Soil water content by EM38

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Key findings

- Soil water can be predicted from EM38 measurements made on the soil surface in southern dryland cropping soils.
- It is possible to estimate the amount of water and its distribution in the top 50 cm of soil.
- Rapid surveys of large areas and/or high numbers of experiment plots will be possible.

Introduction

Traditional soil moisture measurements using neutron moisture meters (NMM) are expensive, laborious and highly regulated. The EM38 offers an attractive alternative; it measures the electrical conductivity of the soil and is portable, allowing time and cost effective surveys of large areas. Electromagnetic (EM) methods have been applied to estimate soil water in irrigated vertosols in northern NSW and southern Queensland. This project tests the ability of the EM38 to predict soil water in rainfed agricultural systems in southern NSW.

Site details

Location	NSW DPI, Wagga Wagga Agricultural Institute
Soil type	Red Kandosol
Experiment design	Measurements were made to coincide with the field activities of two existing experiments: 1. Neutron moisture meter (NMM) access tubes installation on a plant pathology experiment. 2. Soil sampling of a pulse field trial to evaluate soil pH stratification. An additional experiment was conducted to measure changes in soil water and soil conductivity measured by the EM38 following lucerne irrigation.

Treatments

Soil sampling and processing

In all three experiments soil was sampled using a tractor-mounted push corer. The sampling depth and increments sampled varied between experiments. Soil was dried to a constant weight in either an oven or dehydrator and the gravimetric soil water content calculated. Soil bulk density was estimated from knowledge of the soil core diameter and length, and the dry weight of each soil sample.

EM38 measurements

A series of measurements was made at each soil sampling location using a Geonics™ EM38 MkII dual coil instrument. Before measurements started, the instrument was zeroed according to the manufacturer's instructions. The soil's apparent conductivity (ECa) was measured with the instrument placed on the soil surface with its coils in both vertical and the horizontal orientation. This resulted in four measures of ECa:

1. vertical coils and 100 cm coil spacing (EMv100)
2. vertical coils and 50 cm coil spacing (EMv050)
3. horizontal coils and 100 cm coil spacing (EMh100)
4. horizontal coils and 50 cm coil spacing (EMh050).

Pathology experiment

Eight access tubes were installed to a depth of 150 cm; four were in plots containing disease susceptible wheat varieties and four in plots of disease tolerant varieties. The cores were subsampled into 10 cm lengths centred on the depths where NMM measurements were to be made; 5, 15, 40, 65, 90 and 115 cm.

Pulse experiment

These samples were taken from an experiment designed to demonstrate the performance of commercial pulse varieties. Three soil profiles were sampled immediately pre-harvest beneath chickpea, lentil and faba bean crops and the bare ground between plots.

Irrigated lucerne

Two plots of dryland lucerne were irrigated using domestic soaker hoses. Soil profiles were wetted up over five days, with water applied for six hours every 12 hours. Two 150 cm deep soil cores were taken in each plot and sub-sampled in 10 cm intervals to 50 cm and 25 cm intervals to 150 cm. EM measurements were made between the two soil sampling locations.

Analysis

Soil water stored to 10, 20, 30, 40, 50 and 100 cm deep in the soil was calculated for each sampling location. Correlation was used to assess relationships between soil water and EM38 measurements.

Results

The plots had a range in soil water storage from a low beneath the chickpea in the pulse experiment to the fully watered profile under the lucerne (Figure 1).

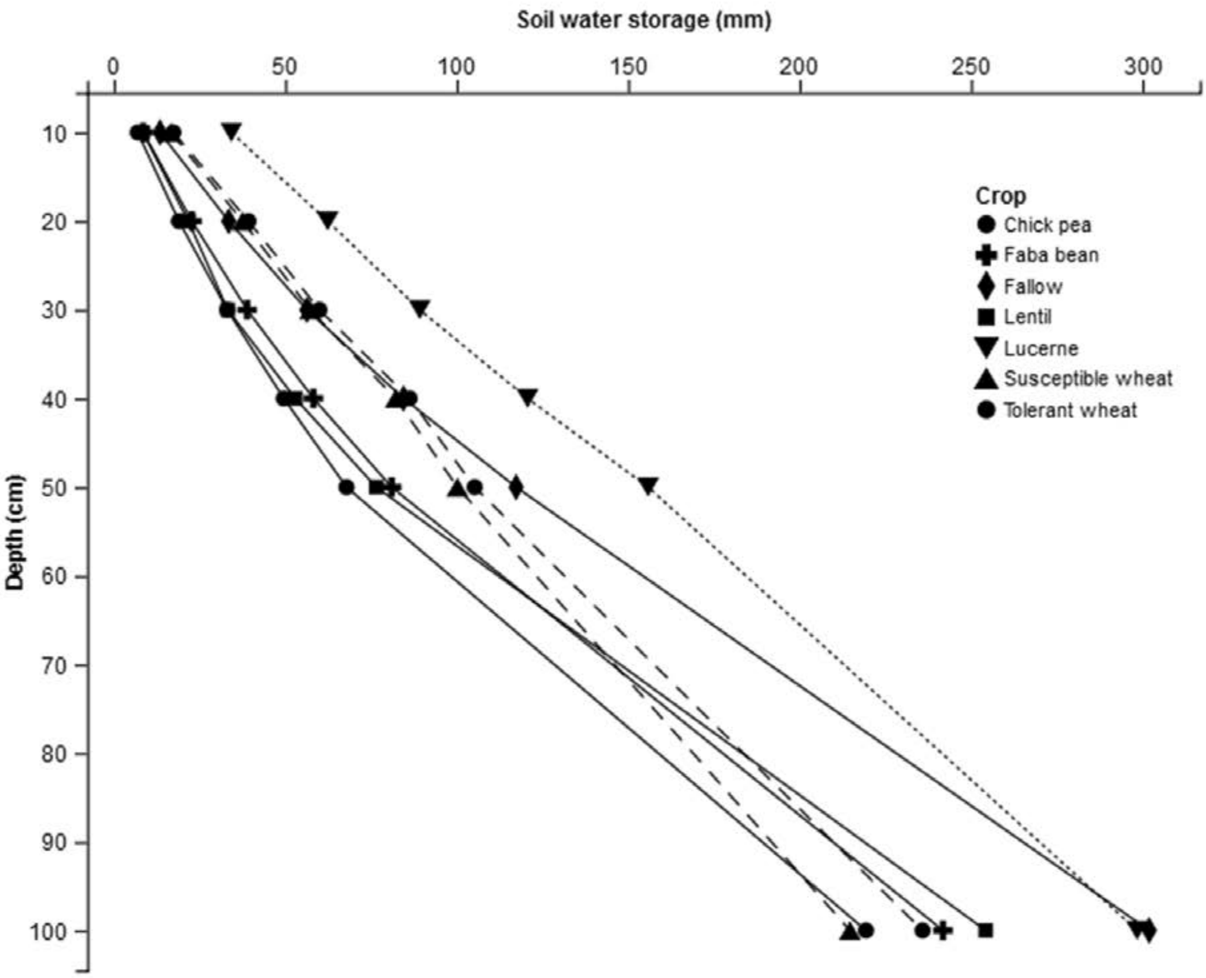

Figure 1. Variation of soil water storage with depth for the different crops and experiments. The lucerne experiment is shown as the dotted line the pathology experiment the dashed lines and the pulse experiment the solid lines.

Soil water storage was most highly correlated with the instrument in the horizontal orientation (Table 1). At depths less than 50 cm, soil water storage was more highly correlated with the ECa measured by the 50 cm coil separation (EMh50). Below 50 cm, a coil separation of 100 cm (EMh100) was more correlated with soil water storage. The correlation between soil water storage in the top 100 cm of the profile and ECa measurements was poor for all coil configurations.

Table 1. Pearson correlation coefficients between ECa measured with the EM38 in different coil orientations and spacing and soil water stored to different depths.

Coil		**Depth (cm)**					
Orientation	**Spacing (cm)**	**10**	**20**	**30**	**40**	**50**	**100**
Horizontal	100	0.773	0.787	0.791	0.769	0.824	0.395
	50	0.807	0.878	0.871	0.866	0.739	0.123
Vertical	100	0.540	0.602	0.604	0.586	0.544	0.131
	50	0.267	0.355	0.345	0.358	0.201	0.019

Soil water stored in the top 50 cm of the soil is predictable by ECa measurements made with the instrument on the soil surface (Figure 2). These have an accuracy of ±12 mm in the top 50 cm, ±8 mm in the top 40 cm, ±5 mm in the top 20 cm and ±4 mm in the top 10 cm.

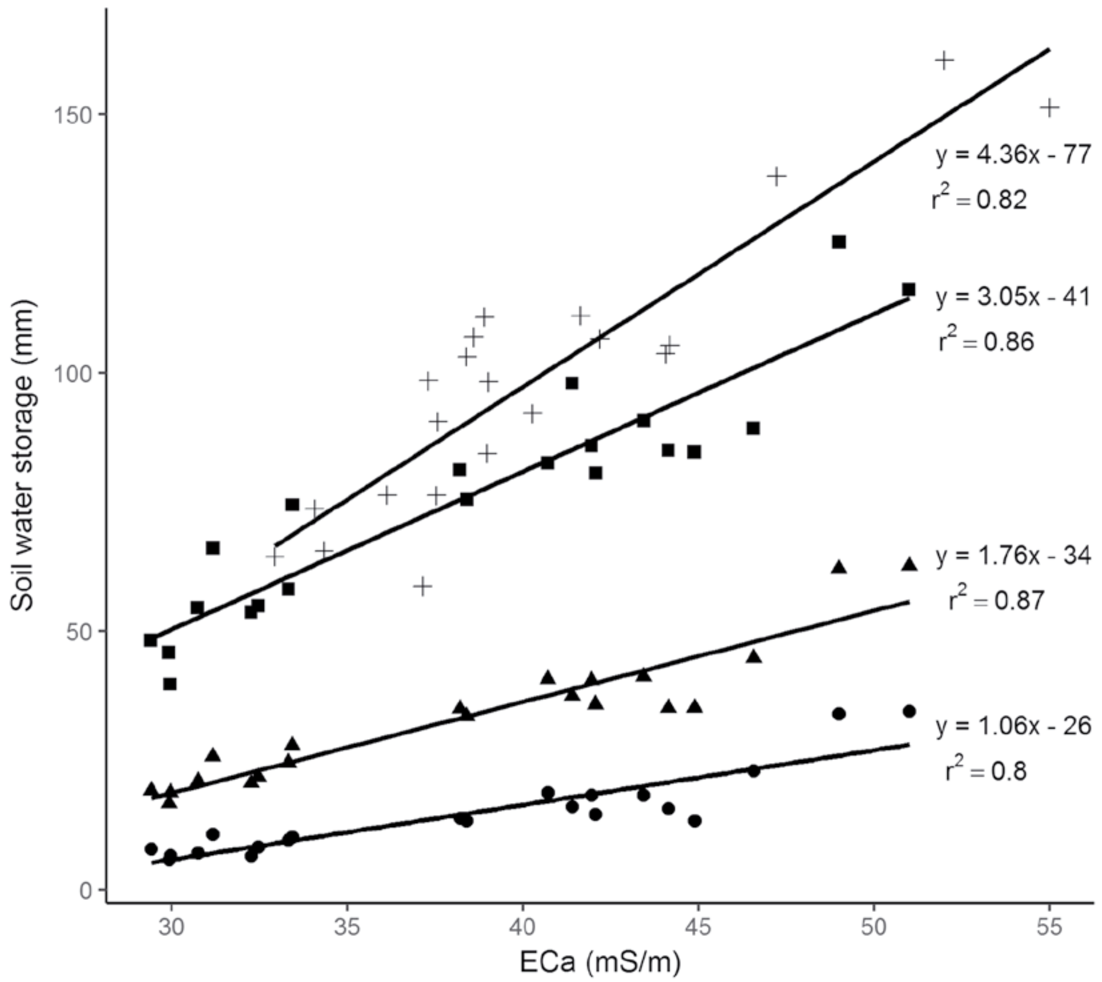

Figure 2. Water stored to four depths in the soil vs ECa measured at the soil surface with the EM38 instrument with the coils oriented horizontally. Storage in the top 50 cm is plotted against EMh100 the other depths are plotted against EMh50. The equations and adjusted r^2 of the least squares regression of each ECa storage relationship is shown.

Summary

The EM38 successfully predicted water stored in the top 50 cm of soils typically used for dryland cropping in southern NSW. These predictions were possible with a single measurement made using a dual coil EM38 instrument in the horizontal orientation. The time and cost of surveying will be much reduced as a single measurement is all that is needed to estimate stored soil water at a location.

Acknowledgements

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