WATER USE EFFICIENCY IN THE AUSTRALIAN COTTON INDUSTRY

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Summary

The Australian cotton industry has used values of Gross Production Water Use Index (GPWUI$_{farm}$) to benchmark water use efficiency since 1988/89. GPWUI$_{farm}$ for 2006-07 and 2008-09 were 1.17 and 1.14 bales/ML, and both seasons had reduced plantings, low water availability and cotton prices. In contrast, for 2012–13, which saw record planting and full production, the GPWUI$_{farm}$ was 1.12 bales/ML. There was no significant difference in GPWUI$_{farm}$ between the three seasons indicating the cotton industry is performing as water efficient in years of full production. Variation in GPWUI$_{farm}$ between farms indicates the scope for further efficiency gains.

Introduction

The Australian cotton industry gauges its water use efficiency (WUE) performance by using irrigation benchmarks. New South Wales Department of Primary Industries (NSW DPI) has measured WUE benchmarks over three recent seasons 2006-07, 2008-09 and 2012-13. Williams and Montgomery (2008) found a 40 per cent improvement in GPWUI$_{farm}$ since the previous industry estimate conducted by Tennakoon and Milroy (2003), later confirmed by Montgomery and Bray (2010).

The 2006-07 and 2008-09 seasons were very dry, water availability was low and coupled with relatively low cotton prices the Australian irrigated cotton planting was low, at around 140,000 ha. In comparison, 2012-13 saw full storage dams, good allocations and record plantings of 365,268 ha (ABS 2014). The benchmarks measured in 2012/13 will show if Australian cotton irrigators manage water efficiently when their farms are close to full production.

Methods

Over three seasons, around 40 cotton irrigators located from Central Queensland to Southern NSW provided information to benchmark their irrigation water use (Table 1). Each year the same farms were approached to participate in the project. Due to changes in farm ownership and/or management or irrigators choosing not to participate only thirty per cent of farms surveyed appear in more than one year. The sampled farms cover a wide cross section of the cotton industry, including family and corporate farms, managing a range of cotton areas with varying water entitlement. The majority of these farms irrigated using furrows, with only a small farm area under overhead or bankless systems (< 2 %).

The web-based benchmarking program WaterTrack Rapid™ (WTR) was used each season, to provide consistent benchmark calculations across the years.

WTR utilises agronomy and water data comprising: yield, soil type, planting, harvest and irrigation dates, rainfall, water harvested on farm, licensed water diversions, changes in soil water and on-farm storage volume over the season. It generated a Water Summary Report which displays the total available water (irrigation water, on-farm storage water,

Year	No. Farms	Area Planted (Ha)			Bales produced		
		Surveyed farms	Australian total[a]	% of Aus. Production	Surveyed farms	Australian total[a]	% of Aus. Production
2006/07	36	11,868	134,000	9	109,038	1,199700	9
2008/09	45	16,774	141,923	12	105,881	1,416,800	7
2012/13	46	35,575	365,268	10	410,965	4,384,000	9

[a]ABS 2014, 2010, 2008 [b]The Australian Cotton Grower Cotton Year Book (2007, 2009, 2013)

TABLE 1. The number of farms, area of cotton grown and bales produced from surveyed farms compared with the Australian cotton industry.

harvest water, rainfall and soil moisture), crop evapotranspiration (ETc) and on-farm water losses.

ETc, was computed by the WTR calculator using ETo values from SILO (Jeffery et. al 2001) with a set range of FAO56 Dual Crop Coefficients (Allen et al 1998) with effective rainfall calculated using the USDA rainfall runoff model (USDA 2004).

WTR calculated on-farm water losses as the difference between the total available water and ETc. All the on-farm water losses were combined into a single value, which included seepage and evaporation from fields, storages, supply drainage and tailwater systems and operational losses.

A number of water use performance indicators were calculated including the Gross Production Water Use Index ($GPWUI_{farm}$), Irrigation Water Use Index ($IWUI_{farm}$) and Crop Water Use Index (CWUI) and were displayed in the Performance Indicator Report.

Water use indices relate production output to a water input and are a performance indicator used to assess WUE. CWUI relates total production to the amount of water consumed by the crop (ETc). The CWUI depends mostly on agronomic factors rather than irrigation efficiencies and is useful for estimating potential crop water use and for examining crop productivity. $IWUI_{farm}$ relates total production to the amount of irrigation water supplied. It does not include rainfall or soil moisture. A more meaningful water use index for comparing WUE between seasons is $GPWUI_{farm}$, which relates total production to total available water, i.e. irrigation water + effective rainfall + soil moisture.

The WTR reports for each farm were collated to retain anonymity. Statistical analysis was conducted on each performance indicator by fitting a linear mixed model with season as a fixed effect and region as a random effect to examine if there were any significant differences in the industry benchmark figures between the three seasons. Predicted means and standard errors for each year are shown in Figures 1 and 2.

	2006–07[a]		2008–09		2012–13	
	Mean (SD)	Min Max	Mean (SD)	Min Max	Mean (SD)	Min Max
Yield (Bales/ha)	10.69 (1.91)	4.07 13.19	10.63 (1.49)	8.00 13.57	11.14 (1.55)	7.18 14.37
Total available water (ML/ha)	9.31 (1.88)	5.12 12.79	9.66 (1.75)	5.88 13.31	10.16 (1.75)	6.61 15.47
Crop evapotranspiration (ML/ha)	7.36 (0.88)	5.42 9.13	7.59 (0.74)	5.60 8.61	8.48 (0.81)	6.55 9.83
On-farm water losses (ML/ha)	1.95 (1.94)	-1.43 6.88	2.07 (1.53)	0.01 5.24	1.64 (1.44)	0.00 6.40
CWUI (bales/ML)	1.46 (0.26)	0.58 1.90	1.41 (0.21)	1.01 1.92	1.31 (0.16)	0.94 1.70
$IWUI_{farm}$ (bales/ML)	1.4 (0.45)	0.80 2.78	1.99 (0.96)	0.82 5.75	1.41 (0.39)	0.76 3.01
$GPWUI_{farm}$ (bales/ML)	1.17 (0.25)	0.69 1.71	1.14 (0.27)	0.64 1.58	1.12 (0.17)	0.73 1.43

[a] includes 7 farms with negative on-farm water losses, which were excluded in Williams & Montgomery 2008.

TABLE 2. Yield, water used, crop evapotranspiration, on-farm water losses and irrigation benchmarks established for 2006–07a, 2008–09 and 2012-13 cotton seasons.

Results and discussion

The most striking feature of the data is the variability of yield (bales/ha), total available water (ML/green ha), ETc (ML/green ha) and water use indices in all three irrigation seasons, 2006–07, 2008–09 and 2012–13 presented in Table 2. This variability shows there is scope for large improvement in crop water management.

No significant differences were found between the yield and on-farm water losses in the different seasons (Figure 1). However, there were significant differences in ETc and total available water from season to season. This was likely due to varying climatic conditions between the seasons, which affect the crop water requirement.

While yields in 2012–13 were comparable to the 2006–07 and 2008–09 season, ETc was significantly higher (Figure 1) resulting in a significantly lower CWUI in 2012–13 (1.31 bales/ML) (Figure 2).

The variation in $IWUI_{farm}$ between the seasons (Figure 2) is due to the variation in rainfall. Both 2006–07 and 2012–13 were very dry with little in-crop rainfall, irrigation water made up 89 and 83 per cent respectively of the total available water. Whereas in 2008–09 the average irrigation water supplied was only 65 per cent of total available water. The difference in the $IWUI_{farm}$ between the seasons illustrates the influence that rainfall has on this index.

The $GPWUI_{farm}$ for the 2012–13 season was 1.12 bales/ML (range 0.73–1.43 bales/ML). There was no significant difference in $GPWUI_{farm}$ between the seasons (Figure 2). While this suggests little change in $GPWUI_{farm}$ over this time, importantly, cotton irrigators in 2012–13 were managing larger cotton areas and handling larger volumes of water. In 2012–13 the average area planted on the participating farms was 773 ha, which was 135% higher compared with the area planted in 2006–07 (330 ha). The average amount of total available water managed on farm was 8,216 ML in 2012–13, which was 166% higher compared with the 3,082 ML available in 2006–07. Cotton irrigators were able to manage this extra water and produce on average an extra 5,600 bales of cotton at a similar $GPWUI_{farm}$ to 2007–6 and 2008–9 when water was scarce.

Conclusion

The average $GPWUI_{farm}$ for the Australian cotton industry in the 2012–13 season was 1.12 bales/ML. This was statistically similar to $GPWUI_{farm}$ in the 2006–07 and 2008–09 seasons, even though cotton irrigators were managing much larger cotton areas and volumes of water in 2012-13. This suggests the cotton industry uses water as efficiently in times of full availability and production as in times of water shortage. Variation in $GPWUI_{farm}$ between individual farms indicates scope for further efficiency gains. Irrigation benchmarking provides performance indicators with which individual cotton growers can rank their performance within the industry and so enable continuous improvement in water use efficiency.

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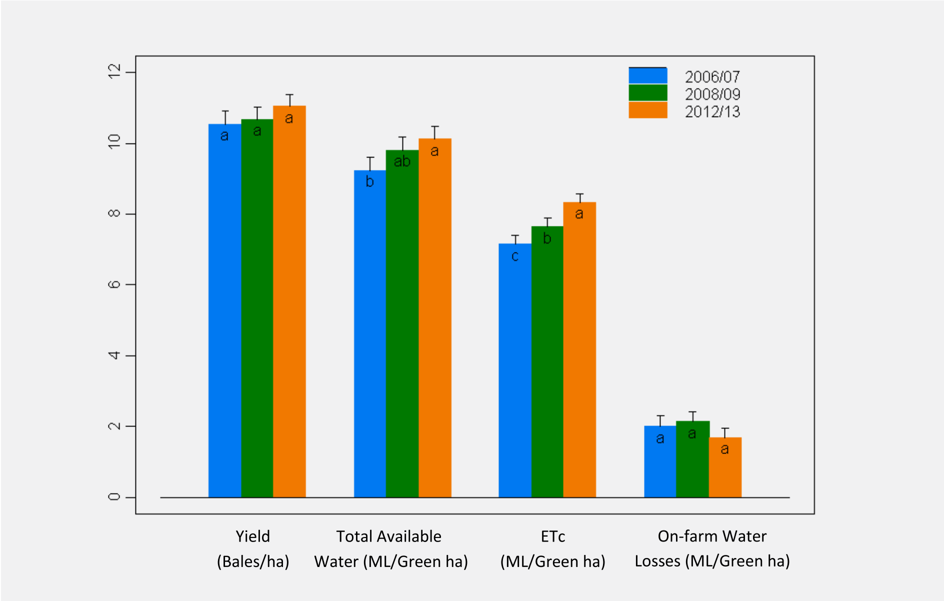

FIGURE 1. Variation in yield, total available water, ETc and on-farm water losses over three seasons. (The standard error (SE) of the predicted mean is shown a top of each bar. For each variable, bars that do not share a common letter are significantly different).

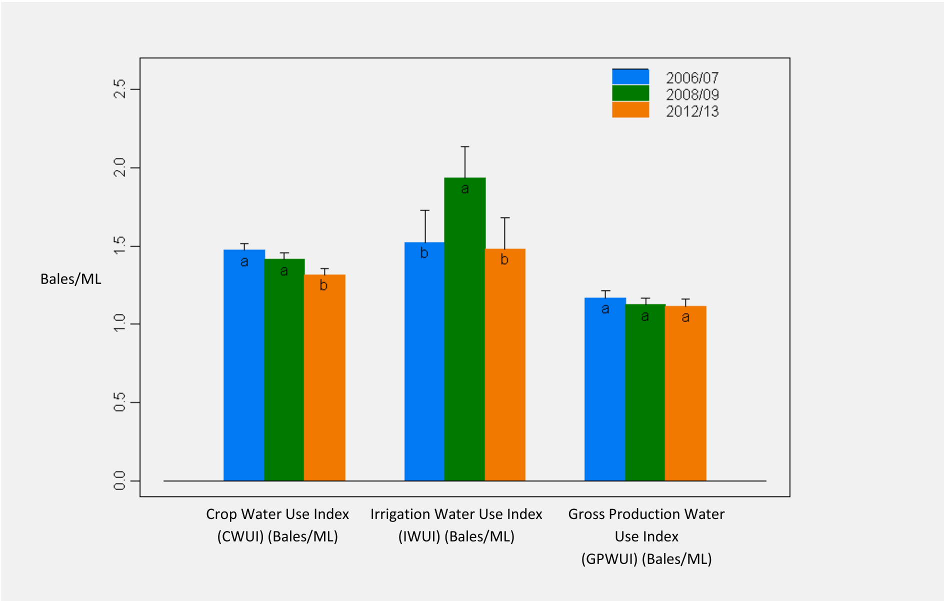

FIGURE 2. Variation in water use indices over three seasons (The standard error (SE) of the predicted mean is shown a top of each bar. For each variable, bars that do not share a common letter are significantly different).

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