Identifying Subsoil Hardpans Using an Electromagnetic Induction Technique

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Introduction

- Presence of subsoil hardpans is a major yield limiting factor for most agricultural crops
- Apparent soil electrical conductivity has a unique utility of estimating topsoil thickness
- Several soil parameters can be related to soil hard pan *i.e.,* soil temperature, structure, soil moisture and bulk density

What is Soil Compaction

- Soil Composition
  - Air
  - Water
  - Minerals
  - Organic matter

- Bulk Density
  - Indicator of soil compaction
  - $BD = \frac{Dry\ weight\ of\ soil\ (g)}{Volume\ (cm^3)}$

[7]

- Varying soil BD affects plant growth
  - 1.6 $\frac{g}{cm^3}$

[8]

Soil texture	Ideal bulk densities for plant growth (g/cm^3)	Bulk densities that affect root growth (g/cm^3)	Bulk densities that restrict root growth (g/cm^3)
Sands, loamy sands	<1.60	1.69	>1.80
Sandy loams, loams	<1.40	1.63	>1.80
Sandy clay loams, clay loams	<1.40	1.60	>1.75
Silts, silt loams	<1.40	1.60	>1.75
Silt loams, silty clay loams	<1.40	1.55	>1.65
Sandy clays, silty clays, clay loams	<1.10	1.49	>1.58
Clay (>45% clay)	<1.10	1.39	>1.47

[8

[5] Earth Soils. (2021, November 21). *Soil composition*. Earthsoils. Retrieved January 10, 2023, from https://earthsoils.com/soil-composition/

[6] DeJong-Hughes, J. (2018). *Soil Compaction*. UMN Extension.

[7] Arshad , M. A., Lowery , B., & Grossman , B. (2011, September 19). *Bulk density*. Soil Quality: Indicators: Bulk Density.

[8] Nyeki, A., Milics, G., Kovacs, A. J., & Neményi, M. (2017, February). *Effects of soil compaction on cereal yield: A review*

Effects on Sustainable Agriculture

Negatively affects crop growth
- ➢Nutrient and water uptake

Water infiltration
- ➢ Waterlogged fields
- ➢ Erosion
- ➢ Surface compaction

[5]

[9] Magdoff, F., & van Es, H. (2021, July 29). *CH 6. soil degradation: Erosion, compaction, and contamination*. SARE.

[10] Thacker , J. (2016). *Waterlogged Field near Dial House Farm © Jonathan Thacker*. Waterlogged field near Dial House Fam .

[11] UNIVERSITY of NEBRASKA–LINCOLN. (2017, May 24). *Extension crop reports May 22-26*. CropWatch

Effects of Tillage on Soil

Tillage

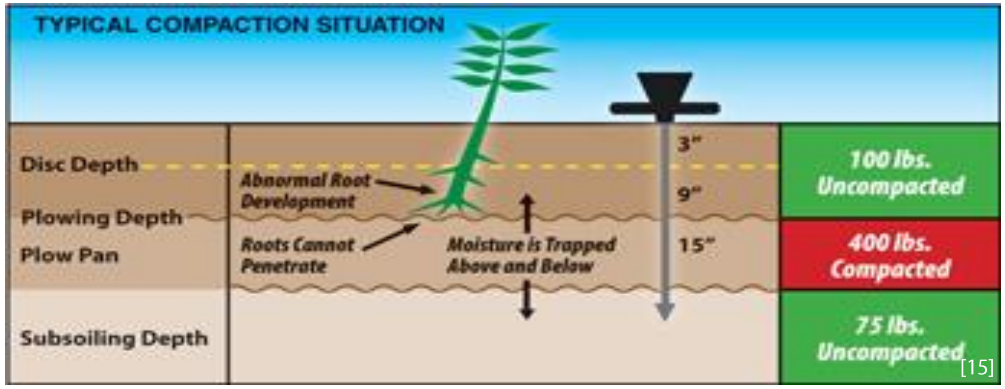
- Turn over cover crops
- Bury crop residue
- Seedbed preparation
- Weed suppression

Degrades

- Soil quality & structure
- Loss of organic matter
- Bulk density
- Increases runoff & erosion

Excessive tillage and equipment movement


[12]



[15]

[12] Perry, B. (2020, May 18). *Gardening for profit: Most profitable small farm you've ever seen pulls in $100k an acre*. organicgardentips.com.

[15] Agri Partner. (2016, October 28). *Compaction-Chart1*. Agri Partner.

Purpose of Research

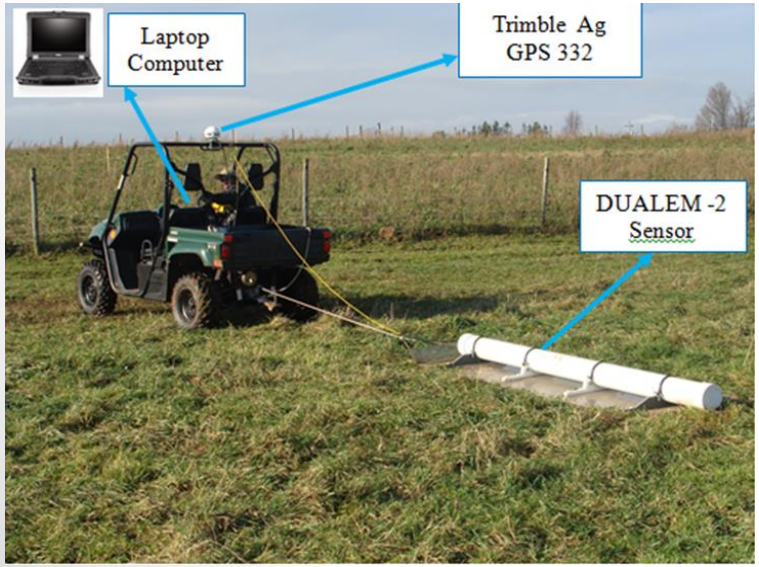
Help potato farmers on PEI to improve and adapt sustainable farming practices

- ✓ Delineate management zones
- ✓ Variable rate tillage
- ✓ Soil conservation
- ✓ Improve yields and profitability

[16] WelcomePEI. (2022, October 5). *Pei potatoes*. Welcome PEI. Retrieved January 10, 2023.

Objectives

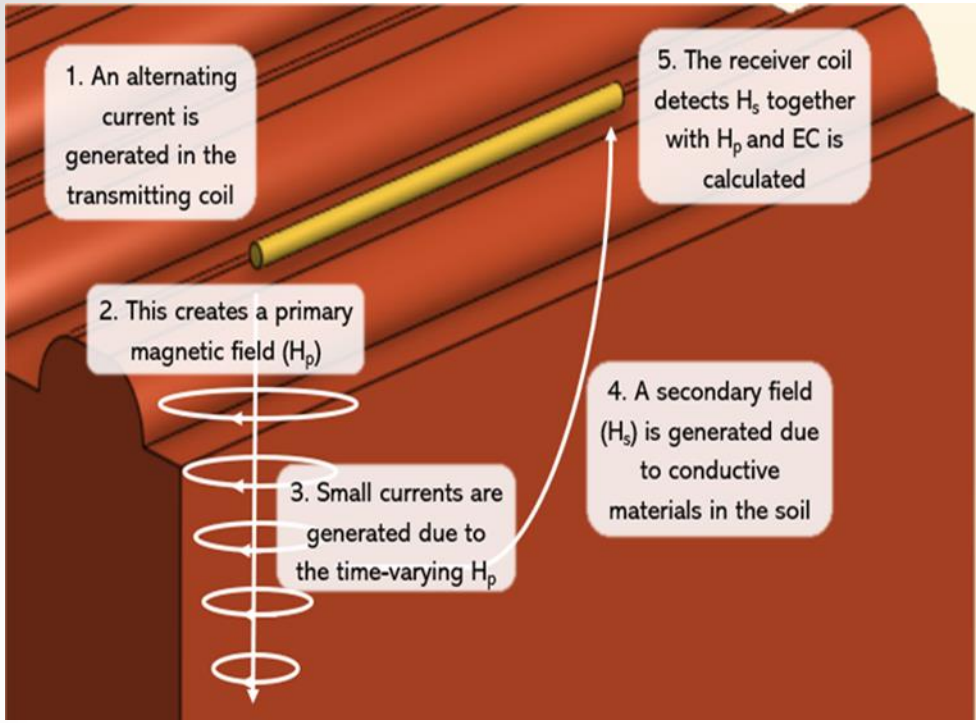
- Investigate the capabilities of the DUALEM – 2 for detection of soil compaction in top 40 cm
- Examine the potential of SWATBOX to detect soil compaction up to 40 cm below the soil surface
- Delineate management zones for variable rate tillage to break the hardpan in site-specific fashion

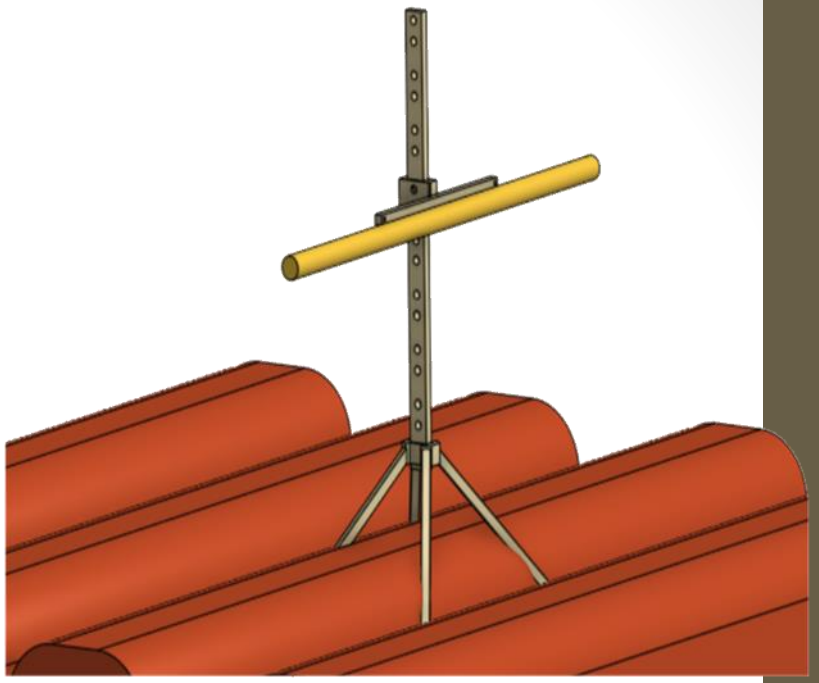


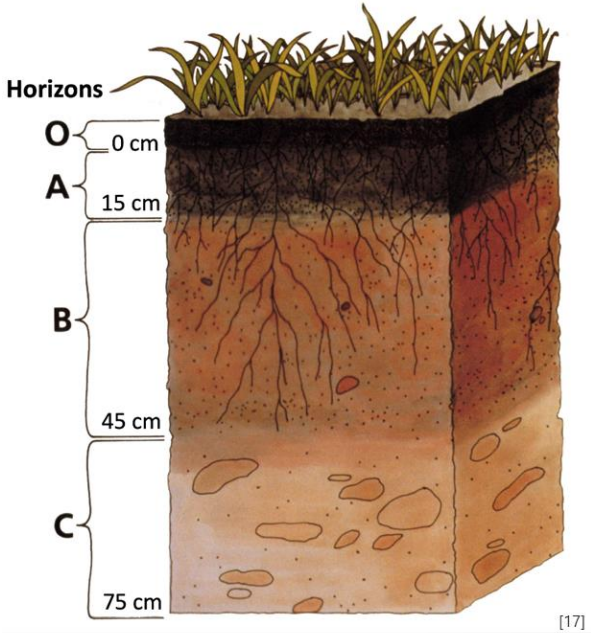
Data Collection

Data Collection

Data Collection

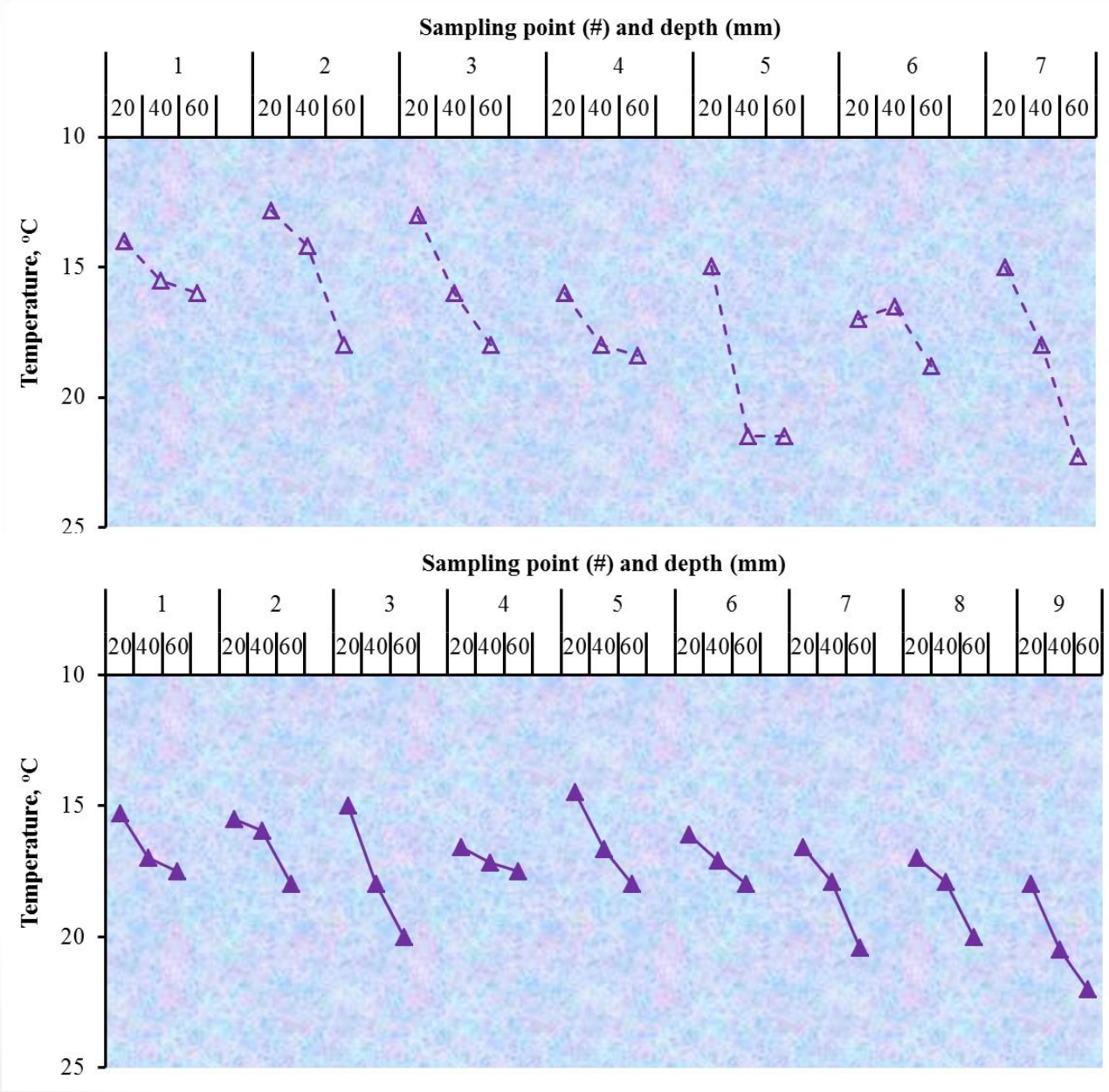

1. An alternating current is generated in the transmitting coil
2. This creates a primary magnetic field (H_p)
3. Small currents are generated due to the time-varying H_p
4. A secondary field (H_s) is generated due to conductive materials in the soil
5. The receiver coil detects H_s together with H_p and EC is calculated



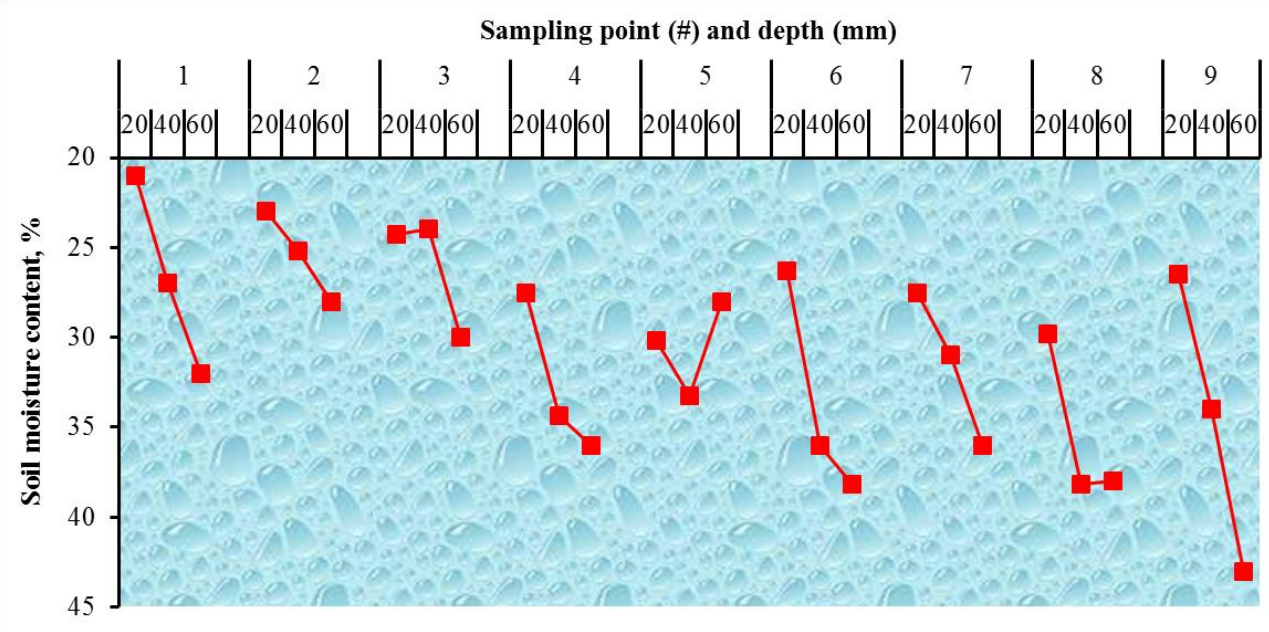

Horizons
O
0 cm
A
15 cm
B
45 cm
C
75 cm

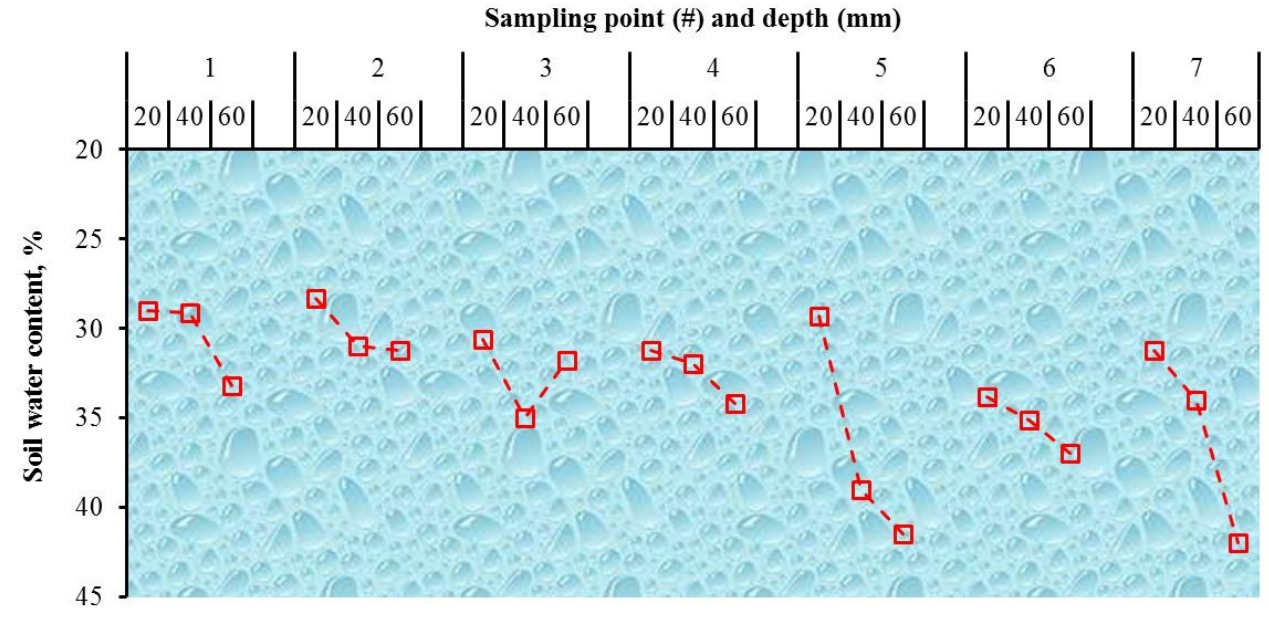
[17]

Soil Temperature - Different Depths

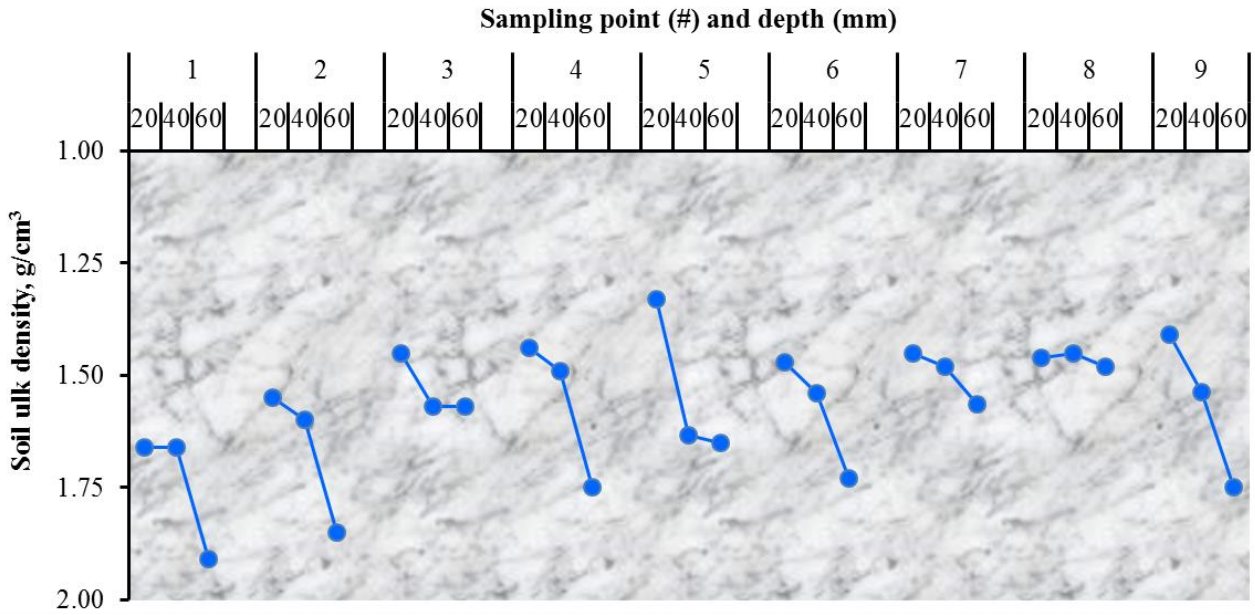


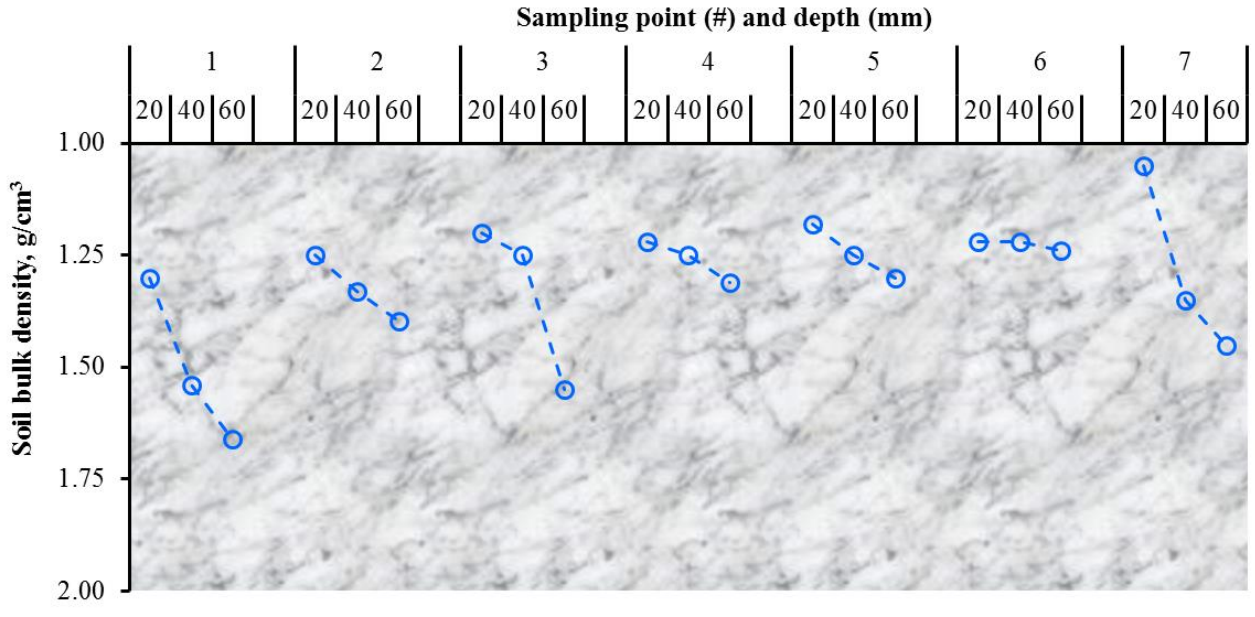
Soil Moisture - Different Depths



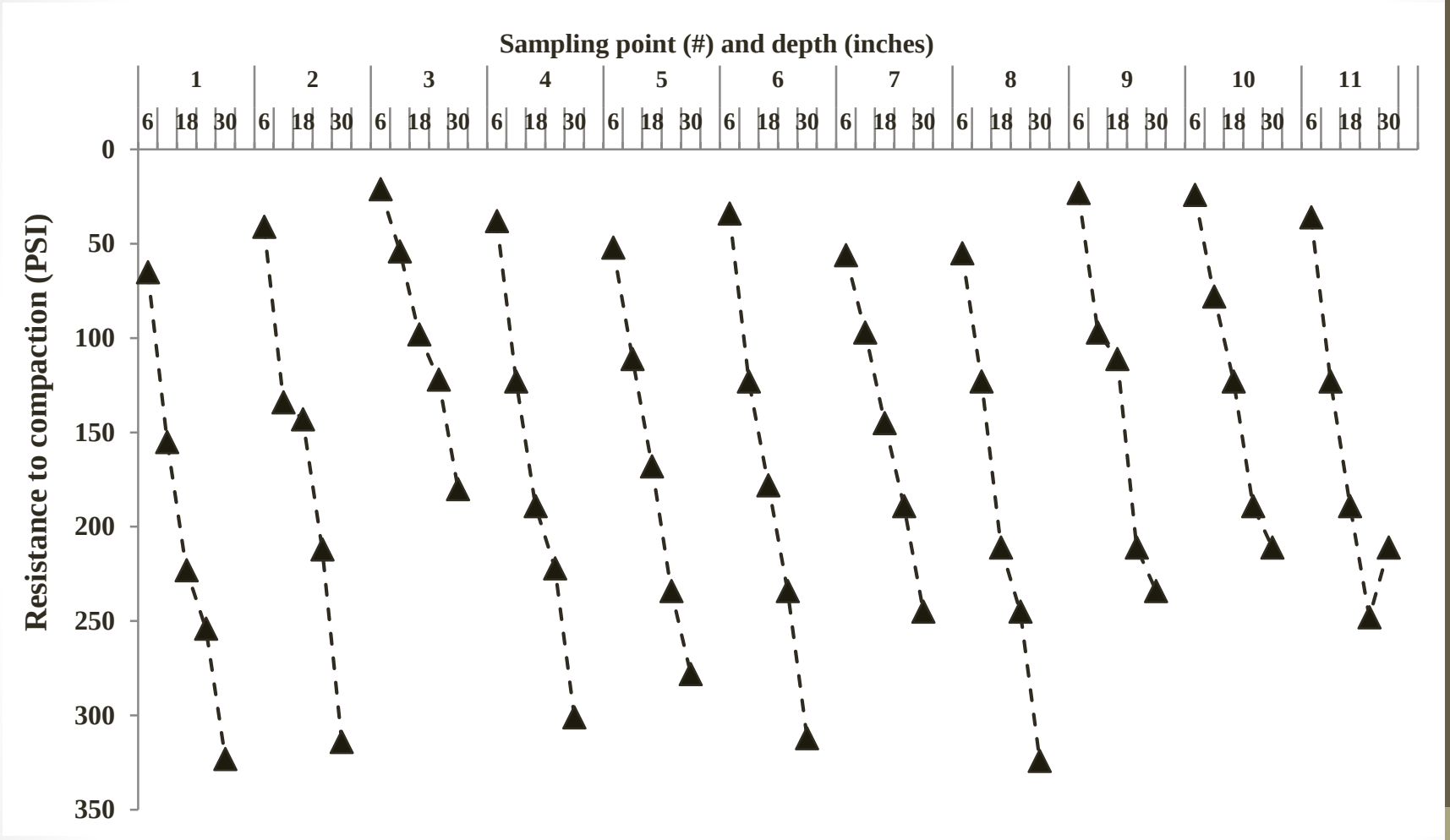


Soil Bulk Density - Different Depths

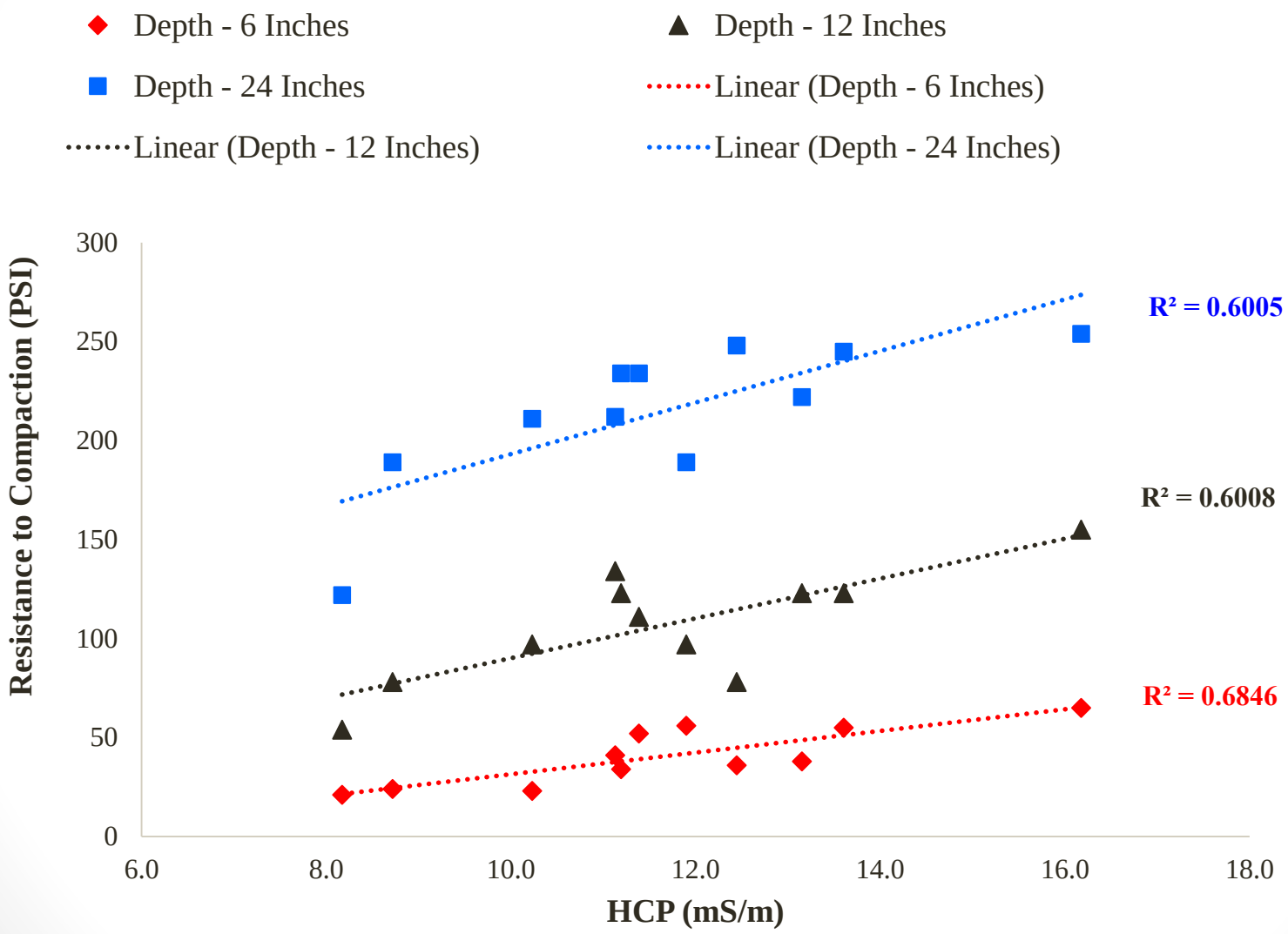




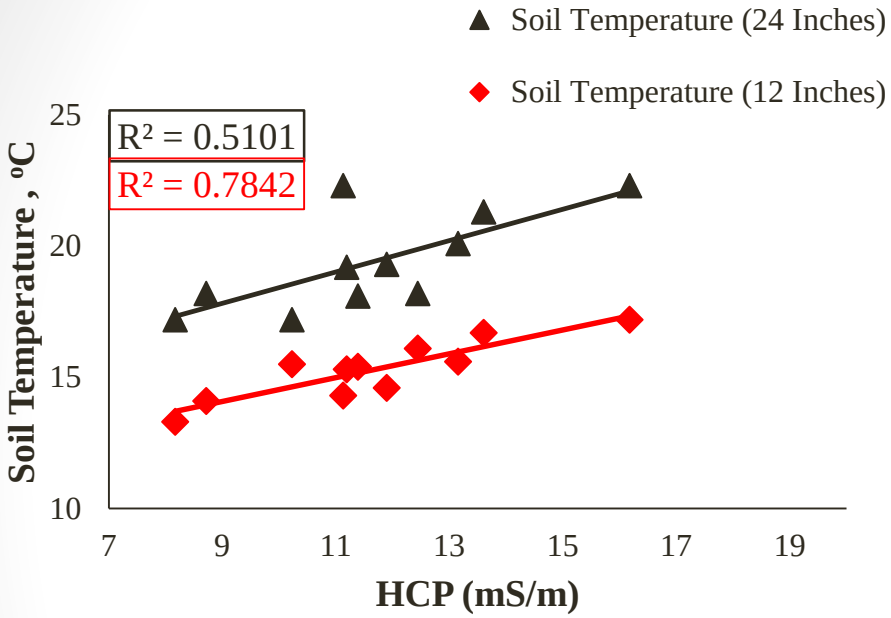
Soil Compaction - Different Depths

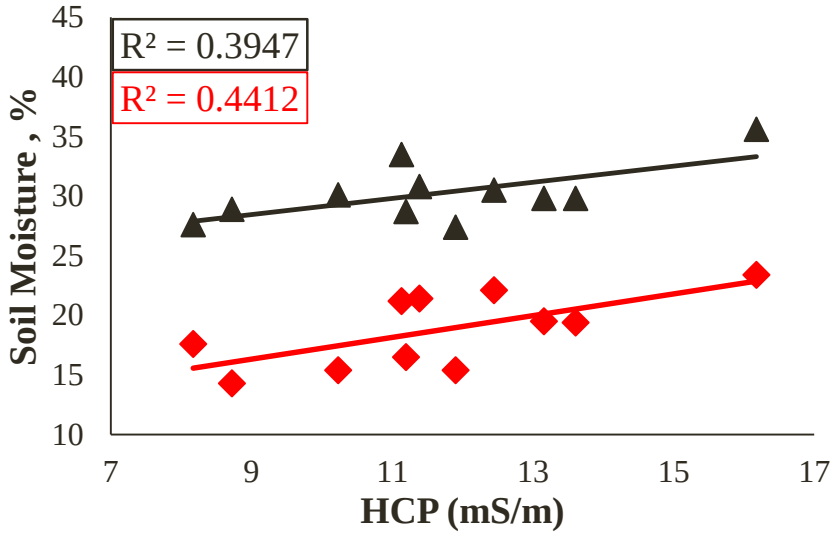


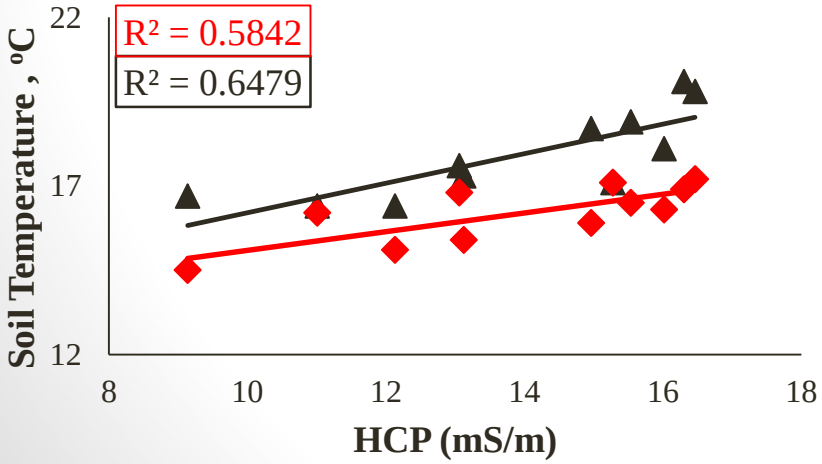
Soil Compaction - Different Depths

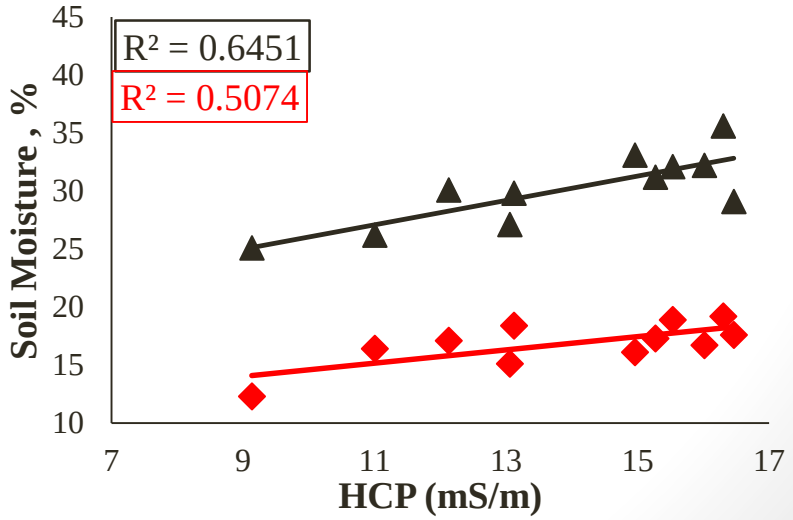


Electrical Conductivity - Soil Variables

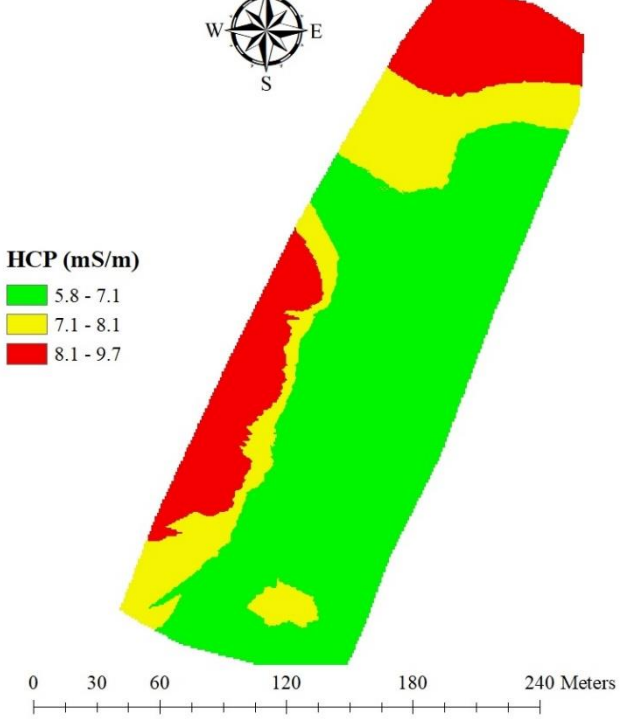


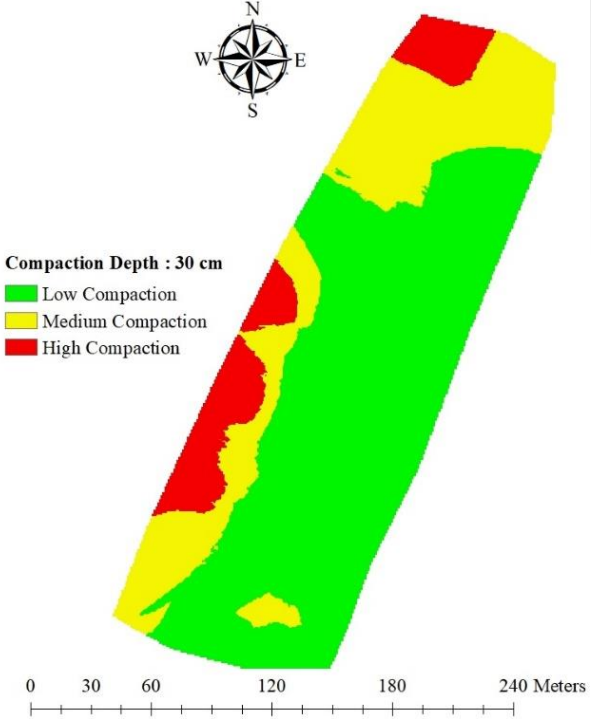


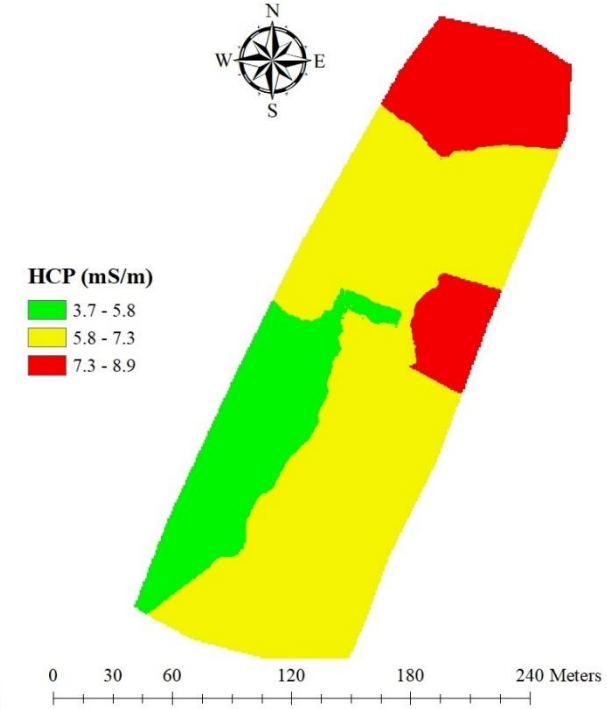


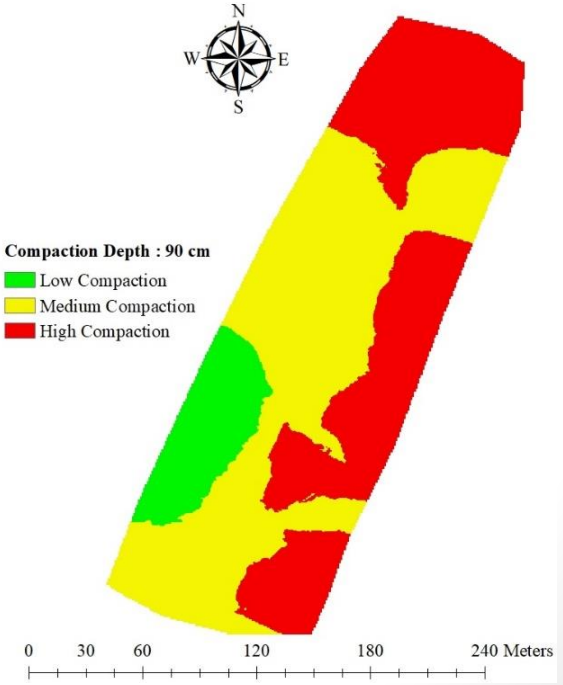


Layered Electrical Conductivity









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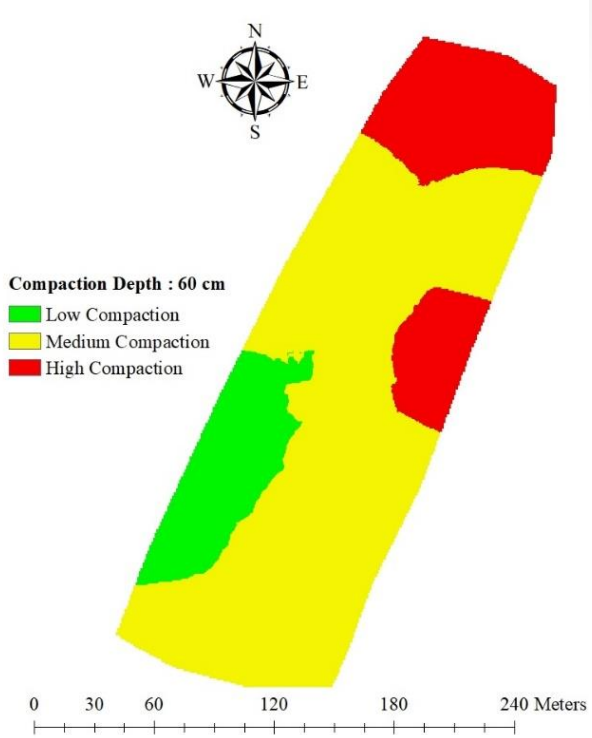

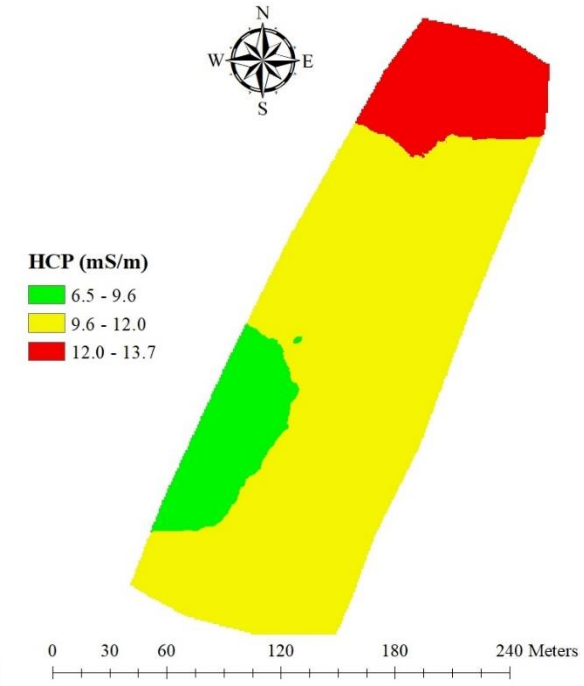

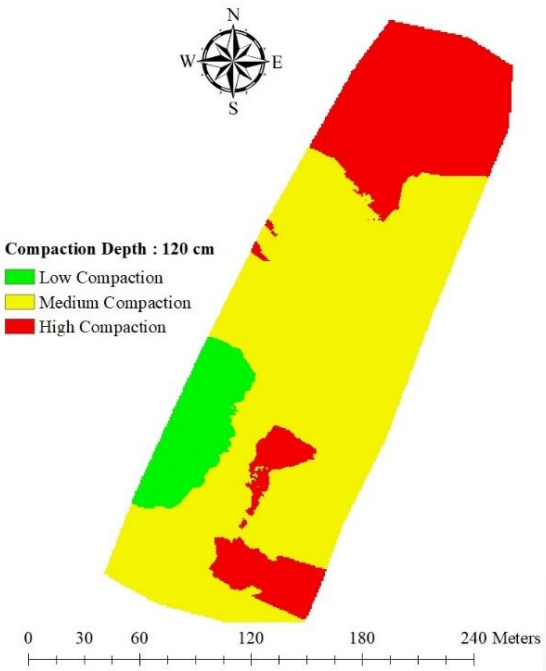

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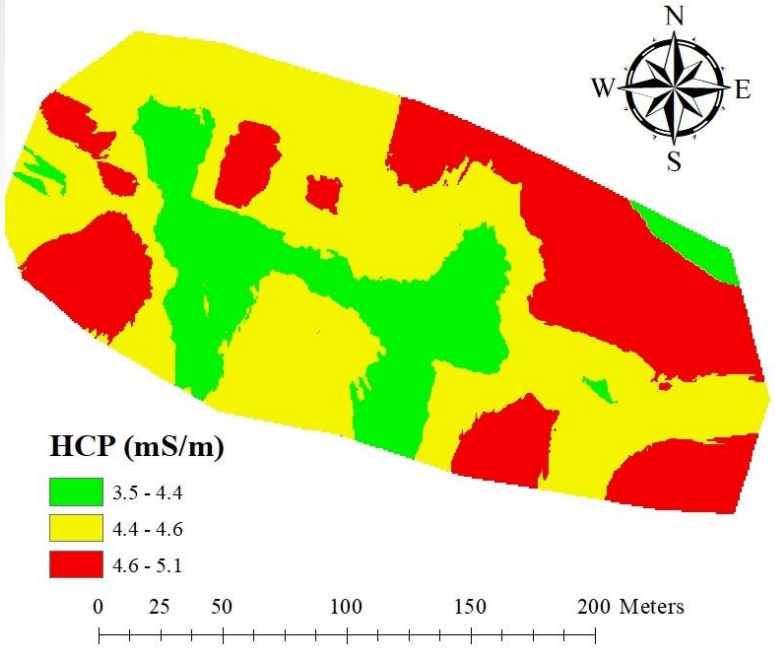

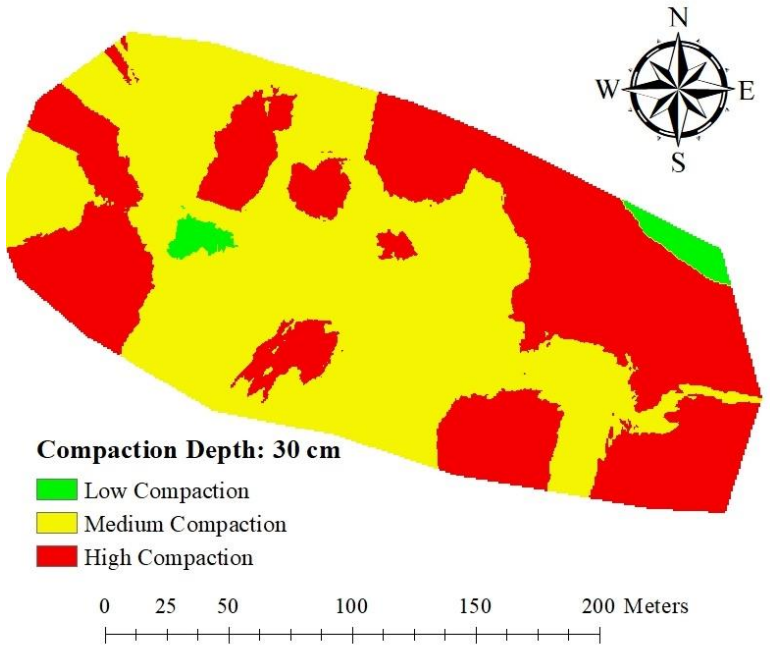

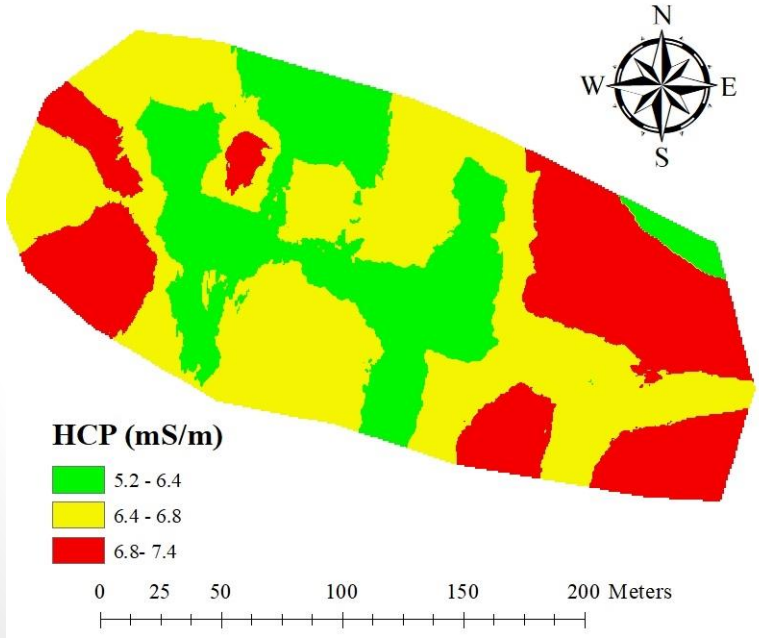

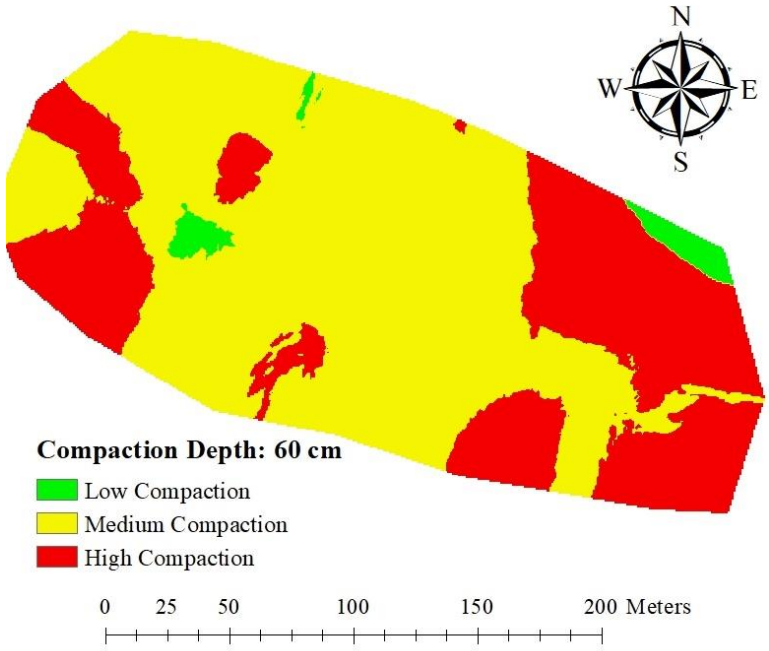

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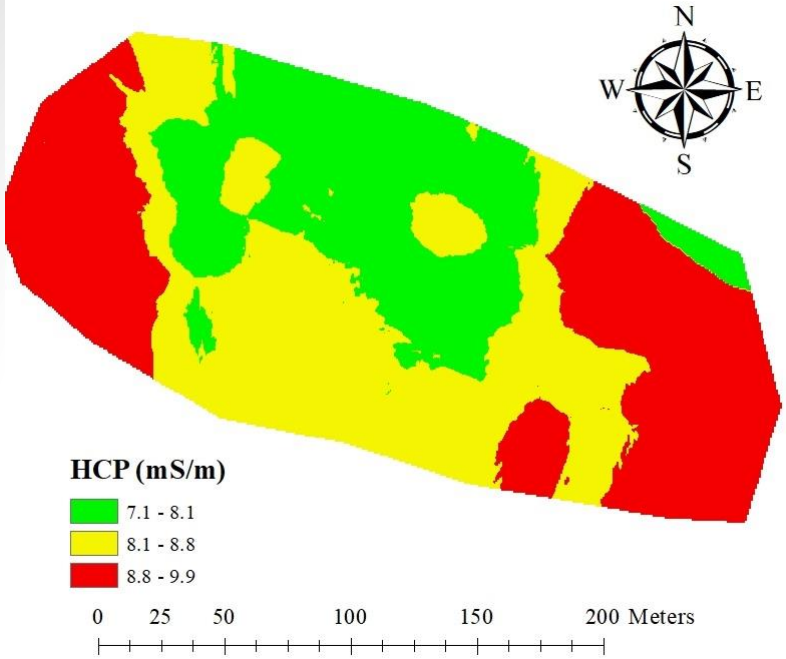

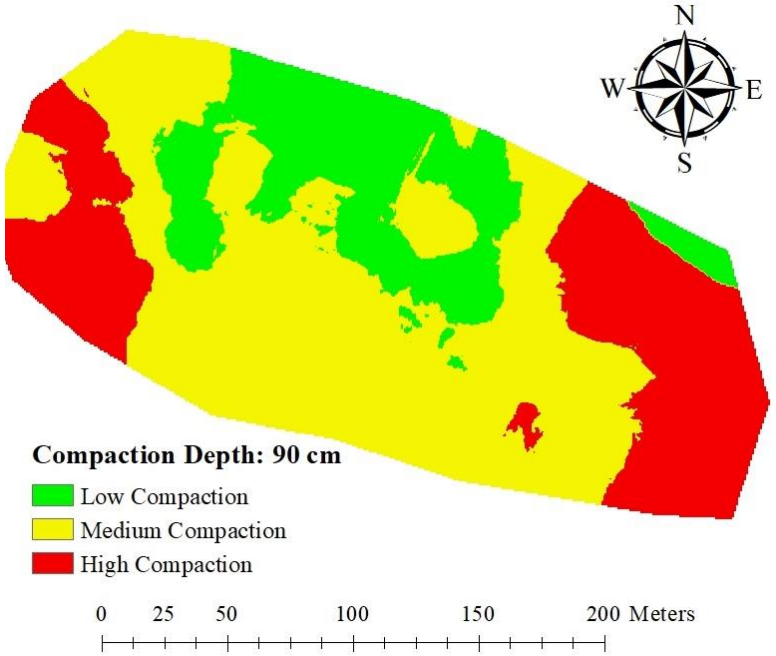

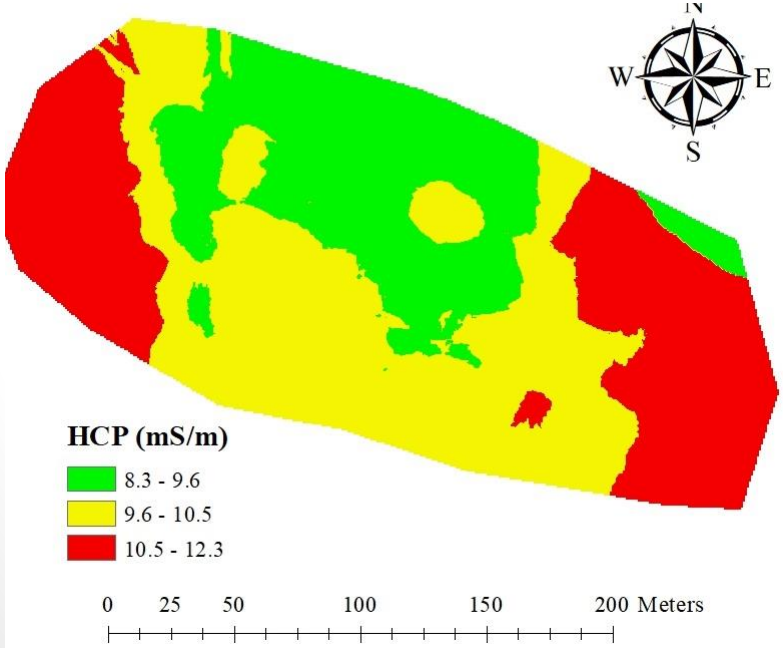

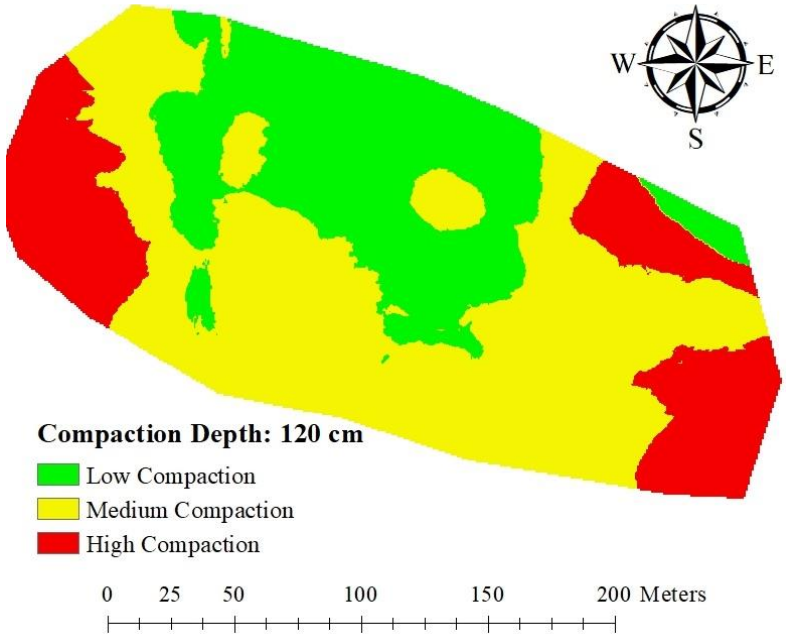

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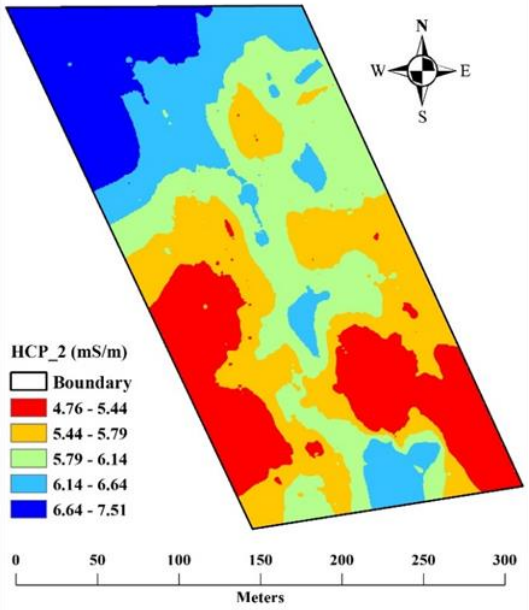
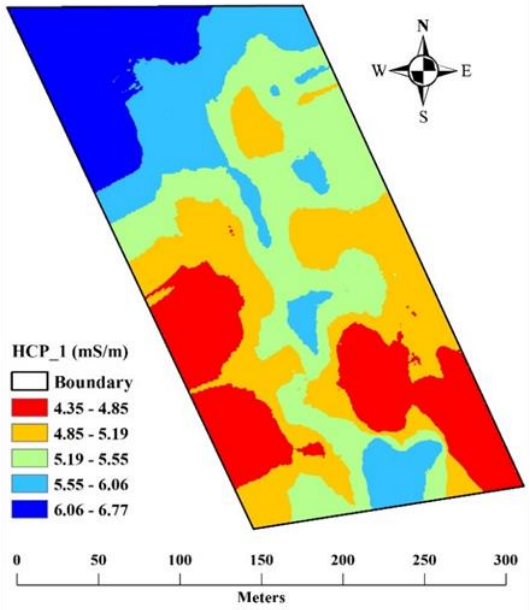
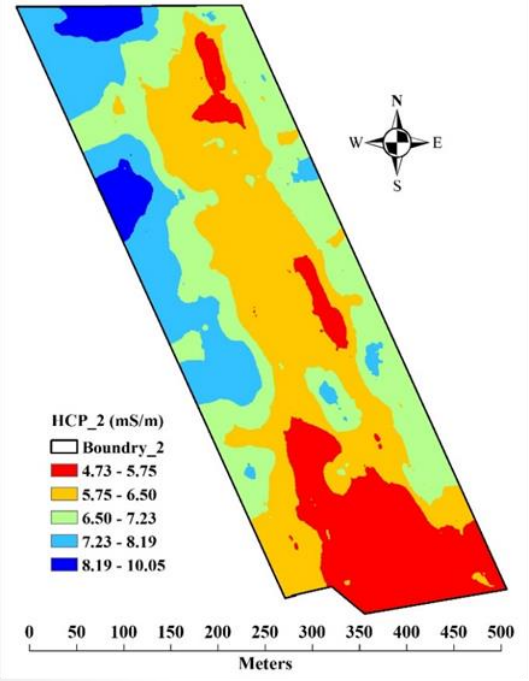
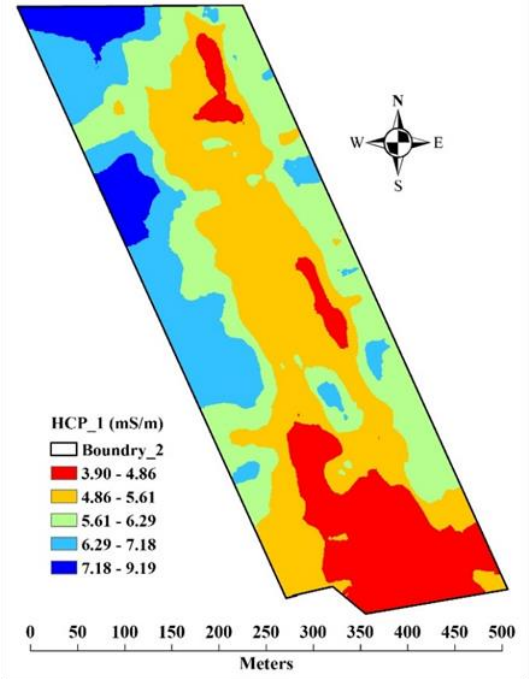
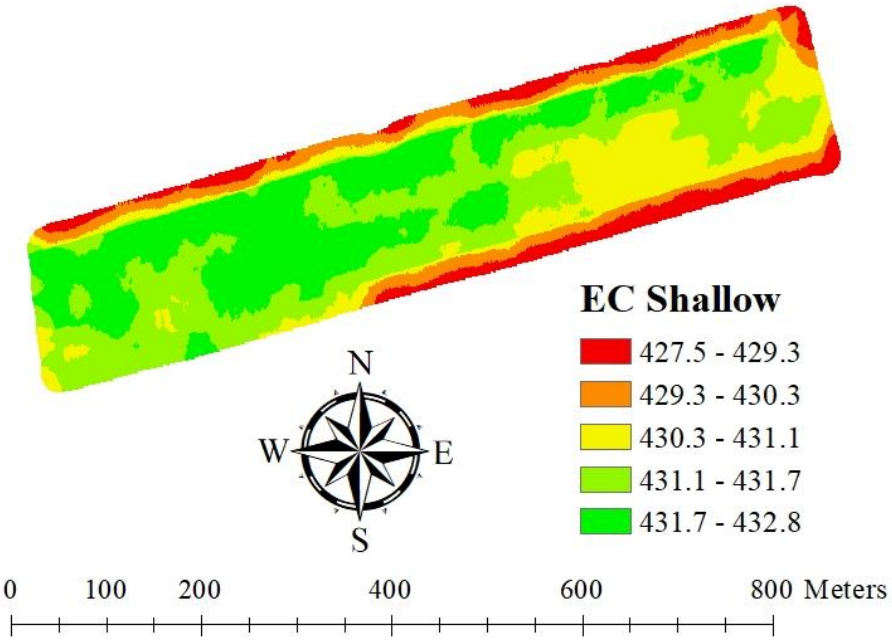


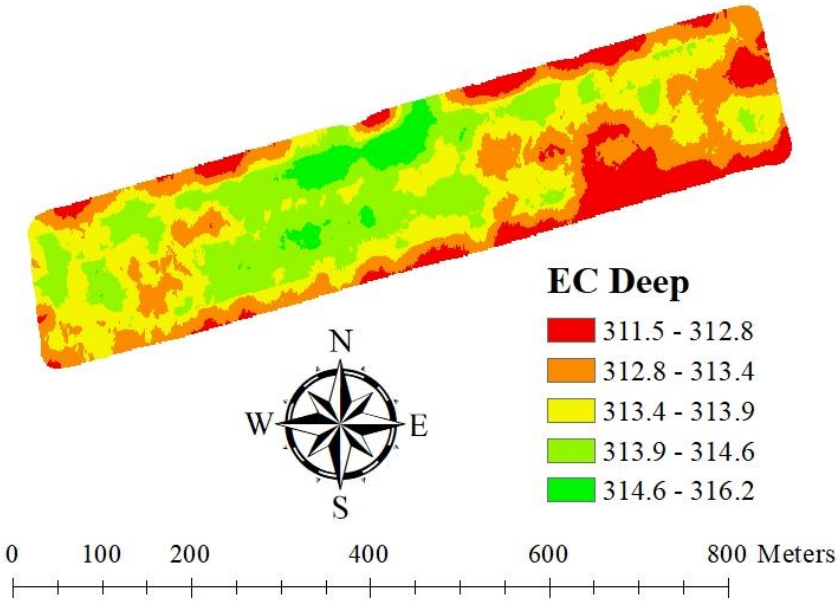




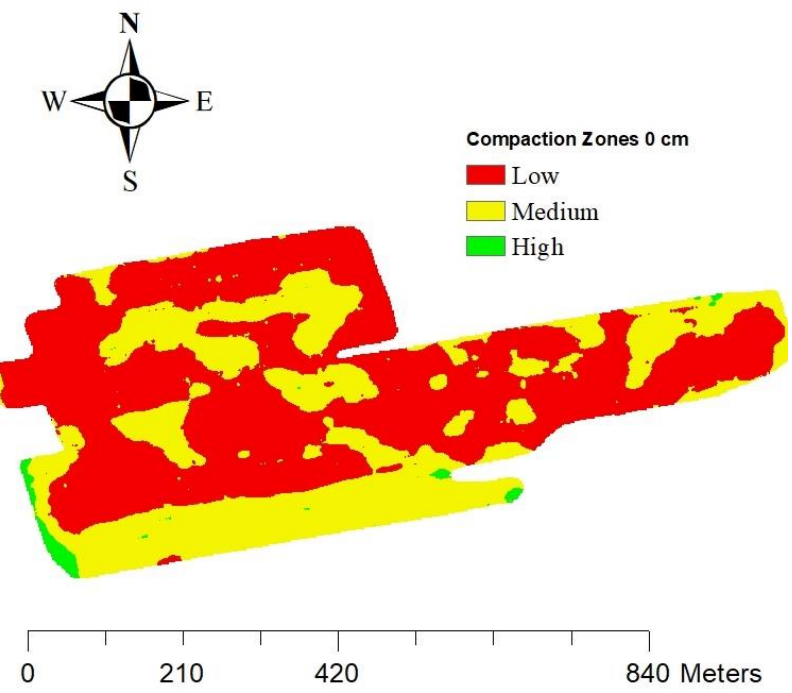


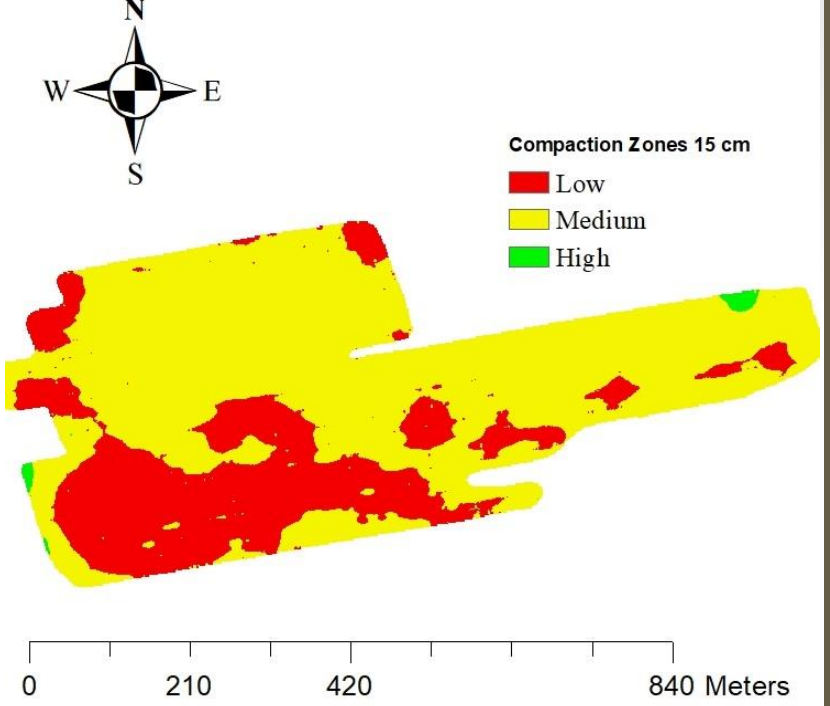
Possible Future Application

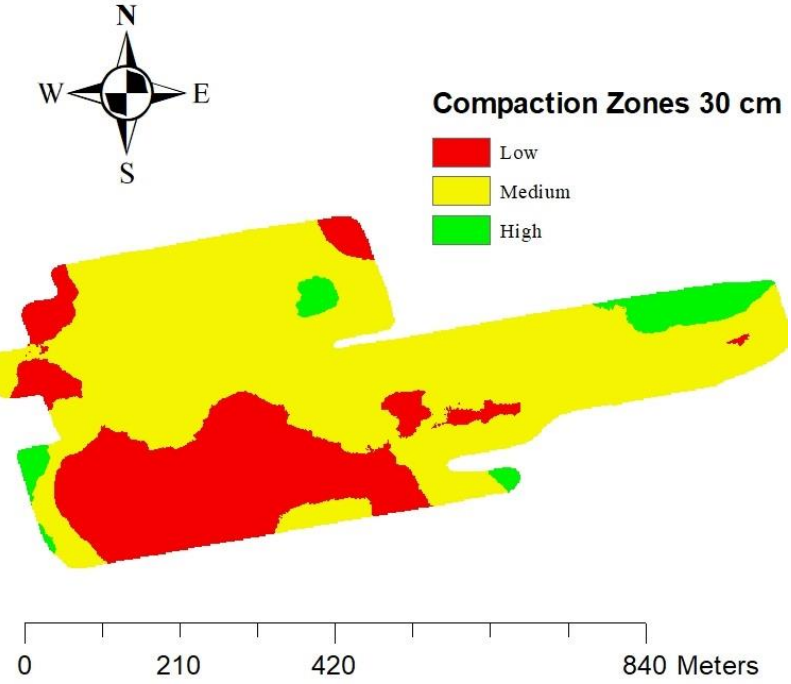


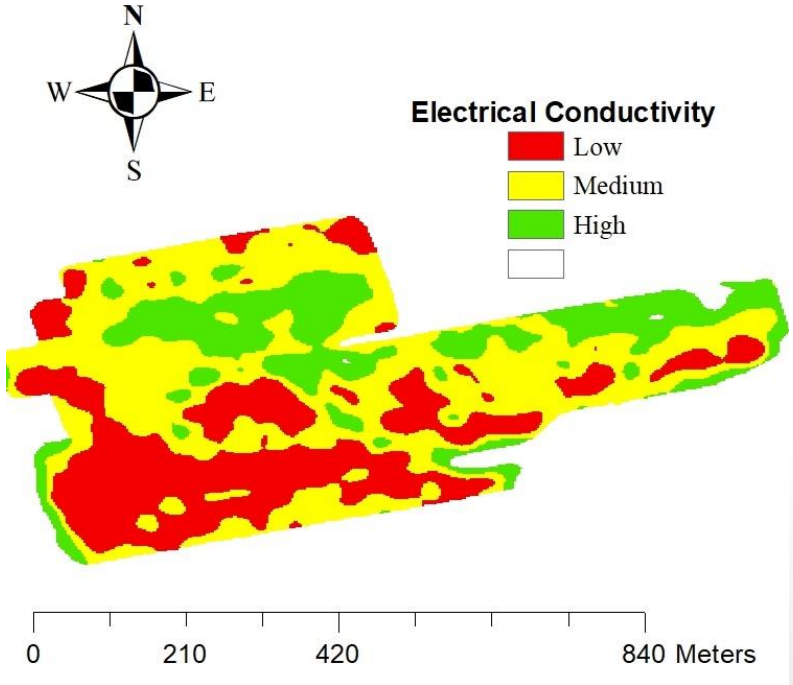


Layered Electrical Conductivity







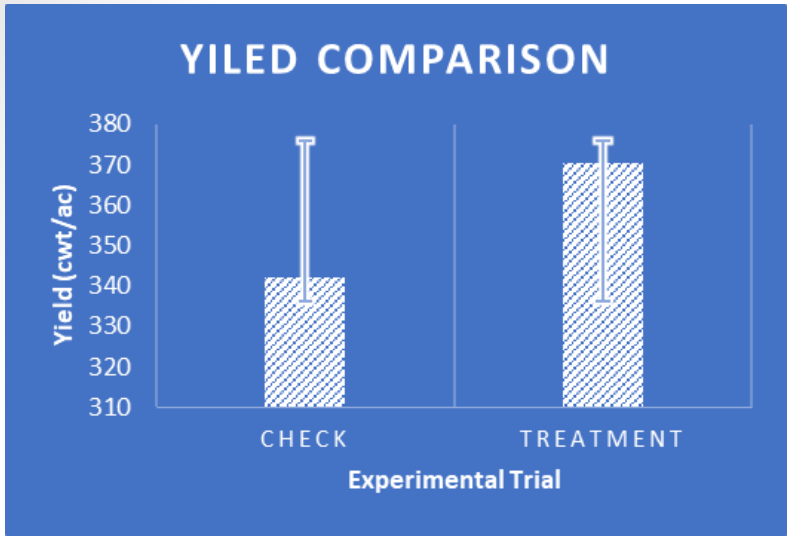


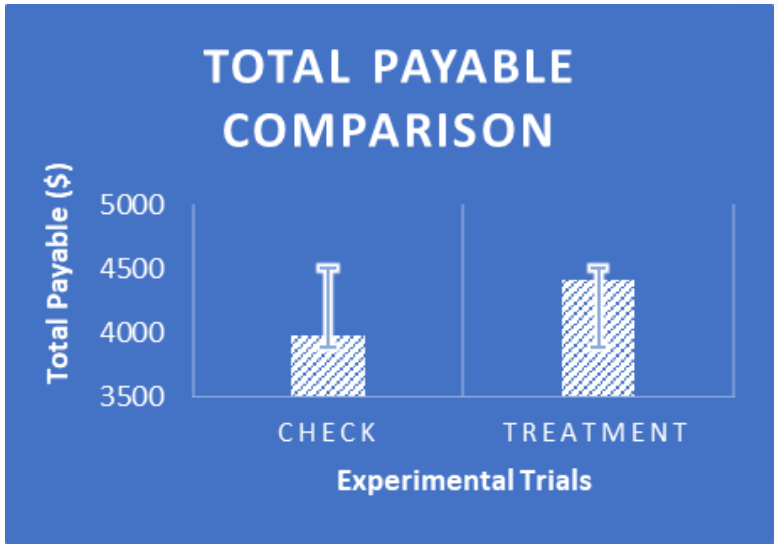
Yield Analysis

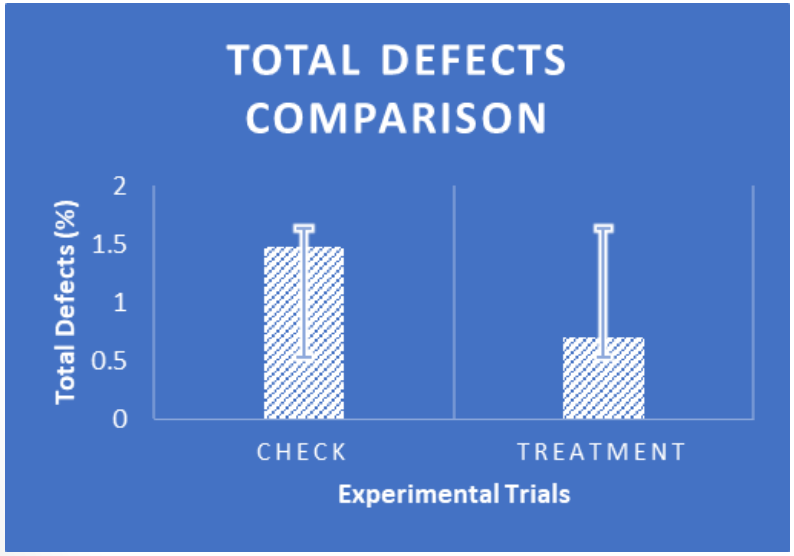
- Six potato tuber yield samples were collected from two treatments, e.g., compacted vs non-compacted

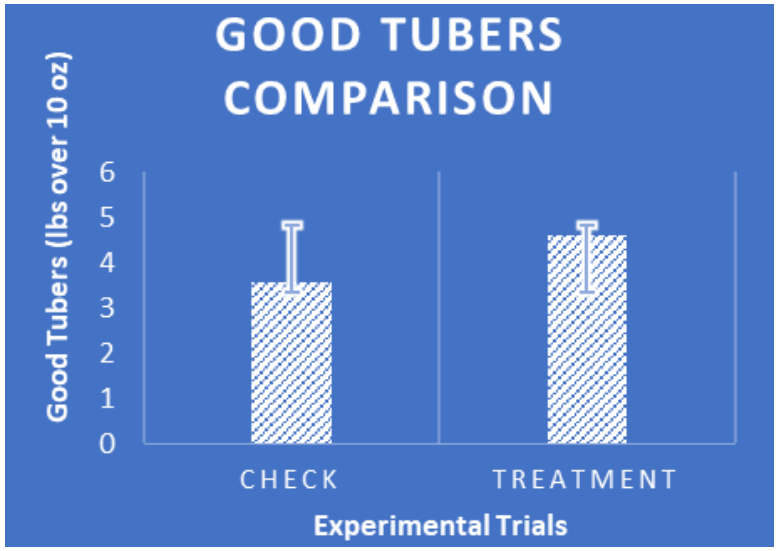
- The yield samples were analyzed for quantity and quality parameters

- Descriptive and statistical analyses were performed for both treatments at two experimental sites.

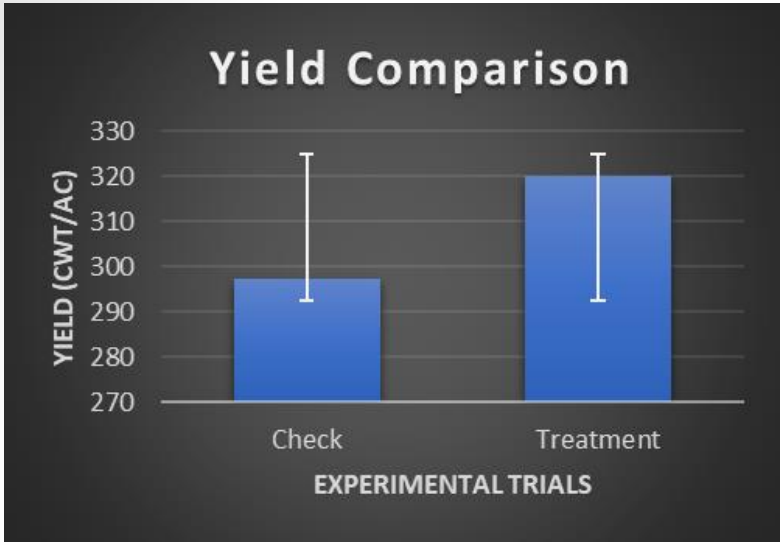


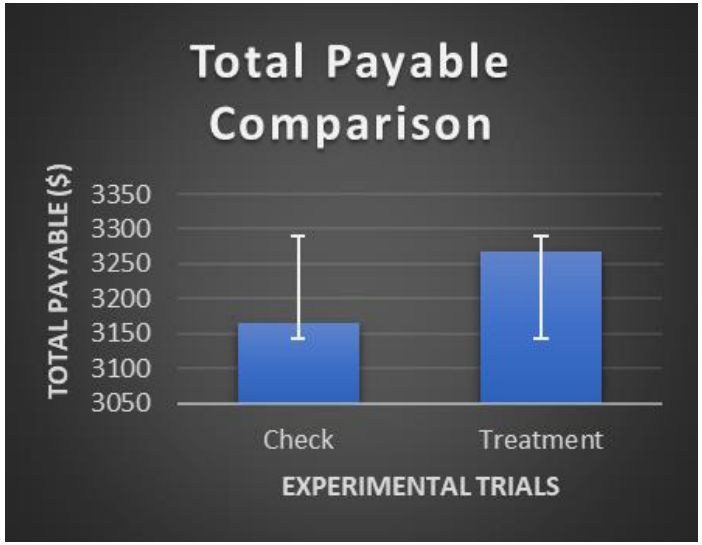


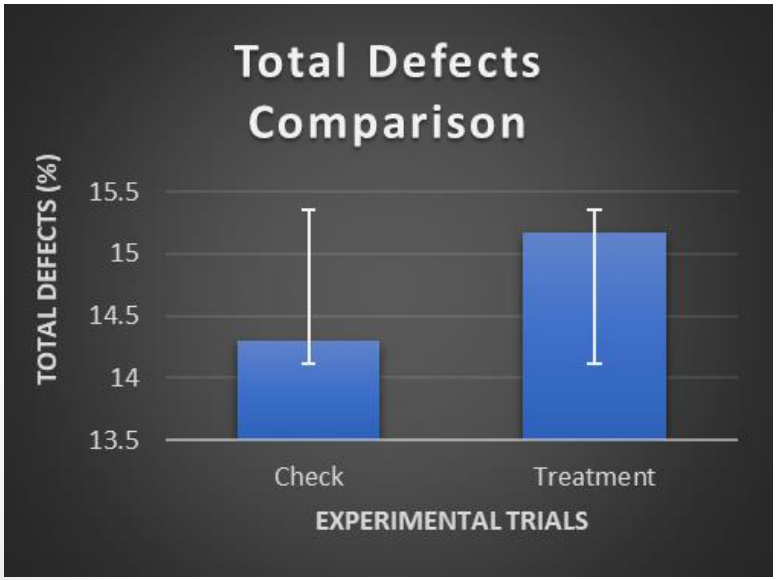


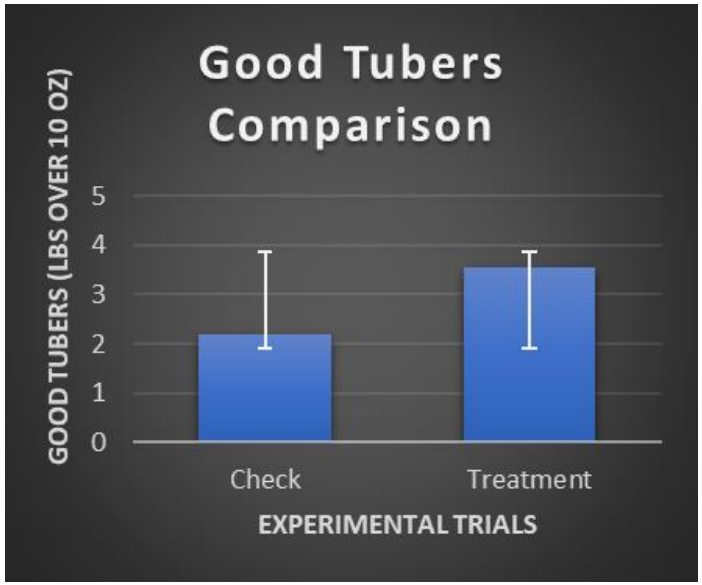


DRF-Cairns Field


Yield Comparison
YIELD (CWT/AC)
330
320
310
300
290
280
270
Check
Treatment
EXPERIMENTAL TRIALS


Total Payable Comparison
TOTAL PAYABLE ($)
3350
3300
3250
3200
3150
3100
3050
Check
Treatment
EXPERIMENTAL TRIALS


Total Defects Comparison
TOTAL DEFECTS (%)
15.5
15
14.5
14
13.5
Check
Treatment
EXPERIMENTAL TRIALS

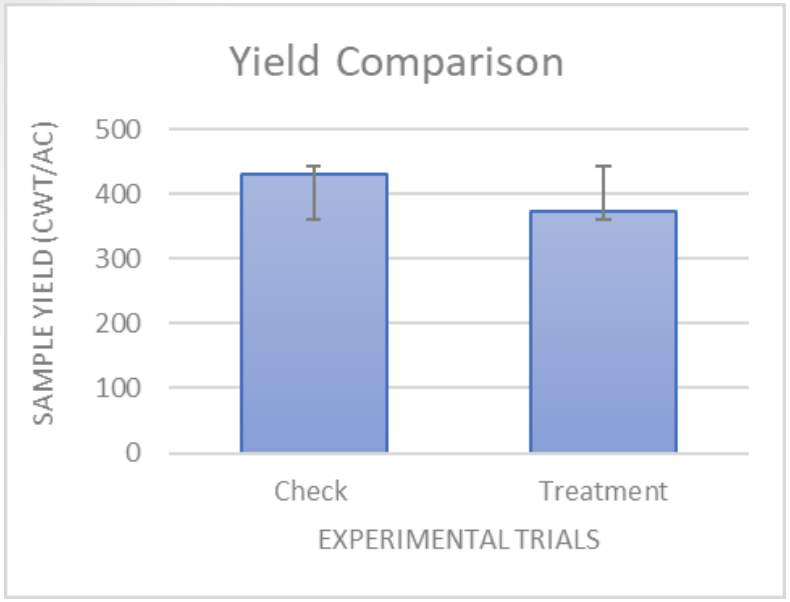

Good Tubers Comparison
GOOD TUBERS (LBS OVER 10 OZ)
5
4
3
2
1
0
Check
Treatment
EXPERIMENTAL TRIALS

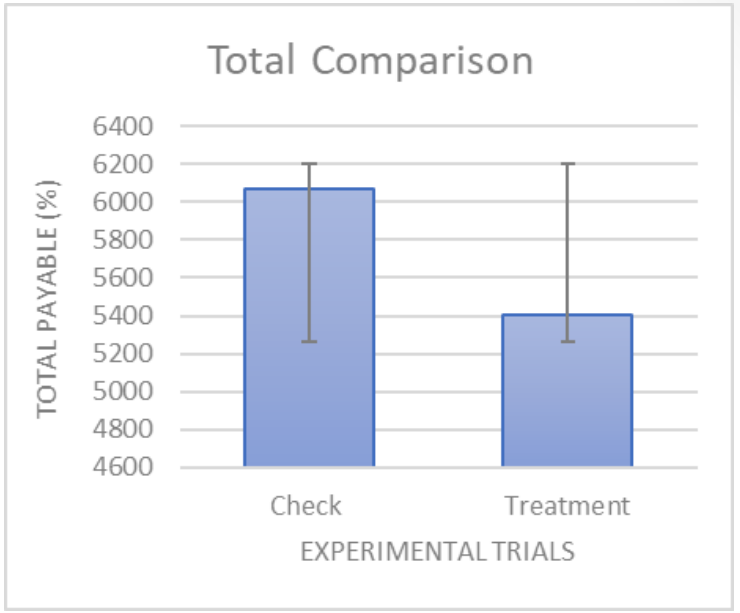
DRF-Delaney

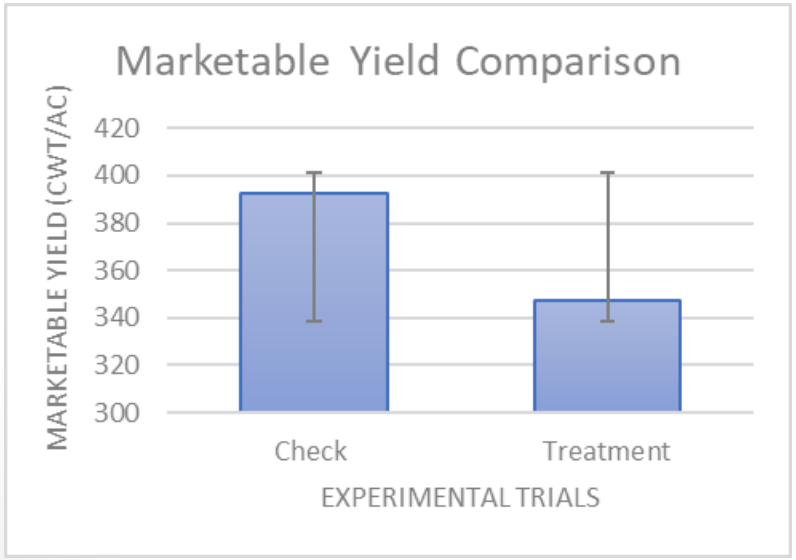
Analysis of Variance - 2021

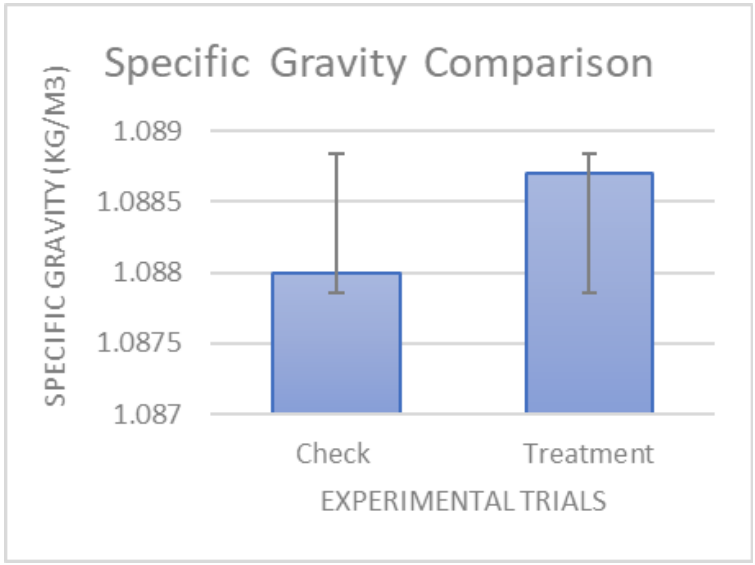
Site	Response	Significant
DRF-Cairns	Sample Yield (cwt/Acre)	No
	Percent Smalls (%)	No
	Total Payable	No
	Specific Gravity	No
	Total Defects (%)	No
	Good Tubers (<10 oz)	No
	Good Tubers (>10 oz)	No
DRF-Delaney	Sample Yield (cwt/Acre)	No
	Percent Smalls (%)	No
	Total Payable	No
	Specific Gravity	No
	Total Defects (%)	No
	Good Tubers (<10 oz)	No
	Good Tubers (>10 oz)	No

AIM-Subsoil 1 Field

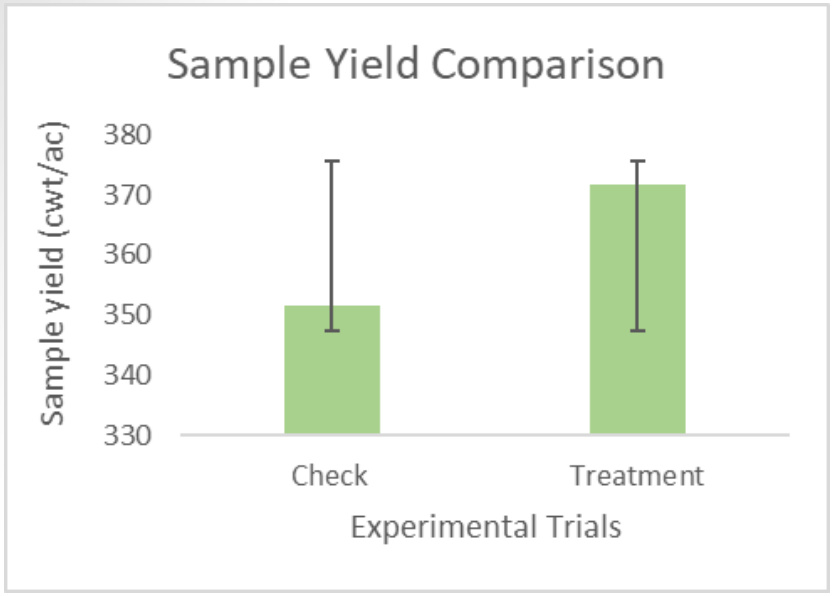


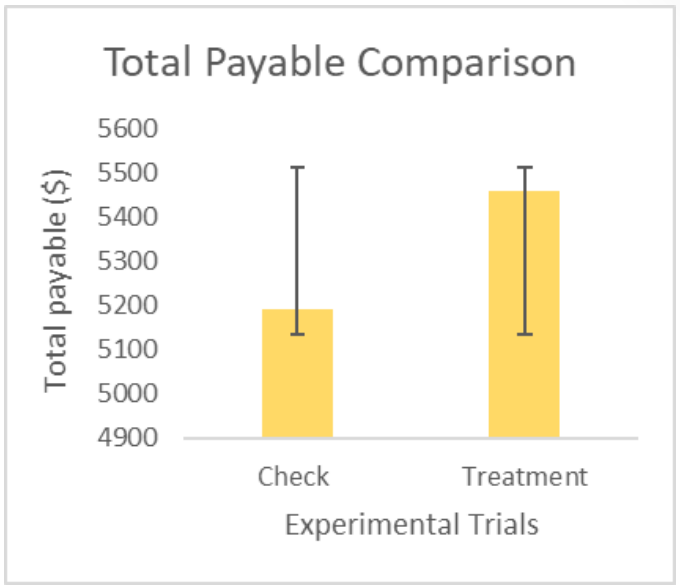


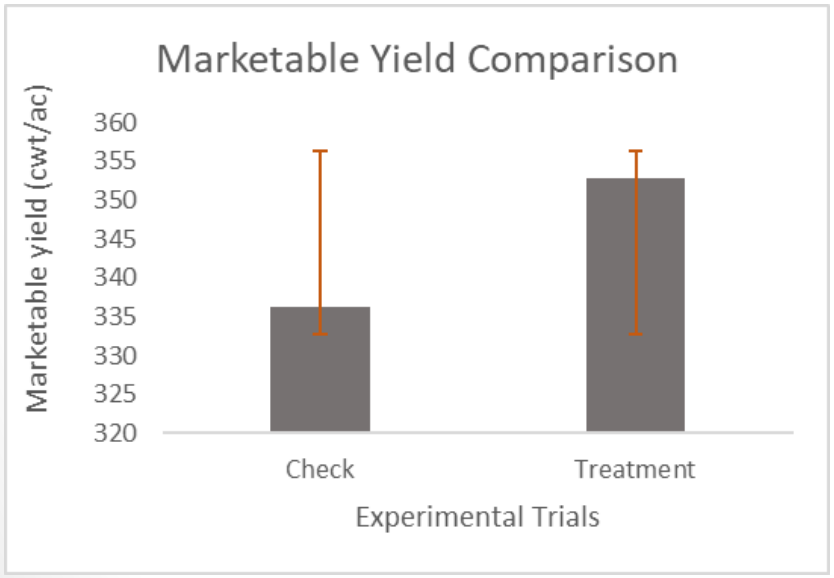


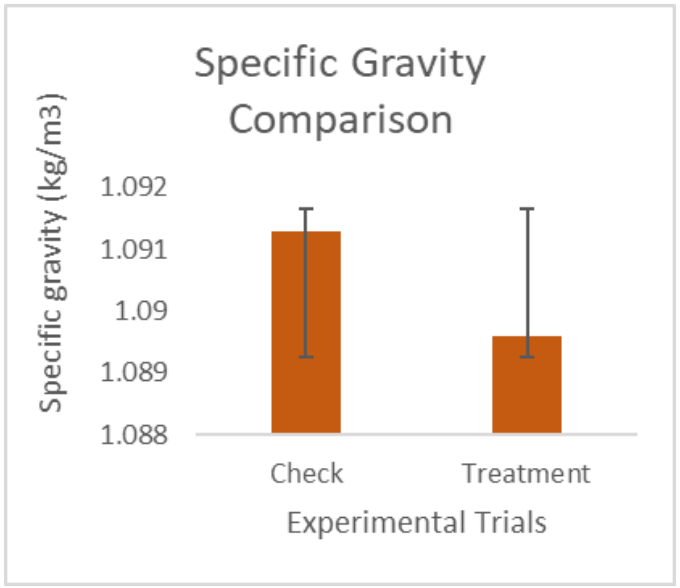


AIM-Subsoil 2 Field









Yield Analysis Summary

- The descriptive statistics showed promising results as all the selected parameters in both fields performed well in treated trials compared with control

- No statistical significance recorded in both the fields

- The major reason could be the sample size.

- The statistical significance may be observed by increasing the sample size in the coming years.

Modeling ECa for Detection of Soil Compaction

- Processing and modeling software to analyze soil ECa
- EM4Soil
- Aarhus Workbench

EMTOMO
EM4Soil

Aarhus Workbench
• Geophysics • Geology • GIS •

DualEM-2 Survey Location

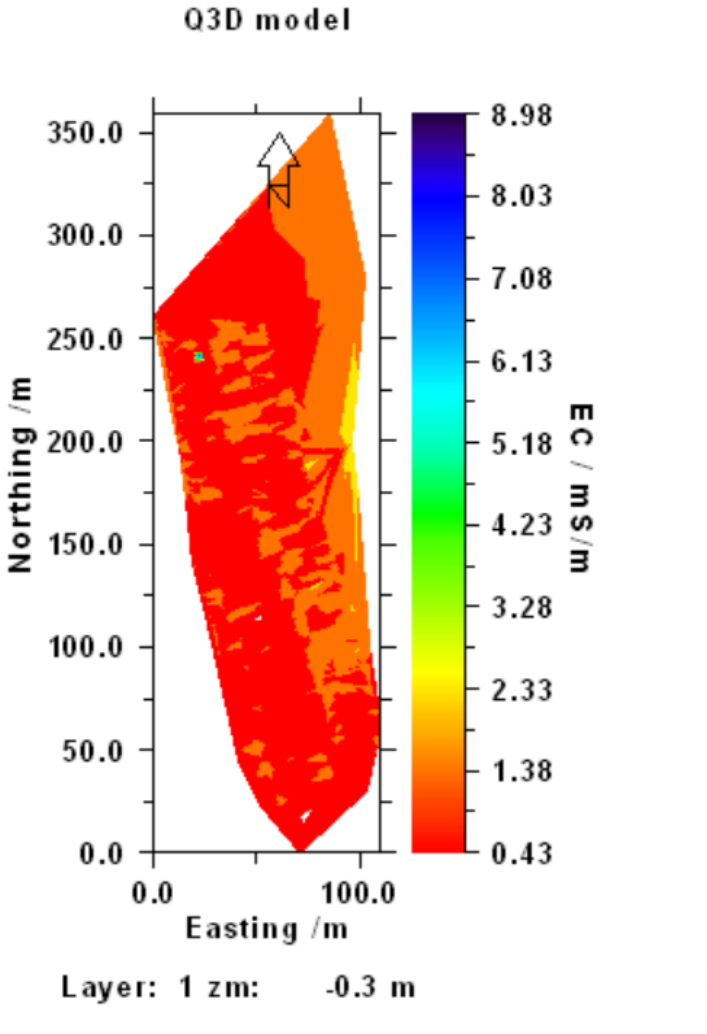
Lower Freetown, PEI

Data Processing

EMTOMO

EM4Soil

- Raw data
- ECa variation throughout fi
- Clean and filter points
- Create 3D model

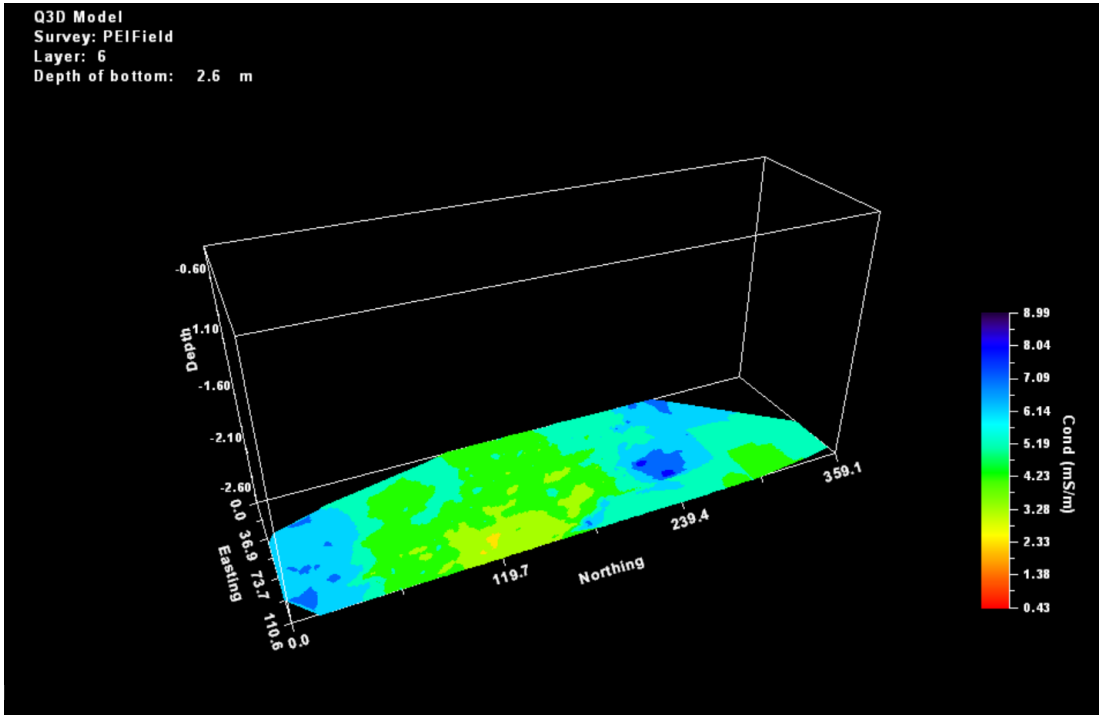


3D Model of ECa

EMTOMO

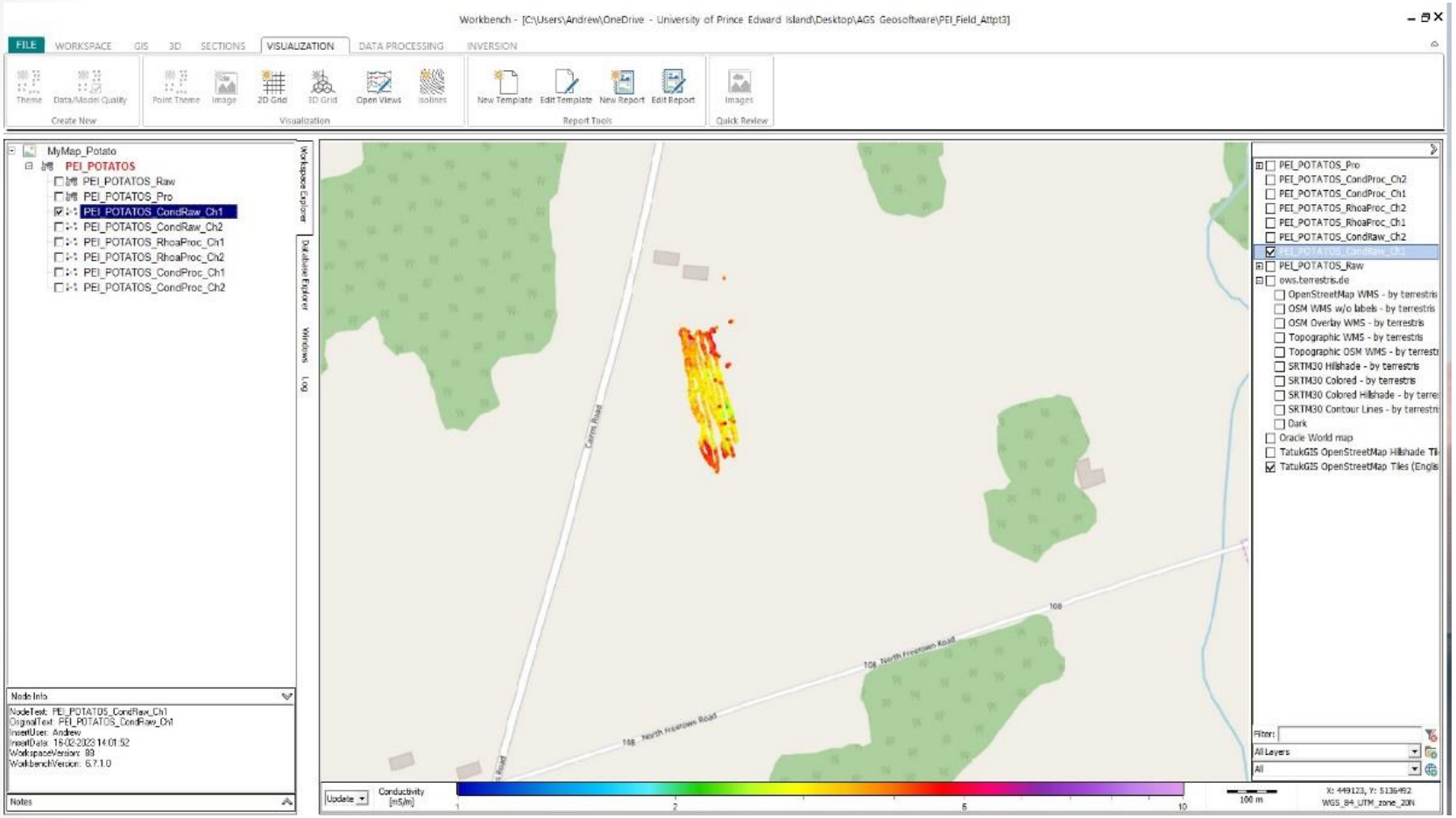
EM4Soil

- ECa variations at various depths

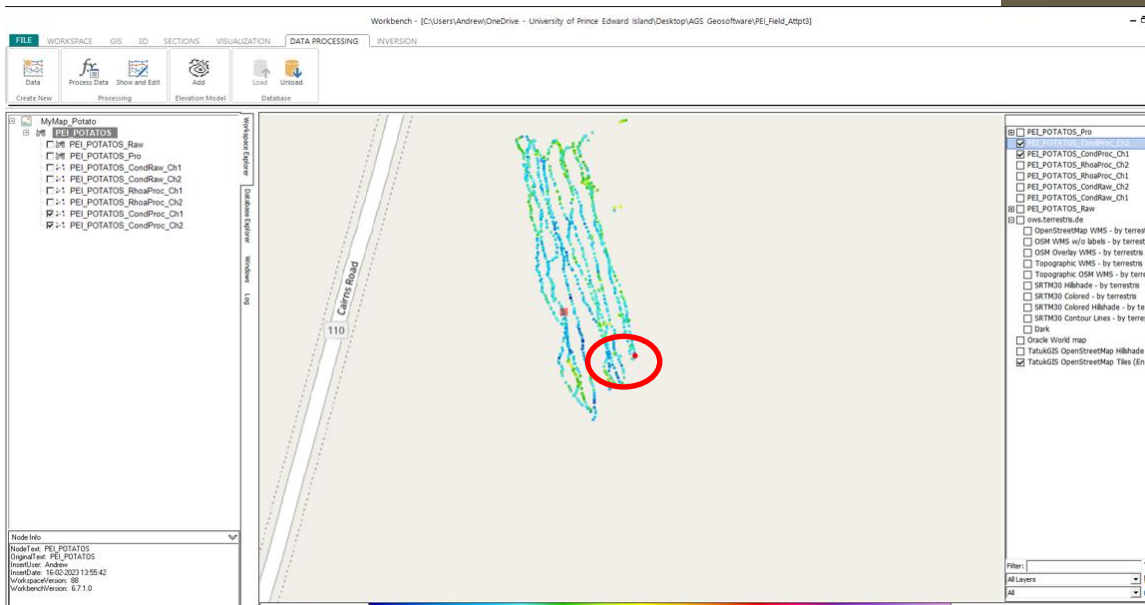


Data Processing

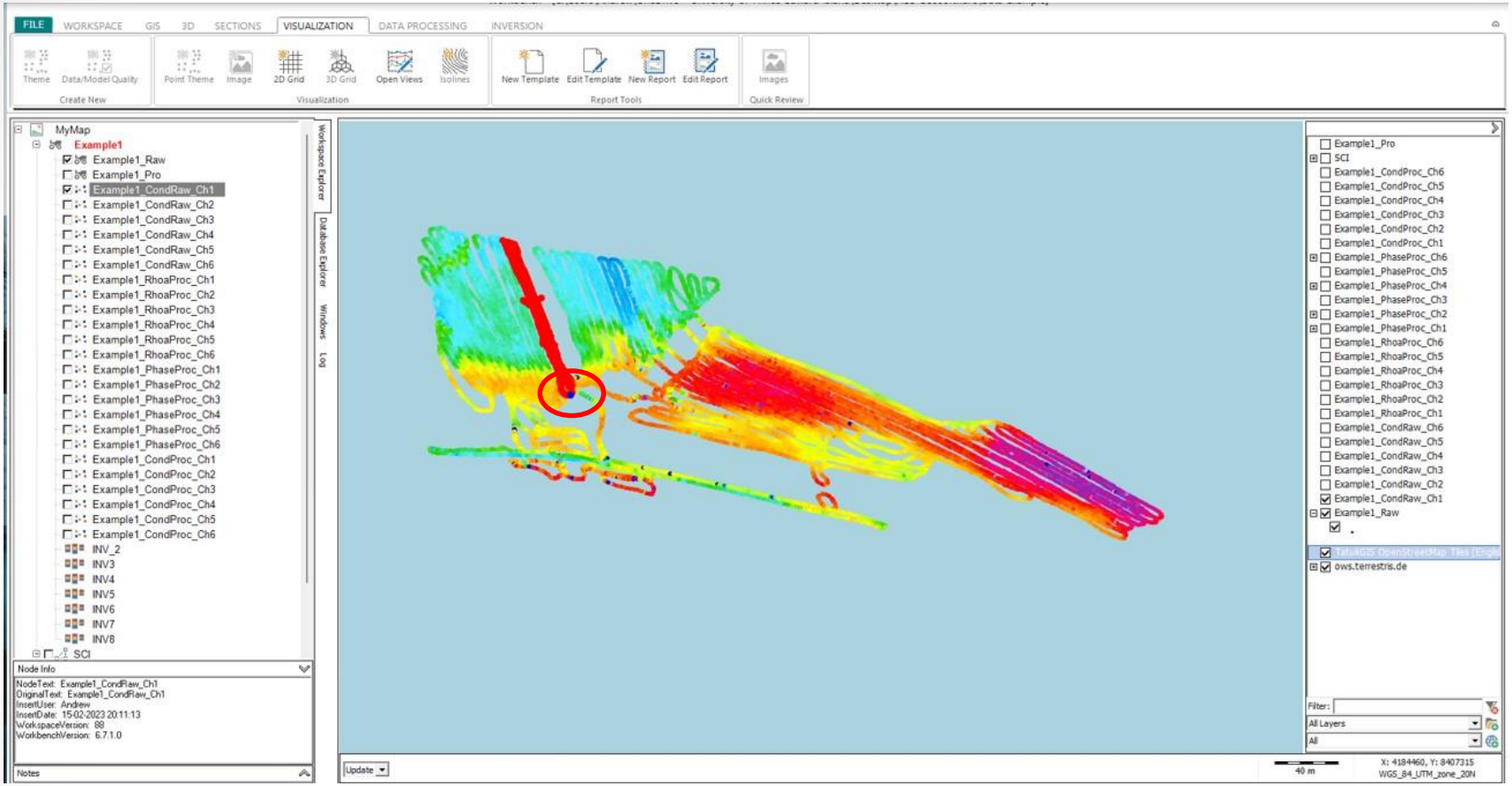
Aarhus Workbench
• Geophysics • Geology • GIS •



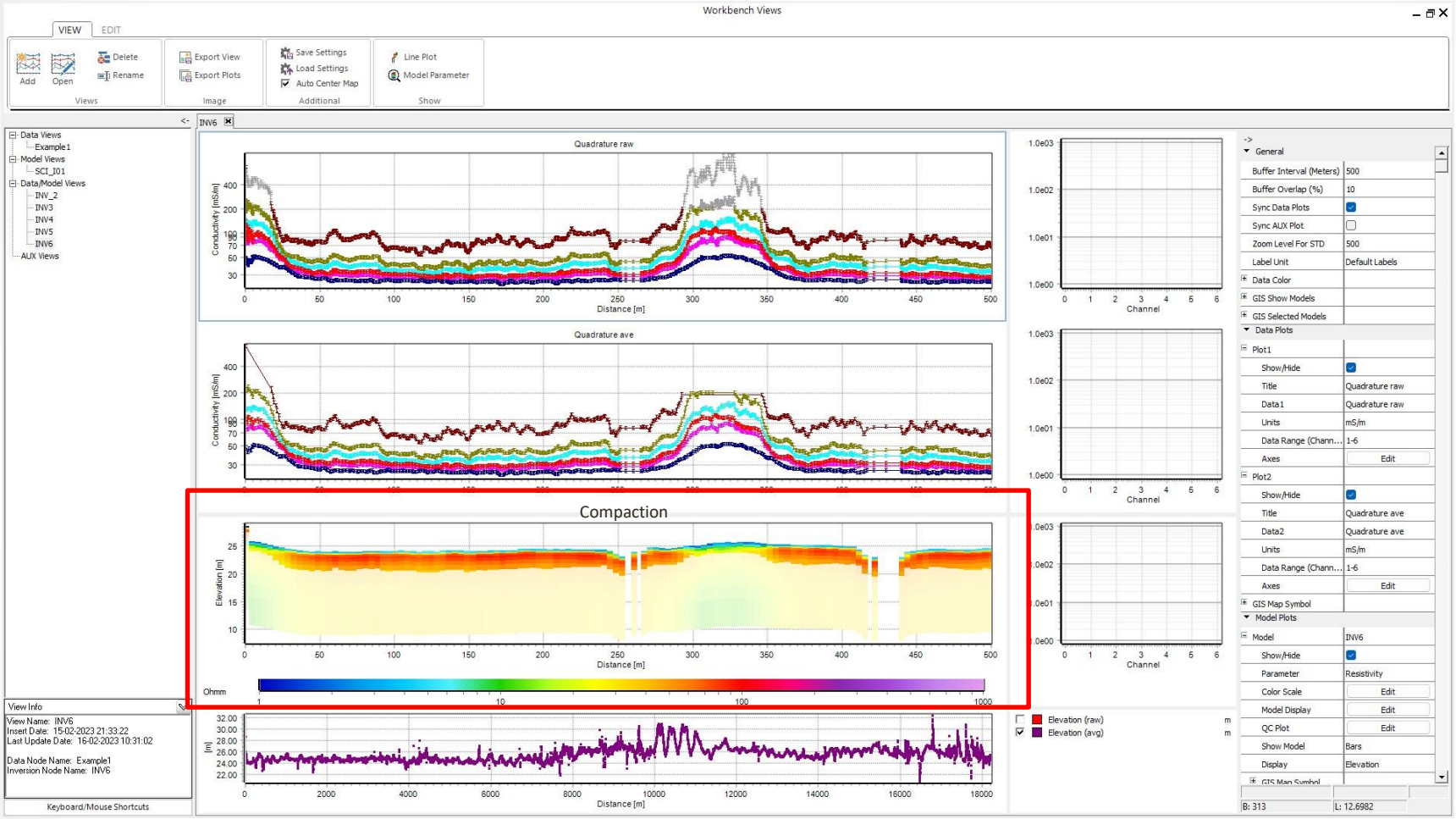
Data Processing – Noise Removal



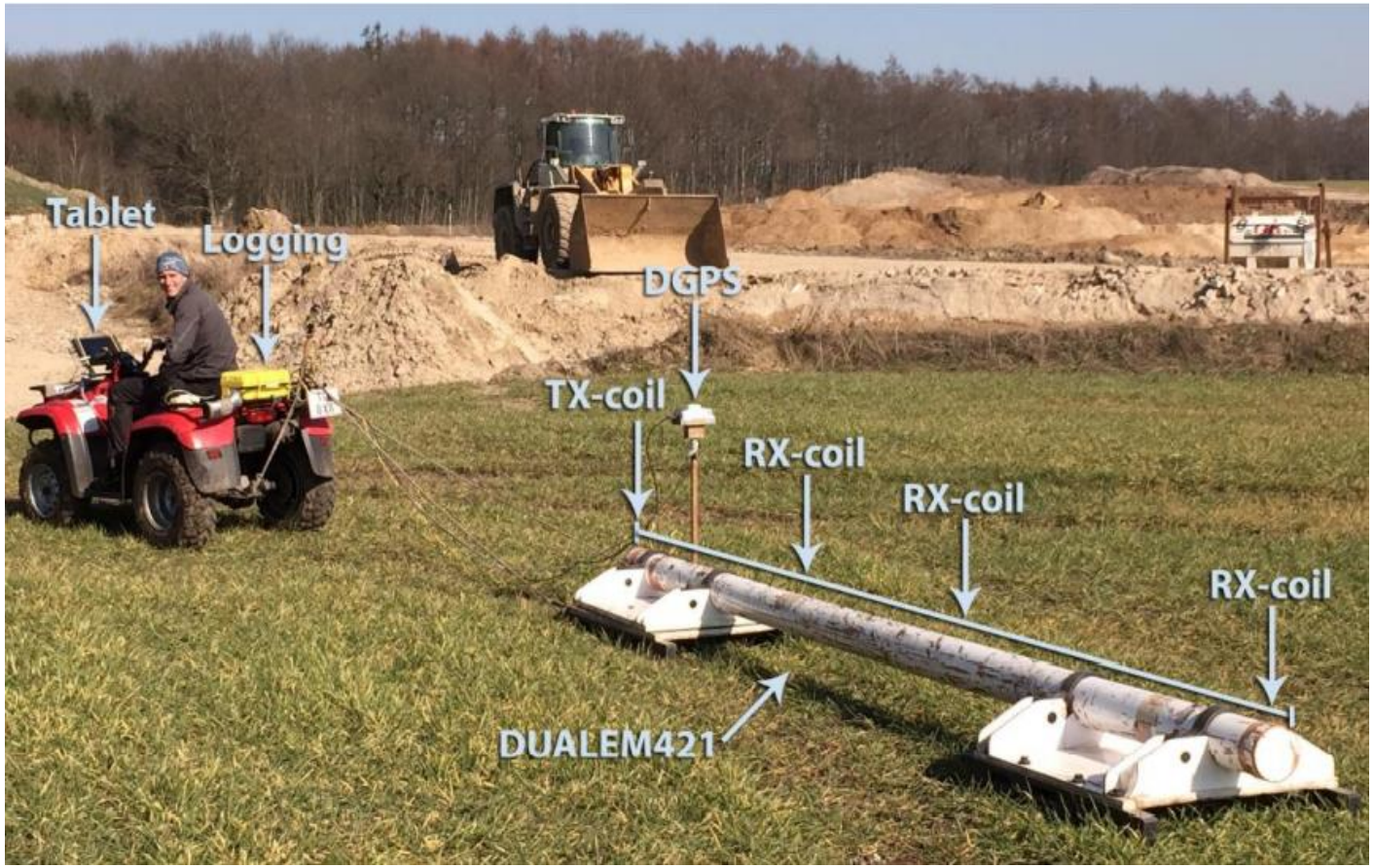
Data Processing – Noise Removal



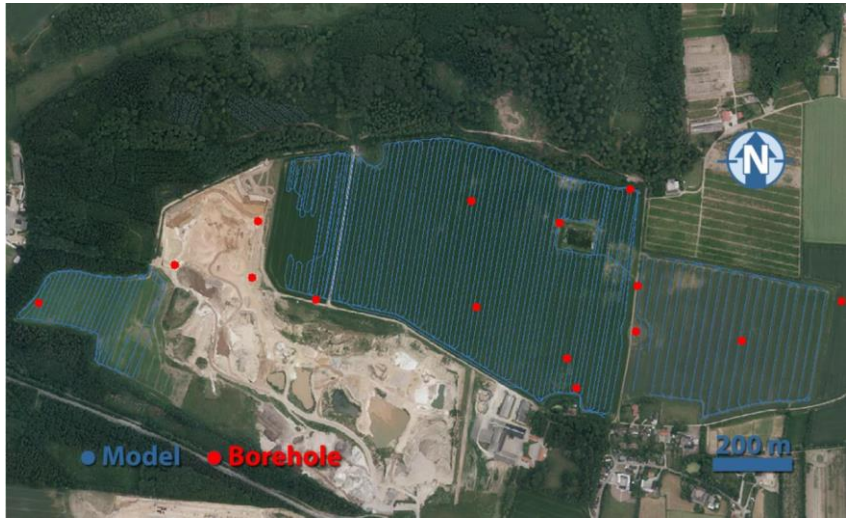
Data Processing – Noise Removal

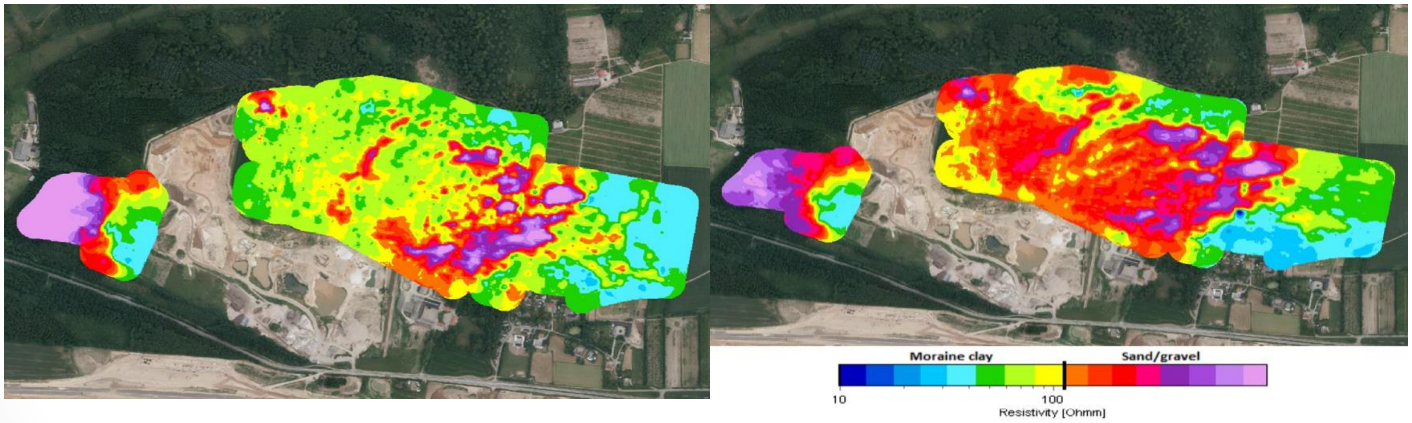


Gravel Pit Extension



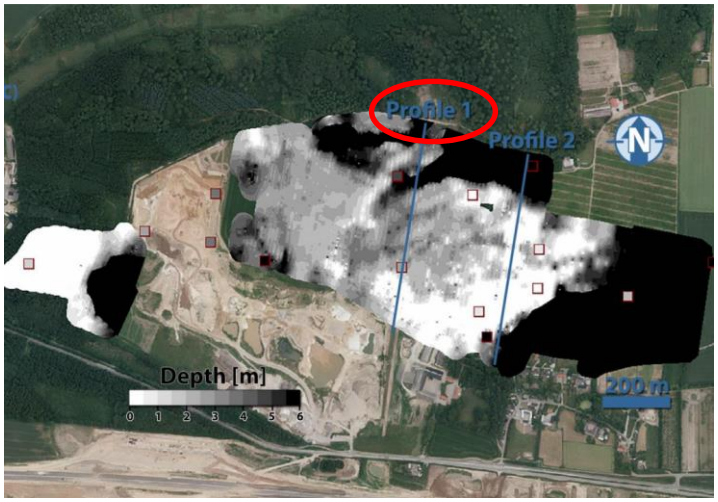
Survey Area

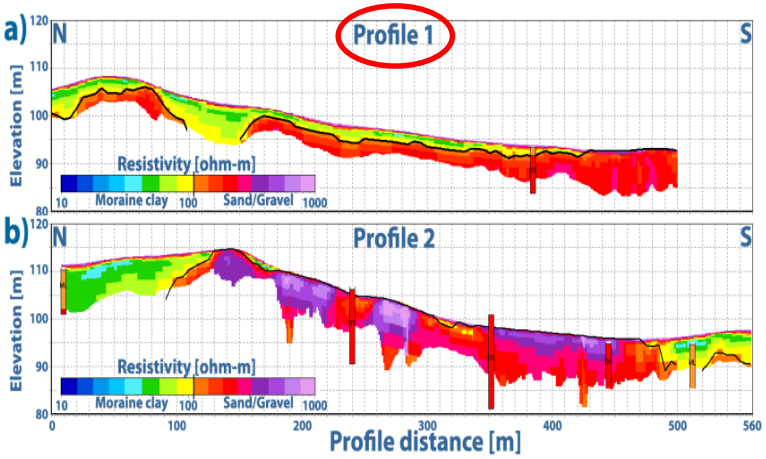




Aarhus. (Geosoftware. nd.). *Aarhus geosoftware white papers*. Aarhus GeoSoftware. Retrieved January 18, 2023, from https://www.aarhusgeosoftware.dk/white-papers

Extension Area





Aarhus. (Geosoftware. nd.). *Aarhus geosoftware white papers*. Aarhus GeoSoftware. Retrieved January 18, 2023, from https://www.aarhusgeosoftware.dk/white-papers

Conclusions

- Higher values of soil temperature, soil moisture and bulk densities were recorded under deeper soil depths
- Field work and data collection reflected the presence of hardpan under deeper soil depths
- Soil electrical conductivity correlated well with penetrometer resistance reflecting the potential of hardpan detection
- Layered hydraulic conductivity may potentially be used for variable rate tillage operations
- Yield was observed to higher in treated areas when compared to check!
- More research work is needed to establish efficacy of the EC in predicting/detecting the compaction.

Collaborators/ Funding Agencies

Precision Agriculture Research Group – UPEI

THANK YOU FOR YOUR ATTENTION

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