Development of a Mobile Electromagnetic Sensing System for soil salinity assessment in irrigated cotton fields

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Introduction

Traditional methods of generating soil information on the field scale have involved the design and adoption of soil sampling regimes and laboratory analysis. Due to the time consuming nature of this approach only limited soil information can be collected. Nevertheless, soil maps are generated and inferences about the spatial distribution of soil properties, and soil condition *etc*, are made from this cursory information. Unfortunately, the use of such maps leads to errors in interpretation and possibly soil management. In more specific investigations such as soil salinity assessment and determination of irrigation\drainage efficiency more detailed quantitative soil information is required, in order to provide the necessary information to manage soil salinity or related problems.

The development of new technologies and instrumentation has revolutionised the way in which this information can be generated. Electromagnetic (EM) induction instruments, which measure the apparent electrical conductivity (EC_a) of soil, have successfully been used to estimate various soil variables and properties including: salinity (Lesch, *et al.*, 1995); clay content (Williams and Hoey, 1987); depth to clay (Doolittle *et al.*, 1994), nutrient status (Suddeth *et al.*, 1995); and, moisture content (Kachanoski, *et al.*, 1988). The reason for the wide application is due to the fact that the EM instruments are responding to various soil attributes including clay content, soil mineralogy, moisture content and salinity. When moisture content is uniform (ie. recent heavy rainfall or irrigation) and soil salinity is negligible then most of the instruments response will be a function of clay content and mineralogy and hence will be describing the variability of these variables (ie. geology).

To improve efficiency of EC_a data collection, Rhoades (1992) and others (eg. Cannon *et al.*, 1994) have incorporated Global Positioning Systems and EM instruments onto Mobile EM Sensing Systems (ie. MESS). As a result larger amounts of data can be collected on the fieldscale which can be used to map the spatial distribution of soil salinity and other related soil variables. In the following paper we describe the development of a MESS developed by the University of Sydney in association with the Coordinating Committee of the lower Namoi valley water users association. The MESS was developed to allow rapid, repeatable and reliable collection of EC_a data and is illustrated in Figures 1a and b. The system includes: a 486 computer for data logging, display and instrument set-up; a Trimble™ Ag132 Global Positioning System (GPS) which provides a wide-area differential correction for real-time sub-meter accuracy; a Trimble™ FieldGuide GPS for positioning and guidance; and a Geonics™ EM38 for root-zone and Geonics™ EM31 for subsoil EC_a measurement. All of these components have been mounted on a 4WD hydrostatic and articulated tractor, powered by a 20 HP Kohler Petrol Engine.

Figure 1a. From left to right, Trimble Ag132 mounted on GPS400, RMD and 486 data logger/control box.

Figure 1b. MESS deployed in a dryland cotton field located 40 km south-east of Moree, Gwydir valley.

Materials and methods

Rootzone assessment of soil EC_a

In order to estimate electrical conductivity (EC_a) or soil salinity within the agriculturally significant portion of the root-zone, Geonics Ltd. developed an instrument known as an EM38. The instrument, due to its 1 m intercoil spacing and operating frequency of 13.2 kHz, can provide estimates of soil EC_a to depths of 1 or 2 m depending on whether the instrument is held in the horizontal or vertical mode of operation, respectively (McNeill, 1986). The instrument is enclosed within a 2.5 m hollow vinylester tube. The tube is aligned parallel to direction of travel (Figure 2a) and is affixed to a stainless steel cylinder. This is attached to a hydraulically driven chain mechanism which allows the instrument to be raised from a minimum height of 0.10 m above the ground surface to a maximum of 1.60 m. It also allows the EM38 to be positioned at various heights above the ground surface. A small rotating arm enables a 90° rotation allows EC_a measurements to be made in vertical or horizontal mode of operation. The manufacturing and design of these components was carried out by Mr David Jones of the National Centre for Engineering in Agriculture (NCEA) located at The University of Southern Queensland.

Deeper subsoil assessment of soil EC_a

The Geonics Ltd EM31, which is larger than the EM38, is positioned approximately 2.0 m in front of the tractor and suspended 1.0 m above the ground. This is achieved using a PVC cradle and nylon guys attached to the roof of the tractor and cradle (Figure 2b). The instrument is manually positioned into the vertical or horizontal mode of operation. The depth of EC_a measurement achieved theoretically at this height above the ground is approximately 6.0 and 3.0 m, respectively, (McNeill, 1986). It has been included to provide information on the presence of shallow saline aquifers and deeper salt stores as well as identify sand lenses and suitable areas to locate large earthen water storages and supply channels and provide complimentary information, to the EM38, on deeper subsoil variability.

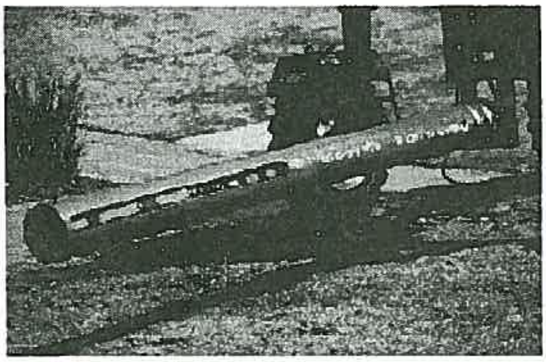

Figure 2a. EM38 located at rear of the MESS.

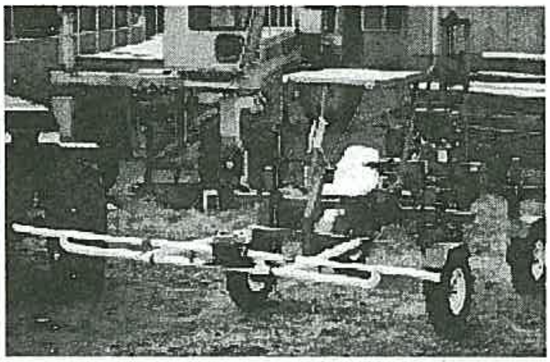

Figure 2b. EM31 located out front of MESS.

Positioning and guidance

Positioning and guidance are provided by the Trimble™ FieldGuide. The basic system includes a rugged map display (RMD), a GPS400 receiver and an antennae (Figure 3b). The RMD allows the progress of vehicle to be monitored in the field by indicating current position, speed, number of transects and area covered to date. In fields where no irrigation channels are present parallel swathing can be performed. The lightbar provides guidance by indicating to the driver where the current pass is and how to maintain the correct bearing as well as directing him as to where the next pass should be made. A second Trimble GPS provides wide-area differential correction to ensure sub-meter accuracy. This is provided by the Trimble™ AG132 using a RACAL satellite differential signal (Figure 3a). Both GPS units are powered using the 12 V car battery situated on the MESS.

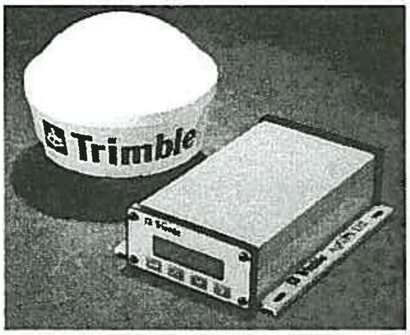

Figure 3a. Trimble Ag132 including; antennae and receiver.

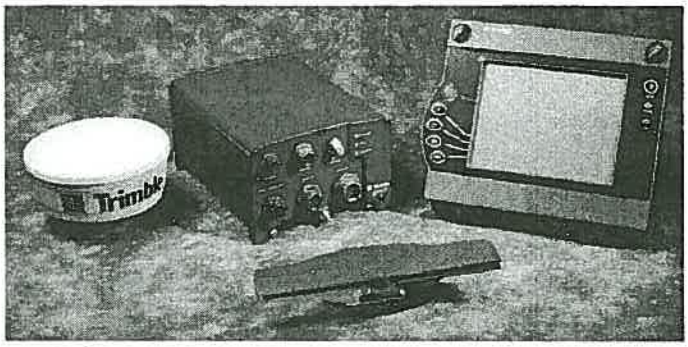

Figure 3b. Trimble Fieldguide including; antennae, GP400, rugged map display and lightbar.

Data logging and MESS control

The various EM38 and EM31 instruments and GPS units are hooked up to a 486 computer which integrates and logs this information into a single file that stores GPS Easting and Northing, and EC_a measurements as read by the EM instruments. The 486 computer also acts as the controller allowing the operator to designate whether vertical or horizontal data is collected and the height EM38 measurements are made. The data logger system was developed by Mr Danny Dusza of the NCEA.

Future research

The MESS developed here is currently being applied to assess soil salinity in dryland cotton growing areas and estimating deep drainage on the field-scale in irrigated cotton growing fields. Recently, work has commenced in the field of precision agriculture. Other applications of the system include assisting with dam site location and identification of leaking water storages and channels, etc.

Acknowledgments

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