

Final Research Report Prepared for the BC Cranberry Marketing Commission

**Assessing Telemetry Components of Soil Moisture Sensing Systems for British Columbia Cranberry
Production**

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

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

Executive Summary

Irrigation automation and precision water management in horticultural crops is incredibly important for yield optimization, crop health, and fruit quality. The majority of British Columbia cranberry producers do not currently utilize soil moisture sensing technology, nor have they widely adopted sensor-based irrigation automation to manage their crop water needs. Data collection through 2018-2020 at the British Columbia Cranberry Research Farm (BCCRF) indicates that fields spend the majority of the growing season in a saturated state, which is not conducive to the formation of healthy root systems or high yields. Cranberry producers would therefore stand to benefit from the adoption of affordable and reliable soil moisture sensing technology to help guide irrigation decision-making and more precisely provide for crop water needs. The soil moisture sensor company with the dominant presence in British Columbia currently is Hortau, which offers an accurate and user-friendly product for industry; however, technology adoption remains scarce for several reasons, including affordability. To offer 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, this study tested the candidate sensors for an additional year in the field, as well as the telemetry (remote data access) components of the sensor and logger systems. Two sensor-logger systems were found to be user-friendly, reliable, and more affordable than the Hortau system: Meter’s TEROS 32 tensiometer with the Zentra Cloud online platform and Spectrum’s FieldScout TDR 350 with the SpecConnect subscription and FieldScout Pro mobile application. Each system accurately tracked soil moisture conditions in the field and remote data access proved effective and reliable. By providing affordable and user-friendly soil moisture sensing options to 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.

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

Summary of 2020 Activities			
January - March	April - June	July - September	October - December
Project proposal submitted and funding approval received	Purchased hardware and subscriptions for chosen sensor systems (Meter and Spectrum); re-installed selected sensors in Field 3 at BCCRF	Continued data collection and sensor validation in field; generated soil moisture maps; no 2020 BCCRF drop-in event	Sensor removal prior to harvest; data analysis; progress and final report submission to BCCMC

Objective 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”.*

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 and hardware were purchased in the spring and summer as needed, and sensors were redeployed in Field 3 at BCCRF in the same location as the 2019 field demonstration area. Data was accessed throughout the year using the online platforms and mobile application to check for consistency of access, ease of use, and general reliability. The Zentra Cloud platform (Figures 1 and 2) proved to be a great resource for remote monitoring of soil moisture conditions at the farm, with the added benefit of additional sensor ports on the data logger. With these additional ports, any extra sensors can be added to the logger system, such as weather stations, temperature or humidity sensors, etc. The Zentra Cloud platform also allows for customizable graphs of field data and the addition of multiple users if required for farm management. The SpecConnect subscription was also user-friendly and allowed for the generation of field moisture maps (Figures 3-6). The FieldScout TDR 350 collected precise data that was logged on a Bluetooth-enabled phone in the field using the FieldScout Pro app, which was then accessible on desktop through the SpecConnect platform.

Objective 2: *Continue field validation of the top performing sensors identified in the above project.*

The top candidate sensors identified in 2019 were once again assessed for their performance in 2020 (Figures 7-9). 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 and 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 3-6). Sensors were removed in early October, just prior to harvest.

The Meter TEROS 32 tensiometer once again performed well in the field and offers the best alternative stationary sensor to the Hortau tensiometer. The Spectrum FieldScout TDR 350 mobile sensor also performed well in the field and was able to accurately capture the subtle soil moisture variations even in saturated peat. The Acclima TDR 310H stationary sensor collected accurate moisture data for a second year, but falls behind the Meter and Spectrum systems in terms of user-friendliness; however, the company continues to improve on their products and offerings, so future potential exists with this accurate sensor.

Objective 3: *Correlate soil water potential with volumetric water content (VWC) readings taken in organic soils in BC growing conditions.*

Soil water potential and VWC readings were taken simultaneously at BCCRF throughout the season using the Hortau tensiometer, the Meter TEROS 32 sensor, and the Acclima 310H sensor. This data was then analyzed and correlated to estimate optimal VWC readings for the peat-based soil at BCCRF. Fields were exceptionally wet at BCCRF in 2020 due to the recent plug planting in Field 5 and the need to keep the establishing plants well-watered. These saturated conditions narrowed the range of VWC and soil water tension readings captured in 2020 (Figures 10-12). Even with the narrow range captured, it was evident that the ~10% VWC threshold recommended in other regions (Jeranyama 2014 and Tilberg 2017) is not transferable to peat-based soils in BC with high organic matter content. The VWC threshold for BC production is likely closer to 35%-40% in peat-based soils, assuming an ideal soil water tension between 2-5 kPa.

Readings were analyzed for correlation using Pearson's correlation test ($r=-0.805$, $p=0.000$) using Minitab Statistical Software version 18.1. A linear regression was also calculated to predict VWC and soil water tension outside of the range detected at BCCRF in 2020. VWC is equal to $(43.59 - (1.085 (\text{soil water tension})) + (0.04596 (\text{soil water tension})^2))$ using this linear model ($R^2=64.89\%$, $p=0.000$).

Objective 4: *Continue to provide a demonstration area at the BC Cranberry Research Farm for soil moisture technology to maximize grower engagement and knowledge transfer.*

The demonstration area in the south end of Field 3 was set up similarly as in 2019 (Figure 13). COVID-19 significantly reduced the number of grower visits to BCCRF in 2020. A presentation will be given to BC, Washington, and Oregon growers at the 2021 Pacific Northwest Cranberry Congress. Knowledge transfer is also continuous through the Principal Investigator's extension role at Ocean Spray Cranberries.

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 benefits and features that are inherent in its mobility, such as the option to create full field moisture or temperature contour maps and diagnose problem areas, but does not track trends over time. Both tools have a place and use in cranberry production and the optimization of yields and field conditions. The Acclima 310H sensor performs well on its own in terms of accurately measuring soil moisture through the Time Domain Reflectometry (TDR) technology, 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 for future use. With the use of these sensors, it was shown that VWC recommendations for other regions with mineral-based soils are not directly transferable to BC growing conditions, particularly for peat-based fields. Given the findings of this study, the ideal range for soil water tension in BC is likely 2-5 kPa and the ideal VWC is likely 35%-40% for peat-based soils. If growers choose to adopt these more affordable technologies for soil moisture sensing, they will ideally be able to monitor their water usage more closely and make informed irrigation decisions, in turn optimizing this important agronomic input for the enhancement of overall plant health and yield.

Project Expenses

Expense Description	Cost
Spectrum FieldScout TDR 350, SpecConnect yearly subscription	\$3151.29
Meter TEROS 32 tensiometers, Zentra Cloud yearly subscription, auger kit, Bluetooth reader	\$2955.93
Acclima sensor repair (customs charges)	\$27.89
Field supplies	\$27.40
Shipping charges	\$28.00
Total (CAD)	\$6190.51

Other Funding

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

Acknowledgements

Thank you to the BC Cranberry Research Committee, the BC Cranberry Marketing Commission, and the BC Cranberry Research Farm for funding and project support.

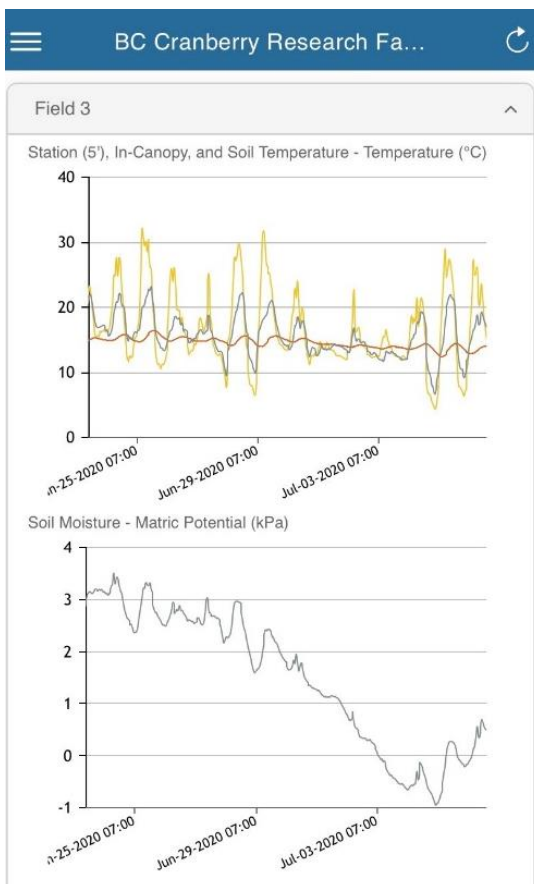
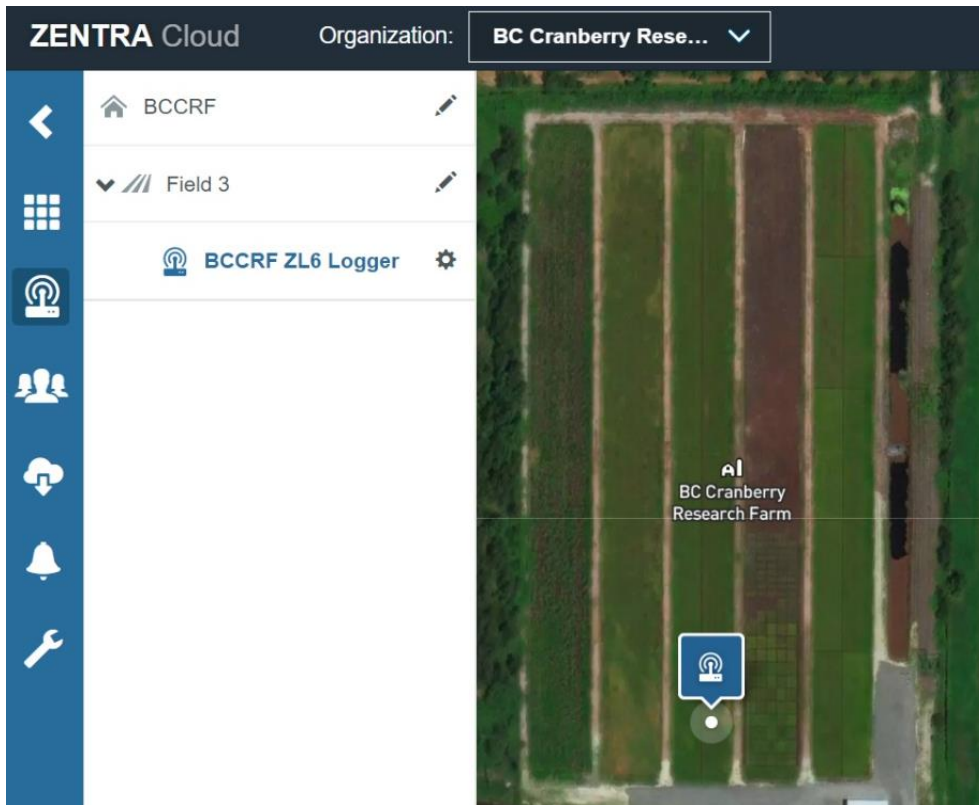


Figure 11 (above): Zentra Cloud desktop view showing sensor location in the field at BCCRF. Additional users can be added to give multiple viewers access to data. Custom graphs and logger settings can be formatted here.

Figure 12 (left): Zentra Cloud mobile application showing remotely-accessible field data for BCCRF.

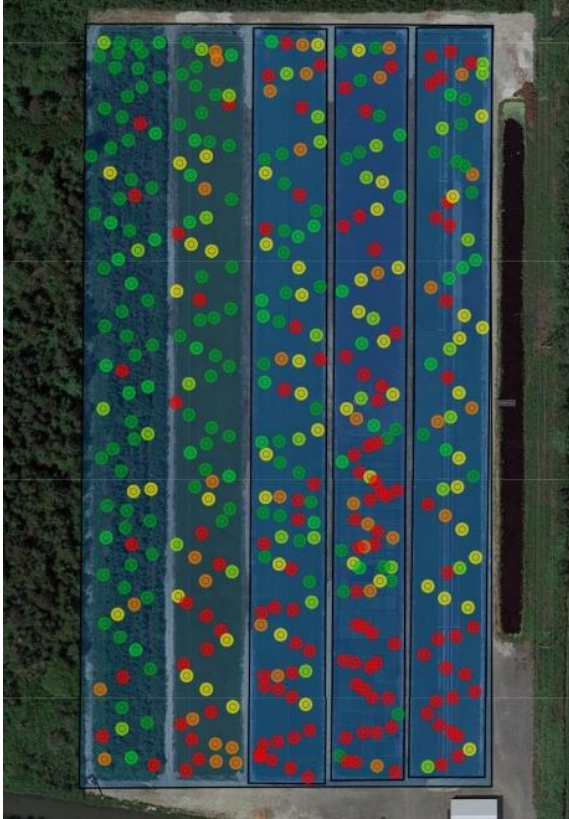
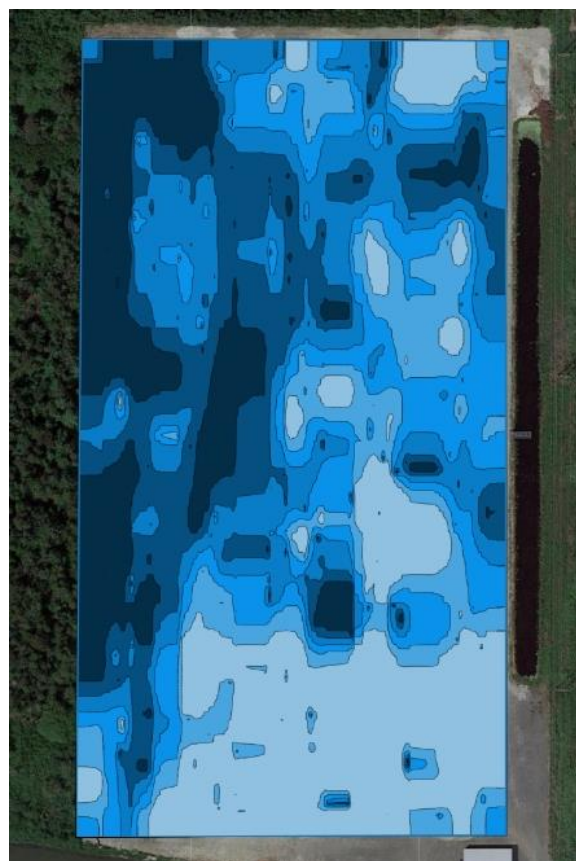
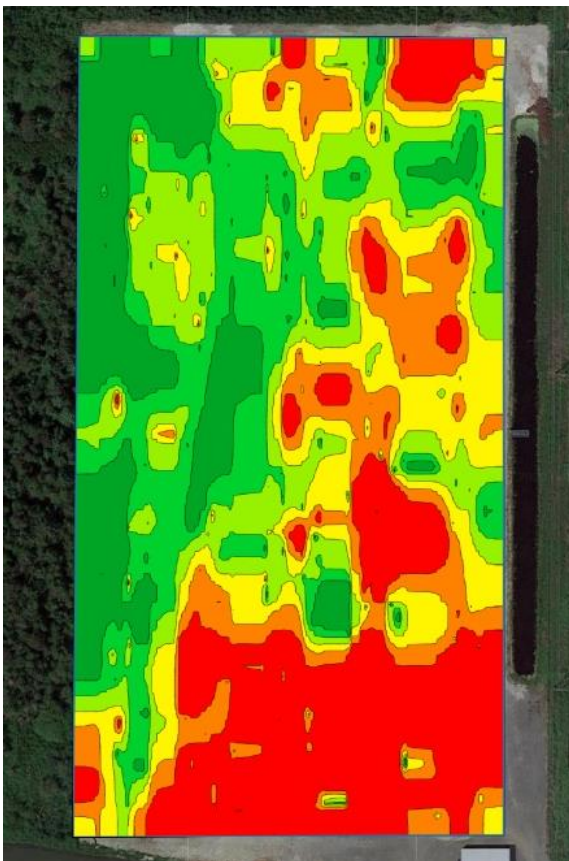


Figure 3 (left): Individual VWC point readings taken on September 1, 2020 at BCCRF in all five fields. Data collected using the Spectrum FieldScout TDR 350 and a Bluetooth-enabled phone with the FieldScout Pro application.

Figures 4 and 5 (below): Field contour maps generated using the SpecConnect desktop platform and the individual point reading data from Figure 3. Maps can be customized to narrow ranges to show greater sensitivity, as well as different colour profiles to better visualize water patterns in field. A soil moisture pattern at BCCRF was evident using this mobile sensor, with a clear gradient in increased moisture moving south to north and east to west.



FieldScout Surface Report - BCCRF

Hide Statistics No

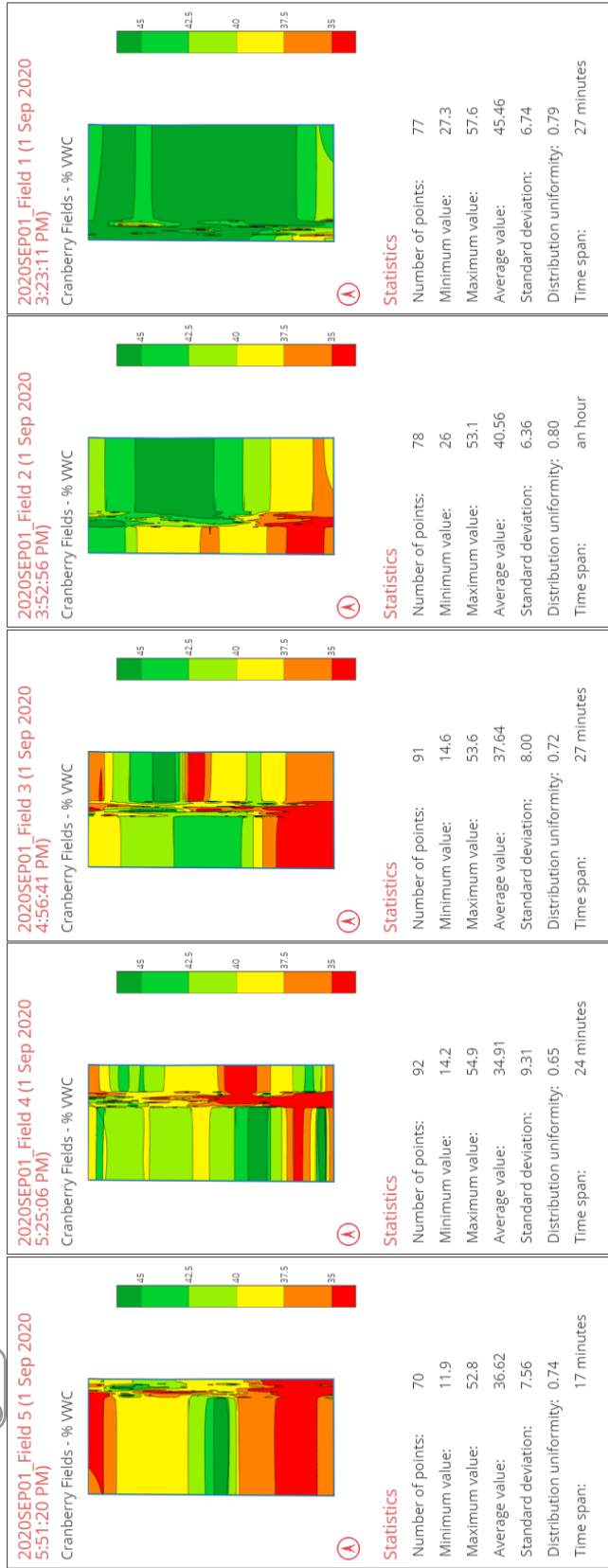


Figure 6: Data summary of VWC readings taken at BCCRF in Fields 1-5 using the FieldScout TDR 350. Data summarized and report generated using the SpecConnect platform.



Figure 7: Spectrum FieldScout TDR 350 mobile VWC sensor.



Figure 8: Meter TEROS 32 soil water potential tensiometer in Field 3 at BCCRF.



Figure 9: Acclima 310H time domain reflectometry VWC sensor.

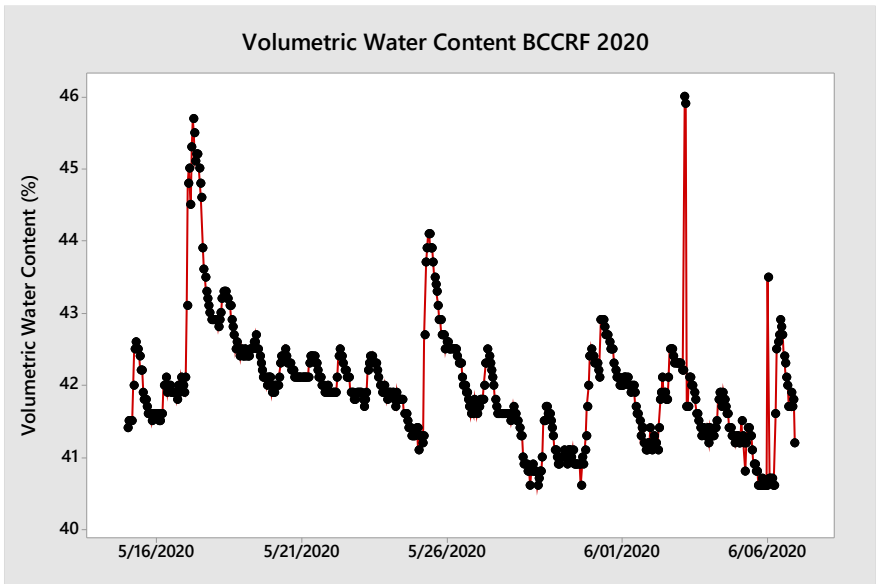


Figure 10: VWC readings taken with the Acclima 310H sensor through mid-May to mid-June in Field 3 at BCCRF

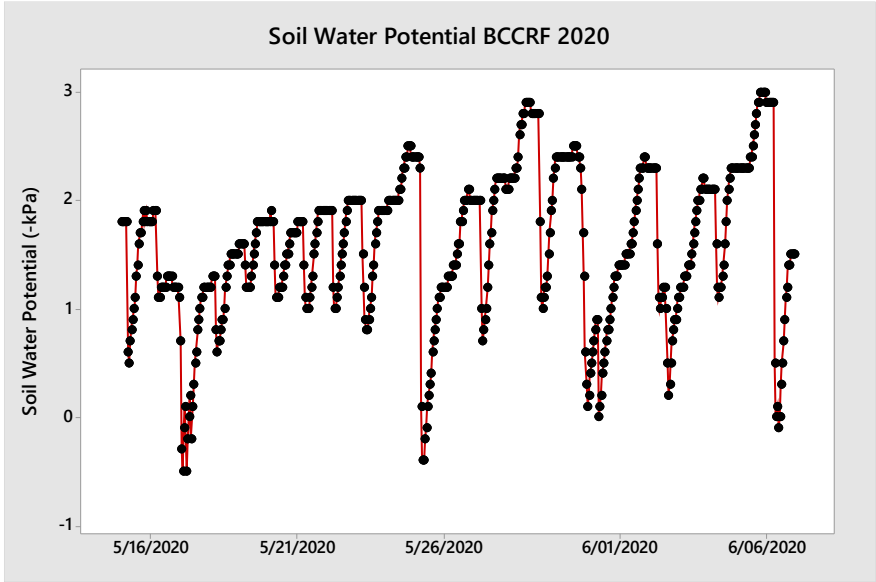


Figure 11: Soil water potential readings taken with the Hortau tensiometer through mid-May to mid-June in Field 3 at BCCRF

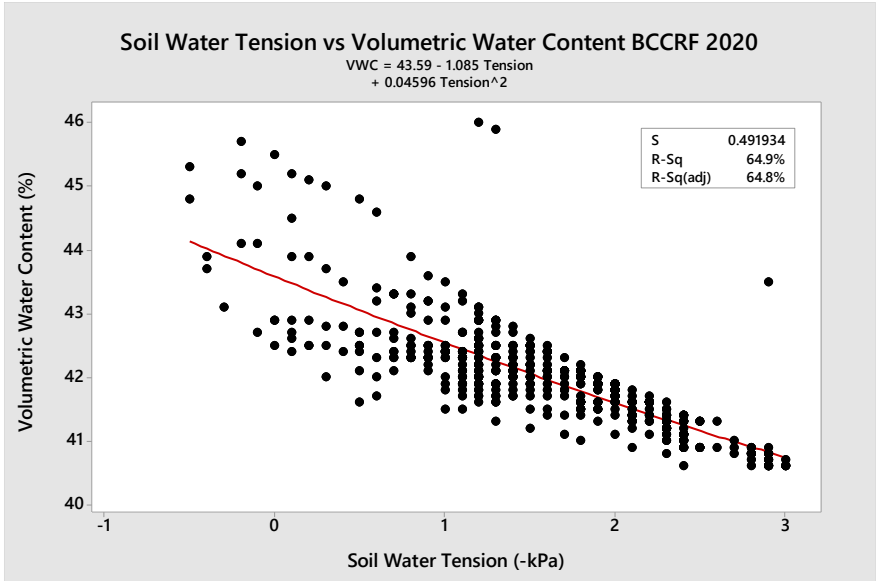


Figure 12: Fitted line graph of 550 VWC readings and soil water tension at BCCRF in peat-based soils (organic matter content of 76.6 %). Readings were strongly correlated ($r=-0.805$, $p=0.000$), and the linear regression equation was: $VWC = 43.59 - (1.085 (\text{soil water tension})) + (0.04596 (\text{soil water tension})^2)$.



Figure 13: Location of sensors in the south end of Field 3 at BCCRF for grower and visitor visibility. Photo depicts the Meter ZL6 datalogger connected to the TEROS 32 sensor. Optional sensors can be added to this logger, including the ATMOS 41 Weather Station (located on top of logger and pole), adding versatility and value to this sensor-logger system.

Relevant Literature

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