Benchmarking irrigation is crucial if an irrigation enterprise is going to improve its water use efficiency. Knowing how you are performing compared to your region or industry facilitates continuous improvement in management and water use. Unfortunately irrigation benchmarking data has in the past not been well recorded. The performance indicators are generally not well defined and calculations have not been standard across the industry.

We talk about bales per megalitre, but what do we mean? The cotton industry has been developing an ongoing process to capture water use information from growers and consultants. There are currently web-based tools available to collect this information, including the Water Benchmarking Tool (Cotton Community Catchments CRC and CRDC 2007) and the commercially available Watertrack Rapid. The significance of these tools is that calculations of water use indices are standardised and are defined.

**DATA COLLECTION**

Water use figures for the 2006-07 cotton season were collected from 42 cotton farms from Hillston to Emerald using Aquatech’s online calculator Watertrack Rapid. This water balance model provides a simple approach to rigorous calculation of essential irrigation performance...
indications and is an important starting point in establishing the water use efficiency of a farming operation.

Of the 42 farms visited, 36 had complete sets of data. The data collected included yield from ginning reports, several water input values (incorporating combinations of rainfall, soil water, storages, harvested, pumped), irrigation dates and the identification of soil type based on water holding and infiltration characteristics.

Rapid obtained calculated evapotranspiration (ET₀) and rainfall from SILO online. To determine crop evapotranspiration (Etᵣ), the Rapid calculator combined the ET₀ values from SILO with a set range of crop coefficient (Kᵣ) values for cotton.

Interestingly, an error arose in the estimation or measurement of water volumes on farm. This showed up quite significantly in the Rapid report when seven farms had negative farm water losses. In essence, it means that the total amount of water used to grow a crop was less than the amount required for that crop in that season by the crop transpiration figure based on SILO Evapotranspiration data.

The SILO data was suspected, but neighbouring farms had similar figures so the only other explanation can be an under estimation of water volumes on farm. As this water includes water pumped, storage volumes and harvested rainfall, some of which are not metered, it is easy to understand that inaccuracies can occur. Measurement of water volumes, particularly on farm, needs to be improved significantly.

It took no more than two hours to collect the information from any individual grower and at the end of collection, Rapid generates two reports that allow a grower to see their results on the spot with most figures calculated in bales per hectare or ML per hectare.

When this data is collated anonymously with data from other growers, it is possible to then compare the data that was collected within a given region or across the whole industry.

Information outputs

With Rapid, all farm water losses are combined into a single figure and these losses include:

- All seepage and evaporation losses from supply systems, ring tanks and dams, drainage and tailwater systems;
- Infield losses such as evaporation from the soil surface and deep drainage; and,
- Rainfall runoff that is not harvested.

A number of irrigation performance indicators are calculated including:
---STANDARDISING WUE BENCHMARKS---

- Gross Production Water Use Index (GPWUI);
- Irrigation Water Use Index (IWUI); and,
- Crop Water Use Index (CWUI).

The Watertrack Rapid reports contain good definitions that explain the origin and relevance of most figures.

Seasonal factors for the 2006–07 season

The 2006–07 season was very dry. Soil profiles and channel pads were dry and few irrigation storages were used. First irrigations used a lot of water as did any transfer of water around farms. There was little to no in-crop rainfall across all regions. Surface water allocations too, were very low or non-existent.

RESULTS

Variations in whole farm water losses

Seven farms reported a negative water loss. As previously suggested it is likely the Total Water Inflow figure has been underestimated in these cases. If these seven farms have underestimated their Total Water Loss, then it could be assumed that some of the farms with losses greater than zero have also underestimated their Total Water Inflow. If this is the case then the average Total Water Loss could be higher than stated.

The average water loss (from the 29 farms with positive losses only) was 2.64 ML per green hectare. This was around 25 percent of all water used on farm for the crop – that is, water diverted from river and/or bores, water harvested on farm, effective rainfall and soil water. So on average, the farms were able to utilise around 75 percent of their water through the plant productively. In this survey, the six farms with the highest combined farm water losses were only averaging around 60 percent of their total water through the crop in a productive manner.

Water use indices

The water use indices used to benchmark irrigation water use are presented in Figure 1. Crop Water Use Index (CWUI) relates the total production to the amount of water consumed by the crop (Crop Evapotranspiration). Although interesting to see what amount of water the crop has actually consumed, this index is dependent mostly upon non-irrigation related factors such as variety, disease, pests, nutrition and soil constraints and can only be improved by increasing yields. It is not a useful index for benchmarking irrigation water use but it is useful for estimating potential crop water use.

The Irrigation Water Use Index (IWUI) relates total production only to the amount of irrigation water sup-
plied to the farm (or pumped). It does not include rainfall or soil moisture and is therefore only useful for comparing nearby fields or farms in the same season. The average IWUI was 1.31 bales per ML, ranging between 0.90 and 1.92 bales per ML.

A more meaningful water use index for comparing irrigation water use between farms and regions and across seasons is the Gross Production Water Use Index (GPWUI) as it relates total production to the total amount of water used from all sources – irrigation water, effective rainfall and soil moisture. The average GPWUI was 1.13 bales per ML, ranging between 0.82 and 1.71 bales per ML.

The significance of these results is that the collection and calculation of the water use indices has been standardised, enabling meaningful comparison between the farms surveyed. The average IWUI is 1.31 bales per ML compared to the more meaningful GPWUI of 1.13 bales per ML. This is a significant difference and using the IWUI may give a false sense of security in irrigation performance.

The average GPWUI of 1.13 bales per megalitre is the figure that is representative of the cotton industry water use in 2006–07. It is this figure that can be used to benchmark water use so the industry can gauge if it is further improving and the rate of improvement over time.

Tennakoon and Milroy (2003) obtained production and water use data from 25 cotton farms and over 200 individual fields over three seasons, 1996–97, 1997–98 and 1998–99. They found the industry average GPWUI at that time to be 0.79 bales per ML. The data collected in this survey for 2006–07 shows a significant increase in GPWUI of around 40 per cent to 1.13 bales per ML.

Yield comparisons – highest 10 whole farm yields

Figure 2 compares the Rapid results from the top 10 yielding farms in the sample of 36 farms. On average these farms grew 12.70 bales per hectare using 10.24 ML per hectare of water. The crop was estimated as requiring 7.88 ML per hectare of water to grow, leaving an average loss per farm of 1.93 ML per hectare. The variation in yield and crop transpiration was minimal, whereas the total water inflow and total farm losses are quite varied. This variation could be attributed to a number of factors including differences in rainfall, soil moisture storage, irrigation scheduling, farm design and storage management.

The figures for the highest yielding farm tell an interesting story. With a yield over 13 bales per hectare, this crop was a single field, closely managed by an experienced grower, but was watered by a bore pumping straight into the head ditch. There was no rain and no tailwater due to tight irrigation management. The impressively low loss figure demonstrates what can be done, but this situation was far from a normal setup.
Yield comparisons – lowest 10 whole farm yields

The lowest 10 yielding farms produced on average, 35 per cent less cotton with eight per cent less water compared to the average of the 10 highest yielding farms. The crop was estimated as requiring 6.96 ML per hectare of water to grow. This is 13 per cent lower than the average crop transpiration for the 10 highest yielding farms. On farm water losses were 21 per cent higher with an average loss per farm of 2.34 ML per hectare.

CURRENT AND FUTURE INDUSTRY POTENTIAL FOR BALES PER MEGALITRE

The data that was collected for the Rapid survey provides an interesting insight to the potential theoretical water use indices that can currently be achieved as well as providing projections to what could be achieved in the future.

The average CWUI for all farms was 1.53 bales per ML (refer Figure 1). It relates yield to the crop water use (Et), not total water delivered to the farm and therefore there are no water losses. There were 12 farms that had a CWUI greater than 1.53 and these 12 farms are presented in Figure 3. We can assume that crop management on these 12 farms allowed the crop to produce more lint (bales) per ML of water consumed by the plants (Et). That is, crop stress from pests, disease, nutrition or water management were minimal. So these farms represent the current potential towards which the rest of industry can move.

These 12 farms had an average GPWUI of 1.26 bales per ML (refer Figure 3) compared to the average GPWUI of all farms, 1.13 bales per ML.

The average yield for these 12 farms was 11.12 bales per hectare. Taking into...
FIGURE 3: An estimated target GPWUI based on current best practice

- Crop Water Use Index (CWUI)
  - 39 farm Average: 1.53 Bales/ML

- Total Gross Available Water Index (GPWUI)
  - 39 farm Average: 1.13 Bales/ML

- Current Crop Transpiration plus 1.5 M/ha Winter loss estimation

- Top 12 GPWUI
  - Av: 1.20

- Target GPWUI
  - 1.39 Bales/ML
    - (based on Top 12 av yield of 11.12 bales/ha)

Top 12 above 1.53 – CWUI bales per ML

Top 12 – Current bales per ML

Top 12 – Potential bales per ML

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account the crop water use (E_t) for each farm and assuming that the best irrigation practice results in a total water loss of 1.5ML per hectare, Figure 3 shows the theoretical potential GPWUI for each farm. The average of these farms therefore represents the industry GPWUI that growers should be targeting, which is a GPWUI of 1.39 bales per ML.

Using this same scenario, but assuming a yield of 14 bales per hectare, the potential GPWUI is 1.64 bales per ML, which is significantly higher than the current 1.13 bales per ML 2006–07 survey average.

CONCLUSIONS

The process of collecting Water Use data for the 2006–07 cotton season has been a valuable exercise. The information obtained is very useful at all levels of the industry. It has provided a benchmark to gauge how industry Gross Production Water Use Index (GPWUI) has improved over the past decade or so. It will also be used as a benchmark for future comparisons of water use indices. The process was simple and quick and more importantly, utilised a consistent approach which included rainfall and seasonal weather conditions, allowing on-farm water use to be compared across the industry. The calculation of the water use indices were standardised and defined, enabling meaningful comparison.

The survey has highlighted the need for better measurement of water volumes. For the process to improve further and become more valuable, the inaccurate estimation of water volumes on farm needs to be addressed.

Determining where water is used and lost across a whole farm can be a challenging exercise. But identifying where losses are occurring is fundamental to achieving greater farm water use efficiency. Whilst it is possible to perform some basic calculations at the whole farm level, it can be quite difficult to partition water use and loss to different components of the irrigation system. This requires increased measurement opportunities and more accurate measurement on farm through better monitoring and the adoption of more accurate metering equipment.

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