Comparison of neutron scattering and DFM capacitance instruments in measuring soil water evaporation

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ABSTRACT

Soil water evaporation is an important parameter that needs to be accurately measured for the design of water-efficient agricultural systems. With this study, the abilities of the DFM capacitance probes and a neutron water meter (NWM) to measure evaporation from the soil surface were compared. Measured evaporation was compared to the control values measured with mini-lysimeters. Calibration of DFM capacitance probes and the NWM was done in the laboratory using the topsoil of a Bainsvlei soil form. Field measurements of soil water content were done on the same Bainsvlei soil. Calibration results indicated a good correspondence (r^2 = 0.99) between the measured values and known volumetric soil water contents. There was no significant difference (p = 95%) between the DFM evaporation measurements and the control, whereas the NWM and control differed significantly. It was concluded that the DFM capacitance probe is a better tool than the NWM in measuring evaporation from the topsoil surface.

Keywords: neutron water meter, capacitance probes, evaporation, soil wetness

INTRODUCTION

In order to use the scarce water resource for agricultural production effectively, it is important that soil water content be measured as accurately as possible. The amount of water in the soil determines how strongly water molecules are retained by the soil matrix. Soil water can range from thin hygroscopic films tightly held around soil particles to saturation, where all of the soil macro-pores are filled with water. The amount of soil water determines the forces that control its movement. These forces in turn determine the availability of soil water for plant use and processes of water movement like evaporation and drainage. Thus, accurate measurement of soil water determines how accurately these components of the water balance can be quantified.

The conventional method of determining soil water content is described by Gardner (1986). With this method, a soil sample is taken and kept in an air-tight container until it is weighed; hereafter it is oven-dried at 105°C for 24 h and weighed again. The difference between the wet and dry mass expressed as a percentage of the dry mass provides the gravimetric soil water content. This method of measurement, although very accurate, is time consuming and costly. Furthermore, since the measurement employs destructive sampling, repeated measurements on the same spot are not possible. To overcome this constraint, indirect methods of soil water content measurement have been developed. One such method is the neutron water meter (NWM). This method was proposed in the 1940s and has been in use since with continual improvement (Bell, 1987). Despite the improvement, the NWM still has some drawbacks. The major concern is the health hazard of exposure to the radioactive source that is needed for neutron scattering. Besides this, although measurements can be done repeatedly, continuous logging of soil water content has not been possible. These drawbacks have been addressed with the introduction of capacitance-based soil water content measurements. The advancement of electronics has enabled capacitance probes to record continuous measurements of soil water content. The ease of use and the relatively cheaper availability of such probes make them a good candidate for use. To capitalise on these advantages due consideration should be given to measurement volumes and installation. Capacitance probes have smaller measurement volumes compared to those of NWM and require careful installation ensuring good contact with the soil.

Measuring the changes in soil water content to quantify evaporation from the soil surface has been done with various instruments. The NWM has been used to measure soil water content at different points in time and, if all the other components of the soil water balance equation are measured, it is possible to calculate the loss of soil water through evaporation from the soil surface (McGowan and Williams, 1980; Bennie et al., 1994; 1998). With the application of the same principle of monitoring change, some studies quantifying evaporation using capacitance probes have also been done (Verhoef et al., 2006; Mounzer et al., 2008). Comparison between the NWM and capacitance probes with regard to measuring soil water accurately has been done (Evett et al., 2002; Heng et al., 2002; Hossain, 2008). However, no comparative studies with regard to the measurement of evaporation have been done. The amount of water lost through evaporation from the top horizon of the soil profile can be considerable, although the change in soil water content induced by evaporation is small when considered on daily time intervals. The comparison with regard to the ability to capture the change in soil water content induced by evaporation is thus crucial.

The objective of this study was to compare the NWM and the DFM capacitance probe to measure evaporation from the soil surface against a control measured with another reliable method.

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