SoilWaterApp – monitoring soil water made easy

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Abstract
The SoilWaterApp (SWApp) is an iOS App that has been developed for dryland and irrigation decision makers as a ready estimate of current soil water status during fallows and crops. SWApp offers a more robust, reliable and economic method for monitoring soil water and SWApp can provide a forward estimate of soil moisture based on historic weather. SWApp allows a user to answer questions such as: Do I have enough water to plant, given the risk of follow up rain? When should I irrigate? How much irrigation am I likely to need for the season? And, is there enough water left after a crop to plant another crop? Of course, many agronomic decisions are influenced by crop expectations, with soil water being an important part of this calculation.

SWApp provides a reliable estimate of soil water at the paddock level. SWApp's estimates of plant available soil water are well within the errors encountered in field measurements (RMSE 30 mm) and customise for any paddock and is available wherever and whenever decisions are made. It does not need to be in mobile phone range to operate, although basic data needs (recent rainfall from BoM)) to be uploaded before going into the all familiar mobile phone blackspots! SWApp is a user friendly water balance simulator that deals with fallows, crops, and irrigation. It is freely available for download and provides robust estimations of soil water status which can be used wherever decisions are made.

Keywords
PAW, rainfall, decision making, water balance.

Introduction
Grain production in Australia is limited in most seasons by water supply. Soil water stored during the fallow and early season maintains crop water supply especially toward the critical time around anthesis.

Recently there has been a heightened interest in "new" methods of measuring soil water at sub-field scales and improving inter and intra-seasonal decision making (e.g. EM38, weather stations and soil probes). However, the time-consuming, labour intensive requirements for calibration, equipment costs and difficultly in interpreting results represents a barrier to grower adoption and commercialisation. The GRDC required new approaches to measure and monitor plant available soil water.

An alternative method which minimises these barriers was to apply "water-balance simulation", using in-field weather data and available soil water measures from a range of devices and estimates. The aim was to provide readily available, real-time estimates of soil-water.

App development
The SWApp was developed in four phases.

Phase 1. Review of methods and industry needs
A review of methods for monitoring soil moisture measurement and industry needs was carried out (http://www.soilwaterapp.net.au/Library/Details/a4cd298f-0756-416f-aaab-e869060a4d3f). A reference group of ~200 early users was established across all GRDC regions to provide feedback on prototype Apps, interface design and estimates of soil water (~50 users per version provided feedback).

Phase 2. Prototype development
A prototype App was released (TestFlight) mid 2015 and updated monthly based on growers and consultant feedback and internal testing. Approximately 150 versions of the App were released during development reflecting the rapid turnaround in testing, but also demonstrating that App development is not easy. Building

connections between databases, sensors and the App provide many challenges. The App development was more time consuming than planned but the functionality improvements gained were valuable.

Phase 3. Model testing
Further development focused on interface refinement, testing the water balance model with readily available data, integration of sensors and development of a context sensitive help system within the App. Datasets from Qld, Vic and WA were used to test SWApp.

Stage 4. Delivery of SWApp and documentation
V3.01 of the SoilWaterApp was delivered to the App Store in February 2016 with releases up to January 2017 completing functionality (Help system, irrigation, connectivity to sensors and accessing rainfall data from an API). The original concept of training material and webinars was replaced with a context sensitive help system, a YouTube video and a library of reference material (http://www.soilwaterapp.net.au/Library).

The App
SWApp estimates daily evaporation, transpiration, infiltration, runoff, deep drainage and soil water using the same computer code embedded in Howleaky? (McClymont et al. 2016). Howleaky? and APSIM (McCown et al. 1996) share much of their water balance code and agreement between the two models was confirmed in model testing.

SWApp uses long-term weather data from Silo (https://www.longpaddock.qld.gov.au/silo/) to provide the climatic context for the current season and probabilistic estimates of future water status. Weather stations and soil probes can be run in parallel with SWApp while building confidence in what is a mature technology - water balance simulation. A "wireless" BlueTooth rain gauge has been developed which interfaces directly with SWApp. Soil and crop type are selectable for each paddock. SWApp allows data for any "site" to be shared with others while reports can be simply emailed. All user data is securely backed up and available, with permissions, for other uses. Starting conditions specified by the user can be adjusted with inputs from: field estimates based on observation (e.g. very wet or dry), soil push probe depths or independent sensors. Input data is securely stored in the cloud and can be accessed from multiple devices.

To initiate SWApp, the user enters a property and paddock name and a relevant climate station. Since SWApp is a smart device, it presents the user with the 5 nearest climate stations from the 4,500 climate stations across Australia. More locally relevant rainfall data can be entered to replace BoM data. A soil type that best represents the site is selected from a list covering the major soil types in each state.

The user then sets a start date and starting soil water and distribution. A starting soil water can be estimated from a push probe and local rain data can be selected or added. Then the user; selects soil cover condition (crop residue) for the fallow and crop period, and fallow or crop type, and adjusts plant and maturity dates (Figure 1).

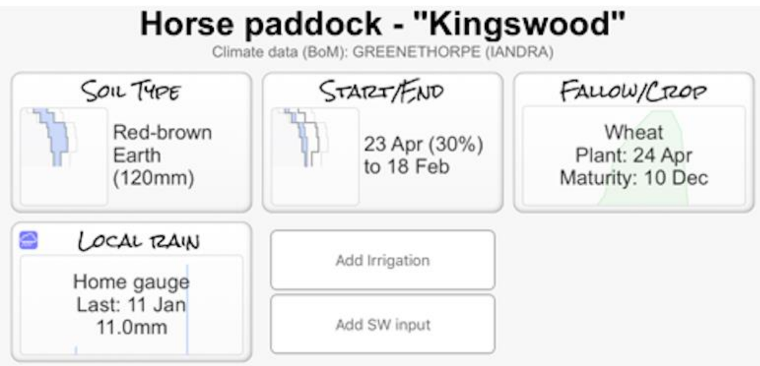

Figure 1. SWApp inputs can be edited with a few taps on an iOS device.

Results are shown as text and graphs. PAWC % and mm water available are central with a water balance table and soil water profile on either side. Graphics show the patterns of water accumulation, and crop cover

(Figure 2). The blue line (Figure 2) to the right of "current" date is a forecast based on previous 40-years weather for the specified conditions. The shaded "plumes" envelop 60 and 90% of previous outcomes.

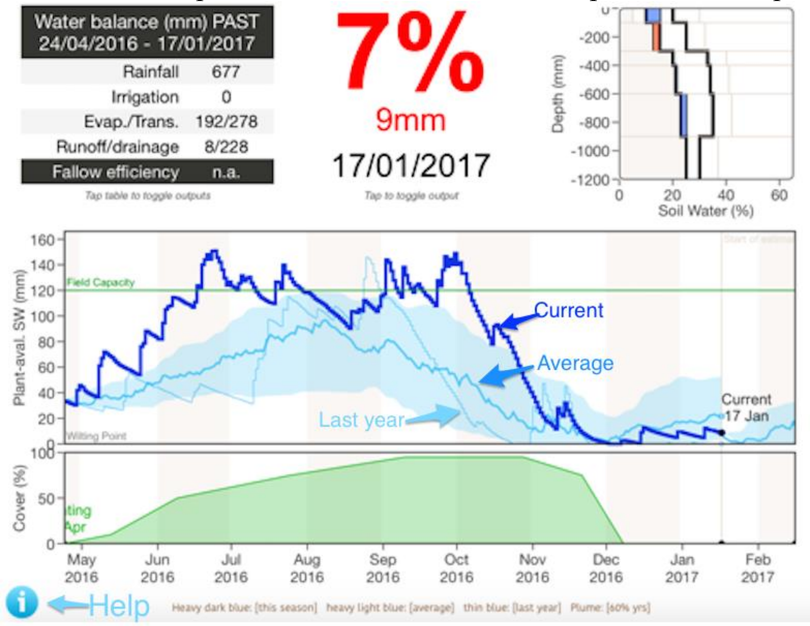

Figure 2. A results screen showing current soil water status, water balance (past and projected), soil water profile and time series of current, average and last year's water traces along with growing and residue cover.

Additional facilities such as report generation, a Push Probe data entry and an irrigation module are currently available. A wireless Bluetooth rain gauge and soil water sensor is being tested that interfaces directly with SWApp when a device is nearby (within 20 metres).

The App's "science" was tested using data from existing studies and near real time data collected by related projects (RPS 2014; Precision Agronomics Australia 2015; Agriculture Victoria 2016).

Example applications of SWApp

SWApp estimates available water during fallows and crops, for dryland and irrigated paddocks. The irrigation section allows users to explore a range of irrigation approaches, from flood to drip, and provides a forward look at water needs using historic rainfall data. Two typical applications for SWApp are shown in Figures 3 and 4. Figure 3 shows the development of the 2016 winter crop season with an average start and a dry finish. When soil water is above field capacity, runoff and deep drainage would be occurring. Figure 4 shows the SWApp output for an irrigated crop mid-season where previous irrigations are known with SWApp estimates for future irrigation demand based on 40 years of weather data.

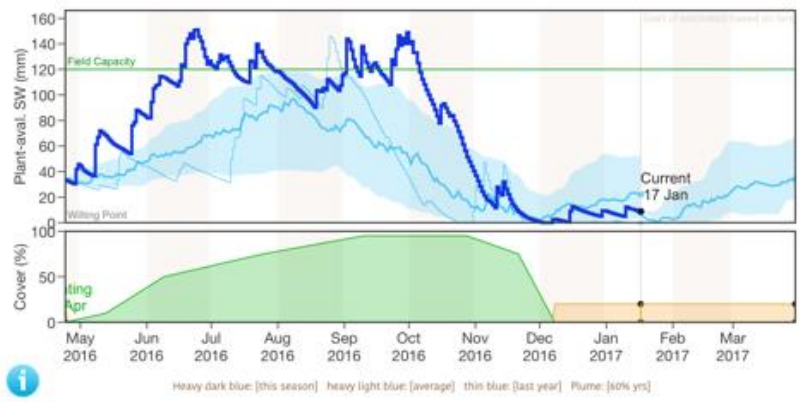

Figure 3. The 2016 winter crop season in review (central NSW) showing well above average rainfall and soil water with a dry finish.

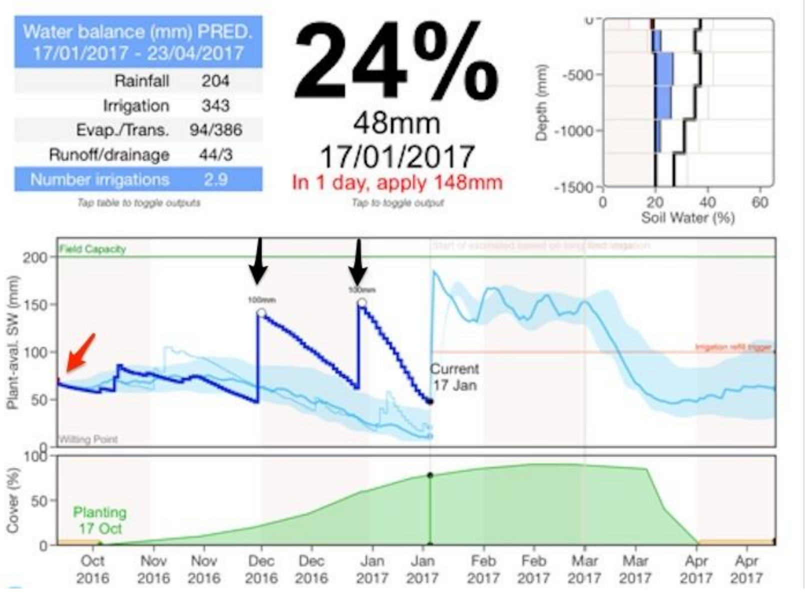

Figure 4. SWApp results for an irrigated crop showing two previous irrigations (black arrows -added manually as known) and projected irrigation (3.4ML and ~3 applications). Input from a push probe was used to initiate this simulation (red arrow).

Future developments

As part of a Commonwealth Government's National Landcare Programme, a project "Soil sensing – new technology" will enhance SWApp with selectable soil types based on device location. Soil descriptions will be derived from soil databases and a national data grid, with specific local soil descriptions available.

Conclusions

- A user friendly water balance simulator that deals with fallows, crops, and irrigation for any specified condition is available. It provides robust estimations of soil water status which can be used wherever decisions are made.
- A simple to maintain website complements the App with resources to support both new and experienced users (documents, presentation slides and YouTube videos).
- Testing of the water balance model in SWApp is a significant improvement over simple rules of thumb (e.g. 20% fallow rainfall stored).

Acknowledgements

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