Comparing management zone maps to address infertility and sodicity in sugarcane fields

Maryem Arshad,

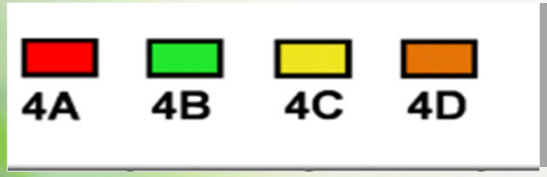
Nan Li, Dongxue Zhao, Michael Sefton, John Trianatfilis

Problem

Digital Soil Mapping
DSM

FuzME

Clustering



Management Zones

Introduction

Australian Sugarcane

Sugarcane (*Saccharum officinarum* L.) occupies ~545,000 ha

70% cultivation in alluvial-estuarine areas, however there are problems because soil

- infertile (sandy > 60 %),
- Acidic (pH < 5.5) and
- sodic (ESP > 15 %)

Implications with regard to;

- Cation Exchange Capacity (CEC)
- Nutrients (**Exch. Ca + Exch. Mg**)
- Unstable (i.e. ESP)

Introduction – An industry “soil”ution?

Six-Easy-Steps
Nutrient management guidelines

Table 1 – Lime guidelines based on exchangeable soil calcium (Ca)

Soil calcium (meq/100g)	Lime application (tonnes/ha)
< 0.2	3
0.2 – 0.4	2.5
0.4 – 0.6	2
0.6 – 0.8	1.5
0.8 – 1.1	1
1.1 – 1.5	0.5

Table 3 – Gypsum guidelines for sodic soils

ESP (%)	Gypsum rate (tonnes/ha)
< 5	0
5 - 10	5
10 - 15	7.5
> 15	10

Six-Easy-Steps (Burdekin Valley)

Ameliorants

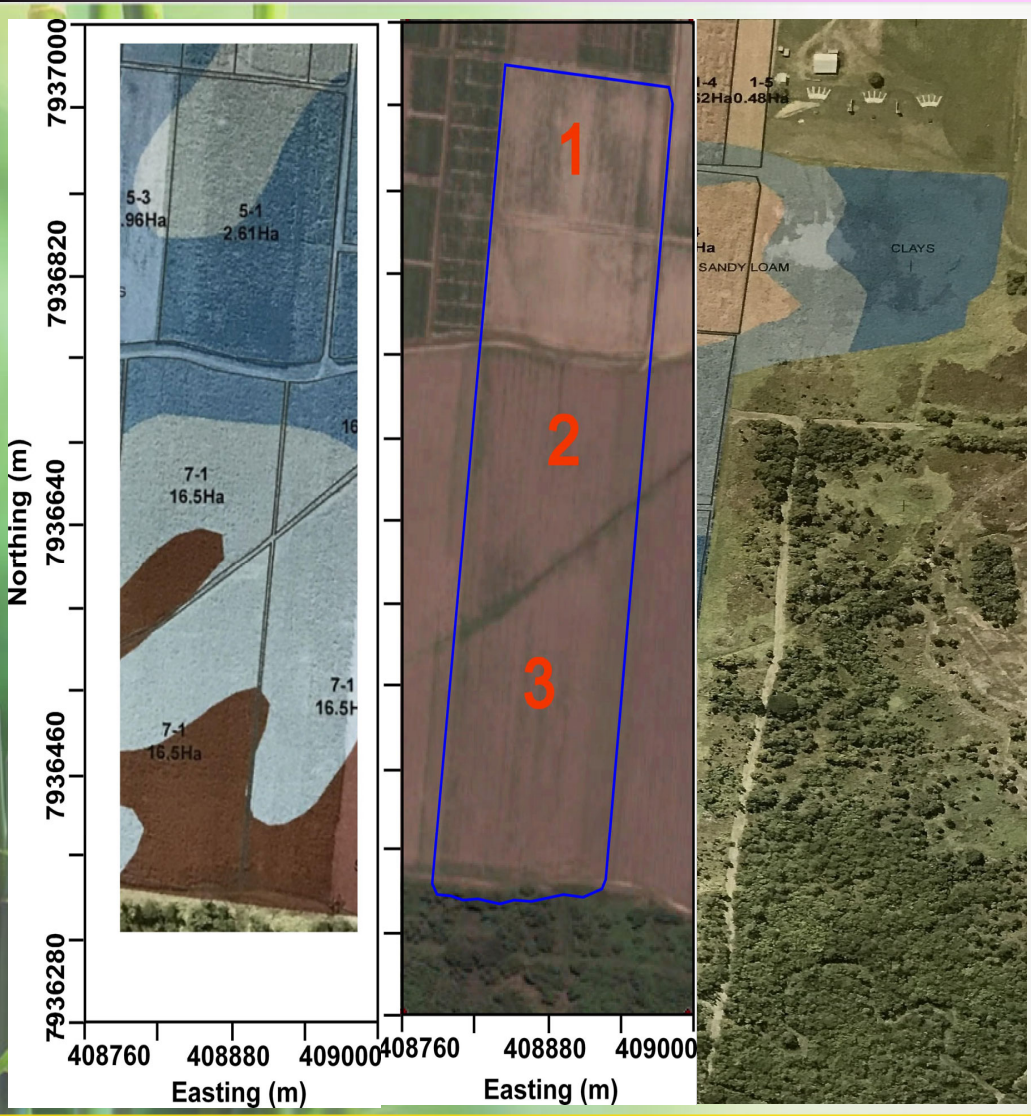
Lime

Gypsum

Infertility
CEC (cmol(+)/kg)
Apply

Sodictiy
ESP (%)
Apply

Management zones: Traditional/Field



Herbert Sugarcane

Alluvial soil varies and has been mapped using Traditional soil texture map

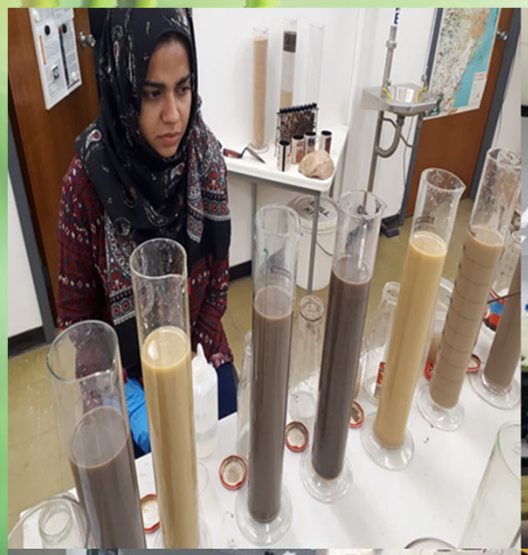
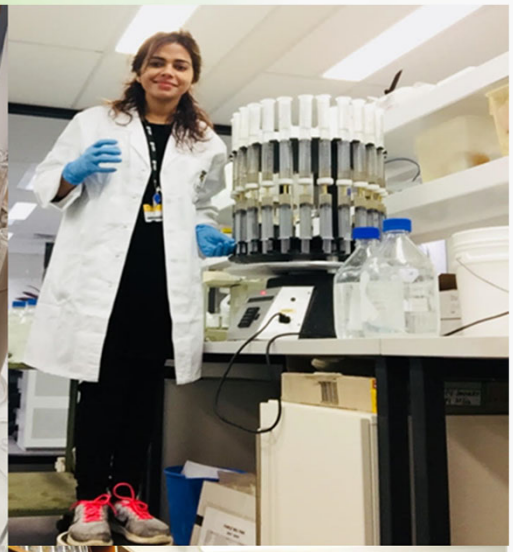
- Clay
- Silty Clay
- Terrace Silt Loam

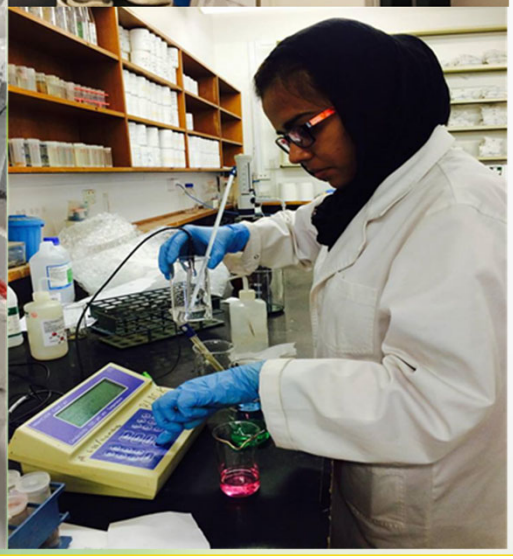
Best-practice requires knowledge of variation to max. yield and min. losses

When soil texture map is unavailable farmers use Field delineations

- Field 1
- Field 2
- Field 3

Soil data



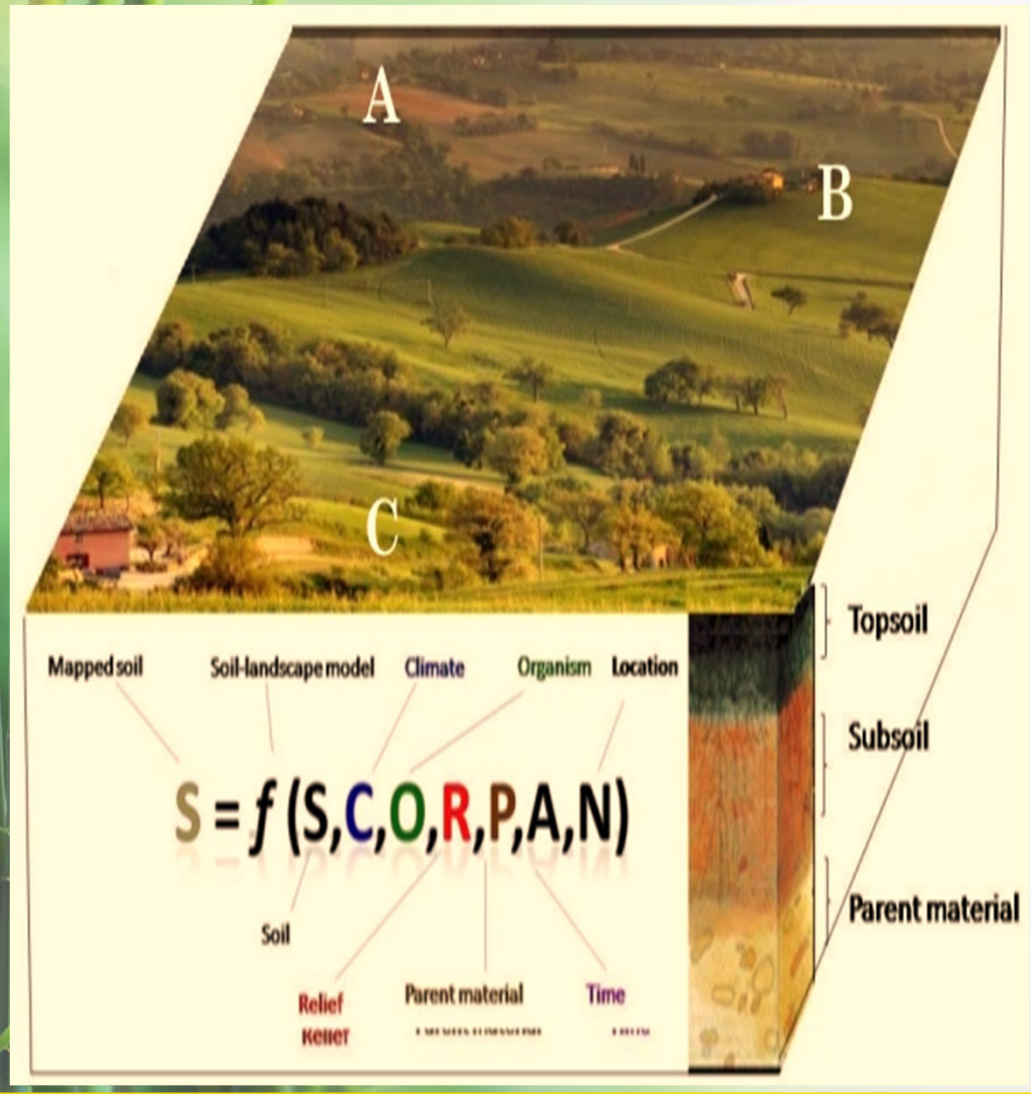
Analysis: time consuming

Chemical (**CEC** and **ESP**) ~24 hours

- Washing
- Extraction
- Analysis
- Calculations

$180

DSM – An innovative “soil”ution?



Digital Soil Mapping

Creation and population of spatial information using

Soil and

Digital data

coupled with **Models** either

Spatial or

Non-spatial inference

Three components:

Soil and

Digital data

Models

Digital data

Table 1. IAEA recommended windows for conventional 3-channel airborne gamma-ray spectrometry (IAEA 1991).

Element analysed	*Isotope used*	*Gamma ray energy MeV*	*Energy window MeV*
Potassium	^{40}K	1.46	1.370–1.570
Uranium	^{214}Bi	1.76	1.660–1.860
Thorium	^{208}Tl	2.61	2.410–2.810

Gamma-ray spectrometer- RS700

Passive proximal sensor which detects gamma-rays from radioactive isotopes

Measures:

K

U

Th

TC

Depth of measurement

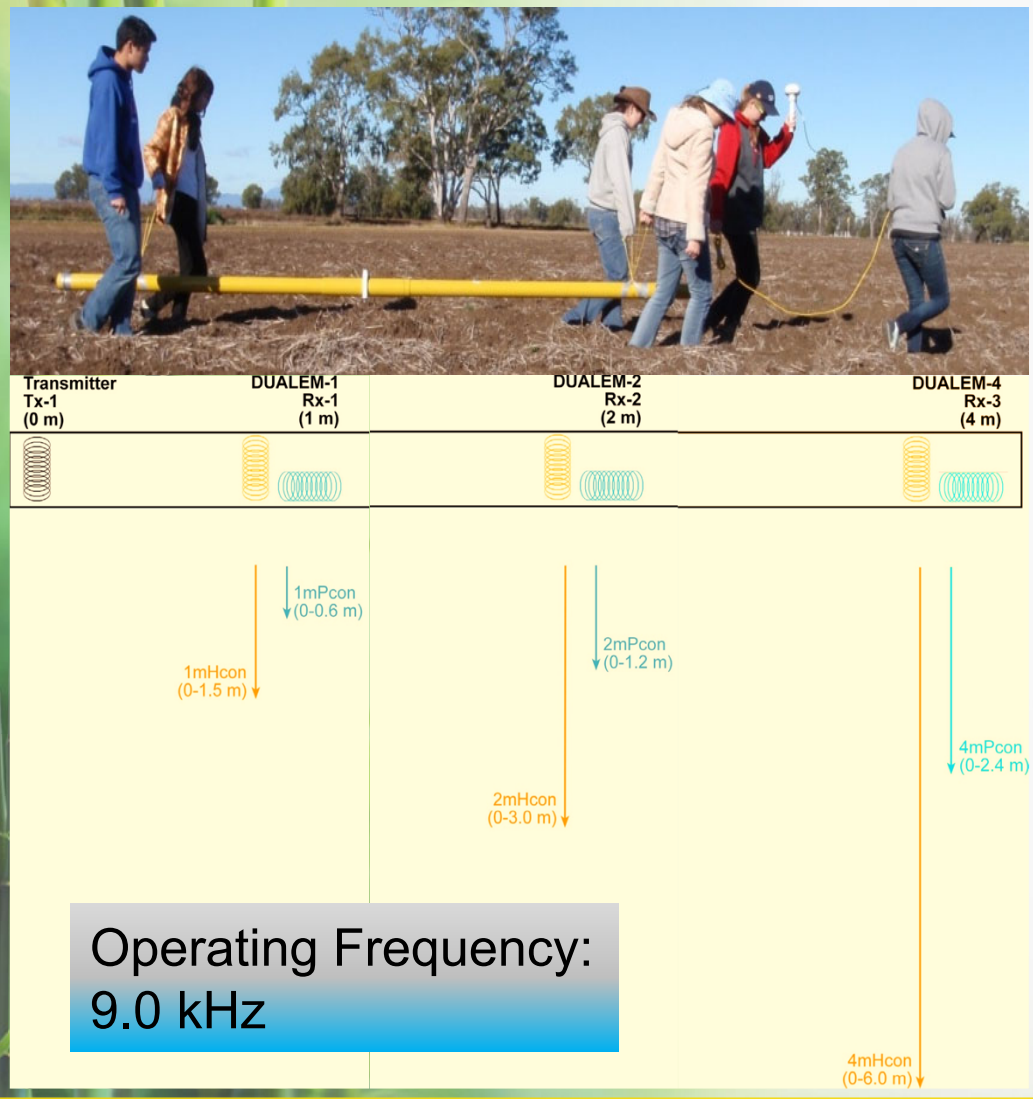
0-0.45 m

Related:

clay,

mineralogy

Digital data



Operating Frequency:
9.0 kHz

Electromagnetic induction: DUALEM-421

Single frequency multi-coil array electromagnetic (EM) instrument

Measures:

Apparent electrical conductivity (**EC_a** –mS/m)

Perpendicular (Pcon) and

Horizontal coplanar (Hcon)

Depth of measurement

1mPcon (0-0.5 m) 1mHCon (0-1.5)

2mPcon (0-1 m) 2mPcon (0-3)

Related:

moisture, salinity,

clay and mineralogy

Aim

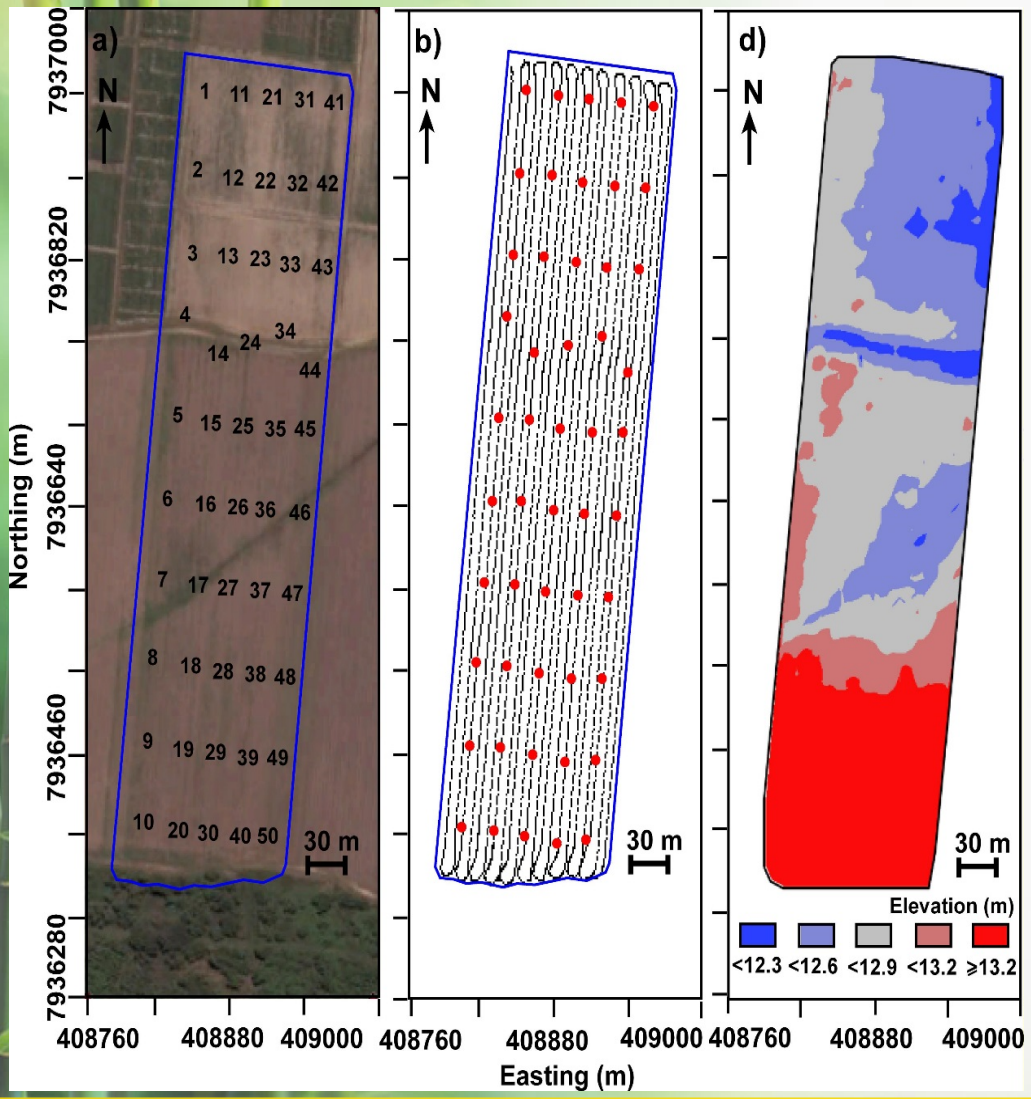
In multiple fields at HCPSL:

a) Can we generate a **DSM**s of management zones to manage
   i) Infertility (CEC) and
   ii) Sodicity (ESP)
using mathematical models and proximally sensed **Digital data**

b) Which method of creating management zones is optimal
   i) **DSM** (DEM, γ-ray and EM)
   ii) Traditional soil texture map
   iii) Field delineations

c) Which data is optimal
   i) Gamma-ray
   ii) ECa
   iii) Both

Data collection: Digital & Soil



Data collection and sampling

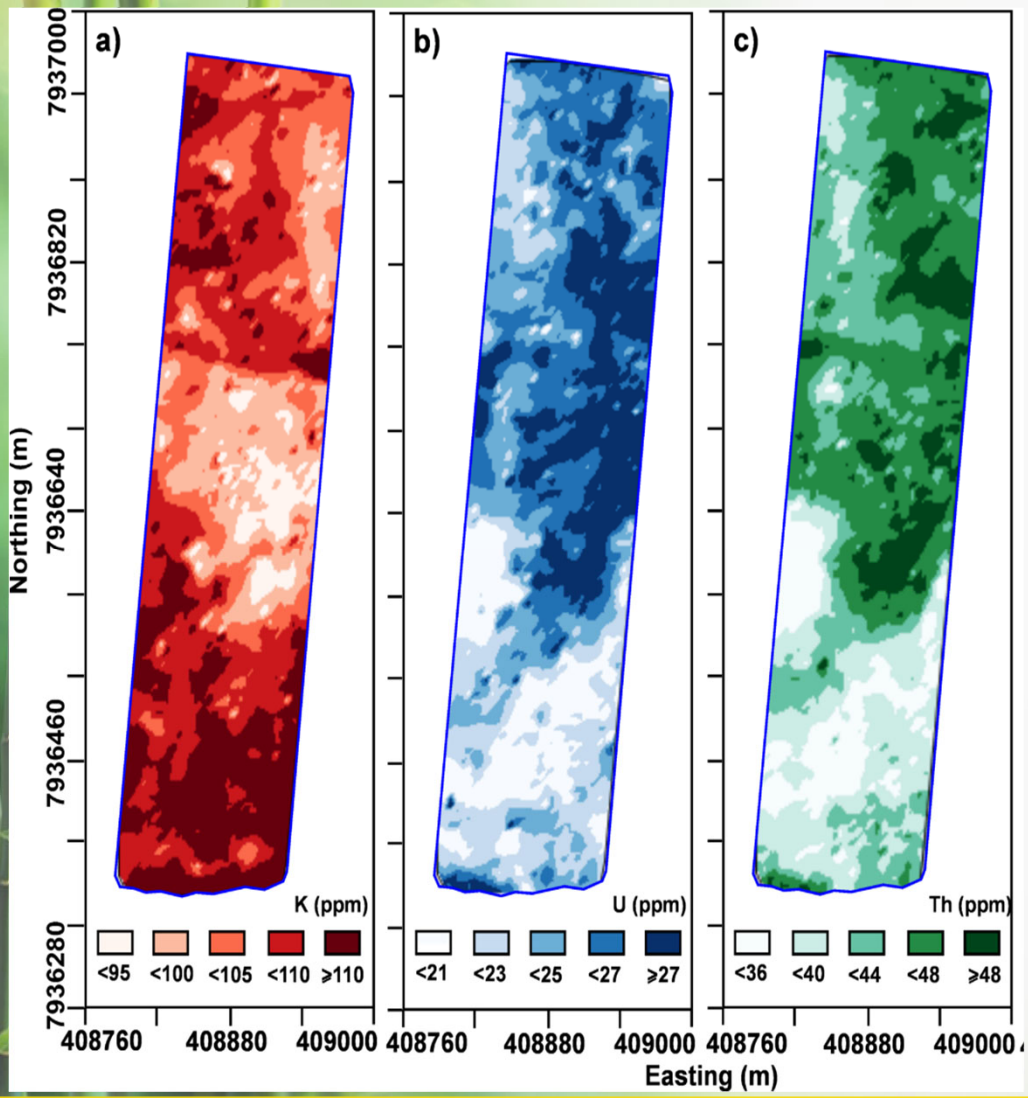
Digital data was collected from 21 transects (6 m apart) using

- **Digital Elevation Model**
- **γ-ray spectrometry**
- **Electromagnetic EM**

Soil samples were collected from 50 sites

- Topsoil (0-0.3 m)

Digital data



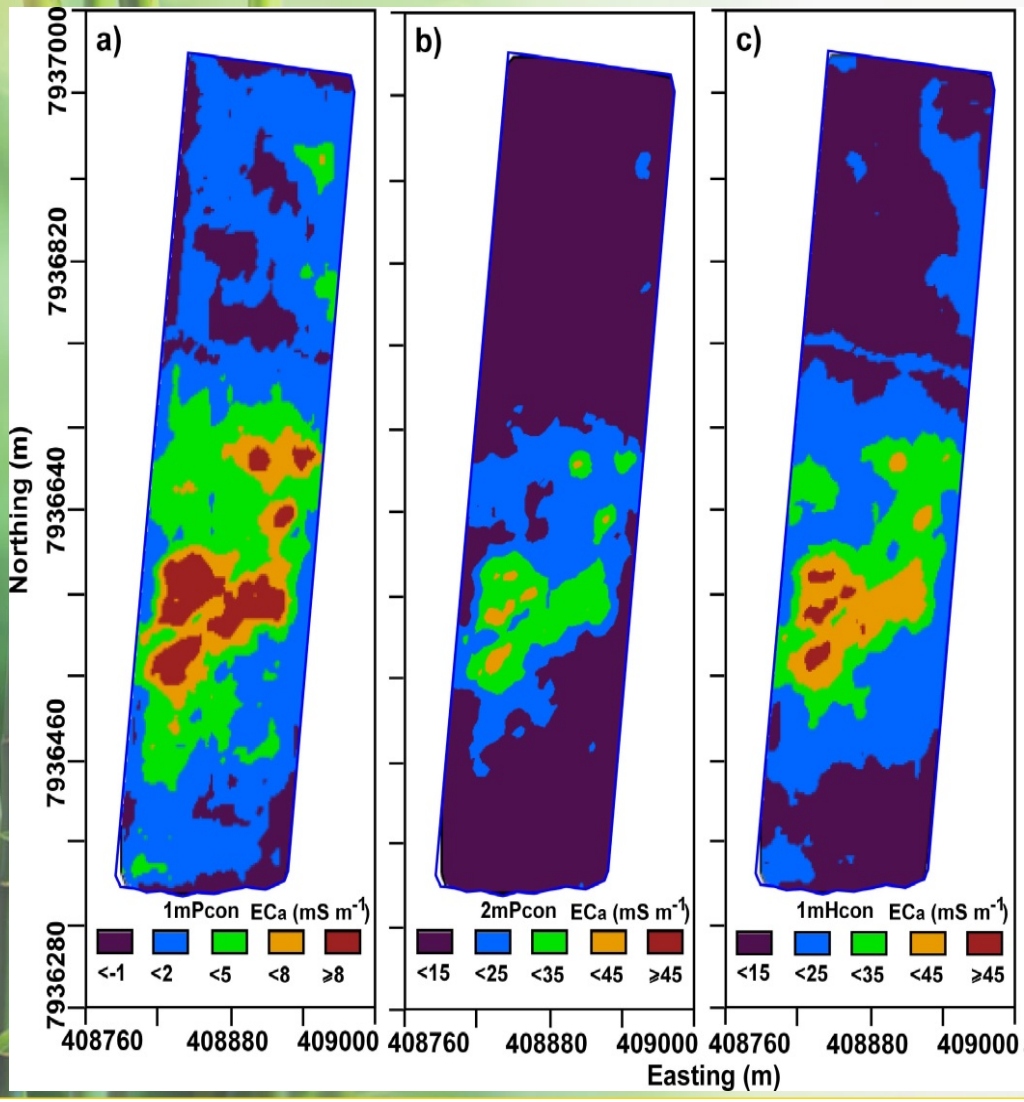
Gamma-ray spectrometer- RS700

K,

U and

Th

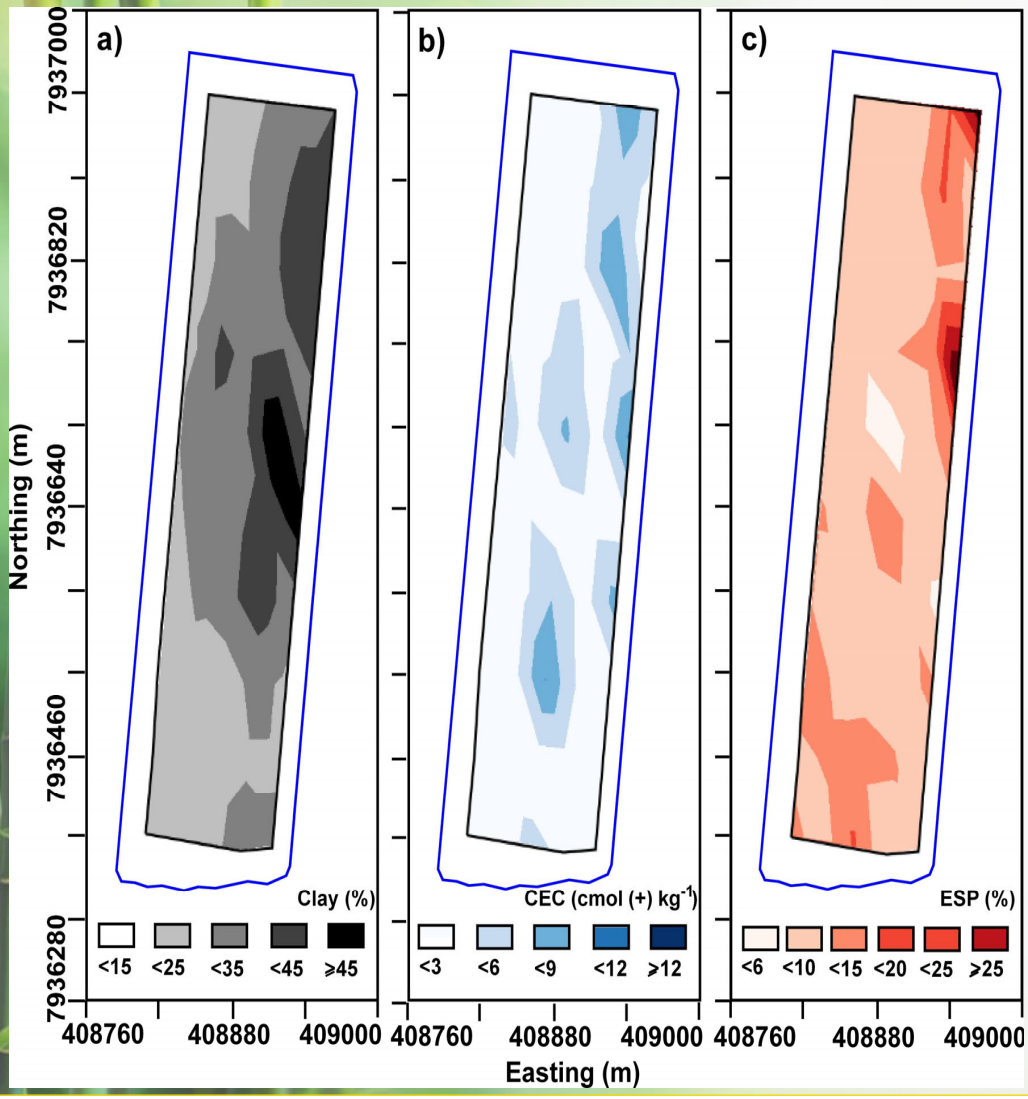
Digital data



Electromagnetic induction: DUALEM-421

1mPcon,
2mPcon and
1mHcon

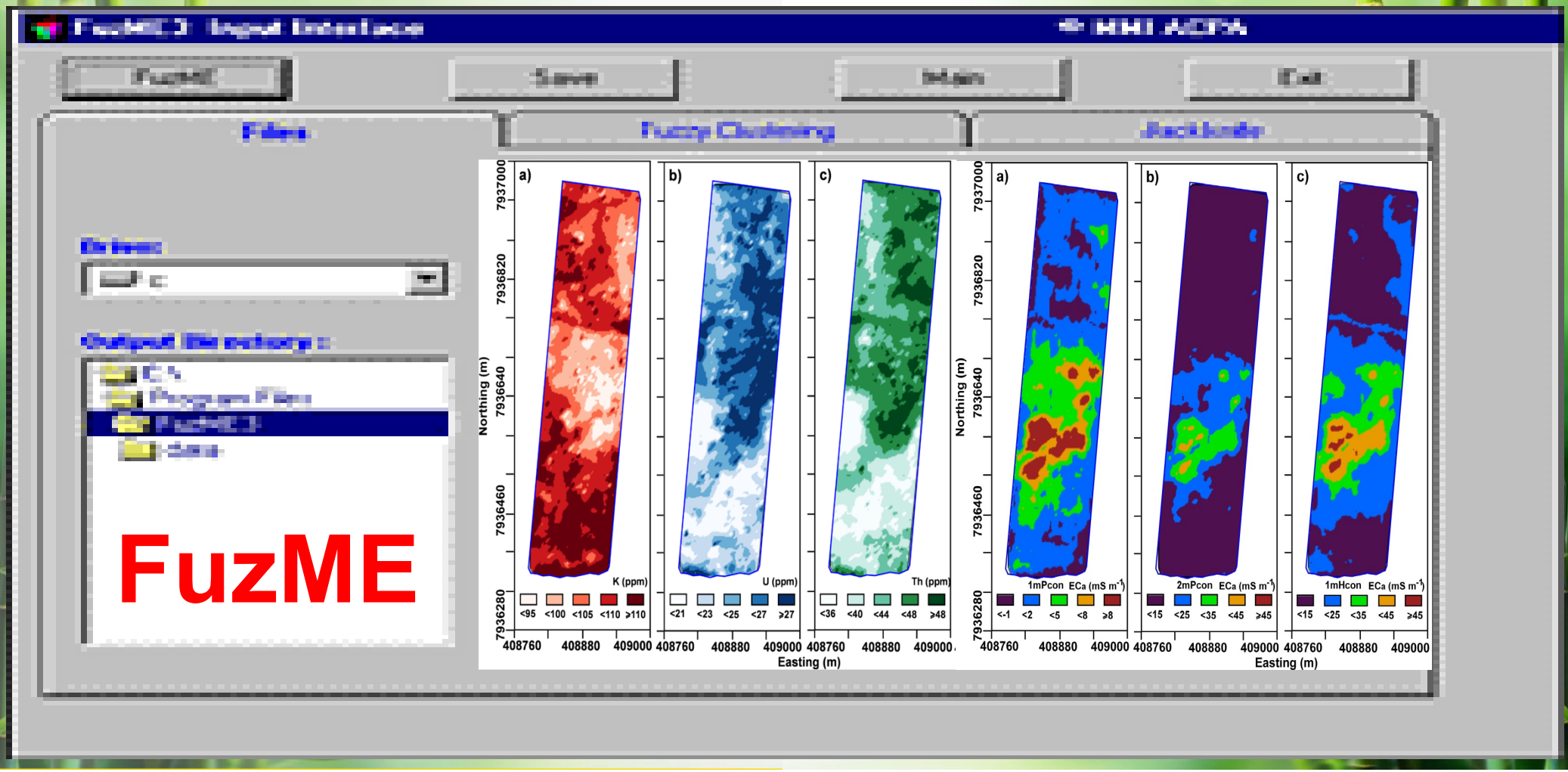
Soil data



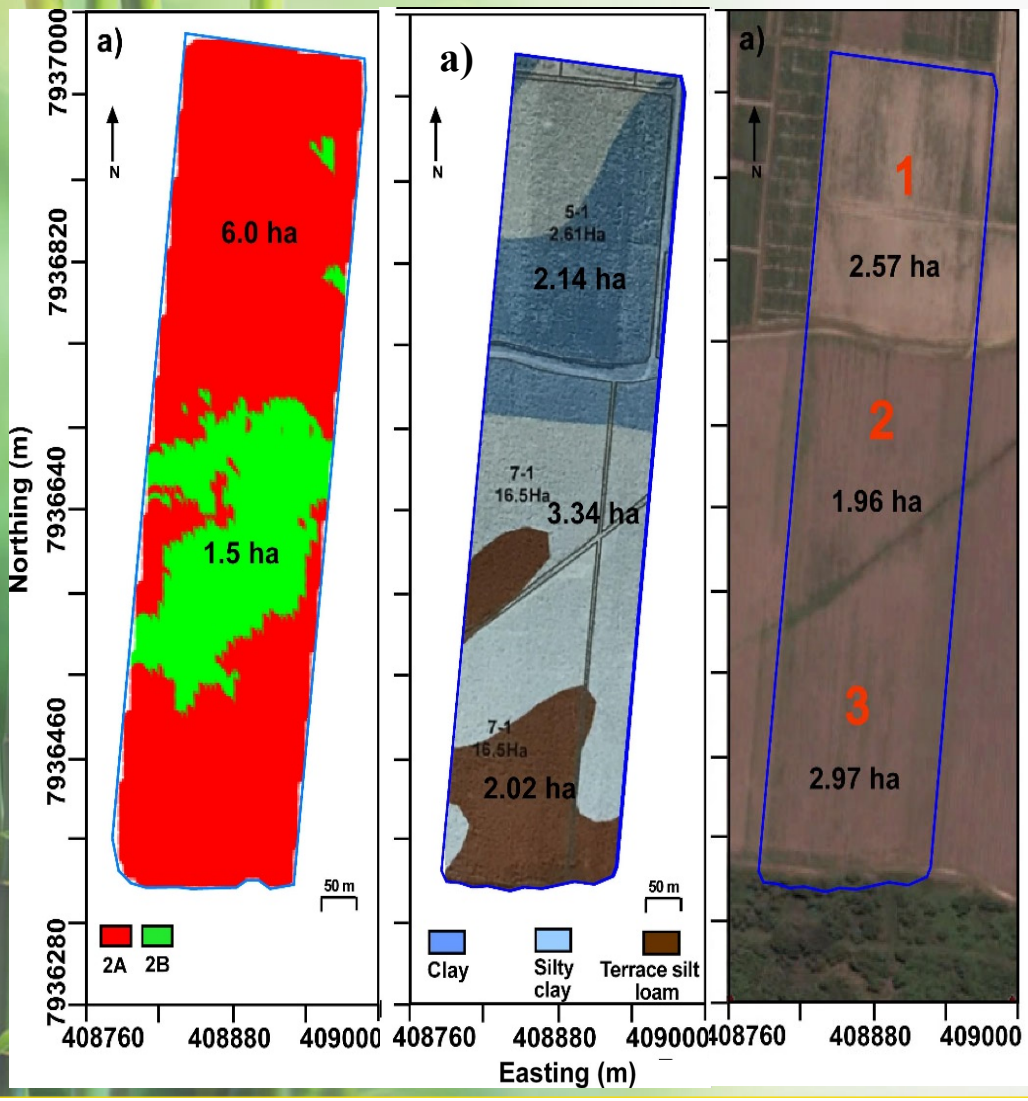
Test data to compare

Clay,
CEC and
ESP

Model: Clustering digital data



Management zones

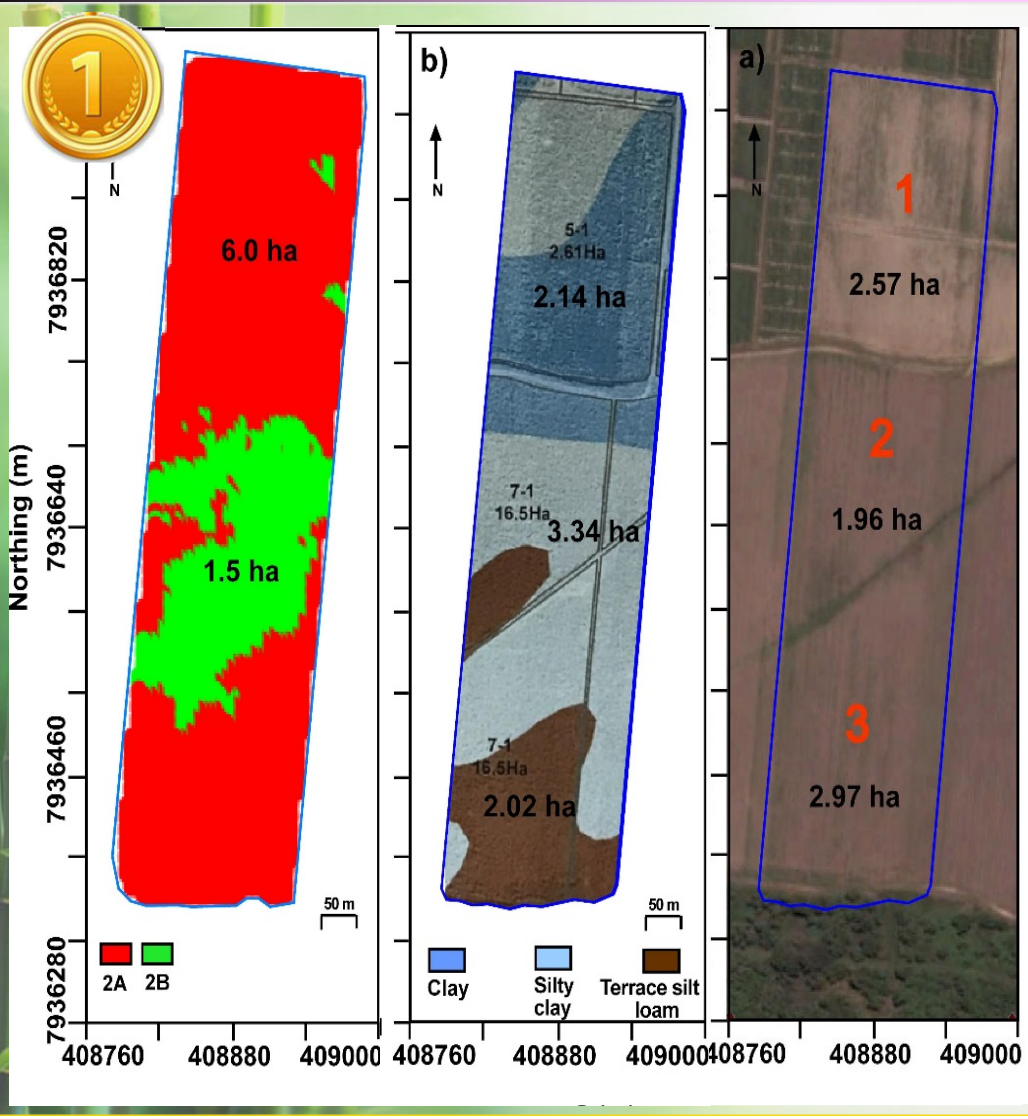


DSM = Digital data + clustering

Traditional map = Soil Texture

Field delineation = 3 fields

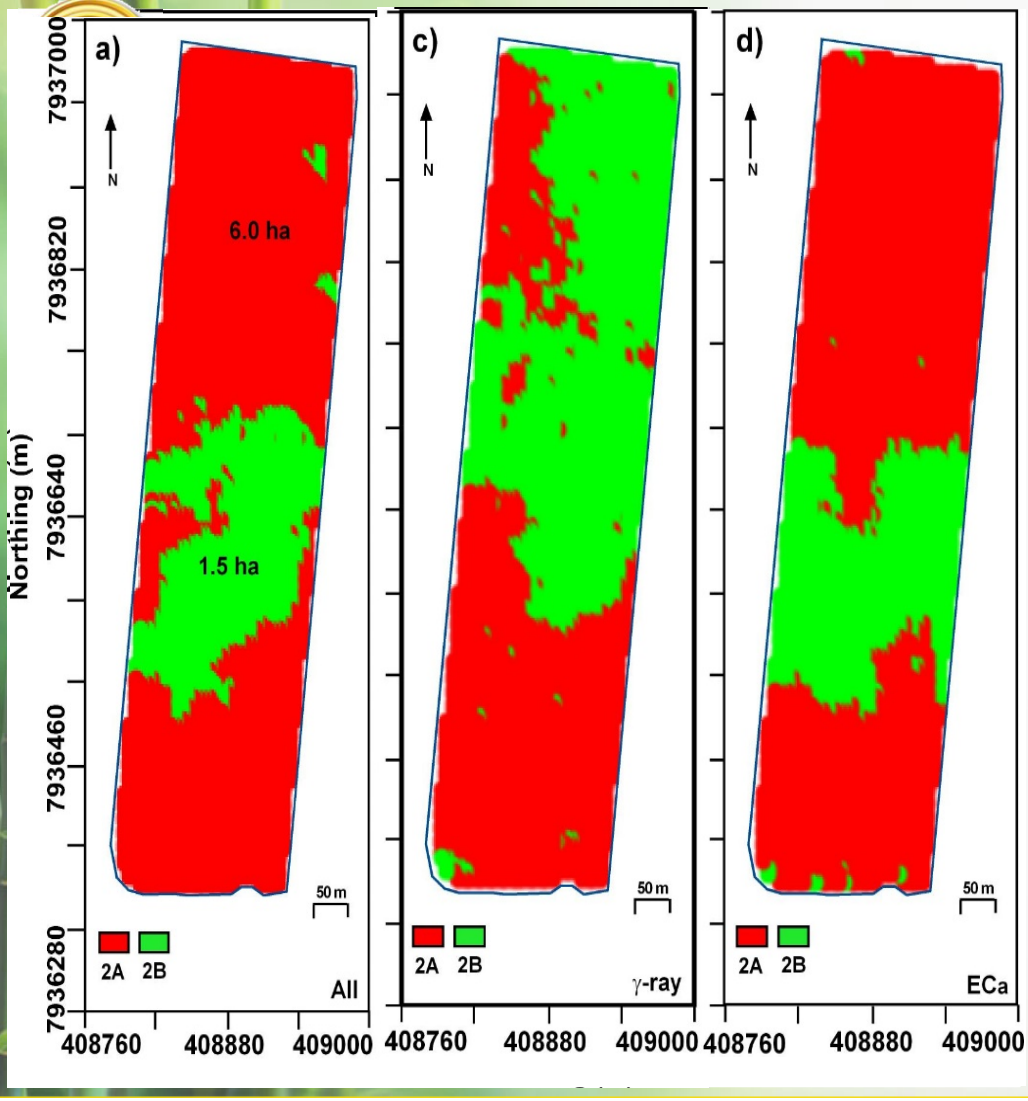
Which one is best to manage infertility?



Mean square prediction error (MSPE)

Properties	DSM k = 2	DSM k = 3	DSM k = 4	Traditional (k = 3)	Field (k = 3)
CEC ([cmol(+)/kg])	**2.20**	2.21	2.34	2.37	2.41

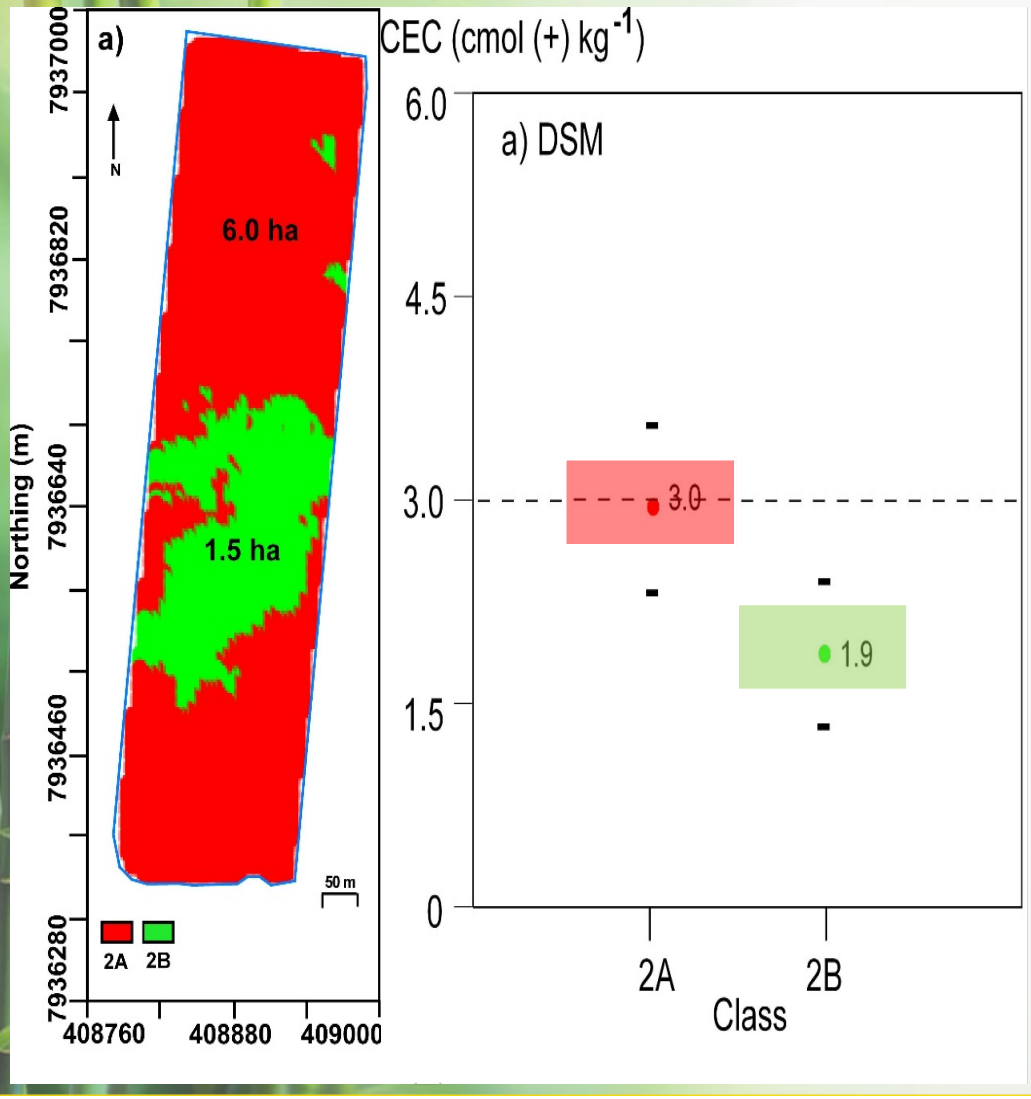
Which one is best to manage infertility?



Mean square prediction error (MSPE)

Properties	All	Gamma-ray	ECa
CEC ([cmol(+)/kg])	**2.20**	2.33	2.22

Lime application rate to DSM



Six-Easy-Step (Herbert Valley)

Infertility

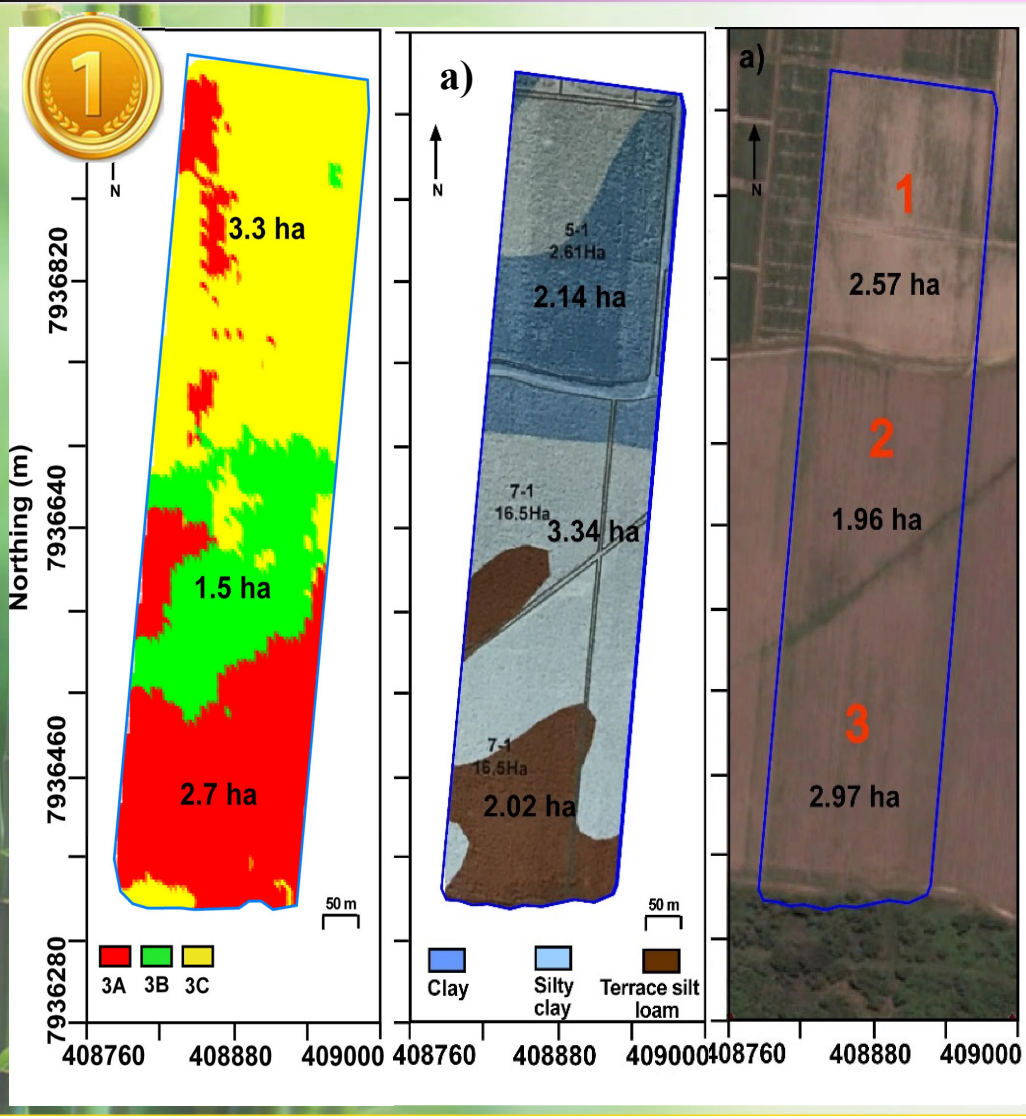
CEC (cmol(+)/kg)

Apply

Table 1 – Lime guidelines for acid soils (when pH water < 5.5)

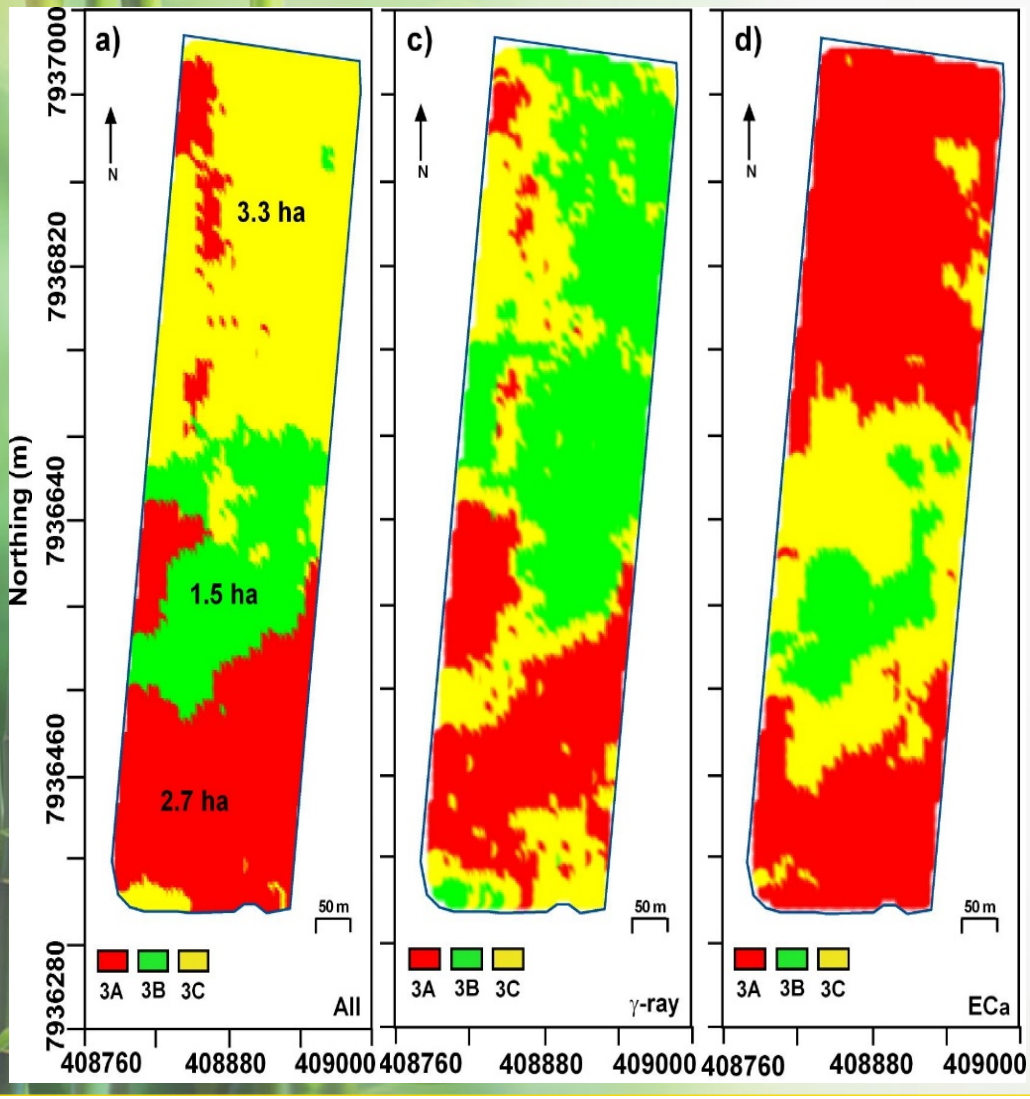
CEC (meq/100g)	Lime application (tonnes/ha)
< 3.0	2.25
3.0 – 6.0	4
> 6.1	5

Which one is best to manage sodicity?



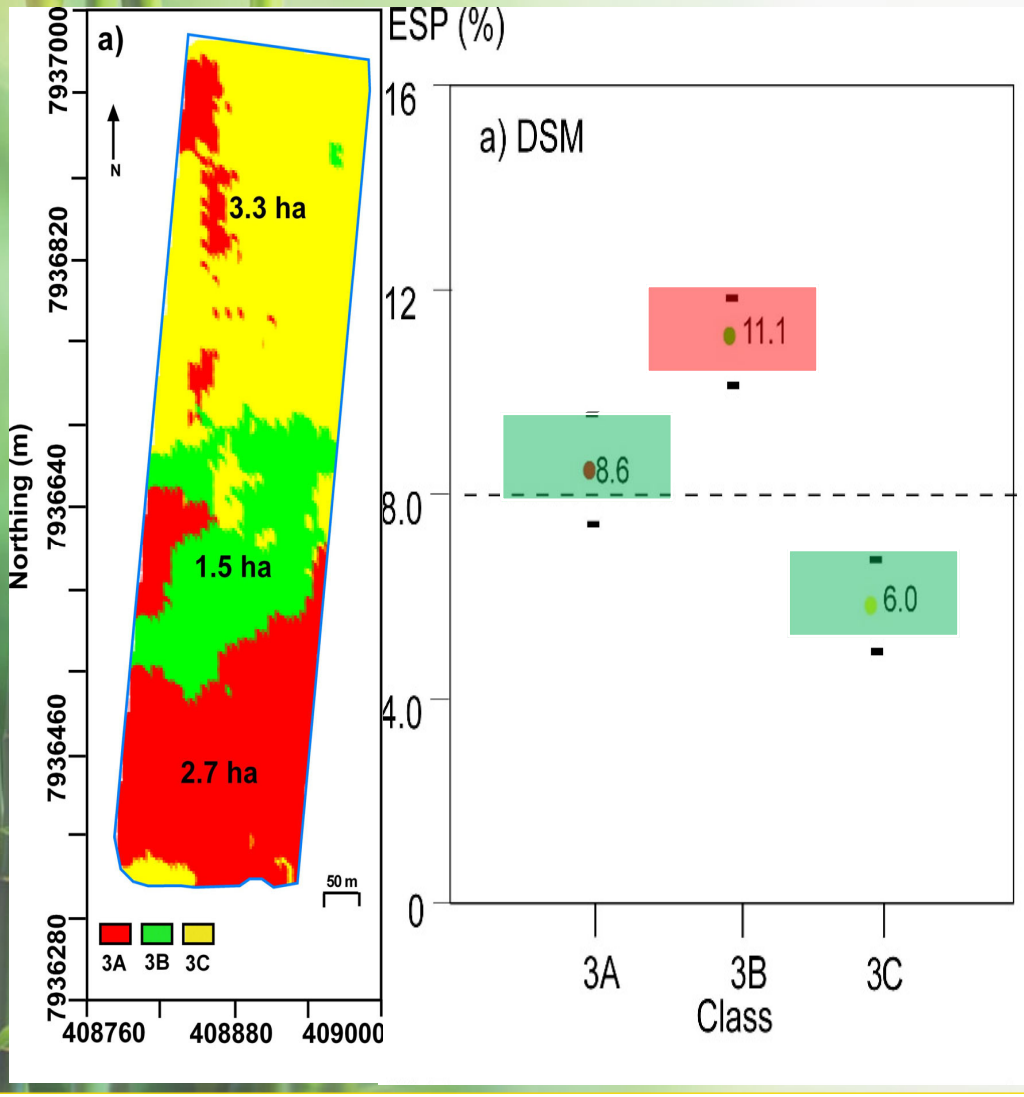
Mean square prediction error (MSPE)					
Properties	DSM k = 2	DSM k = 3	DSM k = 4	Traditional (k = 3)	Field (k = 3)
ESP (%)	5.76	5.60	6.91	7.04	6.2

Which one is best to manage sodicity?



Mean square prediction error (MSPE)			
Properties	All	Gamma-ray	ECa
ESP (%)	5.76	7.09	6.69

Gypsum application rate to DSM



Six-Easy-Step (Herbert Valley)

Sodicity

ESP (%)

Apply

Table 4 – Gypsum guidelines for sodic soils

ESP (%)	Gypsum rate (tonnes/ha)
< 5	0
5 - 10	2
10 - 15	4
> 15	6

Conclusions

DSM better than traditional or field delineations

Combined data better than individual

Evaluate the reproducibility of methods

Perform strip trials

Comparing management zone maps to address infertility and sodicity in sugarcane fields

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Title Comparing management zone maps to address infertility and sodicity in sugarcane fields

Article type Research Paper

Abstract

In the sugarcane growing area of the Herbert Valley, the soil is inherently infertile with low cation exchange capacity (CEC – cmol(+)/kg). It is also characteristically high in exchangeable sodium percentage (ESP %); moderately sodic (6-10 %). To manage these issues, the industry developed the Six-Easy-Steps nutrient management guidelines to assist farmers determine suitable rates of fertilisers (e.g. lime) and ameliorants (e.g. gypsum). In this research, we explore the use of proximal sensed data from a digital elevation model, □gamma-ray (RS-700 spectrometer) and electromagnetic induction (DUALEM-421) instruments to delineate management zones (k = 2, 3 and 4) by numerical clustering (k-means). We test these digital soil map (DSM) derived zones by calculating mean square prediction error (MSPE) relative to topsoil (0 – 0.3 m) CEC and ESP using restricted maximum likelihood (REML). These DSM were compared with zones based on a traditional soil texture map (k = 3) and field-based delineation (k = 3). The DSM of zones was more precise given they minimised the within field MSPE for predicting CEC and ESP as compared to either a traditional soil texture map or field-based delineations (k = 3). This was the case for the DSM of k = 2 and for CEC (MSPE = 2.20) and the DSM of k = 3 for ESP (5.60). Although various proximal sensed data could be used independently, DSM of zones generated using all sources of proximal sensed data was most accurate. Differential application rates for lime and gypsum could be recommended using the Six-Easy-Steps nutrient management guidelines.

Keywords digital soil mapping; management zones; Six-Easy-Steps guidelines

Accepted **Soil Tillage and Research**

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