WATER USE IN ORCHARDS

New app can predict apple orchard water use up to a week in advance

A current multi-year project funded by the Water Research Commission (WRC) has seen the successful development of a smartphone applications (app) for forecasting orchard water use a few days in advance using readily available data from apple orchards as inputs. Article by Sebinasi Dzikiti, Trevor Lumsden, Zanele Ntshidi, Nompumelelo Mobe and Mark Gush.

Over the years, the WRC, in collaboration with fruit industry partners, has funded several research projects aimed at establishing the water requirements of orchards across South Africa. Many of the studies focused on apple orchards in the prime production regions in the Western Cape (e.g. Volschenk et al., 2003; Dzikiti et al., 2018; Gush et al., 2019). In addition, there are currently ongoing related projects in these areas (e.g. Midgley et al., 2019). So, the volume of good quality data of actual orchard water use measurements is growing.

With this in mind, a study aimed at consolidating and adding value to these data was initiated by Dr Mark Gush, now with the Royal Horticultural Society in the UK. The priority of the study was to develop a simple but scientifically credible tool that operates on platforms that are easily accessible to farmers to assist them with irrigation planning in real-time. The resultant innovation comes at the right time when the fruit industry is grappling with water scarcity as a result of frequent droughts and the increasing demand for the limited water resources.

The project, funded by the WRC, commenced in April 2018 and ends in October 2020. The first phase of the study involved developing the methods and identifying the right data to use. The project team decided to develop the app following the internationally recognised FAO 56 principles (Allen et al., 1998) which irrigators are familiar with. According to this approach, the

orchard water requirements, which numerically are equal to the crop evapotranspiration (ET_c), is calculated as the product of a crop factor (K_c) and the reference evapotranspiration (ET_o).

Thus, selecting an accurate online source of daily weather forecasts to predict ET_o a few days in advance was an important consideration. Equally important was the identification and improvement of an approach to estimate the orchard crop factors using readily available data (tree height and fractional vegetation cover). The development and field testing of the application (hereafter called the Orchard Water Use APP or simply APP) were the next steps. The final phase of the project is the roll out of the app on Google Play Store, which is expected before October 2020.

The orchard water use app

The app currently works on Android Smartphones only, however, it will be available on other platforms soon. A schematic representation of the app is shown in Figure 1. Once the app has been successfully installed on the smartphone, the following steps are initialised. On the landing page:

- User enters the orchard information (e.g. orchard coordinates, tree height, fractional vegetation cover, soil type, irrigation system and cover crop status)
- This information is required to calculate the basal (K_{cb}) and crop factors (K_c) using an algorithm developed by Allen and Pereira (2009) and adapted for apple orchards by Mobe et al (2020). This approach enables accurate crop factors to be derived taking phenological stage and canopy size into account. The performance of the crop factors algorithm was tested using actual measured daily water use data collected over entire growing seasons in 13 apple orchards comprising different cultivars and age groups, planted in different apple growing regions in the Western Cape

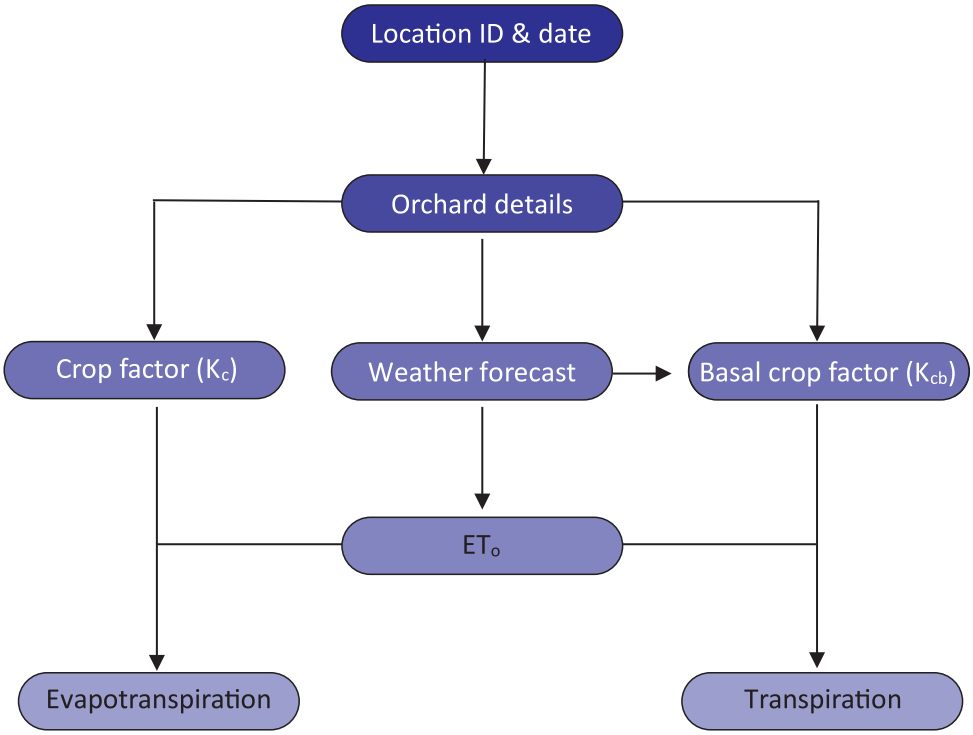


Figure 1. Schematic representation of the orchard water use Smartphone APP.

- Next the user decides how far ahead they want the water use estimates. It is important to note that the system restricts this choice to a maximum of seven days in advance as the accuracy of weather forecasts decreases the longer the forecasting period
- Once the landing page is fully populated, the user then runs the APP using the 'Get Estimates' button
- This action pulls in the necessary daily weather forecast data from an online source (www.darksky.net) providing the relevant weather variables (i.e. maximum and minimum temperature, maximum and minimum relative humidity, wind speed and solar irradiance);
- Calculations of the daily crop factors (K_{cb} & K_c), ET_o, transpiration and evapotranspiration (in mm/d) are then performed in the background
- The data is displayed as graphs or in tabular form
- In addition, a weekly summary of the outputs i.e. total ET_o, transpiration and evapotranspiration (in mm/week), and average crop factors is also generated

Field testing the app

The performance of the app has been tested in collaboration with two farms in the Western Cape, one in the Koue Bokkeveld and the other in Villiersdorp during the 2019-20 growing season. The Koue Bokkeveld orchard was planted to mature Rosy Glow apples under microsprinkler irrigation. In Villiersdorp, data were collected in a mature Royal Gala apple orchard on V-trellis training system under drip irrigation. Data collected included the site microclimate, irrigation volumes, soil water content and tree transpiration (measured using the heat ratio method of monitoring sap flow).

The two farms were selected because they rely heavily on another tool for ET_o forecasting already in use in the industry (iLeaf) for irrigation decision making. The farm decided on the appropriate crop factors to use. Thus, we assessed the relative performance of the two tools in comparison with measured data. Validation of the app was performed as follows: every Monday morning the app was run for each test orchard for the week ahead (Monday to Sunday).

The information was immediately sent to the farm. The farm, in turn, sent back to the researchers their own irrigation forecasts for the week. The Orchard Water Use app and the farm's irrigation forecasts were then compared with the actual measured data. For example, Figure 2 shows a comparison of the forecast daily ET_o by the app and iLeaf against the actual measured data in Villiersdorp.

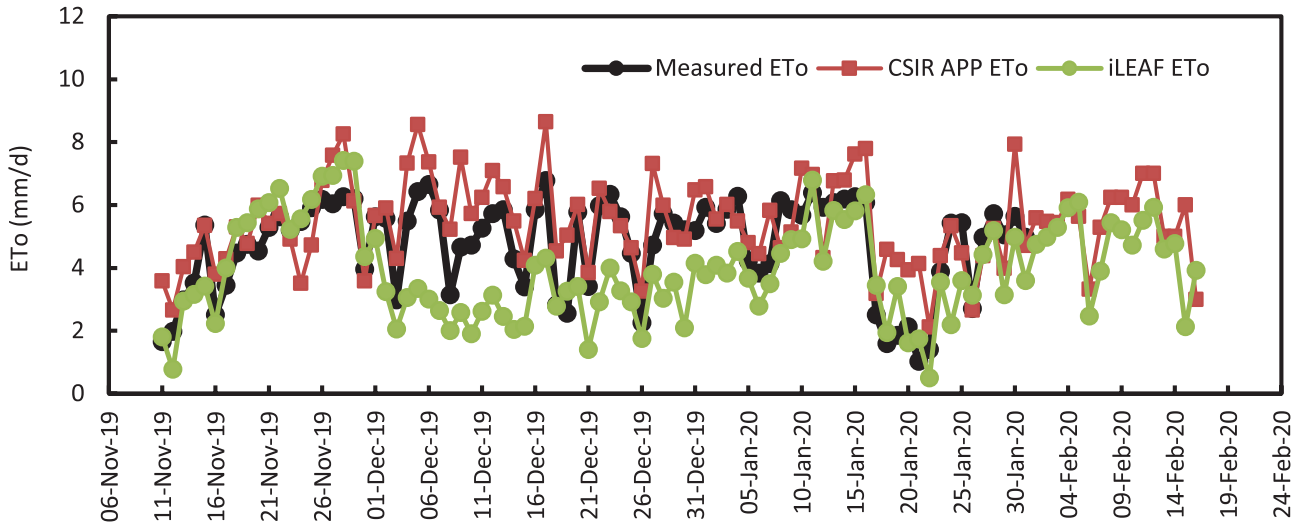


Figure 2. Comparison of the daily ET_o forecasts predicted using the APP (brown line) and iLeaf (green line) against the actual measured data (black line) in Villiersdorp.

A comparison of the actual weekly irrigation applied against that forecast by the APP and iLeaf ET_o in Villiersdorp are shown in Figure 3. The app's irrigation forecasts were within the same order of magnitude as iLeaf and the actual measured irrigation amount.

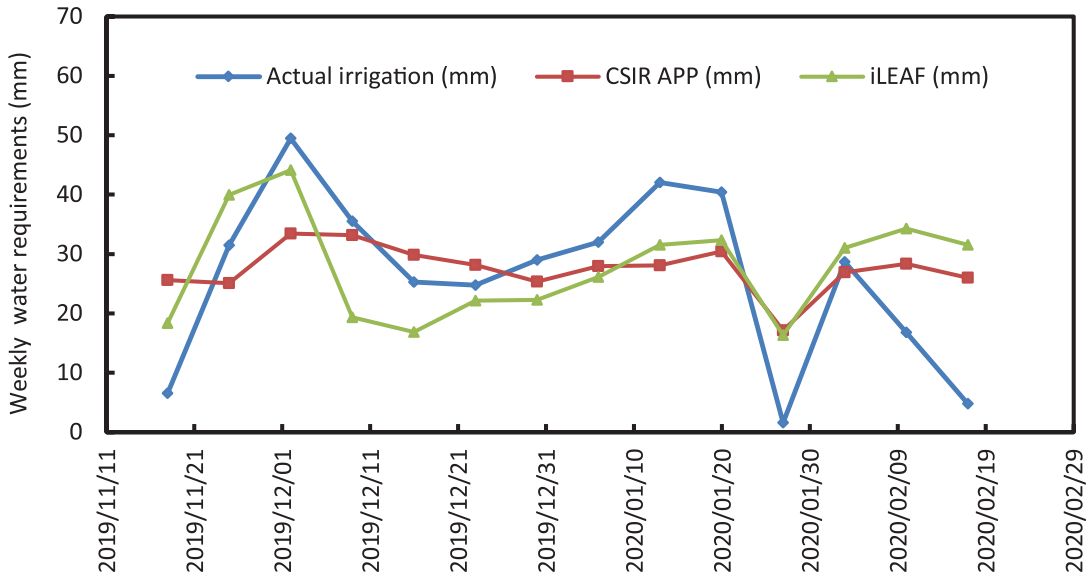
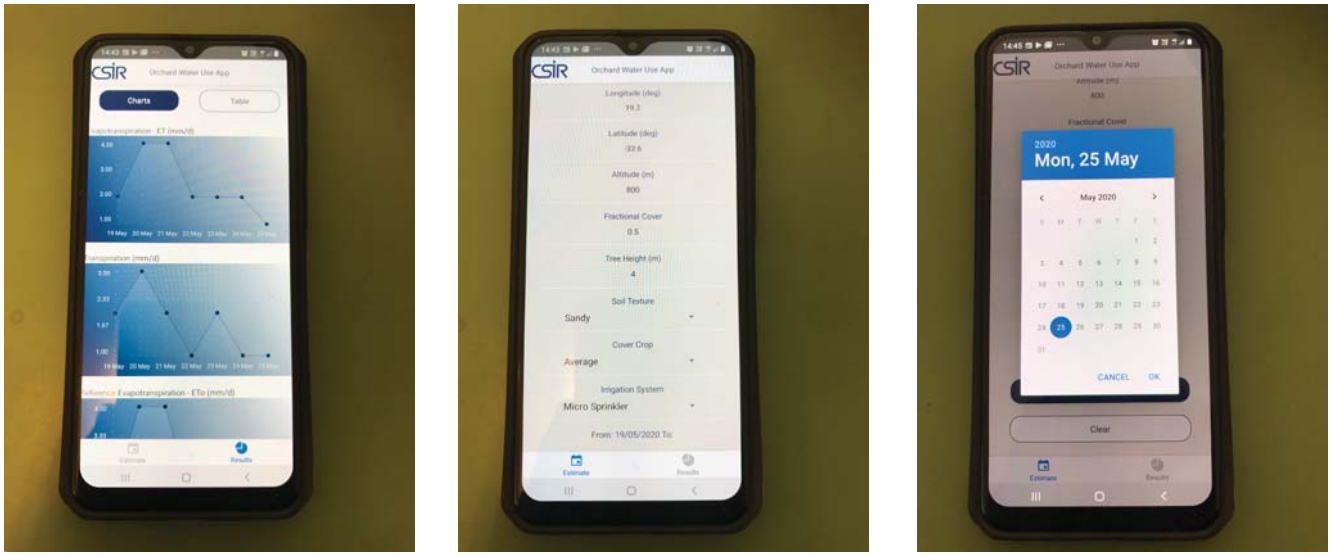


Figure 3. A comparison of the weekly irrigation forecasts determined using the APP and the farm's method against the actual applied irrigation in Villiersdorp.



Courtesy CSIR

Screenshots showing the various phases of running the Orchard Water Use APP.

Next steps

Evaluation of the app using measured data for the period February to April 2020 was in progress at the time of writing. Detailed results of the study, specifically showing how the app's transpiration and orchard ETc estimates compare with the actual measurements will be presented in the final report of the project.

However, the performance of the app during the first half of the season at both sites was satisfactory and it compared well with observed ET_o and irrigation data although we did not show the Koue Bokkeveld site data. A free version of the Orchard Water Use app will be posted on the Google Play Store before October 2020. It is important to note that the current version of the app is designed for apple orchards only. Other tree crops may be added in future.

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