POLICY BRIEF

August 2018
The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

Determining the water use of and water productivity of high performing apple orchards

The deciduous fruit industry in South Africa is a multi-billion Rand sector, employing hundreds of thousands of people, both on farms and in downstream agro-processing industries. The sector is also an important foreign exchange earner, with 40% of fruit being exported.

Apples account for about 30% of the area planted under deciduous fruit. High-yielding apple orchards (producing more than 100 tonnes per hectare) have become common in recent years as a result of improved plant material and orchard management practices. Since the sector is almost wholly dependent on irrigation, the availability and accurate allocation of water is critical for the sustainability and growth of the deciduous fruit industry.

The critical need and lack of prior knowledge on the water use of deciduous fruit prompted the Water Research Commission, in collaboration with the South African Apple and Pear Producers Association (represented by Hortgro Science) to launch a study into the water use of particularly high performing apple orchards. The study focused specifically on the Western Cape, where most of these orchards are found and where water security is a pertinent issue. The information collected through the study can be used to improve irrigation scheduling and water allocation decision-making in the deciduous fruit sector. Among others, the study showed that, through proper management, high apple yields can be produced sustainably in the Western Cape.

Motivation for the study

Most apples produced in South Africa are grown in the Western Cape – mainly in the Koue Bokkeveld and the Elgin/Grabouw/Vyeboom/Villiersdorp regions.

Water supply is key in apple producing regions and the sector is experiencing significant strain. The situation is expected to get worse in future as demand outstrips supply. Major drivers of increased water demand include increasing competition as a result of population growth, drought impacts, and threats posed by climate change.

Prior to this study no information existed on the water requirements of high yielding apple orchards in South Africa. There is a need to understand the water use of these orchards from planting until full-bearing age. Information is also needed on how the high crop loads affect fruit quality, which influences the fruit selling price.

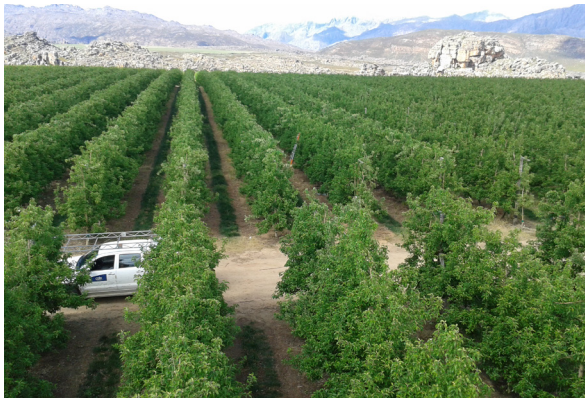
Accurate quantitative information on the water use of unstressed high-performing apple orchards is essential to:

- Improve irrigation scheduling
- For water allocation decision-making
- For water licensing
- For developing water saving strategies to cope with water shortages induced by droughts.

This study aimed to close the existing information gaps using the Golder Delicious/Reinders cultivars, which are most widely planted in South Africa, as well as Cripps' Pink/Cripps' Red and Rosy Glow, which are long season, high-value cultivars.

Data collected in these orchards was used to develop a model for apple orchard water use. The model can be used for extrapolation of the research findings to other production regions.

Study methods



One of the orchards used in the study.

The study was conducted over four years in both prime apple producing regions in the Western Cape. The two regions have different microclimates, with the Koue Bokkeveld characterised by very cold winters and hot summers while the Elgin region has warm winters and mild summers.

Data was collected in 12 orchards of varying age groups. Four of the orchards were young (3 to 4 years), and were not yet bearing and had a low canopy cover.

Another four orchards were mature and with a good record of yielding over 100 tons per hectare in the last few years. These orchards had a high canopy cover. The last four orchards had medium canopy cover, yielding under 50 t/ha.

Detailed data was collected on tree transpiration, orchard evapotranspiration, rootzone soil moisture dynamics, tree water status, tree and fruit growth, yield quality and quantity, among others. The data was used to calibrate and validate a dual source model that partitions orchard evapotranspiration into the transpiration component (beneficial water use to produce fruit) and orchard floor evaporation (non-beneficial water use).

Main findings

The average yield in the two mature Cripps' Pink orchards were approximately 110 t/ha compared to about 88 t/ha in the Golden Delicious orchards. However, average seasonal transpiration (October to June) was lower at about 6 400 m^3/ha for the Cripps' Pink compared to about 7 800 m^3/ha in the Golden Delicious orchards.

The mature 'Golden Delicious' trees had larger canopies compared to the Cripps' Pink trees. These results show that canopy cover rather than crop load is the main driver of orchard water use in the high-yielding mature orchards. This was confirmed with transpiration data in the orchards with medium canopy cover which ranged from 2 500 to 5 500 m^3/ha while that in young orchards ranged from 1 300 to 2 700 m^3/ha/season.

The seasonal evapotranspiration total simulated by the dual source model varied from 9 000 to 11 000 m^3/ha/season in the mature orchards and it peaked at around 5 000 m^3/ha/season in the young orchards. Orchards with medium canopy cover gave water use values between these two extremes.

Orchard floor evaporation accounted for between 18 and 36% of evapotranspiration in mature orchards, depending on the canopy cover. This increased to more than 60% in young orchards.

There were no clear effects of the high crop load on most fruit quality attributes. Only the mature Golden Delicious orchards had smaller fruit, which affected pack out of export quality fruit.

The water use efficiency varied with production region and with cultivar given the different microclimates and canopy management practices for the Cripps' Pink and Golden Delicious cultivars. The key driver of the water use efficiency of the trees was the leaf area which determined transpiration.

Lastly, the water productivity (Rand of gross income per cubic metre of water consumer) was higher for Cripps Pink than for Golden Delicious apples. The primary reason for this is that export-quality Cripps' Pink fetches a higher price than export-quality Golden Delicious and this has a significant influence on orchard gross value.

Conclusions and recommendations

This study showed that high apple yields can be produced sustainably without using excessive amounts of water provided that the canopy is managed optimally. Under the current canopy management practices, mature Cripps' Pink trees tend to have low canopy cover due to heavy pruning or spraying of growth retardants. This is done to promote the development of the red colour on the fruit, but clearly this practice also has water saving benefits.

Mature Golden Delicious trees, on the other hand, tend to have high canopy cover to protect the fruit from sunburn

damage, but this also leads to higher water use rates. High crop loads in this study did not necessarily have a negative effect on most fruit quality attributes in the high-yielding orchards.

In the high-yielding Golden Delicious orchards only fruit size was affected, and management of crop load is essential in this cultivar to produce export quality fruit and to maximise water productivity.

Based on the results of this study, the following recommendations are made:

- Exceptionally high-yielding apple orchards can be sustainably farmed in the Western Cape, but effective canopy management is essential to avoid excessive water use.
- Crop load should be carefully managed in the Golden Delicious cultivar as high fruit numbers reduce fruit size and hence the pack out of export quality fruit.
- Water use efficiency and water productivity increase as orchards mature and achieve higher yields. However, in the Golden Delicious variety there appears to be a ceiling to water productivity relating to small fruit size at very high yield.
- Orchard floor evaporative losses in young micro-sprinkler irrigated orchards is currently very high. It is important to implement water-saving techniques e.g. mulching, drip irrigation, and using narrow range micro sprinkler to reduce water wastage.
- Apple growers with limited or unreliable access to water resources should consider focusing on high-value cultivars for new plantings, and gradually remove lower value cultivars. This would gradually increase the farm level water productivity and so maximise productivity for every unit of water that is available for irrigation.
- Use of shade netting on cultivars that are susceptible to sunburn such as the Golden Delicious should be considered. Shade nets will allow trees with smaller canopies to be grown while minimising sunburn on the fruit.

Further reading:

To order the report, ***Quantifying water use and water productivity of high performing apple orchards of different canopy sizes in winter rainfall areas of South Africa*** (**Report No. TT 751/18**) contact Publications at Tel: (012) 761 9300, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.