SHORT COMMUNICATION

A CONTINUOUS SOIL WATER POTENTIAL MEASUREMENT SYSTEM FOR IRRIGATION SCHEDULING ASSESSMENT

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Abstract

In this study, the application of a relatively inexpensive continuous soil water monitoring system to assess crop model predictions of under- or over-irrigation was investigated. Three Watermark soil water potential sensors and a soil temperature sensor were linked with a relatively inexpensive 'Hobo' data-logger capable of recording hourly measurements. These measurement systems were installed in four sugarcane fields with the Watermark sensors at three depths: 15, 30 and 60-80 cm, dependent on site conditions. In-field data were recorded from August 2007 to July 2008, a period covering the sugarcane growing season. Continuous monitoring of the soil water potential provided strong evidence in support of other studies that the fields were under-irrigated. At one site, the crop experienced water stress for as much as 50% of the critical summer growth period. Early in the season, when sugarcane water requirements are relatively low, soil water potential was less than 50 kPa, indicating adequate water for almost 100% of the early growth period. Monitoring systems such as the one described, can add value in providing information to inform irrigation management decisions and contribute to optimising the use of water for crop production to the benefit of individual farmers and the wider community.

Keywords: soil moisture monitoring, soil water potential, Watermark sensors, irrigation assessment, sugarcane

Introduction

In an irrigation benchmarking study undertaken by Greaves (2007), farm water use and corresponding crop yield observations were compared to a range of simulated irrigation water requirements and crop yields. The Greaves (2007) study, which was undertaken on a prominent sugarcane irrigation scheme in the KwaZulu-Natal province of South Africa, provided strong evidence that farmers in the scheme were under-irrigating and that there was potential to improve crop yields by increasing irrigation water applications. Greaves (2007) recommended the use of in-field soil water monitoring to substantiate the unusual hypothesis of under-irrigation.

In the broader context, scarce water resources and increasing competition for water from other sectors (DWAF, 2004) has increased the pressure on irrigators to use water more efficiently. Development and application of tools to monitor soil water status to assess the performance of irrigation systems and scheduling practices, could become increasingly important. In the study reported here, the application of a relatively inexpensive continuous soil water monitoring system to assess the Greaves (2007) crop model predictions of under-irrigation on farms was investigated. Typically, stakeholders, including the Department of Water Affairs and Forestry (DWAF), do not often perceive that farmers would be under-irrigating and the validity of the recommendation to increase irrigation water applications reported by Greaves (2007) was under debate.

Soil water measurement

In the irrigated sector, soil water status may be measured in terms of volumetric water content or soil water potential. Soil water content is a description of how much water is present in a given volume or depth of soil, expressed typically in m^3 water per m^3 soil. A universal challenge with measuring soil water content is to determine whether the water content measured is too wet, i.e. above the drained upper limit (DUL), or too dry, i.e. below the water content at which the plant experiences stress (Charlesworth, 2000).

Soil water potential, on the other hand, is a measure of the suction energy required by the crop to extract water, and is, therefore, a more direct indicator of potential crop stress and whether or not the soil is above the DUL.

The Watermark is a granular matrix sensor which can be used to measure soil water potential down to approximately 200 kPa (Irrometer Company, 2008). Watermark sensors are compact, robust, easy to use, relatively inexpensive and widely accepted by irrigation scientists for their ability to account for changing soil moisture conditions (Vellidis *et al.*, 2008). Furthermore, watermark sensors operate over a broader range than tensiometers and are more robust than gypsum blocks (IEAE, 2008).

Methodology

Watermark sensors were selected as the best option for measuring soil water status in this project. The next steps were to:

- find a suitable data logger
- calibrate the logger and Watermark sensor combination to relate the readings to soil water potential
- install the Watermark-based soil water potential system in the fields
- download and evaluate the water potential data.

The 'H8 Hobo' four-channel data logger from the Onset Computer Corporation was selected based on work reported by Allen (2000). The H8 Hobo loggers are readily available and relatively inexpensive. Furthermore, these loggers are small and inconspicuous and require only a small watch-type battery, and therefore are not likely to be tampered with or stolen.

The total cost of the soil water potential monitoring system in 2007 is given in Table 1.

Table 1. Cost breakdown of soil water potential monitoring system in 2007.

Description	Quantity	Cost (R)
Watermark sensors	3	1 770
Soil temperature probe	1	340
Onset Hobo logger	1	1 200
General purpose box	1	140
	Total	3 450

Installation
A total of four sites, two on each farm, were monitored. All the selected fields, referred to as 1A, 1B, 2A and 2B, were irrigated by dragline sprinkler irrigation systems. Following calibration in a pressure plate apparatus, the Watermark sensors were installed in the cane row at depths of 15, 30 and 60-80 cm, dependent on site conditions.

Results

The Watermark soil water potential sensors were used to record measurements from August 2007 to July 2008. Inman-Bamber (2002) reported that the threshold water potential for stress in sugarcane is approximately 100 kPa. In the summer months between November 2007 and February 2008, the average soil water potential over the profile often exceeded the 100 kPa stress threshold. Growth over this period is rapid, due to the availability of ample radiant energy, and water stress over this period has a substantial impact on the final crop yield (Doorenbos and Kassam, 1979). To illustrate the timing of water stress experienced by the crop on the participating farms, the percentage distribution of the average soil water potential for different growth stages is shown in Figure 1.

For the sites on both farms the soil is very wet in the early growth stage, between August and November, and the opportunity does exist for saving water by reducing irrigation. However, a large amount of water stress was experienced during the critical growth period of the year, particularly on the farm where sites 2A and 2B were located. At sites 2A and 2B, the crop experiences water stress for as much as 50% of the critical summer growth period between November and February. This information substantiates the Greaves (2007) hypothesis that farmers within the irrigation scheme were under-irrigating and that there is potential to improve crop yields by increasing irrigation water applications.

Conclusions and Recommendations

The Watermark soil water potential sensors proved to be a valuable tool in substantiating the Greaves (2007) hypothesis of under-irrigation. The data provided evidence of substantial water stress during critical growth periods but also provided evidence that there was potential to save water early in the growing season. Availability of soil water potential data should, therefore, assist farmers in monitoring the performance of their irrigation strategies and making improvements. Furthermore, near-real-time soil water potential data could be utilised to trigger the timing of irrigation applications.

The Watermark sensor and Onset Hobo data logger combination provided a relatively cheap and robust system of capturing valuable soil water potential data. Downloading data can, however, be tedious and time consuming where data is required on a frequent basis, for example, to make irrigation application decisions. Remote access to data via GPRS is an area that should be explored. Nevertheless, monitoring systems such as the one described, can add value in providing relatively inexpensive information to assist irrigation management decisions and contribute to optimising the use of water for crop production. This will be of great benefit to individual farmers and the wider community.

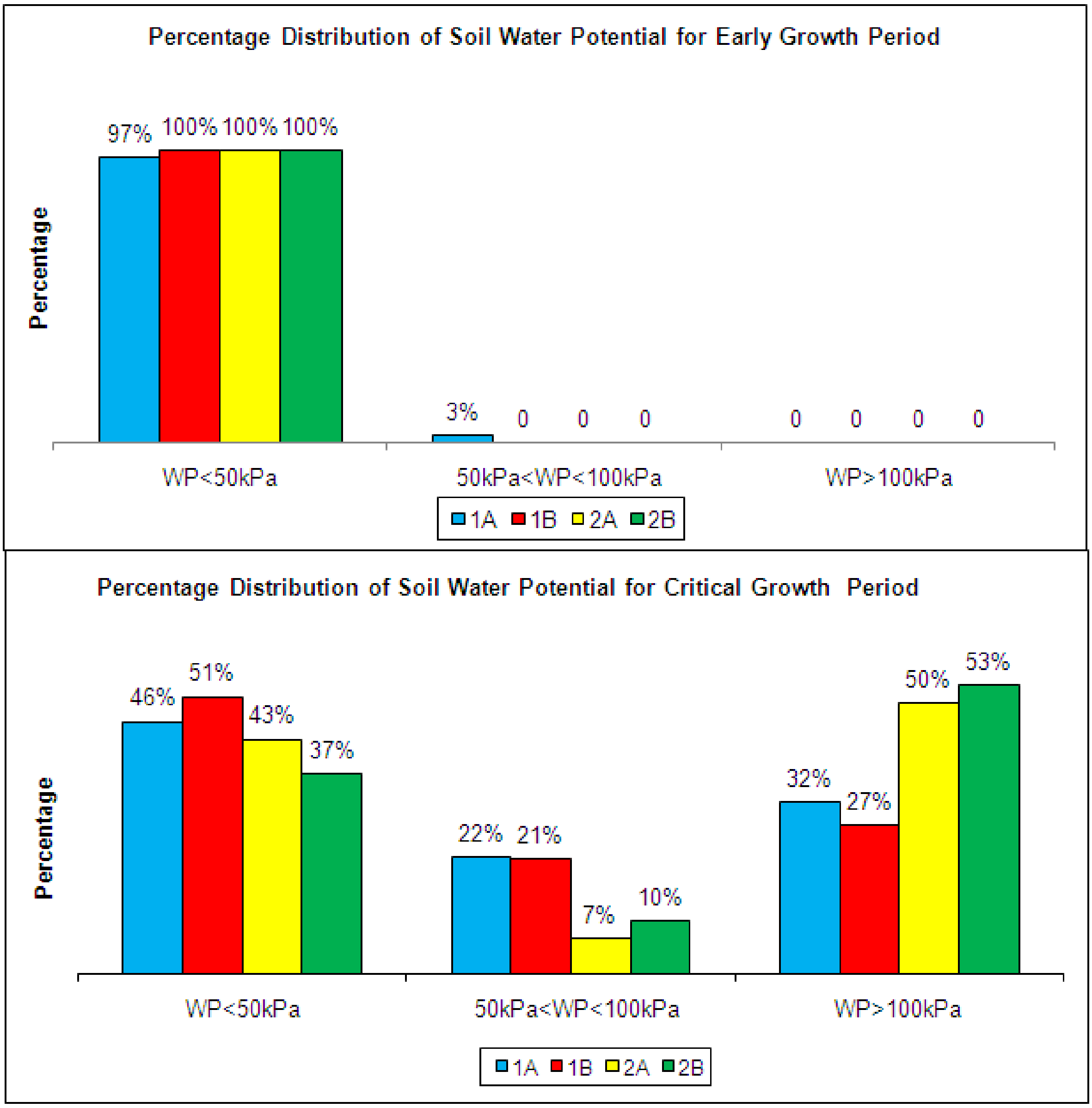

Figure 1. Percentage distribution of average soil water potential at four sites in the KwaZulu-Natal province of South Africa.

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