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Apparent soil electrical conductivity and NDVI to delineate management zones in fruit orchards

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"Excellence in Food and Agriculture Research"

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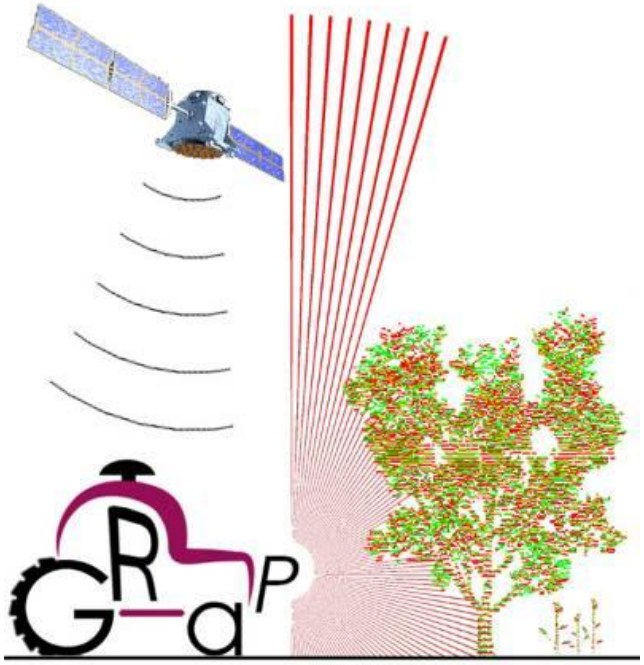
WHO WE ARE?
University of Lleida

School of Agrifood and Forestry Science and Engineering



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Importance of fruit culture in Lleida

Lleida province:

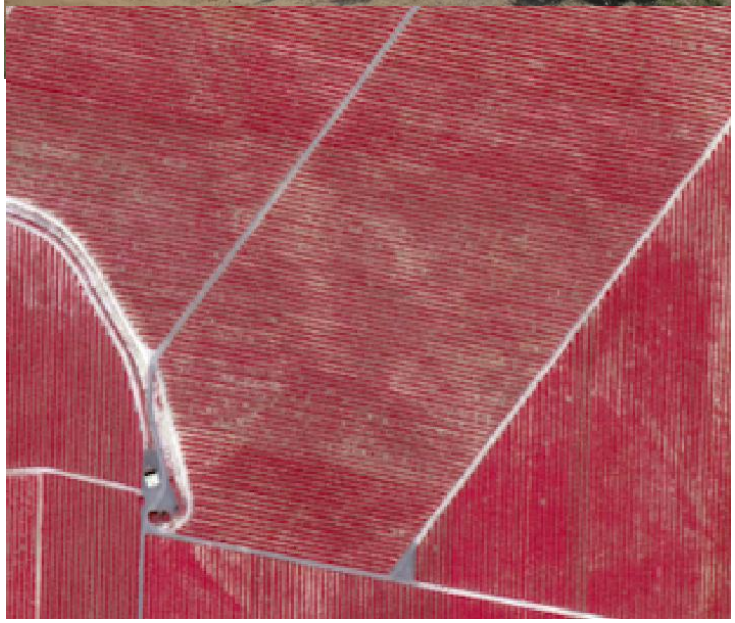
→ Main concentration of fresh fruit surface in Spain (31,500 ha in 2013) and one of the most important in the European Union.

Importance of fruit culture in Lleida

- ✓ Represents the second agrarian sector in Catalonia → 15.5% PIB
- ✓ Main fresh fruit crops: Peach and Nectarine → 15,000 ha and 307,000 tones

From traditional to modern cultivation

- ✓ The fresh fruit sector has experimented continuous transformation in the last decades:
  - Change of varieties, Change of cultivation patterns
  - Drip irrigation, Shade nets
  - Most recently: Use of Vegetation Indices from Remote Sensing images to manage spatial variability



Vegetation Indices & ECa

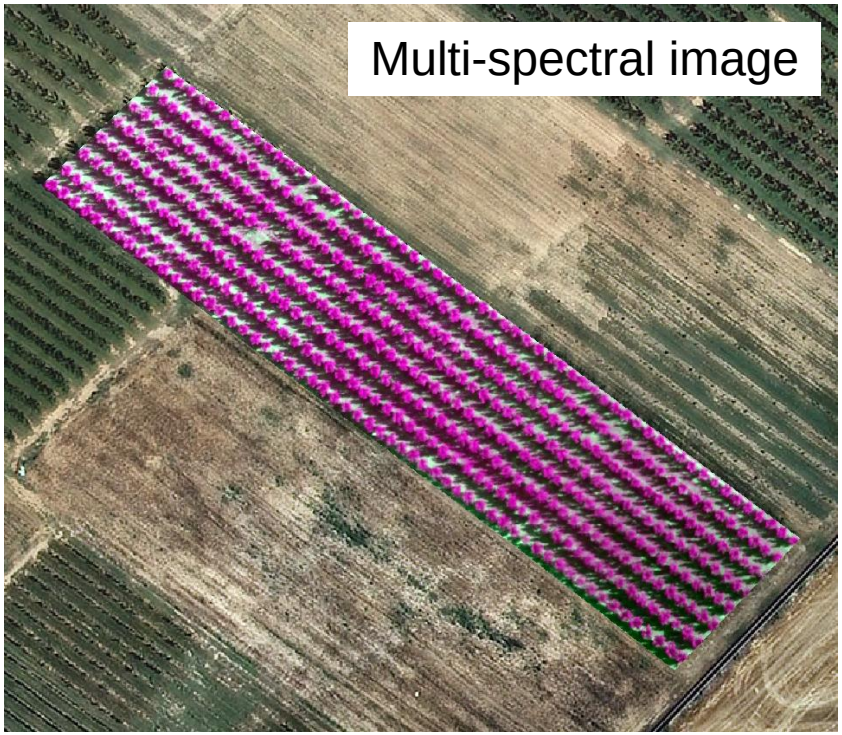
- ✓ The vegetation indices from remote sensing images reflect the status of vegetation in a specific moment.
  - This status depend on previous management operations (pruning, fertilization, irrigation, etc.)

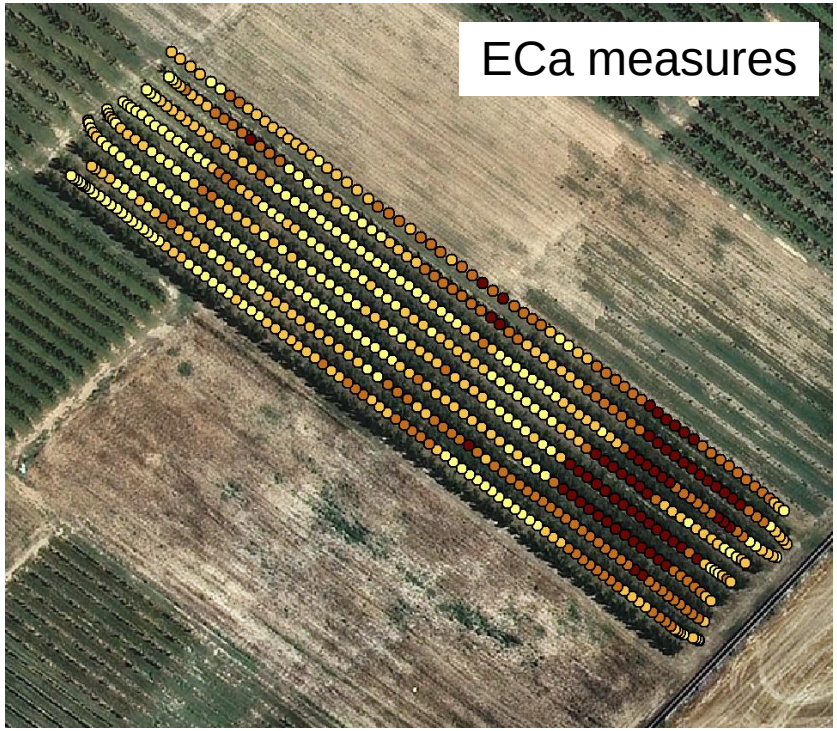
Vegetation Indices & ECa

- ✓ The Apparent Electrical Conductivity (ECa) measured with resistivity proximal (contact) sensors can produce more stable management zones.

Objective

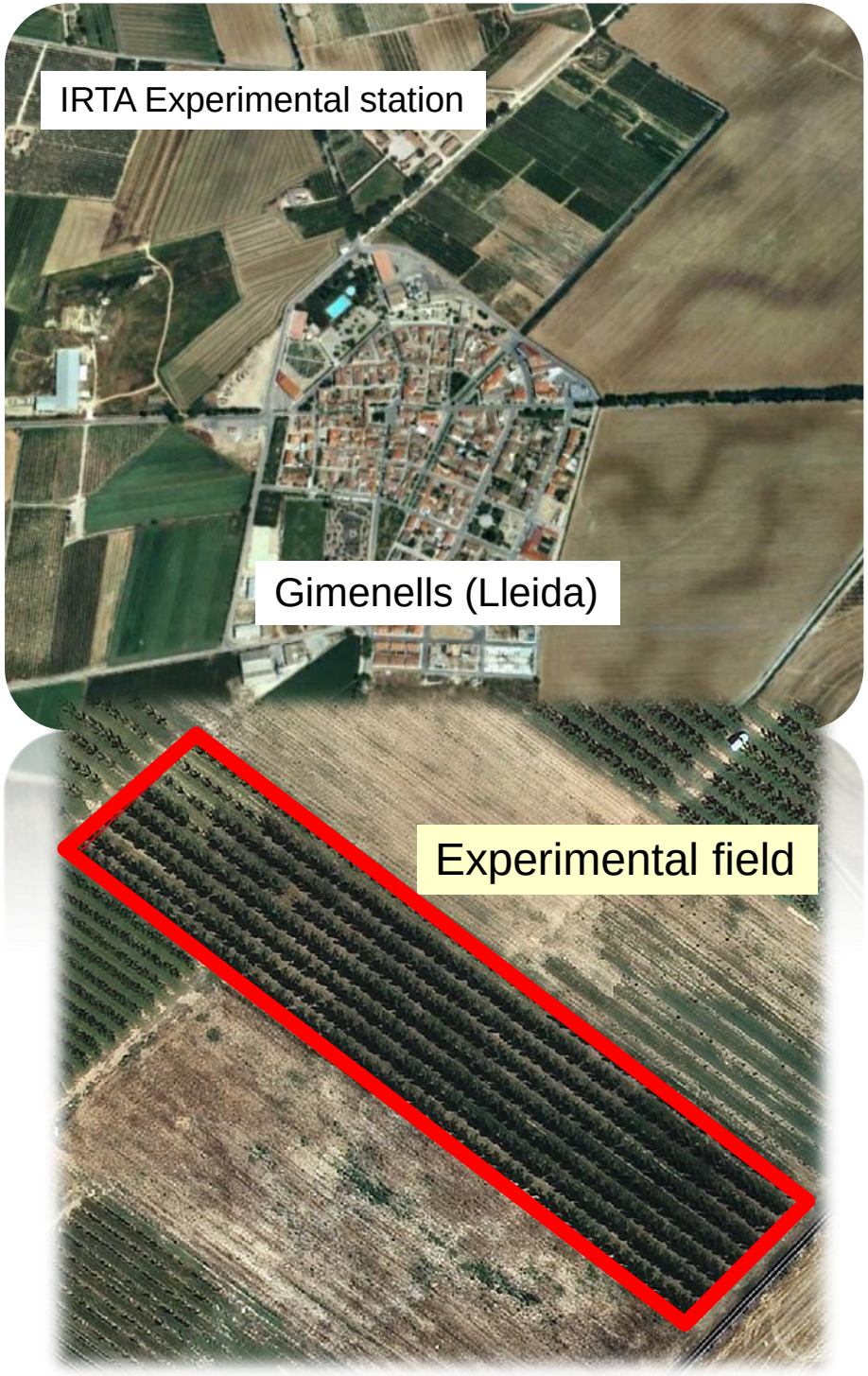
- ✓ The objective of this work is to compare the delineation of management zones in a fruit orchard on the basis of ECa measurements alone and in combination to high resolution NDVI images.





Study area

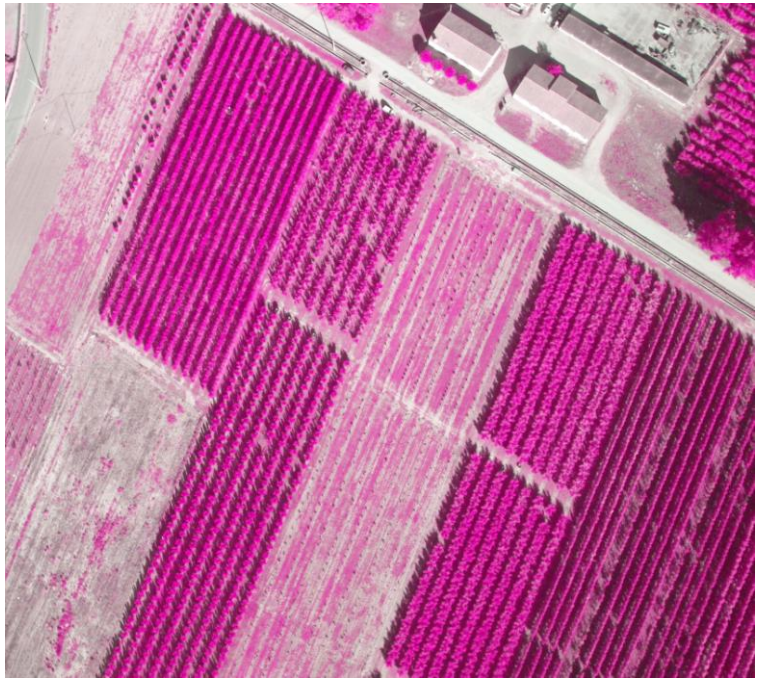
- ✓ Gimenells (Lleida) [24 km west from Lleida]
- ✓ *Prunus persica var. platycarpa* orchard of 0.65 ha
- ✓ Located at the IRTA Experimental Station
- ✓ Plantation pattern: 5 x 2.80 m
- ✓ Soils: Petrocalcic Calcixerept, with a petrocalcic horizon at a variable depth of 40–80 cm.



Material and Methods

Normalized Difference Vegetation Index (NDVI)

- ✓ **Aerial survey** → 30/06/2014 Atmos-6 UAV drone and a VEGCAM-Pro camera (CATUAV, Moià, Catalonia, Spain).



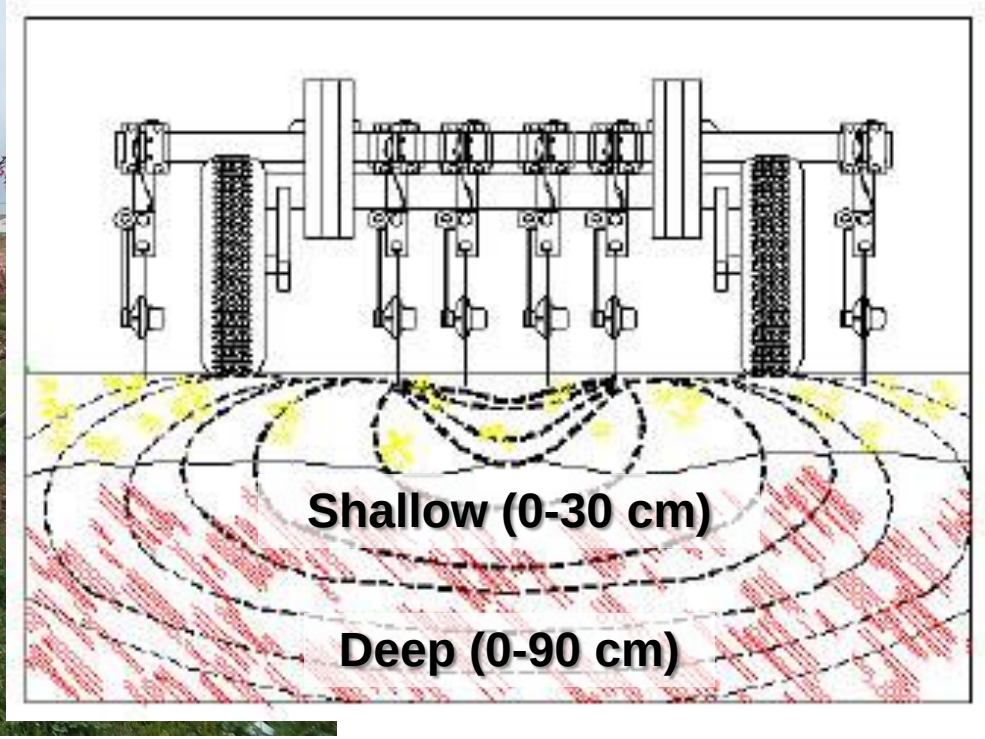
- ✓ Spectral bands:
  - Green (525-575 nm)
  - Red (615-685 nm)
  - NIR (755-805 nm)

- ✓ Spatial resolution of 0.15 m

Material and Methods

- ✓ The ECa was measured with Veris 3100 EC Mapping (Veris Technologies Inc., Salina, KS, USA).

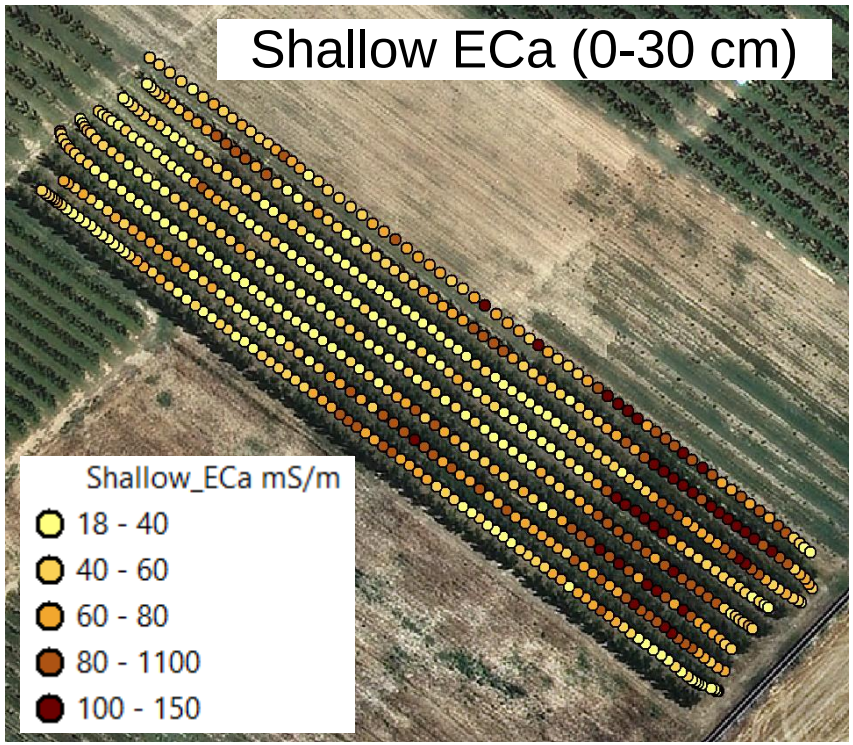
- ✓ It injects electrical current into the soil by a pair of coulter-electrodes → other coulter-electrodes measure the voltage drop at 0-30 cm (shallow ECa) and 0-90 cm (deep ECa).

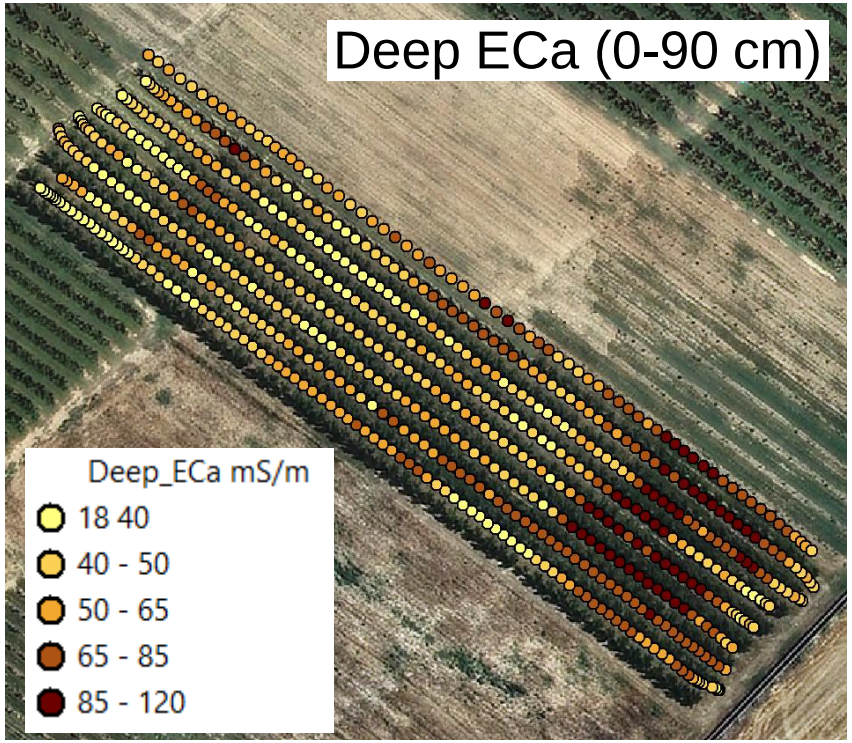


Material and Methods

- ✓ The sensor was connected to a Trimble AgGPS332 receiver with differential correction SBAS based on EGNOS

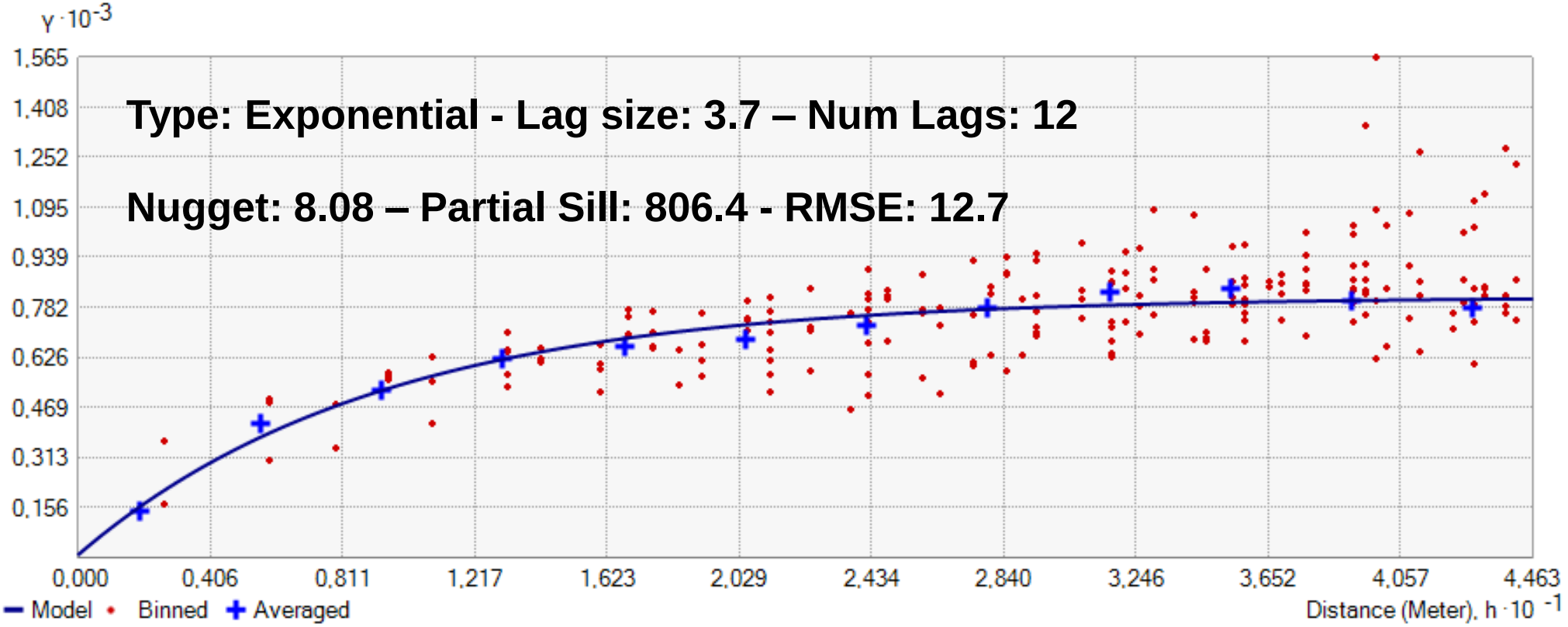
- ✓ The survey was carried out on 23/03/2015, acquiring a total of 644 measurements along the orchard rows (density of 990 points/ha).





Material and Methods

- ✓ ECa measurements → interpolated to a 0.5 m grid by ordinary kriging using exponential semivariograms with ArcGIS 10.3 for Desktop and Geostatistical Analyst (ESRI Inc., Redlands, CA, USA)



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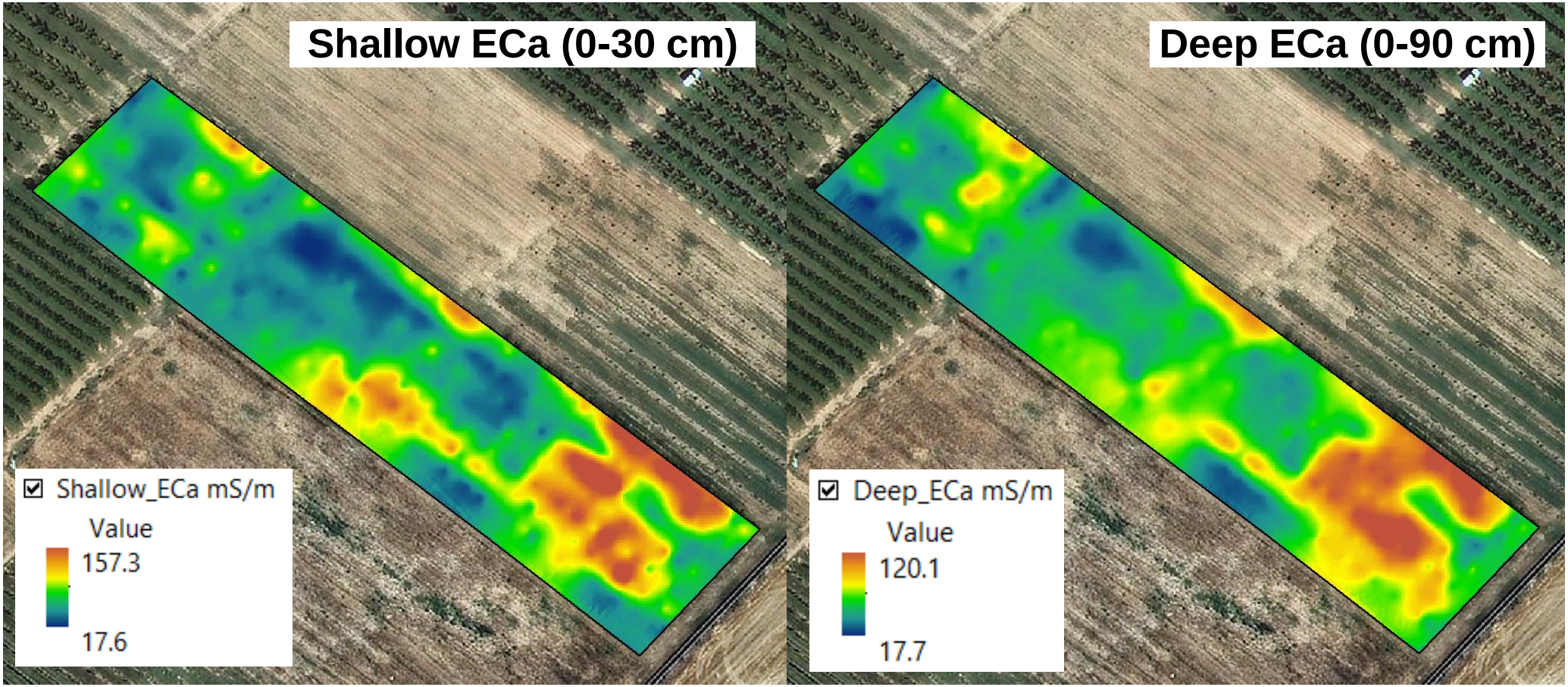


Material and Methods

- ✓ Delineation of management zones using the ISODATA algorithm implemented in ArcGIS 10.3:

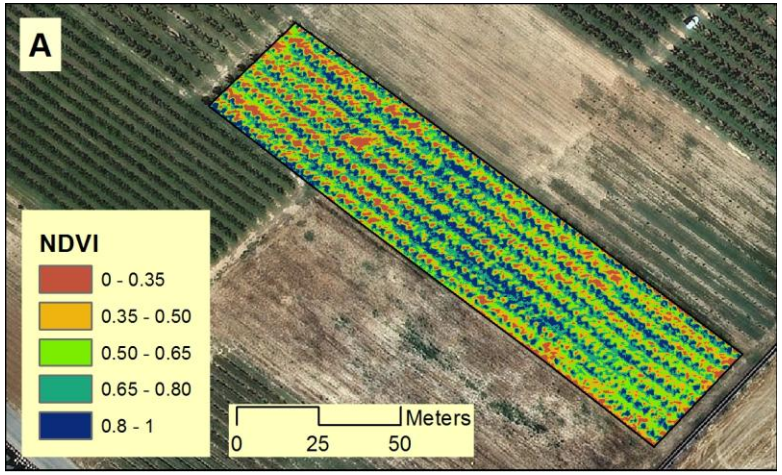
First case→ 2 Zones

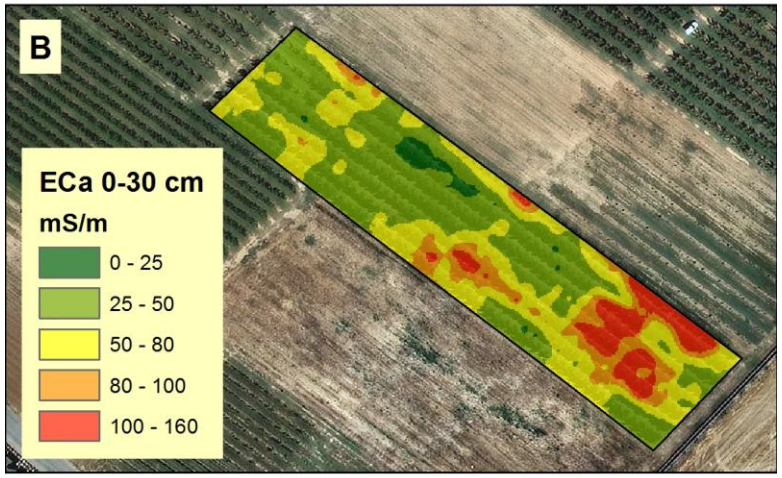
- Shallow ECa
- Deep ECa

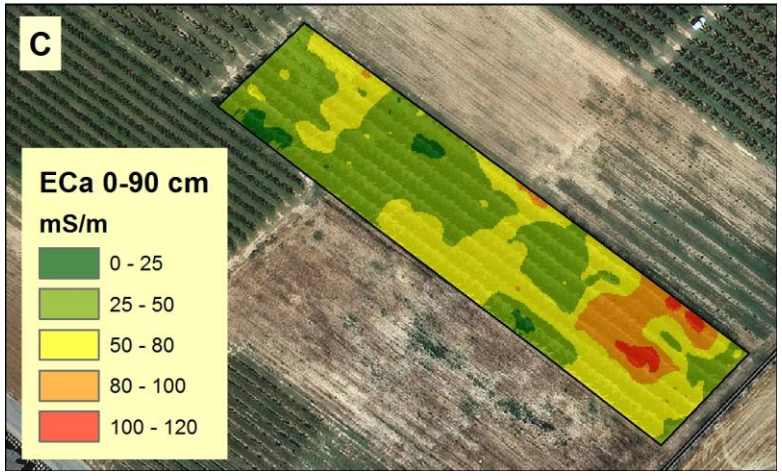
Second case→ 2 Zones

- Shallow ECa
- Deep ECa
- NDVI

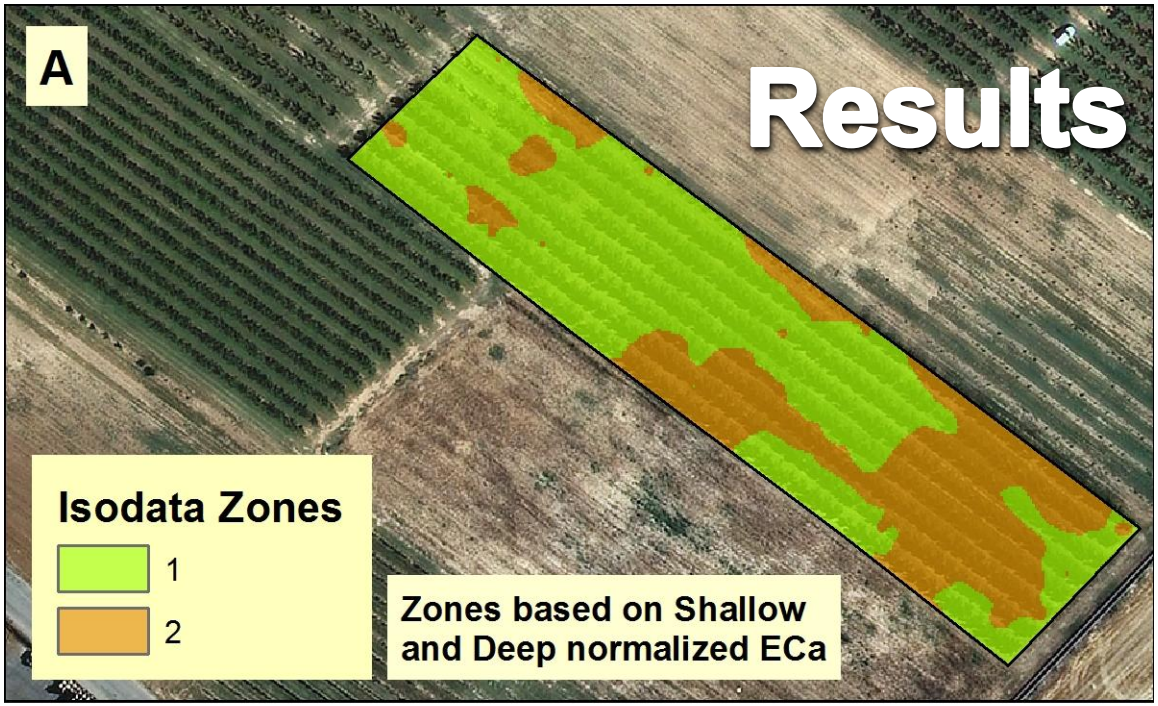
- ✓ ANOVA test to compare the means of the NDVI in the delineated management zones.

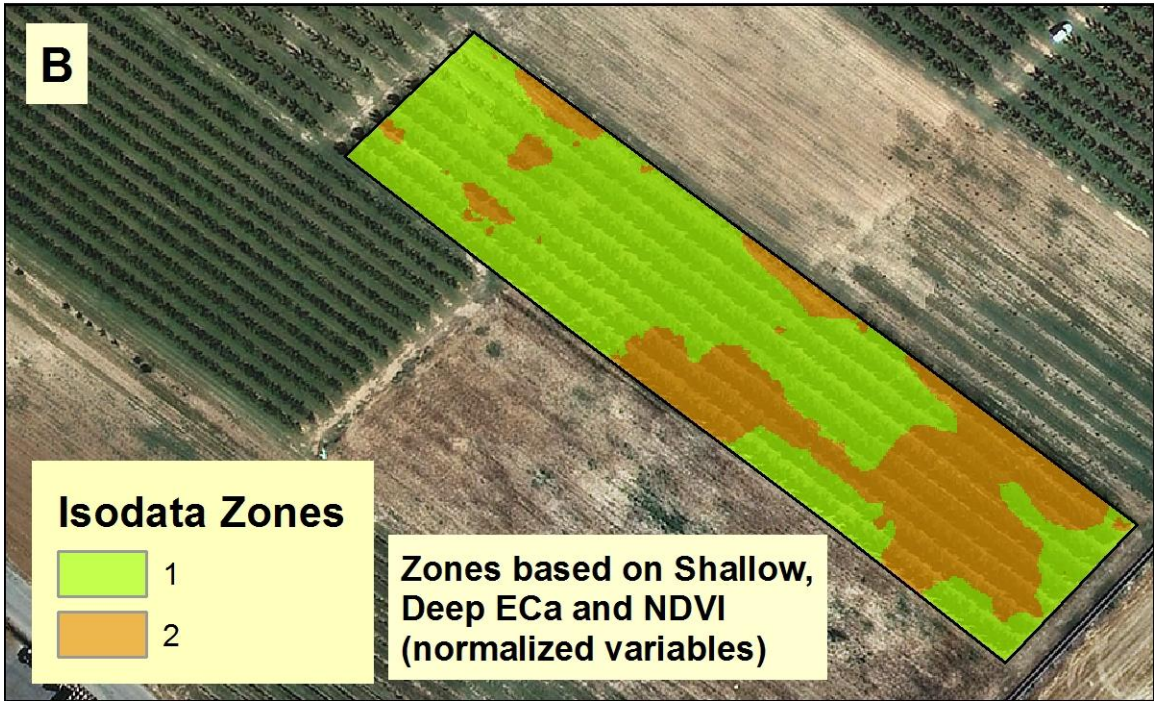

A
NDVI
0 - 0.35
0.35 - 0.50
0.50 - 0.65
0.65 - 0.80
0.8 - 1
0
25
50
Meters

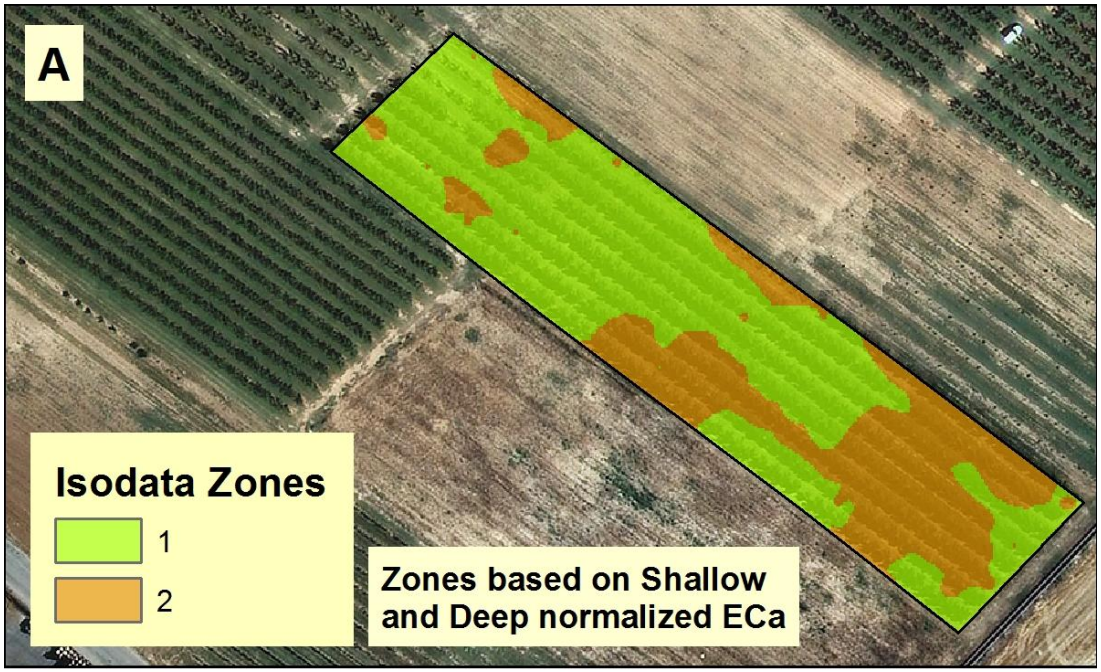

B
ECa 0-30 cm
mS/m
0 - 25
25 - 50
50 - 80
80 - 100
100 - 160

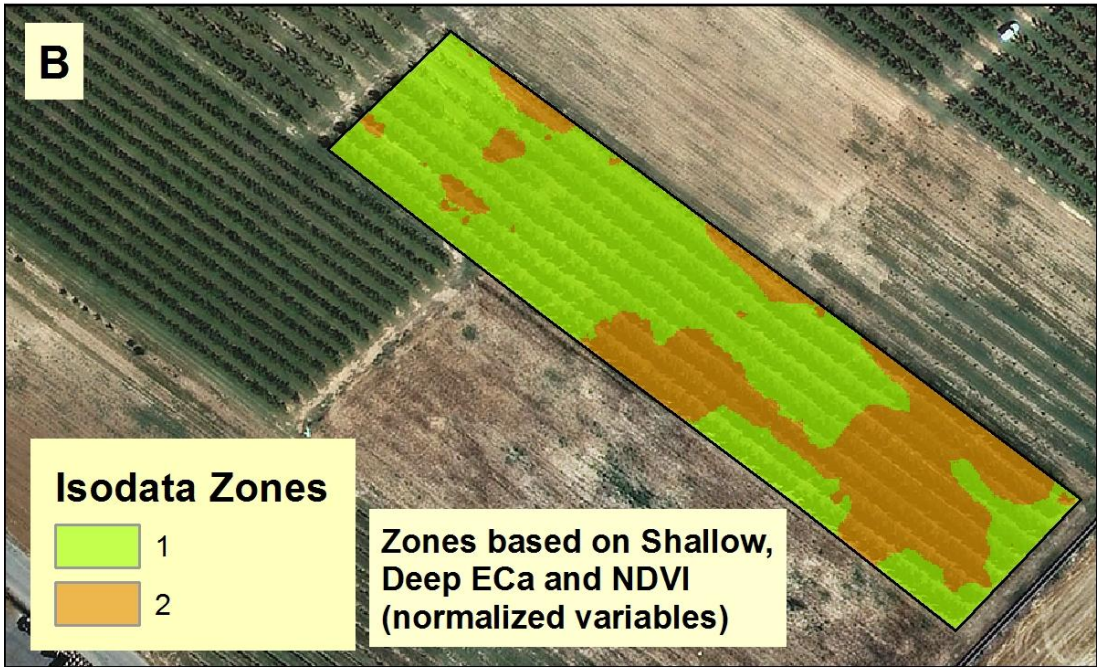

C
ECa 0-90 cm
mS/m
0 - 25
25 - 50
50 - 80
80 - 100
100 - 120

Results


A
Isodata Zones
1
2
Zones based on Shallow and Deep normalized ECa


B
Isodata Zones
1
2
Zones based on Shallow, Deep ECa and NDVI (normalized variables)





Results

Mean and standard deviation of ECa and NDVI in the delineated management zones

ZONES	Shallow ECa (mS/m)		Deep ECa (mS/m)		NDVI	
	Mean	SD	Mean	SD	Mean	SD
1A	42.61	10.80	42.75	9.67	0.59	0.20
2A	87.11	18.94	74.12	14.82	0.64	0.17
1B	42.23	10.47	42.63	9.34	0.60	0.20
2B	86.09	19.32	73.59	14.75	0.63	0.18

In both cases, the means of the variables are different with a p-value <0.0001

Results

Soil depth sampling in 20 random points

SOIL DEPTH vs Eca

Low ECa zones: 45.9±3.0 cm

High ECa zones: 57.1±3.2 cm

(p-value <0.05).

Linear regression analysis using the Deep ECa measurements

$Soil\_depth = 33.6 + 0.29\ Deep\_Eca$ (R^2 = 0.57, p-value < 0.01; RMSE 8.5 cm).

Conclusions

- ✓ The results indicate that the NDVI did not provide relevant additional information to the zoning with the ECa variables.
- ✓ In addition, in both cases the NDVI presented statistically significant different means, which indicates the relation between ECa and NDVI.
- ✓ In the present case study the zones with higher ECa and higher NDVI corresponded to deeper soils in the orchard field.
- ✓ The study showed the utility of ECa mapping to delineate management zones in orchards, providing information about relevant soil properties as soil depth.

ACKNOWLEDGEMENTS

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GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

✓ The experimental work was carried out in the **IRTA Experimental Station** of Gimenells (Lleida)