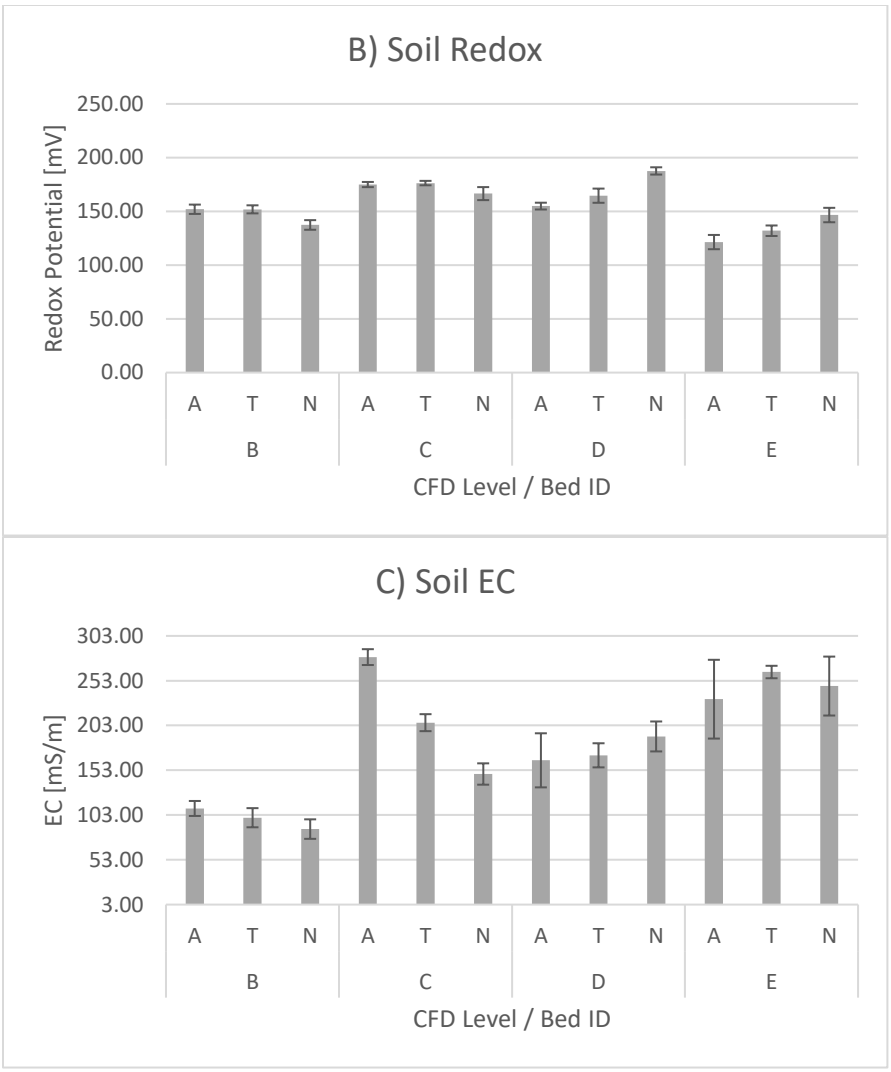



**Figure 3.** Soil data for (A) pH values (B) Redox potential and (C) Electrical Conductivity (EC) at each of the 4 study sites. A = decline affected area; T = transition area; N = non-symptomatic area. Black bars indicate standard error.

**Summary**

The soil data collected this season builds on the data collected in 2015 and is in the process of being analyzed. As was the case last year, the data is highly variable between fields. There is considerable overlap in the results which is a reflection of the variability of soil conditions over short distances in the beds examined. When measuring soil conditions some sites were dominated by organic matter of varied degree of decomposition and/or amount of organic matter relative to mineral content. These factors affect both soil properties which in turn affect plant characteristics. There was a relationship (congruence) between redox and EC.

One of the primary objectives was to evaluate the potential of using in-field measurements to characterize soils for pH, Redox and EC. This research provided critical data to help inform how this instrument may be used, however further field testing will be required to determine if this can be used for in field measurements.

## OBJECTIVE 1B. COLLECTION OF PLANT GROWTH DATA TO DETERMINE THE IMPACT OF CANOPY ARCHITECTURE AND CARBOHYDRATE STATUS OF CRANBERRIES

The data for this sub-objective was collected from the same study area in the 4 beds as the soil data in Obj.1A. This data also builds on the data collected in 2015 and will allow for comparison across years. Collection of plant tissue for carbohydrate analysis is a new component added to the project in 2016.

### Data collected for Characterization

Upright Density

- Number of uprights per 1 $ft^2$ area was counted for both vegetative and flowering uprights at A, T, and N areas in each of assigned bed (**Figure 4**).
- *Sample Size*: 36 samples (3 replication x 3 treatment x 4 beds)
- *Sampling Frequency*: once

Canopy Depth

- Depth of both green and brown canopy was measured by using a ruler at A, T, and N areas in each of assigned bed (**Figure 5**).
- *Sample Size*: 36 samples (3 replication x 3 treatment x 4 beds)
- *Sampling Frequency*: once

**Figure 4**: Setting of the upright counting at a bed. Wooden platforms around and behind the quadrat (1 $ft^2$) were used to minimize damage to the shoots and fruits.

**Figure 5**: Measuring canopy depth from the bottom of the canopy to the approximate boundary between green and brown canopy and to the top of upright (average height)

Rooting Capacity

- Rooting capacity was measured by the 'pull test' which allowed the quantification of the area under the canopy that easily lifted from the soil surface indicating there was limited rooting. Low rooting capacity is related to a large volume of canopy that was lifted. (**Figure 6, 7**).
- *Sample Size*: 36 samples (3 replication x 3 treatment x 4 beds)
- *Sampling Frequency*: once

**Figure 6**(left): Conducting pull-test to measure the height of the canopy lifted.
**Figure 7** (right): Measuring the area of the canopy lifted by the test.

Tissue Nutrient Analysis

- Upright of current season's growth was sampled at A, T, and N areas in each of assigned bed for the tissue nutrient analysis, and the samples were sent to and analyzed at a commercial laboratory
- Lab results were analyzed for a possible trend related to the CFD conditions (data in appendix a).
- *Sample Size*: 36 samples (3 replication x 3 treatment x 4 beds)
- *Sampling Frequency*: once

Yield Analysis

- Berries were collected within a $sf^2$ area at A, T, and N areas in each of assigned bed (**Figure 9, 10**).
- Collected berries were sorted into marketable and unmarketable, counted, and weighted.
- *Sample Size*: 36 samples (3 replication x 3 treatment x 4 beds)
- *Sampling Frequency*: once


**Figure 9**(left): Quadrat ($ft^2$) placement at a bed for berry sampling.
**Figure 10** (right): Sampled berries at a bed participating in the management trial (see OBJ 2b)

**Summary**

This study repeats the work that was carried out in the 2015 season. The trends observed last year are consistent with those observed in 2016.

Carbohydrate Analysis

Four fields were selected for detailed analysis to quantify carbohydrate status of the vines throughout the growing season. Three of these fields (B, C, D) were also included in the characterization study and samples were collected from the affected (A), transition (T) and non-symptomatic areas (N). Field A was a unique field in that the samples were collected along a transect that went through the affected area which occurred along the irrigation line. In this field, there were 5 areas sampled, one sample collected in the affected area, two selected on either side of the affected area.

Canopy Characteristics defined for each bed

- Canopy depth and rooting capacity were measured at the area adjacent to the canopy sampling spots at A, T, and N areas in each of assigned bed.
- *Sample Size:* 252 samples (3 replication x 3-5 treatment x 3 beds x 6 months)
- *Sampling Frequency*: 6 times (May, Jun, Jul, Aug, Sep-Oct, and Nov)

Tissue Sample Collection

- A handful of vines consisting of current season's, previous season's and ≥2-year-old growth were collected at A, T, and N areas in each of assigned bed (**Figure 11, 12**).
- *Sample Size:* 252 samples (3 replication x 3-5 treatment x 3 beds x 6 months)
- *Sampling Frequency*: 6 times (May, Jun, Jul, Aug, Sep-Oct, and Nov)

Processing Samples

- Canopy samples were separated into green (<2-year-old growth) and brown (≥2-year-old growth), weighted, dried, and ground into powder (**Figure 13, 14, 16**).
- *Sample Size:* 504 samples (252 canopy samples x 2 (green and brown))

Non-Structural Carbohydrate Measurement

The measurements of carbohydrates has not occurred to the unavailability of an HPLC. KPU is in the process of purchasing this piece of equipment. Samples are being stored in airtight containers to maintain sample integrity.

- Non-structural carbohydrate (NSCs) will be extracted from the ground sample. Concentration of NSCs will be measured with High Performance Liquid Chromatography (HPLC).

**Figure 11** (top-left): Sampling equipment setting at a field; **Figure 1**2(top-center): vines cut out from the bed; **Figure 13** (top-right): samples were rinsed and ready for further processing; **Figure 14** (bottom-left) and **Figure 15** (bottom-center): samples are separated into green and brown canopy, respectively; **Figure 16** (bottom-right): samples were dried in an oven for 5 days and ground to powder.

**Status of data collection for Plant Growth and Canopy Characteristics:**

| | | |
|---|---|---|
| Number of beds | : | **4** |
| **1b.1.** Upright Density | : | **Completed** |
| **1b.2.** Canopy Depth | : | **Completed** |
| **1b.3.** Rooting Capacity (pull test) | : | **Completed** |
| **1b.4.** Tissue Nutrient | : | **Completed** |
| **1b.5.** Yield Analysis | : | **Completed** |
| **1b.6.** Carbohydrate Analysis | | |
| **1b.6.1.** Canopy Depth | : | **Completed** |
| **1b.6.2.** Rooting Capacity | : | **Completed** |
| **1b.6.3.** Canopy Sampling | : | **Completed** |
| **1b.6.4.** Sample Processing | : | **Completed** |
| **1b.6.5.** NSCs Measurement | : | **In Progress** |

**RESULTS FOR CHARACTERIZATION**

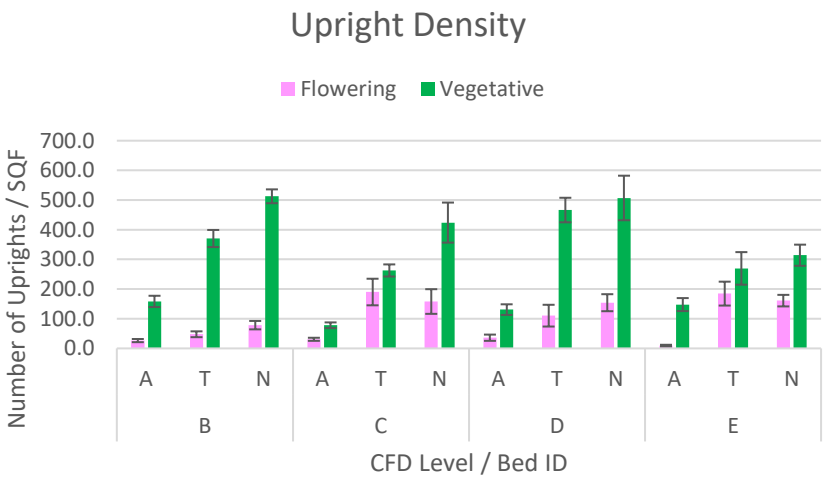



**Fig. 17** Upright (flowering and vegetative) density in CFD affected (A), transition (T) and non-symptomatic (N) areas in 4 beds. Black bars indicate standard errors.

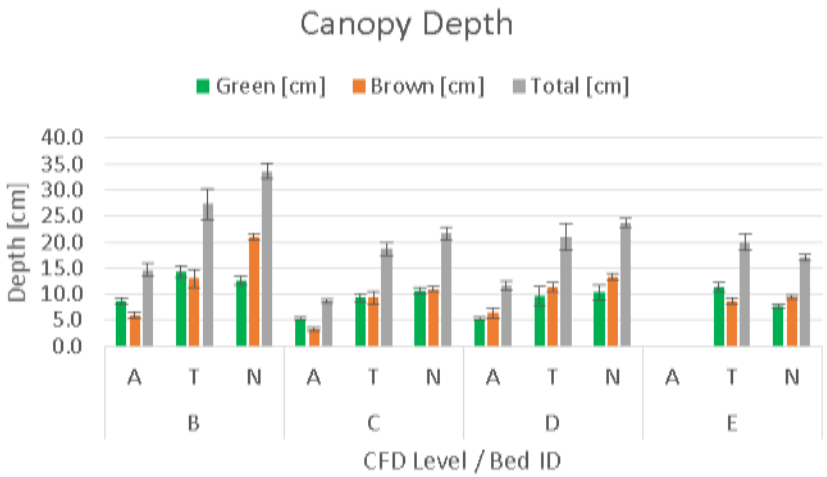



**Fig. 18** Canopy depth, separated into 'green' , 'brown' and total in CFD affected (A), transition (T) and non-symptomatic (N) areas in 4 beds. Black bars indicate standard errors.

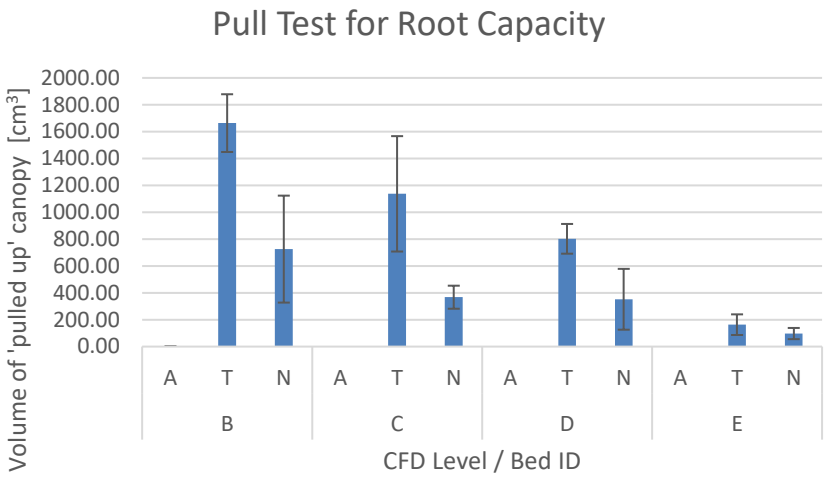



**Fig. 19.** A canopy pull test was developed to quantify rooting capacity. The higher volume of 'pulled up' canopy is an indicator of poor root connection between canopy and soil. Pull test was carried out in transition (T) and non-symptomatic (N) areas in 4 beds, no data was collected in affected areas (A) as the rooting was extremely poor. Black bars indicate standard errors.

**Nutrient Analysis**

Nutrient analysis data was carried out for all of the four test fields and has been analyzed, data is summarized in appendix A.

**SUMMARY**

The data collected in 2016 on canopy characteristics are consistent with observations made in 2015, however thorough analysis has not yet been completed. There is once again significant variability between fields (Fig. 17 and 18). The pull test was a new test carried out this year in hope of quantifying the rooting connection of the canopy. The data suggests that this may be a useful metric to define canopies that are beginning to show signs of decline. Over the winter months, the data will be further analyzed to allow for more comprehensive interpretation of the data.

**RESULTS FOR CARBOHYDRATE ANALYSIS**

**Table 2.** Mean Canopy Depth (n=18) in field A from affected (A), Transition (T) and non-symptomatic area (N). T and N samples were collected from region 'upstream' (U) and 'downstream' from A based on the direction of the vines. Numbers in brackets indicate standard error.

| *Field A* | *CFD* | *Distance Along Transect [cm]* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *0 (NU)* | | *50 (TU)* | | *100 (A)* | | *150 (TD)* | | *200 (ND)* | |
| *Canopy Depth [cm]* | *Total* | 10.8 | (0.7) | 8.9 | (0.6) | 6.4 | (0.4) | 9.1 | (0.6) | 9.8 | (0.9) |
| | *Green* | 7.8 | (0.7) | 7.6 | (0.6) | 4.3 | (0.4) | 5.8 | (0.8) | 7.2 | (0.7) |
| | *Brown* | 18.6 | (0.7) | 16.5 | (0.7) | 10.8 | (0.4) | 15.1 | (0.5) | 17.0 | (0.7) |

**Table 2**. Mean Pull Test Response (n=18) in field A from affected (A), Transition (T) and non-symptomatic area (N). T and N samples were collected from region 'upstream' (U) and 'downstream' from A based on the direction of the vines. Numbers in brackets indicate standard error.

| *Field A* | *Distance Along Transect [cm]* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *0 (NU)* | | *50 (TU)* | | *100 (A)* | | *150 (TD)* | | *200 (ND)* | |
| *Height Lifted [cm]* | 1.6 | (0.3) | 6.5 | (1.5) | 8.6 | (1.1) | 3.7 | (0.5) | 2.1 | (0.3) |
| *Area Lifted [$cm^2$]* | 572.3 | (72.7) | 1158.6 | (109.0) | 1275.7 | (120.0) | 716.1 | (55.0) | 550.0 | (78.2) |
| *Volume Under Canopy [$cm^3$]* | 393.3 | (96.9) | 2569.9 | (487.8) | 4007.7 | (814.0) | 979.4 | (218.2) | 489.0 | (147.0) |

**Table 3.** Mean canopy depth for Fields B, C and D (Bed B and C: n=18, Bed D: n=15) from affected (A), Transition (T) and non-symptomatic area (N). Numbers in brackets indicate standard error.

| *Bed ID* | *CFD* | *Canopy Depth* | | | | | |
|---|---|---|---|---|---|---|---|
| | | *Green [cm]* | | *Brown [cm]* | | *Total [cm]* | |
| B | A | 6.4 | (0.3) | 5.1 | (0.3) | 11.6 | (0.4) |
| | T | 14.7 | (0.3) | 10.5 | (0.3) | 25.2 | (0.5) |
| | N | 14.8 | (0.3) | 14.6 | (0.5) | 29.4 | (0.6) |
| C | A | 6.9 | (0.3) | 3.7 | (0.2) | 10.7 | (0.4) |
| | T | 8.3 | (0.3) | 7.5 | (0.3) | 15.8 | (0.5) |
| | N | 11.8 | (0.3) | 11.1 | (0.5) | 22.9 | (0.6) |
| D | A | 7.5 | (0.2) | 6.1 | (0.2) | 13.6 | (0.3) |
| | T | 10.5 | (0.5) | 9.5 | (0.3) | 19.9 | (0.6) |
| | N | 12.2 | (0.5) | 10.6 | (0.3) | 22.8 | (0.7) |

**Table 4.** Pull test response (Bed B and C: n=18, Bed D: n=15) from affected (A), Transition (T) and non-symptomatic area (N). Higher volume indicates poor rooting. no data was collected from the A area as there was minimal canopy. Numbers in brackets indicate standard error.

| *Bed ID* | *CFD* | *Mean Unrooted Area/Volume* | | | | | |
|---|---|---|---|---|---|---|---|
| | | *Lift [cm]* | | *Area [$cm^2$]* | | *Volume [$cm^3$]* | |
| B | A | n/a | | n/a | | n/a | |
| | T | 2.8 | (0.2) | 1136.7 | (73.6) | 1151.9 | (162.9) |
| | N | 1.7 | (0.2) | 879.8 | (61.9) | 579.9 | (114.0) |
| C | A | n/a | | n/a | | n/a | |
| | T | 4.1 | (0.3) | 1352.6 | (119.5) | 2113.2 | (364.4) |
| | N | 2.9 | (0.3) | 1392.1 | (185.9) | 1870.9 | (454.7) |
| D | A | n/a | | n/a | | n/a | |
| | T | 4.5 | (0.3) | 1415.2 | (154.7) | 2877.2 | (394.7) |
| | N | 1.2 | (0.1) | 580.4 | ( 63.0) | 301.3 | ( 35.5) |

**DISCUSSION**

As 3 of the four carbohydrate beds are also beds used in the soil and canopy characterization, this data will be able to help understand the variability across sites and confirm trends observed. Preliminary analysis of the data indicates that there is a relationship between the occurrence of CFD and reduced rooting. Quantification of non-structural carbohydrates will provide an indication of reserves available to the plants.

**OBJECTIVE 2. CONDUCT FIELD TRIALS TO EVALUATE MANAGEMENT TECHNIQUES ON BEDS AFFECTED BY CRANBERRY FIELD DECLINE**

- **a.** Evaluate management practices to remediate cranberry beds affected by cranberry field decline
- **b.** Evaluate current management practices of in order to formulate appropriate recommendation for management practices

**OBJECTIVE 2A: EVALUATING THE EFFECTIVENESS OF MANAGEMENT PRACTICE**

Sanding is a strategy that is used for canopy and disease management in all cranberry producing regions and we have decided to focus on the impact of sanding in fields that are beginning to show symptoms of decline.

**SANDING WITH AERATION TRIAL**

As a part of the management trial, an observational study was conducted in a bed with sand and aeration treatments that had been applied by the grower. The treatment plots in the bed were sanded followed by aeration. Aeration was done by penetrating the soil using Verti Drain set at 8” in working

depth (effective penetration depth was 6”). Soil samples were collected later in the season at each treatment location. The preliminary result suggest that there were improvements in pH and Redox potential. Compared to the measurements at A and N, pH decrease and Redox potential increases in R in the top 15 cm of the soil. However, further investigation will be necessary to understand the effects of aeration and sanding treatment in the soil chemistry of peat-based cranberry beds. Table 4 suggests that aeration by the addition of sand is a worthwhile remediation technique as it appears to improve soil conditions, but will require additional measurements to determine if the effect persists over time.

**Table 4**. Soil Chemistry measurements result of samples collected from the bed with aeration treatment. A: CFD Affected area (not aerated), N: Non-symptomatic area , R: CFD Affected area with Aerated (sanding followed by aeration)

| Soil Depth | pH | | | Redox [mV] | | | E.C [µs/cm] | | |
|---|---|---|---|---|---|---|---|---|---|
| | A | N | R | A | N | R | A | N | R |
| **0-15** | 4.2 | 4.05 | 3.92 | 157.5 | 166.2 | 173.6 | 143.2 | 144.4 | 154.5 |
| **15-30** | 4.14 | 4.64 | 4.18 | 161.2 | 132.3 | 158.7 | 136.7 | 137.6 | 135.4 |

**SUMMARY**

Preliminary data suggest that the sanding with aeration had an impact on soil characteristics in the short term and suggests this is a management practice that should be further explored.

## SANDING TRIAL

### METHODS

Establishing Sanding Trial Plots

- 12 of 1m$^2$ plots separated by 50cm margin were established in 3 beds in a randomized complete block design (Figure 14).
- 2 treatments (sand application 2.5cm and 5cm in depth) and a control (no sand application) were randomly assigned to each plot.

Sample/Data Collection: Soil Chemistry

- Soil core samples (ϕ=2cm x 15cm) will be taken within each plot and measured for pH, Redox potential, and electrical conductivity (EC) by using CDS107 (Omega Engineering Inc.).
- *Sample Size*: 72 samples (24 plots x 3 beds)
- *Sampling Frequency*: beginning and end of seasons

Upright Density

- Number of uprights per 1 ft$^2$ area was counted for both vegetative and flowering uprights within each plot.
- *Sample Size*: 72 samples (24 plots x 3 beds)
- *Sampling Frequency*: once

Canopy Depth

- Depth of both green and brown canopy was measured by using a ruler within each plot.
- *Sample Size*: 72 samples (24 plots x 3 beds)
- *Sampling Frequency*: beginning and end of seasons

Rooting Capacity

- Rooting capacity was measured by the area under the canopy without major rooting points, by pulling the canopy at the center of each plot
- *Sample Size*: 72 samples (24 plots x 3 beds)
- *Sampling Frequency*: beginning and end of seasons

Yield Analysis

- Berries were collected within a square foot area at A, T, and N areas in each of assigned bed.
- Collected berries were sorted into marketable and unmarketable, counted, and weighted. [**In Progress**]
- *Sample Size*: 72 samples (24 plots x 3 beds)
- *Sampling Frequency*: once

Growth Analysis

- 1 $sf^2$ plant core (plant-soil intact core) 15cm deep into the soil will be collected within each plot. (scheduled for next season)
- Plant cores will be separated into 4 sections (green canopy, brown canopy, underground vine, and roots, all of which will be measured for fresh and dry weight. (scheduled for next season]
- Additional data (soil chemistry, upright count, canopy depth, and rooting points count) might be collected depending on the condition of the plant core. (scheduled for next season)
- *Sample Size*: 72 samples (24 plots x 3 beds)
- *Sampling Frequency*: once ( in the 2nd season)

## RESULTS

This is the first year of a two year study. As the sanding treatment was applied this year, it is anticipated that the impact on rooting and canopy characteristics will be observed in 2017 and therefore additional data should be collected next season.

### OBJECTIVE 2B: EVALUATE CURRENT MANAGEMENT PRACTICES OF IN ORDER TO FORMULATE APPROPRIATE RECOMMENDATION FOR MANAGEMENT PRACTICES

All growers that agreed to participate in the study also agreed to share management information with the researchers, growers are currently providing the final information to the researchers.