Challenges in estimating soil water

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Introduction

Most of Australia's dryland cropping is characterised by unreliable rainfall with frequent long gaps between falls. Stored soil water is therefore essential to support crop growth during the growing season while water stored during fallows has varying importance, depending on soil type and rainfall patterns in relation to cropping periods. For example, a winter crop at Walpeup in Victoria derives 10% of its water supply from soil water at planting while a winter crop at Emerald will access 80% of its water supply from stored soil water (Thomas et al 2007). Even when dependence on stored water is small, extra water can make a valuable difference to crop yield and profitability, especially in typical dry-finish seasons (Kirkegaard et al 2014). An understanding of available water before a crop is planted can influence management decisions (area planted, fertilizer rates). Estimating plant available water (PAW) also requires an estimate of a soils ability to store water, its plant available water capacity (PAWC).

This paper presents some observations of soil water from a 17-year study comparing water balances (runoff, evaporation and deep drainage) for a set of small contour bay catchments near Roma in southern Queensland. Our aim is to demonstrate some of the challenges associated with field measurement of both PAWC and PAW. This analysis is an extension of a detailed description of the development of SoilWaterApp (Freebairn et al. 2018).

Method

As part of a long term (1982-2000) hydrology and water quality study at Wallumbilla (Freebairn et al 2009), soil water was measured gravimetrically at least three times per year: after winter crop harvest; mid fallow and soon before planting around May. Soil samples were collected from hydraulically driven soil cores to a depth of 1.5m. Each core was separated into six depth intervals (0-10, 10-30, 30-60, 60-90, 90-120, 120-150cm) with nine cores collected within each of four ~4 ha contour bay catchments 2.4-5.9 ha in area (Figure 1).

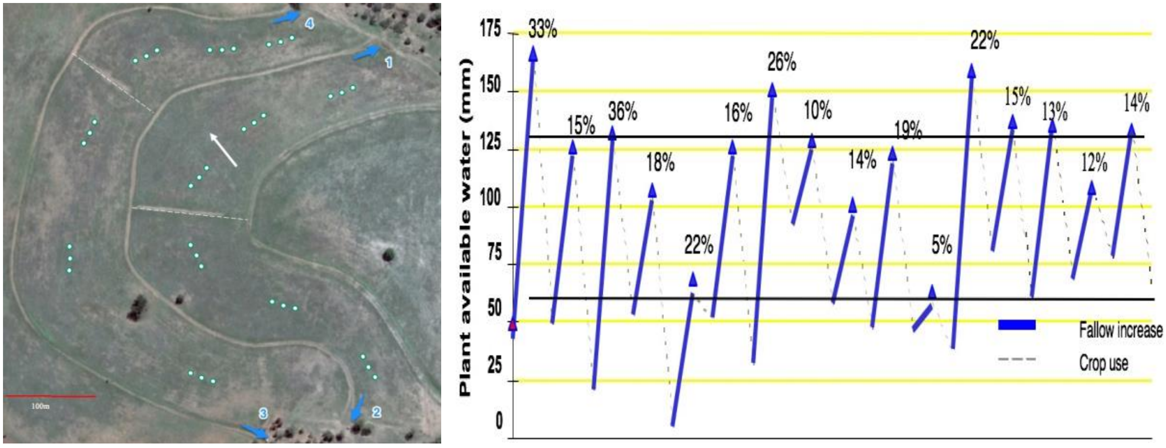

Figure 1: Aerial composite of the Wallumbilla catchment study (right) showing four contour bays with outlets (blue arrows), approximate location of soil sample sites in each catchment (white dots) and general flow of water (white arrow) and (left), increase in PAW during fallows (blue arrow) over 16 seasons (Bay 3). Percentage values indicate proportion of rainfall stored in the soil (fallow efficiency).

PAWC was estimated from field measures of PAW over the 17 years, being the difference between the wettest and driest sample date (mean of nine cores). The mean lower limit or wilting point and bulk density for each soil depth was used to calculate PAW (Lawrence et al 2005). Soil water data were typically analysed to provide a single value of PAW for each bay and sample date. Data for individual sample sites were available for a limited number of dates and are used to describe spatial variability in estimated PAW.

Results

Wettest and driest soil water profiles are presented for the four bays in Figure 2a while estimates of PAW for Bay 3 on 25/5/98 are presented in Figure 2b.

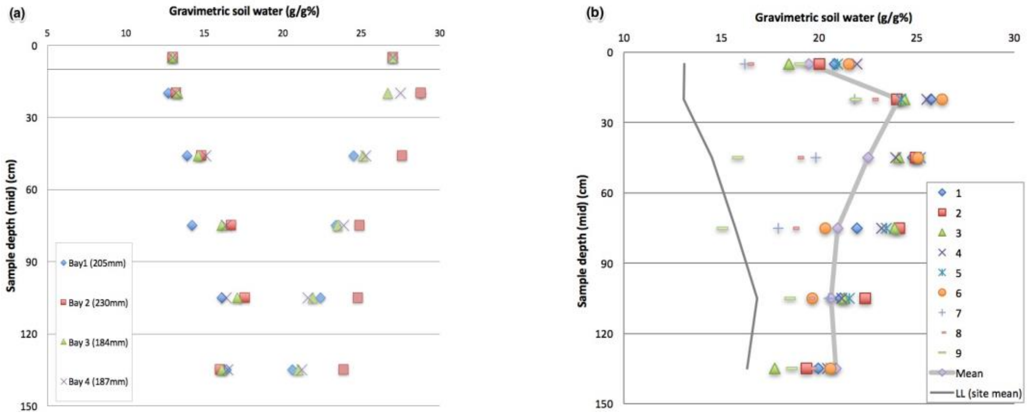

Figure 2: Gravimetric moisture content for the driest and wettest sample dates (mean of nine samples) over the duration of the study (1982-2000), including PAWC values (a); and individual gravimetric soil moisture values for a single sample date at the end of a fallow (25/5/1998) (b).

Discussion

The data used in this analysis has been collected over 17 years, sampling a range of seasons in a small area (25ha) chosen to be relatively uniform and representative of the region. PAWC estimates for the four contour bays vary by 50mm (Figure 2a). Given the focus of the study used in this analysis was on runoff and erosion, less attention was given to soil water except to provide a reasonable estimate of soil water gains and losses over fallows and crop periods. This analysis shows that spatial variability in soil water is high even within a contour catchment of ~4 ha (Figure 2b), with PAW values ranging from 55-170 mm over the nine sample locations.

This raises the question: if planning to locate a soil moisture monitoring site, where should it be situated? Clearly, we are unlikely to understand field variability without a sampling strategy such as employed here. While gravimetric soil moisture estimates are less prone to systematic errors, uncertainty in lower limit and bulk density remain.

One approach to deal with uncertainties due to estimates of lower limit and bulk density or locating a “representative site” for a soil moisture measuring device, is to use a water balance simulation approach such as employed in Yield Prophet (https://www.yieldprophet.com.au) or SoilWaterApp (http://www.soilwaterapp.net.au). But the issue of soil description remains. How important is soil type in estimating available soil water? The answer will be – it depends, but it is not necessarily a deal breaker if it is only loosely described. For example, for the current fallow at Wallumbilla (1/11/2017 to 8/6/2018), model estimates of gains in soil water range from 50-80mm for soil types with PAWC values of 120 to 200mm. Of course, this simple example would not hold for a wet fallow where shallow soils will fill quickly and deeper soils will store towards their capacity (PAWC). A combination of simulation tools and readily accessible soil descriptions available from the National Soil Grid of Australia will alleviate some of these challenges, at least to a point where farmers and consultants can progress to reasonable estimates of their soils PAWC and PAW (http://www.clw.csiro.au/aclep/soilandlandscapegrid/).

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