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SOIL WATER SENSORS FOR EVALUATING CROP WATER STATUS

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ABSTRACT

Approximately 70% of withdrawals of fresh water worldwide are used for agricultural field crop production yet only about 45% of this water is used (transpired) by the crop (World Food Summit, 1996). Efficient use of irrigation water can improve profitability and crop yield for a resource that is increasingly facing competition from domestic and industrial uses. Electromagnetic (EM) soil water sensors can provide valuable real-time information on plant available water status that can be used for improved water management decisions. However, the accuracy of commercially available soil water sensors varies widely and some are being used in applications for which they are unsuitable (Hignett and Evett, 2008).

Soil water sensors can be used to (i) identify if the soil wetting front has reached the depth of the sensor, (ii) schedule irrigations to maintain soil water within the root zone above a management allowed depletion (MAD) level or refill point below which crop yield can be negatively impacted, and (iii) evaluate crop water use between rainfall and irrigation events. All applications require proper field installation and a general understanding of the limitations of the technology. Irrigation scheduling within the water content limits prescribed by a management allowed depletion paradigm requires at the very minimum sensors installed at depths that adequately represent the active rooting zone of the crop and a reliable calibration equation to convert sensor readings to soil water content. Evaluation of crop water use based on soil water measurements also requires accurate soil specific sensor calibrations throughout the rooting zone.

The accuracy of soil water content measurements varies widely by sensor technology. Sources of inaccuracy include (i) a factory soil water content calibration that may not satisfactorily represent the soil and environmental conditions under which measurements are acquired, (ii) temperature sensitivity, (iii) sensitivity to soil bulk electrical conductivity, (iv) the frequency at which the sensor operates, and (v) sensor-to-sensor variability. Soils with elevated clay contents (e.g. clay loams to clays) often require specialized or soil specific calibrations for accurate measurements because a portion of water near clay surfaces is “invisible” to EM sensors and because bulk electrical conductivity is strongly influenced by clay content. Capacitance sensors that operate at relatively low frequencies (<200 MHz) tend to be relatively more sensitive to changes in soil temperature, electrical conductivity, and clay content. In contrast, sensors that are based on the travel time of a pulse typically at higher frequencies (>500 MHz) are less sensitive to these interferences with likely smaller errors associated with factory calibrations.

Use of soil water sensors for irrigation scheduling should consider both the soil texture and the measurement errors of the soil water sensor, which optimistically are no less than 0.02 in/in and in certain instances, could exceed 0.10 in/in. The range of water content managed under irrigation scheduling will range from 0.03 in/in (fine sand) to 0.08 in/in (loams). Consequently, soil water content measurement errors of some sensors may be too great to be useful for managing irrigation with the MAD method.

Down-hole soil water content sensors permit the evaluation of profile water content within the rooting zone while minimizing soil disturbance during installation. The EM sensors with the down-hole configuration measure water content in a region extending laterally to at most one to two inches from the sensor surface and weighted more strongly to soil nearer the sensor surface. Because the measurement region is confined very close to the sensor, installation of these sensors in such a manner as to avoid soil disturbance or compaction is necessary to obtain accurate water content measurements representative of the surrounding soil. Installation in an oversized hole using a soil slurry to fill the space between the access tube and the soil will should be avoided since measured soil water content will be representative of the slurry and not the surrounding soil.

Recent developments in soil water sensor technology show promise in reducing interferences and improving the accuracy of soil water content measurements for use in crop water management.

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