Progress Report Prepared for the BC Cranberry Marketing Commission

Project Title: Assessing Telemetry Components of Soil Moisture Sensing Systems for British Columbia Cranberry Production

Principal Investigator

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Commission Research Priority

1. Irrigation and Chemigation Design and Delivery (High Priority)
2. Canopy Management (High Priority)

Project Duration

April 2020 to February 2021 (1 Year)

Location

British Columbia Cranberry Research Farm, Delta, BC

Project Objectives

1. Assess the telemetry (remote data access) components of the most promising soil moisture sensors identified in the 2019 project "Critically Assessing Available Soil Moisture Sensors for use in British Columbia Cranberry Production".
2. Continue field validation of the top performing sensors identified in the above project.
3. Correlate soil water potential with volumetric water content (VWC) readings taken in organic soils in BC growing conditions.
4. Continue to provide a demonstration area at the BC Cranberry Research Farm for soil moisture technology to maximize grower engagement and knowledge transfer.

Summary of Project Activities

Objective 1: Telemetry options for the most promising sensors from the 2019 field project were identified. Price and functionality were key considerations for candidate sensors and telemetry options. The two telemetry options that were chosen for consideration in this project were:

- Meter's Zentra Cloud online platform (used with the TEROS 32 tensiometer)
- Spectrum's SpecConnect subscription and FieldScout Pro app (used with the FieldScout TDR 350)

Subscriptions/hardware were purchased in the spring and summer as needed, and sensors were redeployed in Field 3 at BCCRF (same location as 2019 sensor placement). Data was accessed throughout the year using the online platform/app to check for consistency of access, ease of use, and general reliability.

Objective 2: The top candidate sensors identified in 2019 were once again assessed for their performance in 2020. The sensors that were reinstalled in 2020 included:

- Meter TEROS 32 tensiometer (replaced Meter T8 tensiometer)
- Spectrum FieldScout TDR 350 (replaced borrowed TDR 300)
- Acclima TDR 310H

Spectrum's SM 100 soil moisture sensor was initially a potential candidate for this portion of the study, but after considering the relative cost of upgrading the Spectrum stationary logger and the SM 100's moderate in-field performance/accuracy, it was excluded. The industry standard, the Hortau tensiometer, was once again installed nearby in Field 3, which captured soil water potential data throughout the growing season for comparison. Additionally, point readings were taken of all five fields at BCCRF using the FieldScout TDR 350 in September to create soil moisture profiles for the farm (figures 5-10). Sensors were removed in early October, just prior to harvest.

Objective 3: Soil water potential and volumetric water content readings were being taken simultaneously at BCCRF throughout the season using the various sensors. This data will be analyzed further to estimate the water retention curve for BCCRF's peat soil.

Objective 4: The demonstration area in the south end of Field 3 was set up similarly as in 2019 (figure 1). COVID-19 significantly reduced the number of grower visits to BCCRF in 2020.

Preliminary Conclusions

Both telemetry options that were assessed performed well and would be acceptable options for BC cranberry growers. Meter's TEROS 32 sensor remains the best alternative to the stationary Hortau tensiometer for season-long moisture tracking (ie. installing the sensor in the field and leaving in the same location all year). Spectrum's FieldScout TDR 350 has other benefits and features that are inherent in its mobility, such as the ability to create full field moisture/temperature contour maps and diagnose problem areas, but does not track trends over time. Both tools have a place/use in cranberry production. The Acclima sensor performs well on its own (accurately measures soil moisture) but does not yet have the telemetry options of the more well-established companies like Meter and Spectrum; however, these options are in development, so the sensor should not be ruled out completely. Further data analysis will take place over the winter for additional comments in the final report.

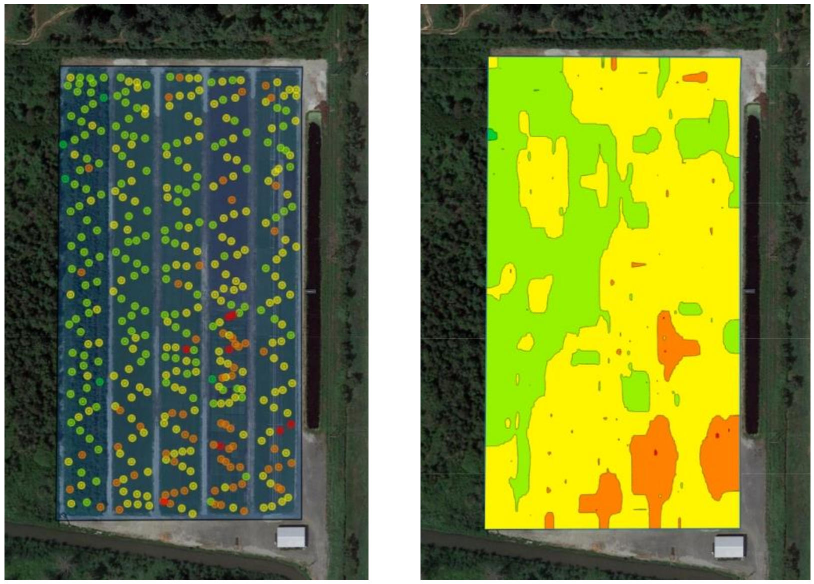
Project Expenses

Expense Description	Cost
Spectrum FieldScout TDR 350, SpecConnect yearly subscription	$3151.29
Meter TEROS 32 tensiometers, Zentra Cloud yearly subscription	$2055.93
Acclima sensor repair (customs charges)	$27.89
Field supplies	$27.40
Shipping charges	$28.00
Total (CAD)	**$5290.51**

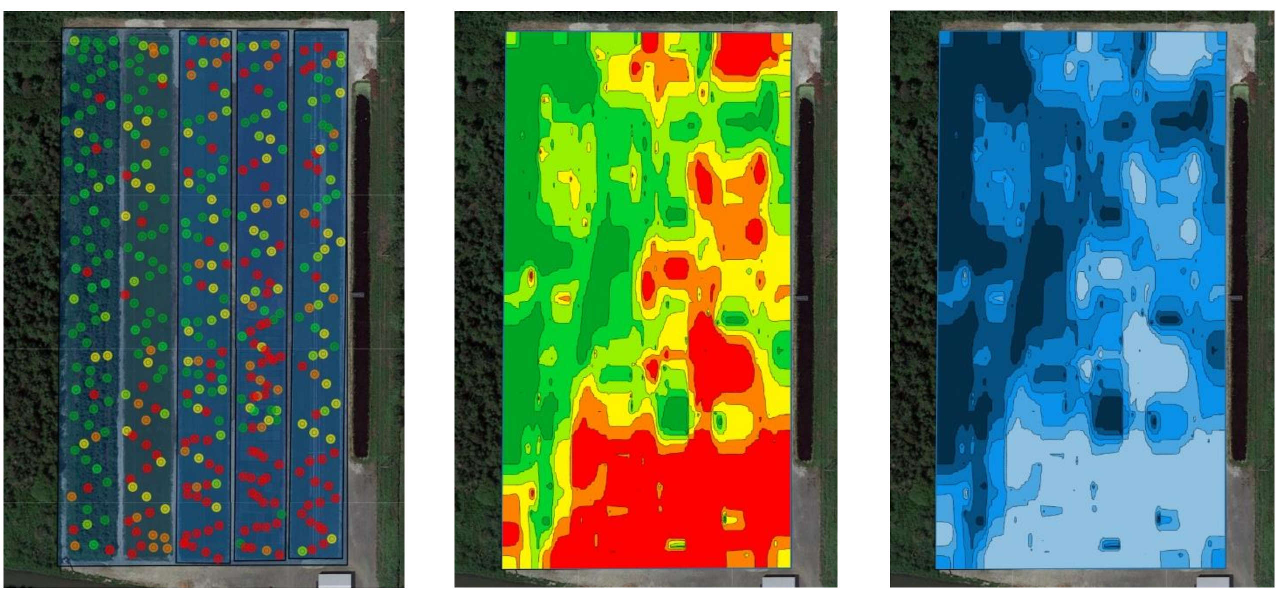
Other Funding

Ocean Spray Cranberries provided Principal Investigator and research assistant wages in-kind, consumables, and costs associated with transportation to the research site.

Figures 1-4: 1) Sensor setup in Field 3 at BCCRF. 2) TEROS 32 tensiometer 3) Spectrum FieldScout TDR 350. 4) Acclima 310H sensor

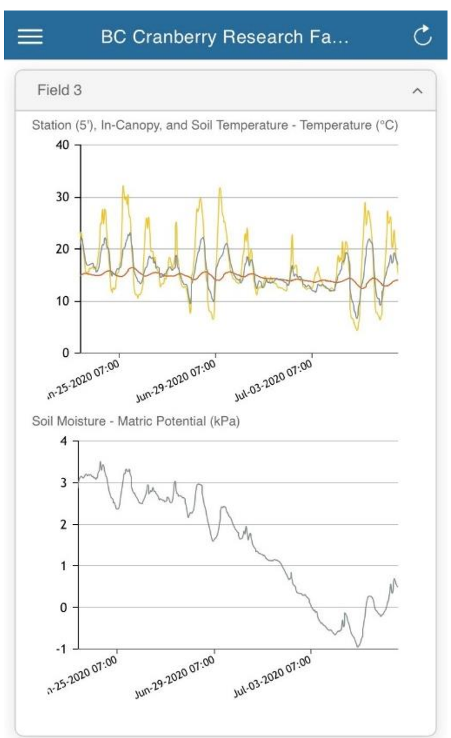


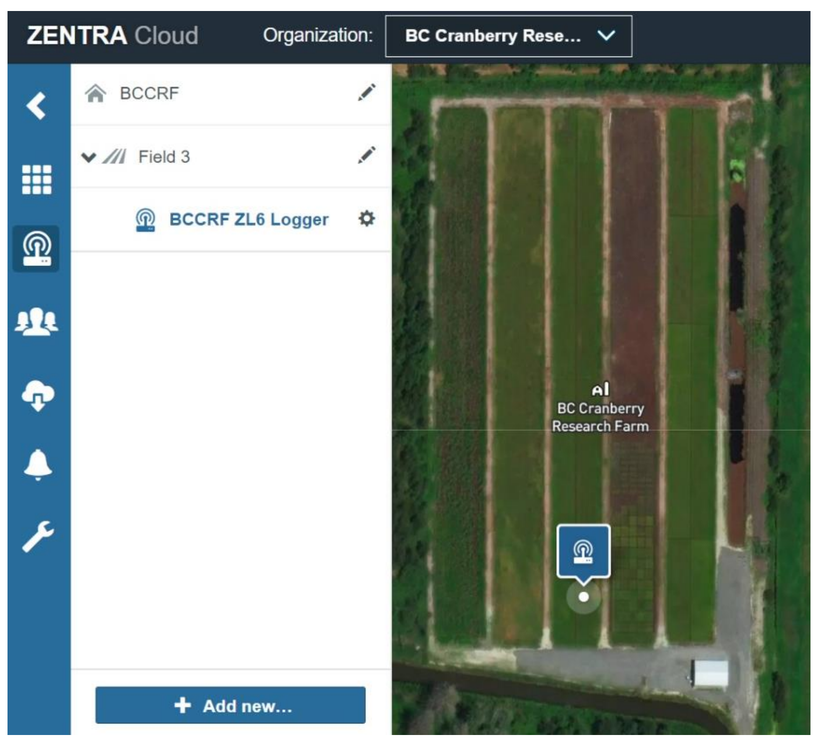
Figures 5 and 6: 5) Individual volumetric water content (VWC) point readings taken with the FieldScout TDR 350 at BCCRF. 6) VWC data with contour map overlap showing moisture trends across farm, made using the SpecConnect subscription/platform.



Figures 7-9: 7) VWC readings with adjusted/sensitized scale to better show moisture patterns on farm. 8) Contour map with more sensitive scale. 9) Contour map showing options for different colour visualizations.

Figure 10: Data summary of VWC readings taken at BCCRF in fields 1-5 (west to east) using the FieldScout TDR 350. Data summarized and report generated using the SpecConnect platform.





Figures 11 and 12: 11) Mobile view of the Zentra Cloud app (Meter telemetry). 12) Desktop view of the Zentra Cloud platform.

Project Background and Literature Review (*from research proposal*)

Research over the last decade, primarily out of Université Laval in Quebec and the University of Massachusetts, has shown that irrigation automation using a soil water potential threshold between either 2-5 kPa or 4-7 kPa can successfully increase cranberry yields and optimize water productivity (Bonin 2009, Pelletier *et al.* 2013, Jabet *et al*. 2016). It has also been demonstrated that exposure to hypoxic soil conditions can significantly reduce photosynthetic activity in cranberries, with particularly damaging effects during bud elongation and flowering stages (Bulot *et al.* 2016 and Pelletier *et al.* 2016). Soil water potential can be very simplistically thought of as the amount of energy required to transport water out of the soil (Cooper and Cuenca 2016).

The Quebec-based irrigation automation company, Hortau, has been deploying their irrigation technology using these research-based thresholds in several cranberry growing regions, primarily Quebec and Wisconsin. The technology is particularly useful and reliable in mineral soils, which are commonplace in these growing regions. However, there is less known about the usefulness of this technology and irrigation threshold in growing regions with organic soils, like those in the majority of cranberry fields in British Columbia.

While there are a handful of British Columbia growers attempting to use the Hortau system on their farms, they are primarily using the sensors only for frost protection and data tracking. The growers do not yet trust the technology to rely on it for irrigation automation. The concerns expressed by growers include:

1.) a lack of information on irrigation automation in organic (peat) soils,
2.) the notorious “floating canopies” of this region are not compatible with this technology,
3.) lack of root interaction with the actual soil moisture due to compromised canopies, and
4.) a fear of collapse when fields are relying on aerial roots and canopy humidity for sustenance.

Soil moisture data obtained from several farms hosting Hortau sensors in 2017 and 2018 showed that fields spent <10% of the growing season within Hortau’s ideal moisture range of 4-7 kPa (Elsby unpublished data 2018). For the rest of the season, soils were almost completely saturated (0-2 kPa), with occasional peaks of extremely dry soils in hot summer weather. Based on research showing the negative impacts of hypoxic soil conditions, it is reasonable to think that the chronically saturated soil on these farms is not contributing to high yields. Additionally, these conditions are not conducive to the deep, healthy root systems that are an integral part of a sustainable cropping system; one which can withstand stressors such as drought, mechanical damage, and resource-demanding phenological windows.

It is evident that British Columbia cranberry growers would benefit from optimizing their irrigation regimes to serve crop moisture needs more effectively, and to improve the overall health of the cropping system. It has also become evident, through grower extension and outreach, that while the Hortau system appears to perform well and deliver accurate soil moisture data, it is outside of many growers’ operating budgets and some apprehension still exists in adopting this technology. It should also be noted that a number of BC growers experimented with Irrometer® brand tensiometers a number of years ago, with limited success, due to the instrument’s lack of sensitivity, which is required for cranberry production. This failure contributed further to growers’ skepticism in soil moisture sensing technology and their willingness for adoption.

Irrigation set points for VWC are even less well understood than soil water potential and can vary greatly depending on soil characteristics. This has created discrepancies in recommendations between cranberry growing regions which have opposing soil structures, such as sand versus peat. Correlations of soil water potential and VWC have been published for Massachusetts and Quebec, but not for other growing regions that could be found (Pelletier *et al.* 2015 and Jeranyama *et al.* 2017). While the soil water potential recommendations from other regions seem consistent and reasonable in the context of BC growing conditions (2-5 kPa or 4-7 kPa), the VWC threshold seems too dry for peat soils (10% VWC) (Jeranyama 2014 and Tilberg 2017). The simplified definition of VWC is the volume of water within a given unit of soil (Cooper and Cuenca 2016).

Considering the influence that soil characteristics such as electrical conductivity, organic matter, porosity, and temperature can have on VWC readings, it is unsurprising that recommendations are not standardized for industry (Evett 2016). Field data specific to the region should be generated to better understand the correlation between soil water potential and VWC in BC cranberry production before any irrigation set points or thresholds are relied upon exclusively for irrigation timing.

Irrigation practices in BC cranberry production could be optimized through the adoption of soil moisture sensing technology. The soil moisture sensor company with the dominant presence in BC is Hortau, which offers an accurate and user-friendly product for industry. However, technology adoption remains scarce due to several reasons, including affordability. To offer BC growers alternative sensor options at lower price points, several soil moisture sensors were identified as candidates and tested in the field in the 2019 project "Critically Assessing Available Soil Moisture Sensors for use in British Columbia Cranberry Production". To further solidify sensor recommendations to growers, a few more pieces of information should be gathered.

The proposed work will validate the selected sensors' performance in the field for a second year; correlate VWC readings with soil water potential data, which has never been done before in BC growing conditions; and assess the telemetry options for each of the sensors, an important function for grower adoption and usability. By providing an array of affordable and user-friendly soil moisture sensing option to BC growers, adoption of this technology will ideally improve, resulting in crops with optimized water inputs and the avoidance of waterlogged soils that are detrimental to root and canopy health.

Relevant Literature

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