# Investigating the soil electrical conductivity in PEI potato fields for improved farming

**S. Tang and A. Farooque**

University of Prince Edward Island, Faculty of Sustainable Design Engineering, PE, Canada

## ABSTRACT

Electromagnetic induction (EMI) is used as a method to measure soil electrical conductivity (EC). Soil EC has been shown to be directly related to several factors that affect crop yield. The DUALEM-2 is an EMI instrument which gives simultaneous EC readings to depths of exploration of 1m (HCP) and 3m (PRP). However, most agricultural soils are stratified into layers with a characteristic conductivity so an inversion technique is required to convert DUALEM-2 data into the true conductivity profile. Vertical electrical sounding was performed where the DUALEM-2 was raised at 0.2m intervals up to height of 1.6m to determine the soil profile or conductive layering within the earth. The calculated conductivities of the root zones can be correlated with yield in order to create soil management zones for variable rate application of nutrients in potato fields.

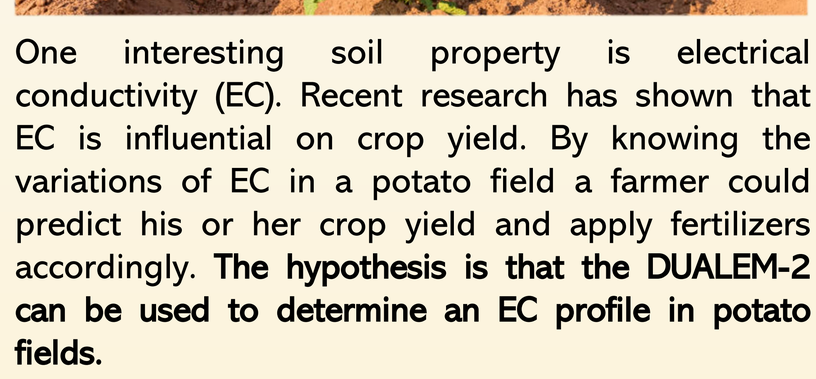
## Introduction

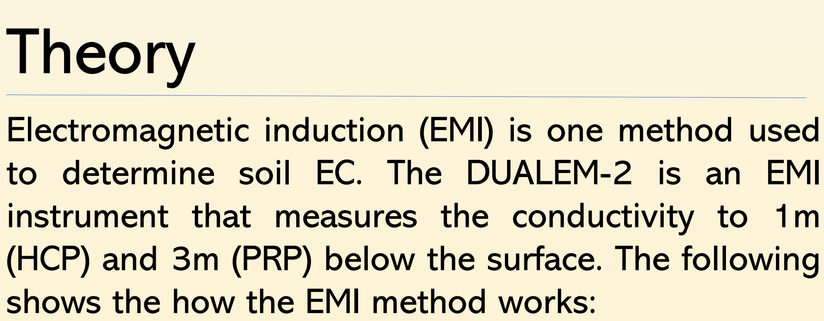
PEI is Canada's number one grower of potatoes by area. However, potato farming requires extensive use of fertilizers, herbicides, insecticides, and fungicides to produce a bountiful and healthy crop. This necessity comes with environmental concerns but also opportunities to explore more sustainable farming. For example, not every part of a field requires the same amount of fertilizer. This new and innovative area of research is called *precision agriculture.*

One interesting soil property is electrical conductivity (EC). Recent research has shown that EC is influential on crop yield. By knowing the variations of EC in a potato field a farmer could predict his or her crop yield and apply fertilizers accordingly. **The hypothesis is that the DUALEM-2 can be used to determine an EC profile in potato fields.**

## Theory

Electromagnetic induction (EMI) is one method used to determine soil EC. The DUALEM-2 is an EMI instrument that measures the conductivity to 1m (HCP) and 3m (PRP) below the surface. The following shows the how the EMI method works:

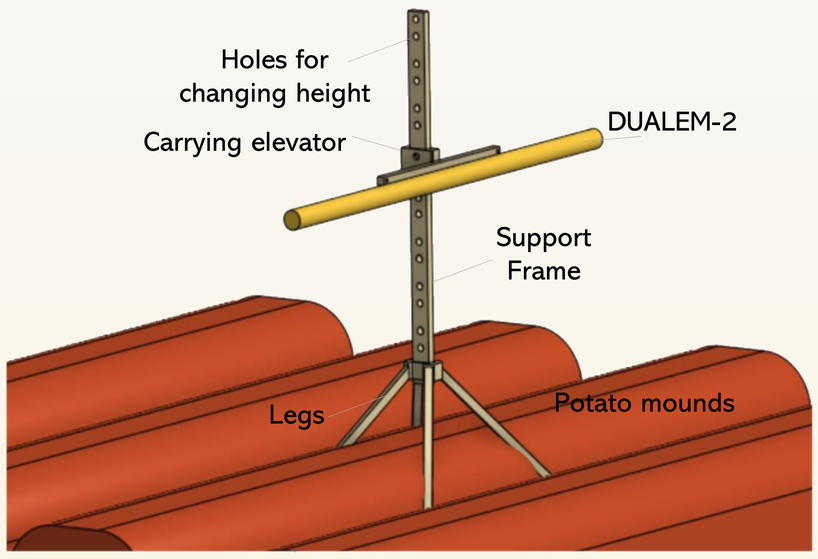



## Methods

*1. Design of vertical raiser*

To investigate the soil EC profile in potato fields, an vertical raiser was designed and built to raise the DUALEM-2 at 20cm intervals to obtain EC readings at different soil depths.




*2. Field experiment*

Two fields were selected in O'Leary and Souris, PE. Twelve points on each field were mapped using GPS and the EC was measured from a height of 0 to 1.6m in 20cm intervals using the vertical raiser.

*3. Homogeneous and two-layered earth models*

Previous studies relating yield and EC have considered a uniform earth, but a more realistic two-layered earth model was predicted for this study:




A custom algorithm was developed where the EC readings at different heights were inverted to determine the three unknown parameters, $\sigma_1$, $\sigma_2$, and $t_1$. A *Microsoft Excel* iteration routine was performed to minimize the error function ($\varepsilon$) relating theoretical and actual EC values:

$$\varepsilon = \left| \frac{\sum[R_{HCP}(h_i) - R^*_{HCP}(h_i)]^2 + \sum[R_{PRP}(h_i) - R^*_{PRP}(h_i)]^2}{N} \right|$$

where

$$R(h) = \int_0^\infty \varphi(h+z)\boldsymbol{\sigma}(z)dz$$

$$\varphi_{PRP}(z) = \frac{2z}{(4z^2+1)^{\frac{1}{2}}} \qquad \varphi_{HCP}(z) = 1 - \frac{1}{(4z^2+1)^{\frac{1}{2}}}$$

## Results

EC vs depth were plotted for both fields (Figs. 1 and 2) and the custom model was fitted to the data. In general, the EC varied both laterally and vertically within the field.

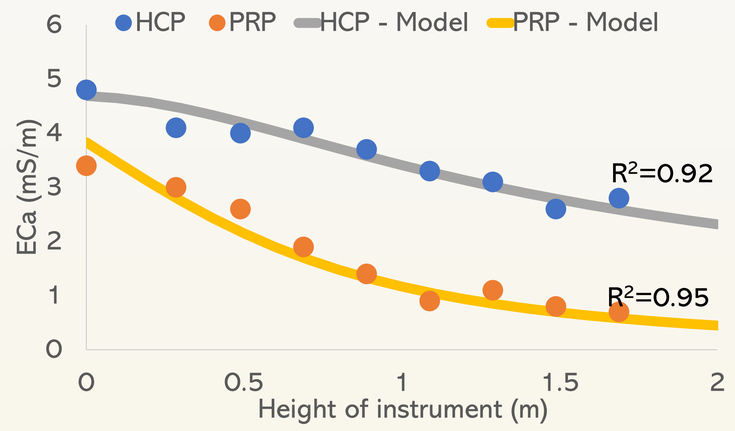



Figure 1. Comparison of measured EC (dots) and model EC (lines) for HCP and PRP for a Field 1 in Souris, PE. ($\sigma_1 = 0.97\text{mS}\cdot\text{m}^{-1}, \sigma_2 = 6.6\text{mS}\cdot\text{m}^{-1}, t = 0.56\text{m}$)

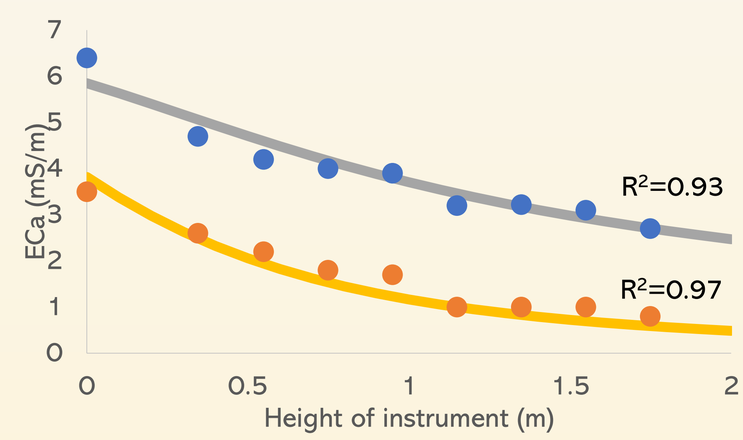



Figure 2. Comparison of measured EC (dots) and model EC (lines) for HCP and PRP for a Field 1 in O'Leary, PE. ($\sigma_1 = 3.7\text{mS}\cdot\text{m}^{-1}, \sigma_2 = 7.6\text{mS}\cdot\text{m}^{-1}, t = 3.9\text{m}$)

## Conclusion

The vertical raiser and the custom inversion algorithm allowed the DUALEM-2 to be used to determine the conductivity profile for PEI potato fields. The next steps are to develop three-layered models and to correlate our results with potato yield. Research relevance map:




## References

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[3]Saey, T., Simpson, D., Vermeersch, H., Cockx, L., & Meirvenne, M. V. 2009. Comparing the EM38DD and DUALEM-21S sensors for depth-to-clay mapping. Soil Science Society of America Journal, 73, 7–12.

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