Realtime soil tests in the field – Science fiction or just over the horizon?

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Authors:

Mike McLaughlin, José M. Soriano Disla, Les Janik and Mohsen Fruzangohar (CSIRO Land and Water, Waite Campus, Urrbrae, SA),

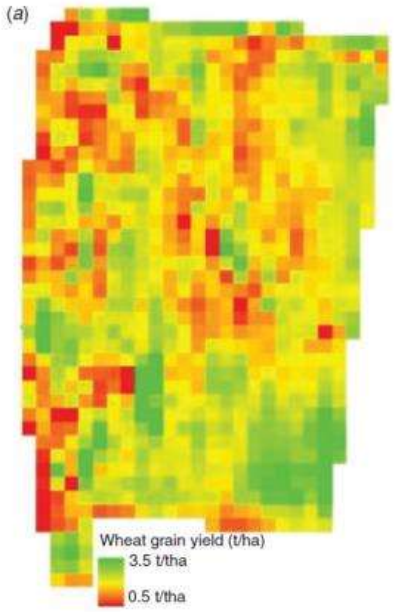
Michael Zerner (University of Adelaide),

Sean Mason (Agronomy Solutions, Magill 5072),

Real time soil tests – key messages

- Not science fiction, but still *just* over the horizon
- Reliant on cheap, robust sensors - new sensor technology coming on line every year
- Electrochemical, infrared and gamma sensors appear to have the most application – IR the most promising to date
- Sensors require careful evaluation before adoption – don't believe the marketing material
- Success with the big four – N, P, K, S – still elusive

Why do we need more soil information?

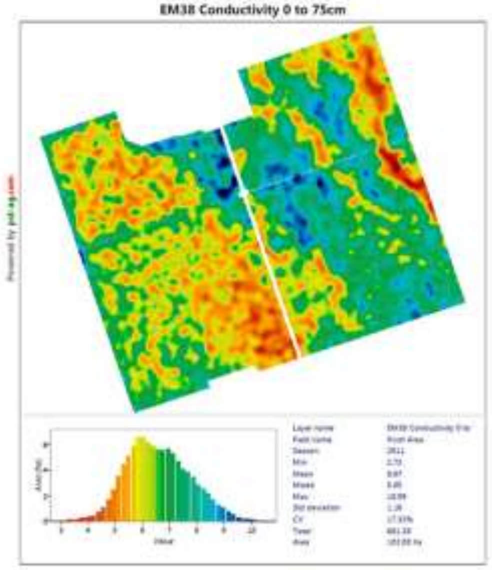


Dang et al. 2009

Wheat grain yield variability across a paddock due to……..

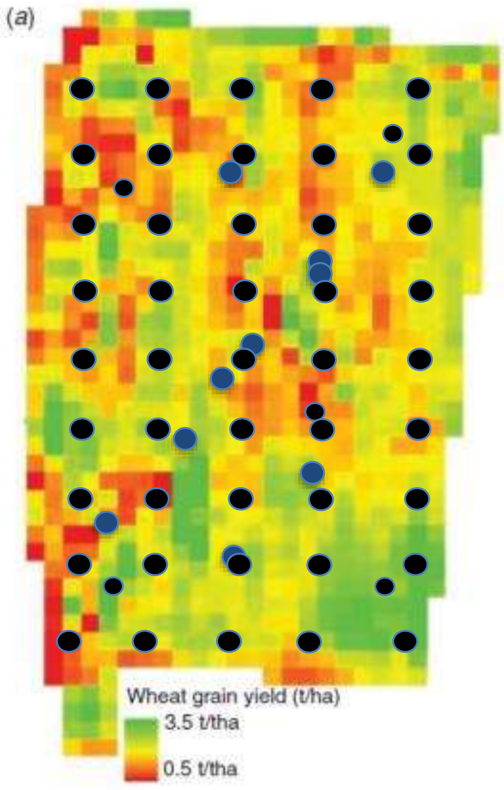
Crop/equipment issues
Topography/water?
Variability of topsoil characteristics?
Variability of subsoil constraints?

What do we have at the moment?



www.gpsfarmmap.com

Soil sampling and analysis – Strategies



Dang et al. 2009

Laboratory analytical cost ~ $90-120 per sample for full analysis

Targeted plan

1) 5 x $100 = $500 analytical cost (one depth – topsoil only)
2a) 1 x $100 = $100 analytical cost (one depth – topsoil only)
2b) 5 x $100 = $500 analytical cost (one depth – top soil only)

Precision plan

45 x $100 = $4,500 analytical cost (one depth – top soil only)

Sensors – getting (more) soil information more easily

A wide range of sensors now available as hand-held or on-the-go devices – how good are they?

On the go soil pH

X-Ray Fluorescence (XRF)

Mid-Infrared (MIR)

Near-Infrared (NIR)

Comparison of hand-held infrared sensors – NIR/MIR

SciO- $1k - NIR

Texas Instruments
NIRScan Nano - $1k

Agilent Exoscan – MIR $60k

Spectral Evolution - NIR $80k

Agilent Flexscan – MIR $60k

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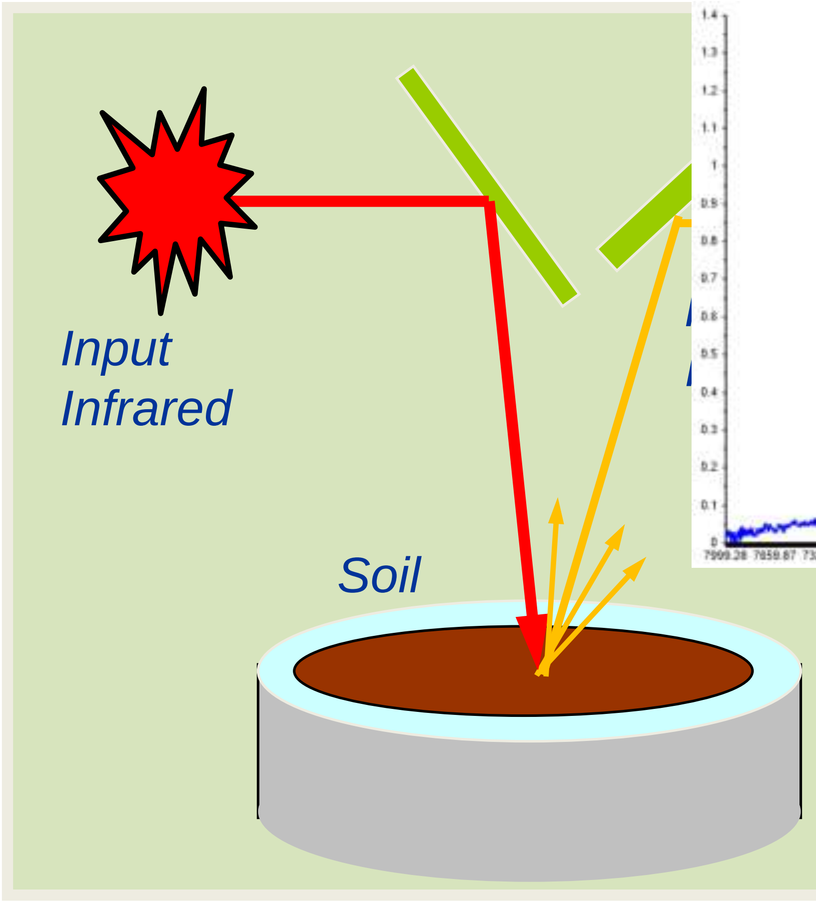
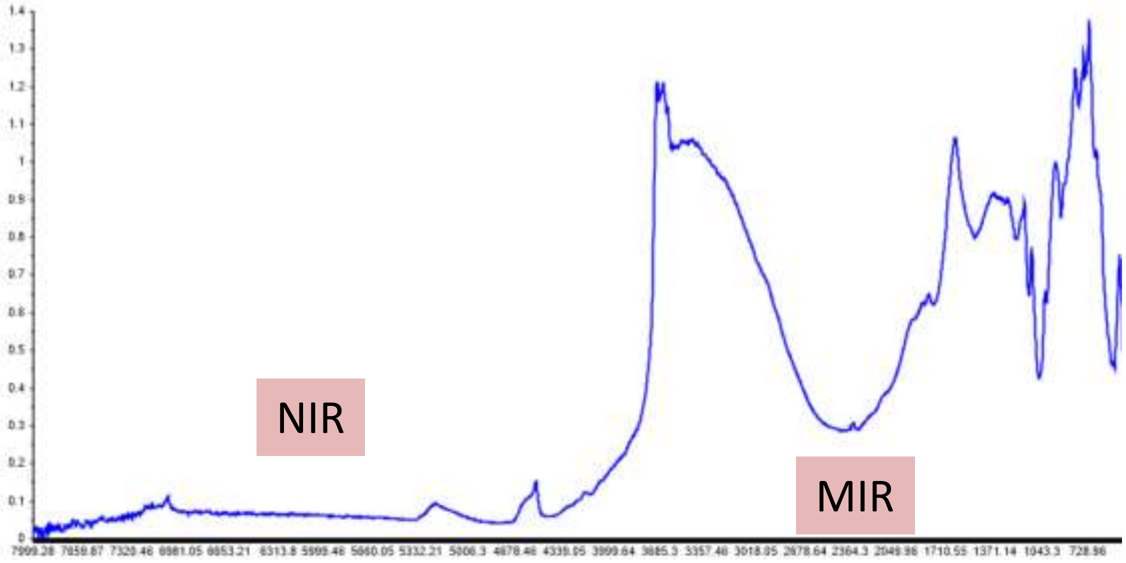
How does IR work?

Note: It measures surface characteristics, does not penetrate sample





- IR focused onto soil surface
- Infrared radiation absorbed by soil
- Characteristic spectra measured

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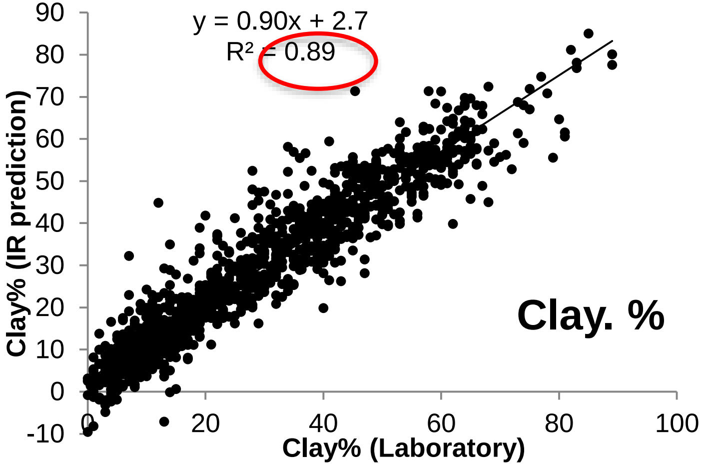
Assessing sensor performance?

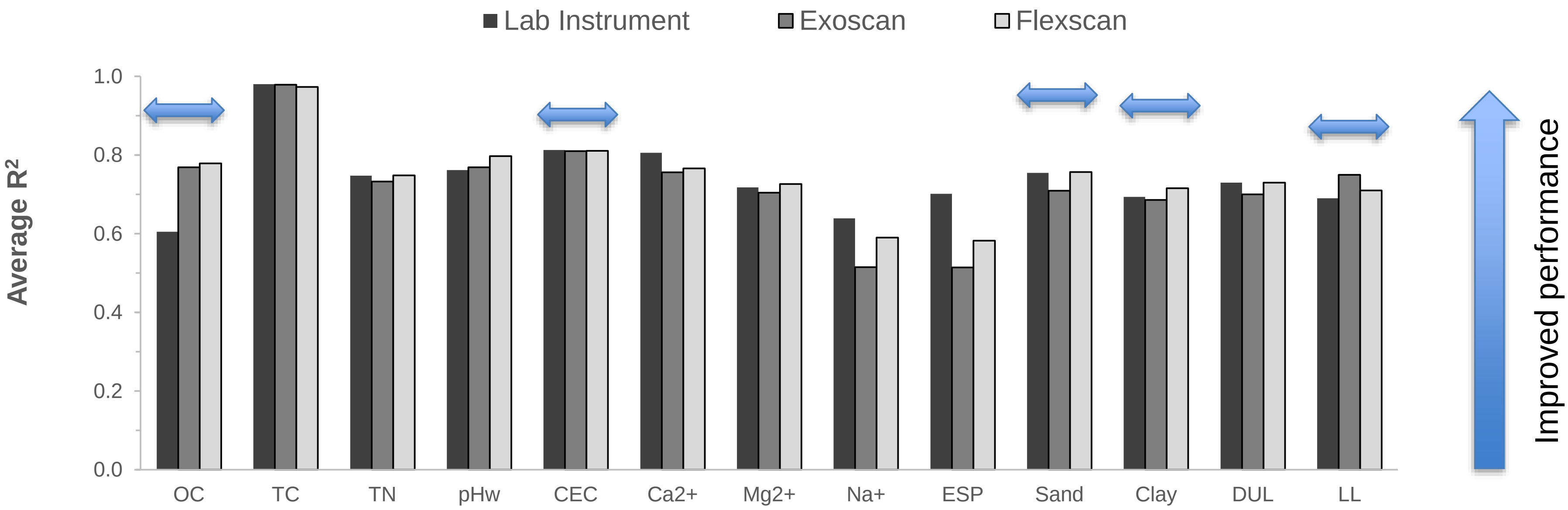
- 80 soil profiles (458 soil samples) from the APSIM database used
- Wide range of soil properties measured in the laboratory
- Soils scanned with all **hand-held** instruments and compared to a **"reference" laboratory** IR instrument
- Predicted properties compared against laboratory chemical measurements



Soil properties assessed

- pH
- EC
- Sand, silt, clay
- Exchangeable cations and CEC
- Exchangeable Na percentage (ESP)
- Total and organic C and N
- Water – drained upper limit (DUL) and lower limit (LL)
- Boron
- Chloride

Instrument performance – MIR instruments



Hand-held MIR instruments as good or better than laboratory instrument

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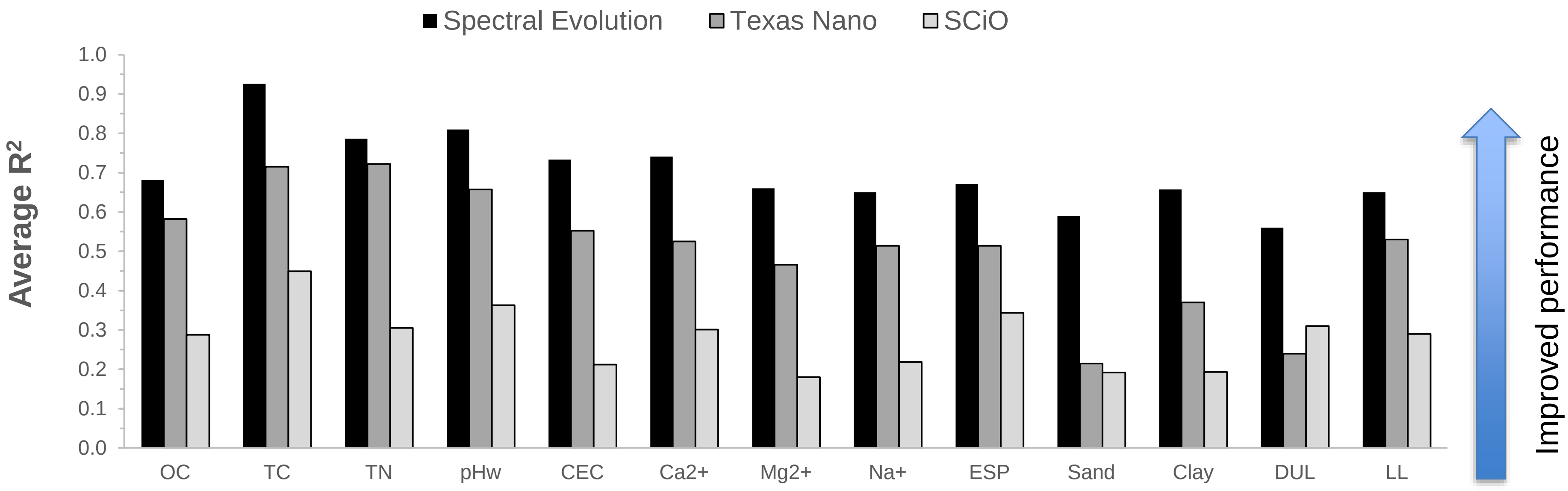
Instrument performance – NIR instruments



Smaller (cheaper) hand-held NIR instruments performed poorly

Miniature IR instrument sensor conclusions

- Miniaturisation does not necessarily lead to loss of performance – smaller MIR instruments were excellent in predicting soil properties
- The cheaper NIR instruments performed poorly, mainly due to a restricted range of wavelengths used in the instruments
- Hand-held instruments that performed well still cost >$50k – this will likely limit adoption to specialist consultants

Real-time or field soil tests – the gaps?

- Sensing available nutrient concentrations in soil is a real gap – P, N, K, S
- Real-time or field sensors for these nutrients are either not robust, not accurate, not fast, or not cheap

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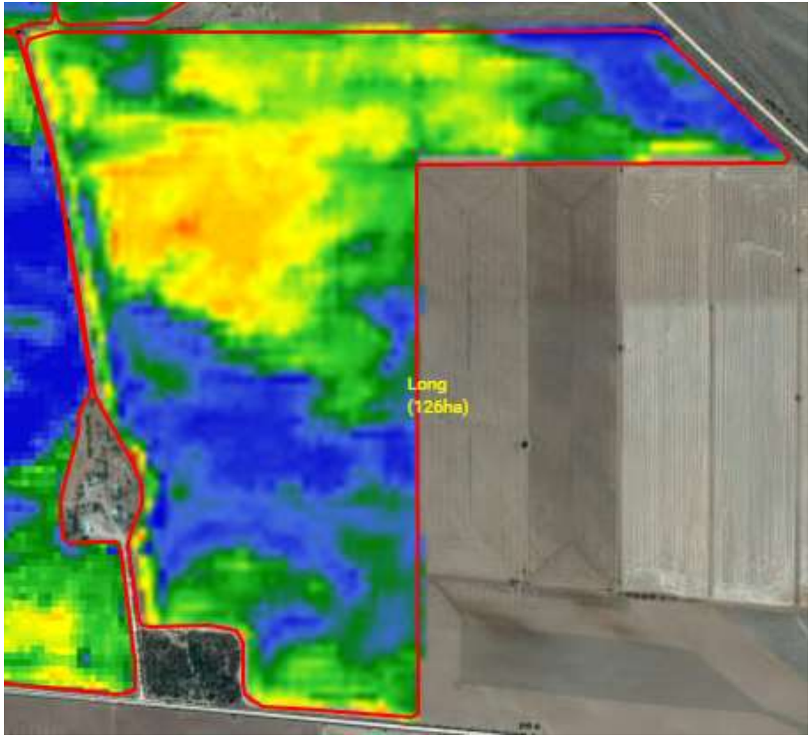
Two in-field examples of using NIR/MIR

1) Ability to paddock map in terms of Phosphorus Buffering Index (PBI)

2) In field determination of crop N content

1) Ability to paddock map in terms of Phosphorus Buffering Index (PBI)

- *Why is PBI important? It can control P availability*



Paddock	Description	PBI	DGT P ug/L	Colwell P mg/kg
Home	High yielding	47	100	39
Home	Low yielding	110	8	38

NDVI map – Warm colours = poor growth (Source: Sam Trengrove)

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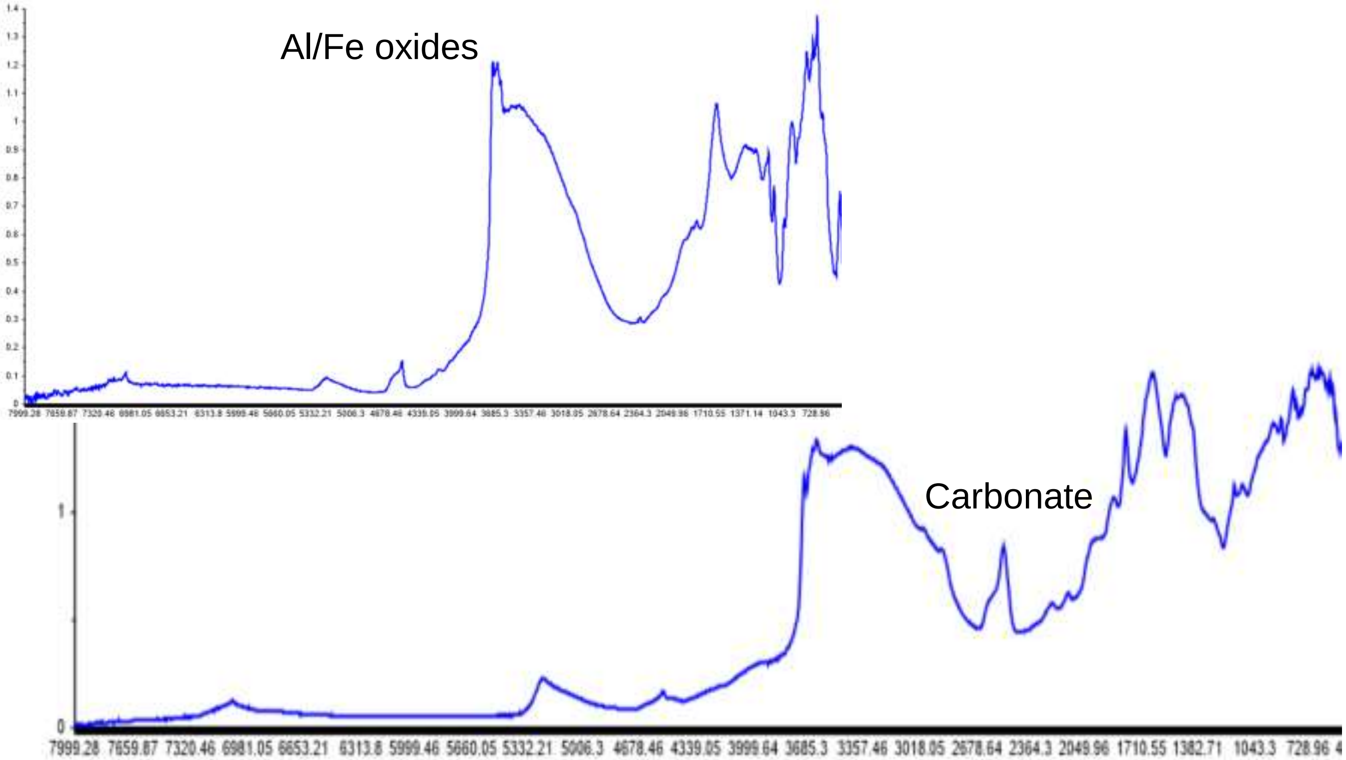
1) Ability to paddock map in terms of Phosphorus Buffering Index (PBI)

- *How does IR predict PBI?*



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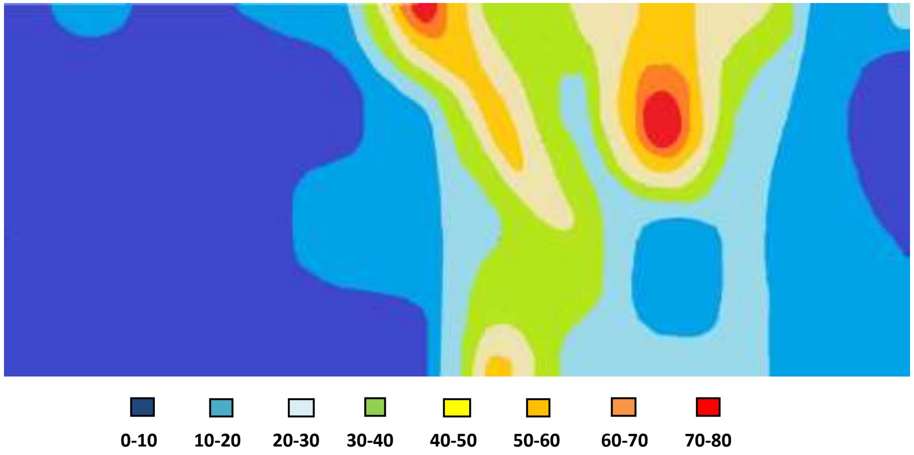
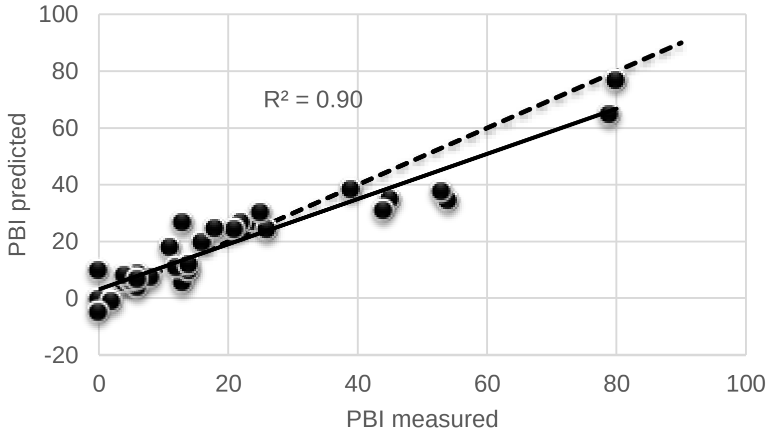
1) Ability to paddock map in terms of Phosphorus Buffering Index (PBI)

80m

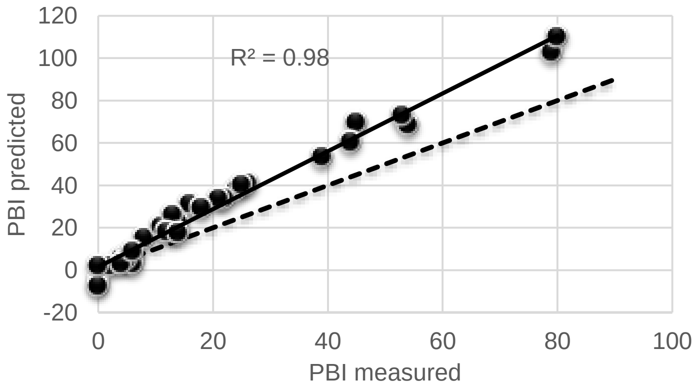


40m

Grid sampling every 10m = 32 samples total



Field moist



Incorporating moisture contents

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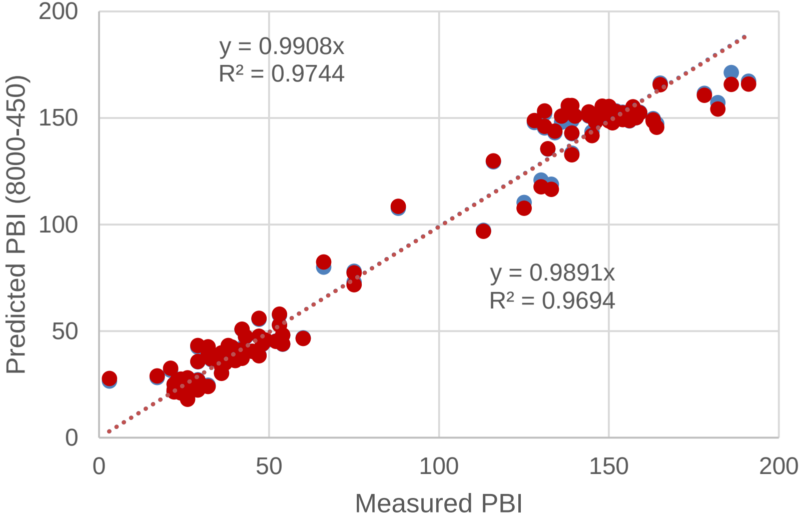
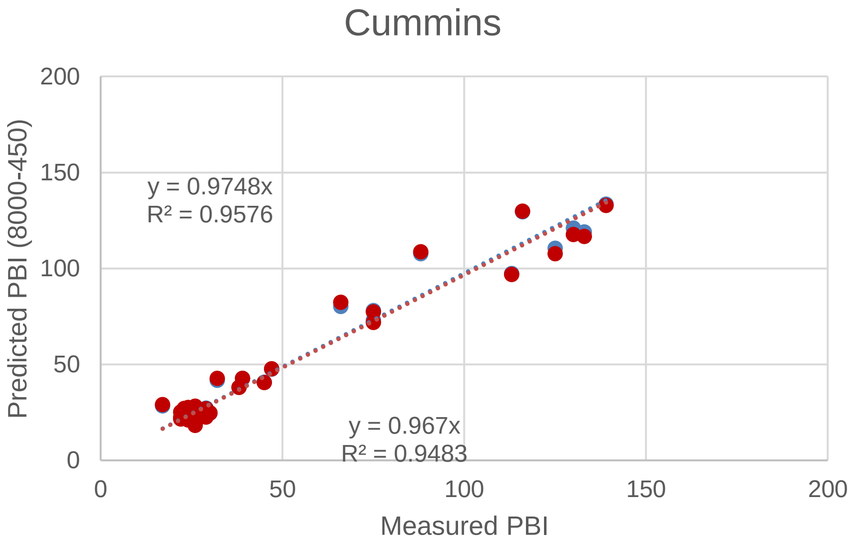
1) Ability to paddock map in terms of Phosphorus Buffering Index (PBI)



Across 6 replicated P response field trials combined



Across 1 replicated field trial (50 x 100m)

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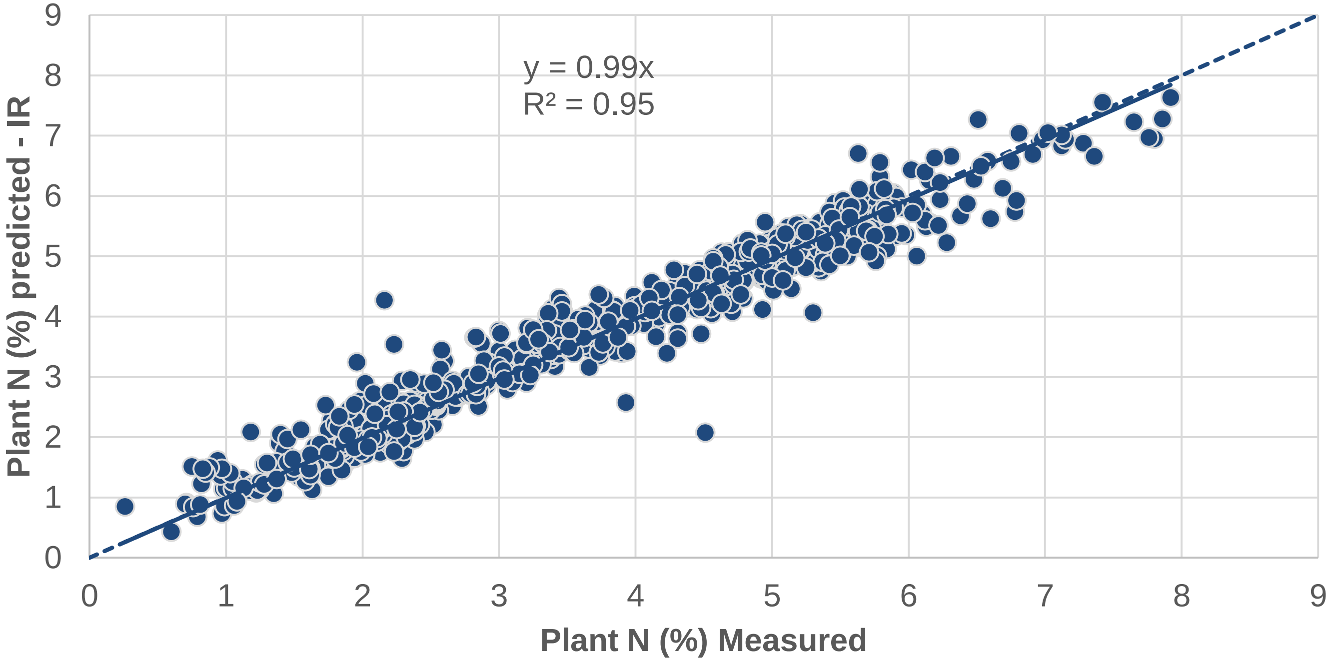
2) Real-time determination of crop N status

Works in the lab does it work in the field?



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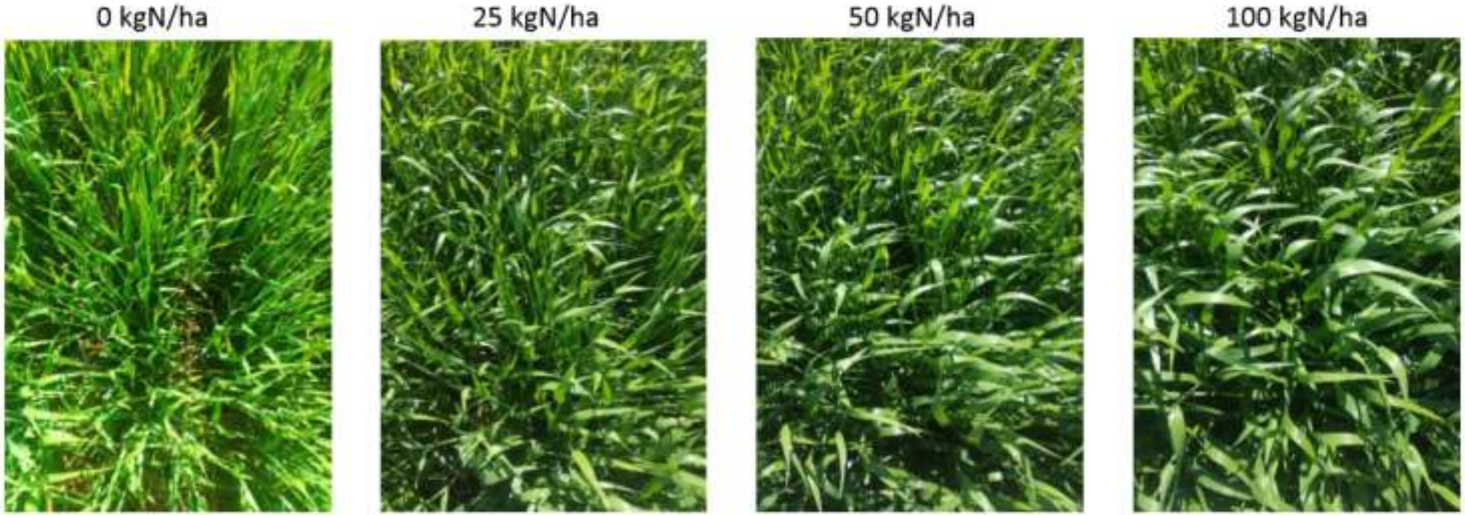
2) Real-time determination of crop N status

Why use NIR?

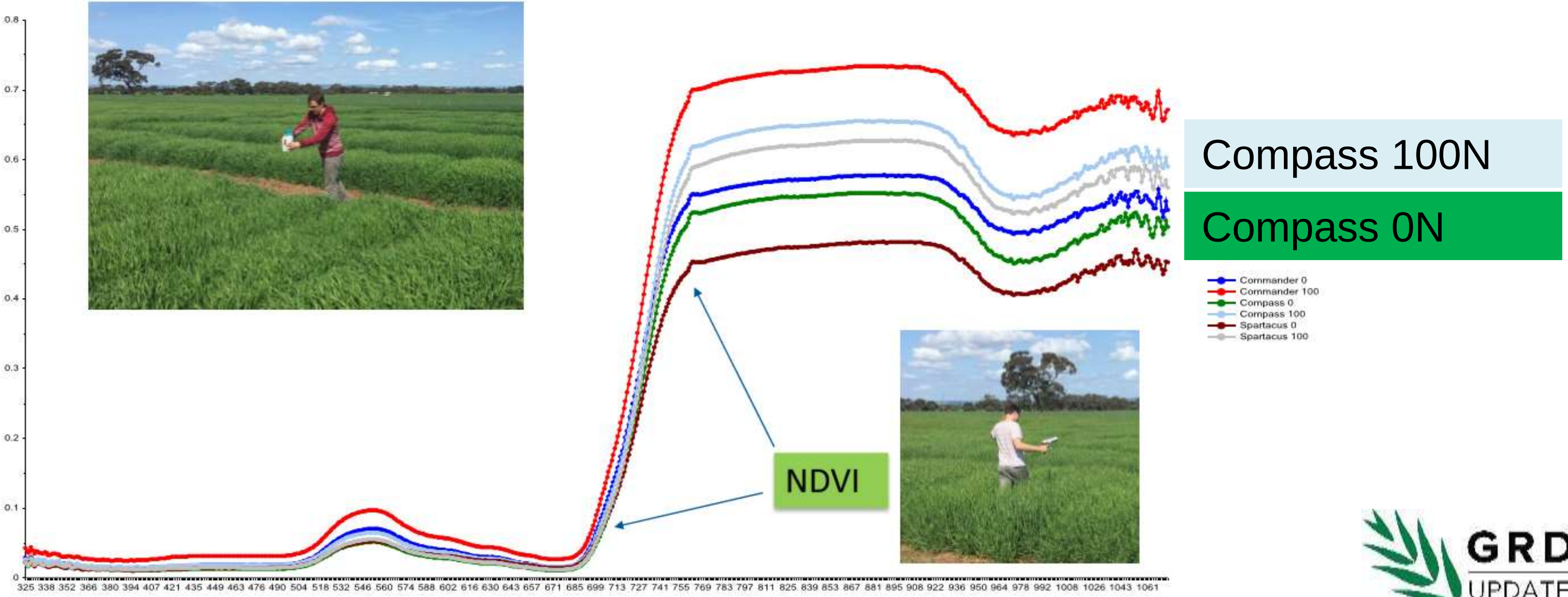


Canopies saturated but differences in greenness remain, NDVI no longer useful but spectral data can build new calibrations for metabolic traits such as N content and WSC which define yield

2) Real-time determination of crop N status

Using ASD Hand-held VNIR ~ $10-15k

In field ASD Spectral data ready for calibration
Roseworthy 2016



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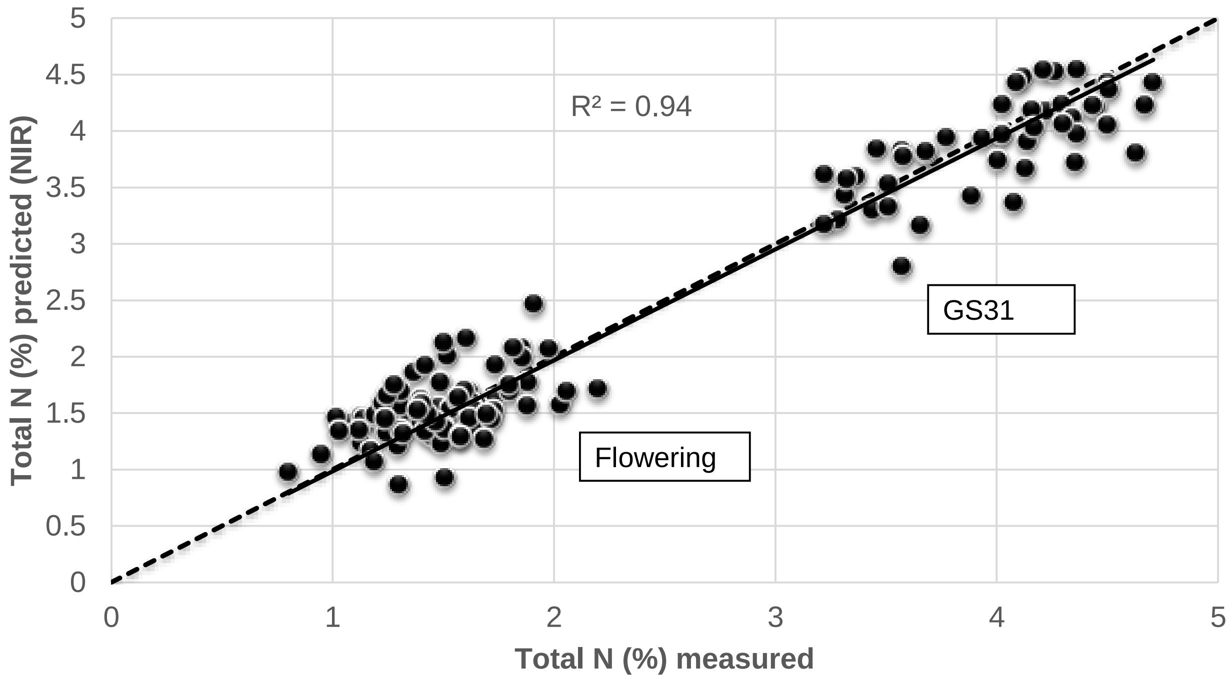
2) Real-time determination of crop N status

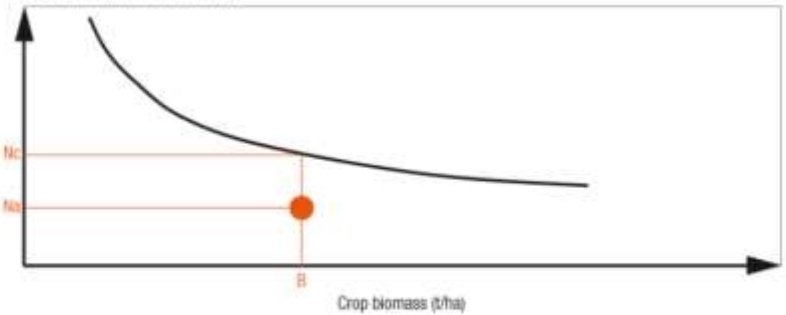


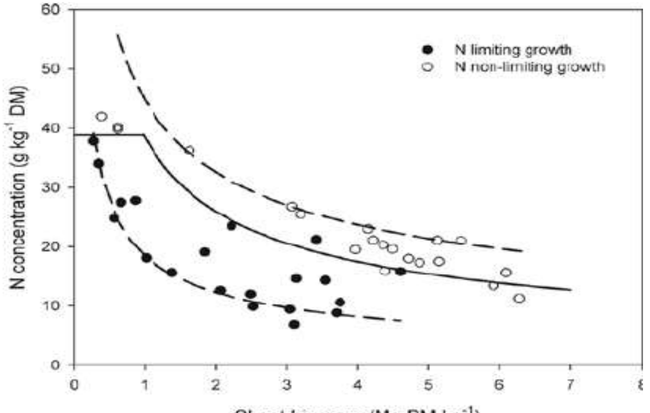
Cross validation of measured total N crop values with predicted crop N contents using portable NIR in field spectrometer.

2) Real-time determination of crop N status
Other benefits of knowing crop N content

N dilution curves and N budgets

Source: Sadras – GRDC Ground cover





N budgets

1 t/ha dry matter @ 5% N = 50 kg N/ha

75% conversion to grain = 37.5 kg N/ha

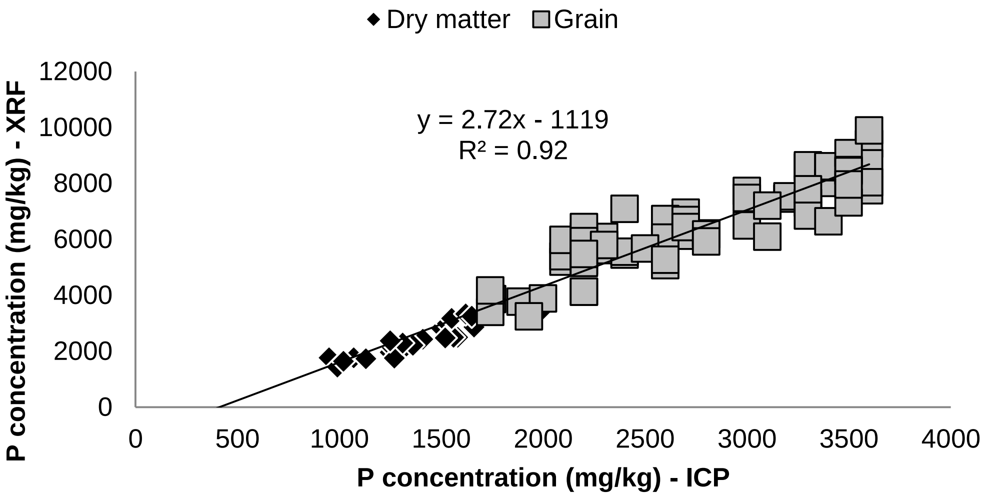
4 t/ha dry matter @ 2% N = 80 kg N/ha

75% conversion to grain = 60 kg N/ha

1t/ha grain @ 10% protein = 23 kg N/ha

What else is out there?

- X-ray fluorescence – measures total elemental concentrations
- Cannot measure available nutrients or elements such as B, Mg, Na
- ~$80k
- Sample needs to be dry



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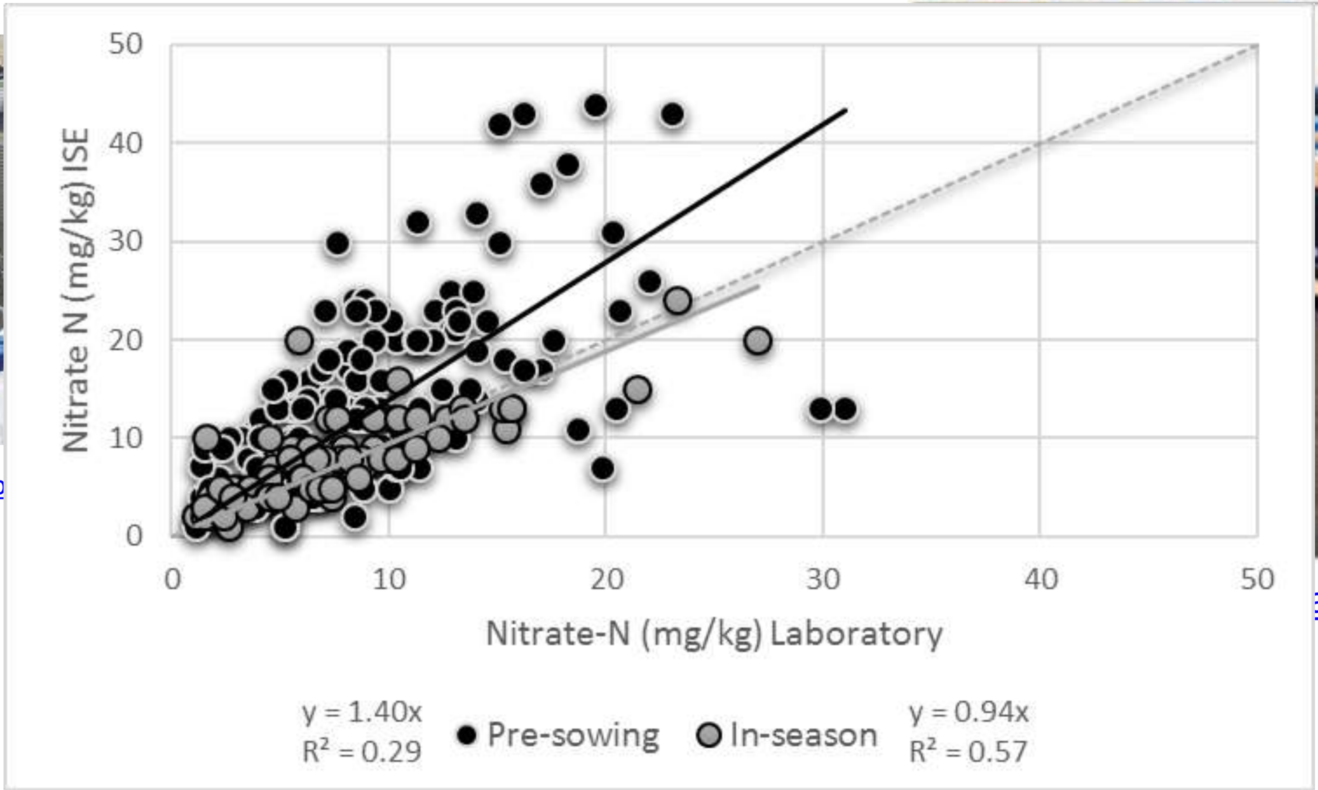
What else is out there?
Electrochemical sensors

http



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Conclusions

- IR technology has significant potential to provide rapid analysis of several soil characteristics and crop N status in the field
- Not a fit for all – need specific skills in order to run spectral data and perform a prediction
- Reliant on cheap, robust sensors - new sensor technology coming on line every year
- Also reliant on continued validation, quality control with a laboratory

- Potential Soil characteristics predicted by IR

pH, OC, TC, TN, Texture, PBI, CEC, $CaCO_3$, DUL, Wilting point

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Questions?

Grains Research and Development Corporation (GRDC)

A Level 4, East Building, 4 National Circuit, Barton, ACT 2600 Australia

P PO Box 5367 Kingston, ACT 2604 Australia

T +61 2 6166 4500

F +61 2 6166 4599

www.grdc.com.au

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