

Siphon-less irrigation systems: So how did they perform?

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There are a number of siphon-less irrigation systems employed by irrigators in the cotton industry. The use of an irrigation system without siphons is not a new concept but is usually associated with overhead or drip irrigation. This project aims to review the siphon-less systems that have been flying below the radar, all of which are older systems — including two types of bay irrigation and pipes through the bank.

Although these systems are not new, they have never been tested for their fit as an efficient irrigation practice, or their potential to be optimised. The siphon-less irrigation project was developed to address this knowledge gap in the cotton industry and provide stakeholders with timely information.

The systems investigated in the project include:

- Bank-less channel irrigation;
- Bank-less head ditch irrigation;
- Pipes through the bank; and,
- Lateral move systems.

Each with a comparative furrow irrigated field. Results to date are only available for the bank-less channel, bank-less head ditch and pipes through the bank systems.

Trial design

Each siphon-less irrigation field was compared to a furrow irrigation field on the same farm, to reduce the impact of variables such as management, soil type and weather conditions. It is important to



There are a number of siphon-less irrigation systems in the industry.

note that with the trial design and preliminary results at this stage, it is not possible to compare each of the siphon-less irrigation systems to each other, only to the comparative furrow irrigated field.

Irrigation performance indices

In comparing WUE of any irrigation system, the WUE indices must be defined so irrigators and industry alike can draw direct comparisons. The indices to compare the siphon-less irrigation system to its comparative furrow irrigated field are defined as:

$$\begin{aligned} \text{Crop Water Used (CWU) (ML/ha)} \\ &= \text{irrigation water used (ML/ha)} \\ &+ \text{effective rainfall (ML/ha)} + \text{soil} \\ &\text{moisture used (ML/ha)} \end{aligned}$$

$$\begin{aligned} \text{Gross Production Water Use Index} \\ \text{(GPWUI) (bales/ML)} \\ &= \text{yield (bales/ha)} / \text{irrigation water} \\ &\text{used (ML/ha)} + \text{effective rainfall} \\ &\text{(ML/ha)} \end{aligned}$$

$$\begin{aligned} \text{Gross \$/ML} \\ &= \text{GPWUI} \times \text{Standardised Bale Price}^* \\ &^* \text{Standardised bale price} = \$400/\text{bale} \\ &\text{(except for Pima cotton where } \$700/ \\ &\text{bale used)} \end{aligned}$$

$$\begin{aligned} \text{Crop Water Use Index (CWUI) (kg/ha/mm)} \\ &= (\text{yield (bales/ha)} \times 227 \text{ kg/bale}) / \\ &(\text{CWU} \times 100) \end{aligned}$$

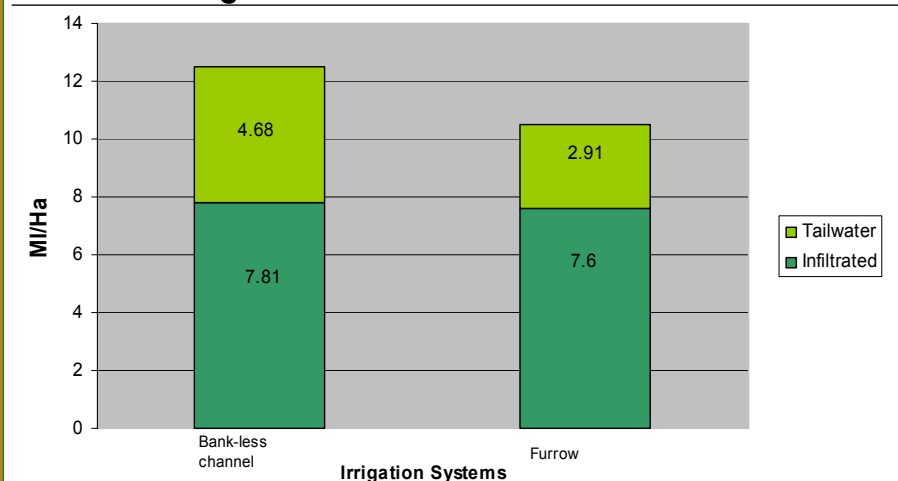
$$\begin{aligned} \text{Effective Rainfall (ML/ha)} \\ &= \text{rain available to the plant} \\ &\text{(determined using Hydrologic)} \end{aligned}$$

Irrigation performance — bank-less channel vs furrow irrigation

The 107 hectare bank-less channel field was divided into three equal bays. The bays are terraced with a 100 mm drop between each.

The bank-less channel is commonly referred to as the “roof top” system. The water is blocked off in the tail drains on either side of the field by check boards and the water is forced to flow up either side of the field from the tail drain to a peak in the middle. At the end of the irrigation for the bay, the check boards are pulled and the water rapidly moves into the next bay which is also blocked off and the process is repeated.

FIGURE 1: Measured irrigation events for the bank-less channel and furrow irrigation



The bank-less channel field suffered from compaction resulting in a possible lower final infiltration rate and subsequently lower irrigated volumes per irrigation but greater waterlogging potential. For example the average water use per bank-less channel irrigation is approximately 10 mm or 0.1 ML per hectare less than that of the adjacent furrow irrigated field. Although the bank-less channel crop was sown four days later than the furrow field, it was harvested almost three weeks after the furrow field requiring one more irrigation and yielding half a bale per hectare less.

It is thought that compaction caused less water to be used per irrigation but also more waterlogging and, consequently, a slower maturing and lower yielding crop. Ultimately this may have contributed to the system falling just short of industry minimum benchmarks for GPWUI and CWUI.

The current design of the bank-less channel system may also have affected crop performance. The inundation period between the bays throughout an irrigation event varies significantly from Bay 1 which had water on it for the whole 12 hours of an irrigation compared to Bay 3 where water is on for six hours.

This may influence yield response in bales per ML and contribute to yield variation across the bays. Efforts to improve the uniformity of irrigation are being addressed over the 2006 winter. Ground-truthed yield maps will give some indication of the impact of design on yield response.

At this stage the furrow irrigation system is performing slightly better than the bank-less channel system. Factoring in the limits, agronomic and design issues associated with the bay irrigation system, a couple of seasons of data is needed to value add to the comparison. The potential for both systems to perform well above industry WUE benchmarks needs to be further investigated.

Pipes through the bank vs furrow irrigation

The pipes through the bank (PTB) system consists of 10" diameter pipes delivering water to 16 rows. Initially this was 32 rows but it has been halved to minimise issues with uniformity. The PTB field is therefore the same design as a furrow irrigated field, except there are 16 row rotobucks compared to two row rotobucks in the siphon irrigated field.

There is not a lot of difference in performance between the PTB and the adjacent furrow irrigated field. But this is a good example of how bales per ML can be

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TABLE 1: Irrigation performance — bank-less channel and comparative furrow irrigated field.

	Industry standard	Bank-less channel	Furrow
Variety	—	71Conv	71Conv
Row length (m)	—	375	770
Per furrow flow rate (L/sec)	—	4	3
Average shift length (hrs)	—	12,8,4	10
Final infiltration rate (ML/ha/hr)	—	0.02	0.03
Number of irrigations	—	9	8
Infiltrated irrigation water (ML/ha)	—	7.81	7.6
CWU TOTAL (ML/ha)	7.5–8.5	9.29	8.34
Yield (bales/ha)	—	10.9	11.4
Effective rain (ML/ha)	—	2.44	2.65
GPWUI (bales/ML = irrigation water + effective rainfall)	1.1	1.07	1.11
CWUI (kg/ha/mm)	2.79	2.66	3.1
Gross (\$/ML = irrigation water and effective rain)	—	\$428	\$445

TABLE 2: Irrigation performance indicators for the pipes through the bank and comparative furrow irrigated field

	Industry standard	PTB	Furrow
Variety	—	289BR	71BR
Row length (m)	—	1020	785
Average per furrow flow rate (l/s)	—	2.2	2.6
Average shift length (hrs)	—	13	11
Final infiltration rate (ML/ha/hr)	—	0.02	0.03
Number of irrigations	—	8	9
Irrigation water (ML/ha)	—	7.4	8.47
CWU (ML/ha)	7.5–8.5	8.2	8.24
Yield (bales/ha)	—	8.6	8.6
Effective rain (ML/ha)	—	2.62	2.62
GPWUI (bales/ML = irrigation water + effective rainfall)	1.1	0.86	0.79
CWUI (kg/ha/mm)	2.79	2.38	2.37
Gross (\$/ML = irrigation water and effective rain)	—	\$343	\$318

TABLE 3: Irrigation performance — bank-less head ditch and comparative furrow irrigated field.

	Industry standard	Bank-less head ditch	Furrow
Variety	—	Pima	71BR
Row length (m)	—	580	830
Average per furrow flow rate (l/s)	—	3.1	2.9
Average shift length (hrs)	—	9	10
Final infiltration (ML/hr/hr)	—	0.02	0.02
Number of irrigations	—	8	9
Irrigation water (ML/ha)	—	6.93	7.16
CWU (ML/ha)	7.5 – 8.5	7.23	8.24
Yield (bales/ha)	—	4	9.94
Effective rain (ML/ha)	—	2.22	2.2
GPWUI (bales/ML = irrigation water + effective rainfall)	—	0.44	1.06
CWUI (kg/ha/mm)	2.79	1.26	2.74
Gross (\$/ML = irrigation water and effective rain)	—	\$306	\$425

misleading because it does not account for other factors apart from irrigation management and their impacts on yield.

Both crops suffered long periods of wa-



The pipe through bank system.

terlogging up to and just past flowering due to a series of isolated thunderstorms that fell on the trial site. Also, both crops were hail damaged. Hydro probes in one field indicated weeks of root inactivity which may have led to significant fruit shedding according to Hydrologic modelling. Consequently, water use was slightly excessive and yields were a little down resulting in low benchmark yields but comparable irrigation performances between the two systems.

Both systems have been improved through the season and changes to irrigation practices next year will result in further improvements. It will be important to monitor and document this progress towards optimisation.

Irrigation performance — bank-less head ditch vs furrow irrigation

The bank-less head ditch is a modified furrow irrigation system where the rotobuck side of the head ditch is removed. Checks are placed 100 metres apart in this modified head ditch and these 100 metres sections are once again terraced with a

drop of 100 mm between each. The water comes into the head ditch through the existing supply pipe and, when checked by the boards, is forced to flow down the paddock. The tailwater return system is the same as in the furrow field. The idea is that, if a high enough flow rate can be maintained, the water will advance quickly and uniformly down the paddock.

This comparison can really only be gauged at the dollar per ML level because of the huge variation in variety. Generally Pima is a lower yielding but higher value cotton so bales per ML cannot be directly compared. The bank-less head ditch used slightly more water per irrigation. But there was a lower plant stand and greater irrigation intervals which probably contributed to higher deficits resulting in this higher than average application when compared to the furrow irrigated field. The poor plant stand, lower than average Pima yield and lower than expected bale price of the Pima together resulted in a significant difference in gross margin per ML.

This system, an innovation on the part of the farming enterprise, has not performed entirely as expected. For example, flow rates were expected to be higher and shift lengths much lower. Some of the design issues have been addressed and another season of experimentation would be extremely beneficial. Currently there is enough information for further research and development of the design of this system and its optimisation.

SUMMARY

This is preliminary data only. The systems have not been fully optimised, with some partially optimised throughout the season. All furrow and siphon-less systems have shown potential to benefit from optimisation, which will be further explored next season — subject to further funding being available.

The preliminary irrigation performance data shows that the furrow system outperformed the bank-less head ditch and bank-less channel systems in all irrigation performance indices. Both systems suffered from agronomic and design issues, some of which will be addressed over the 2006 winter. The PTB performed on par with the adjacent furrow irrigated field.

Distribution uniformity is a limiting factor of all three siphon-less irrigation systems and it will be addressed through system design and optimisation. Application efficiency is sub optimal in the furrow irrigated systems and optimisation will also improve its performance.

FIGURE 2: Measured irrigation events for pipes through the bank and comparative furrow irrigated field

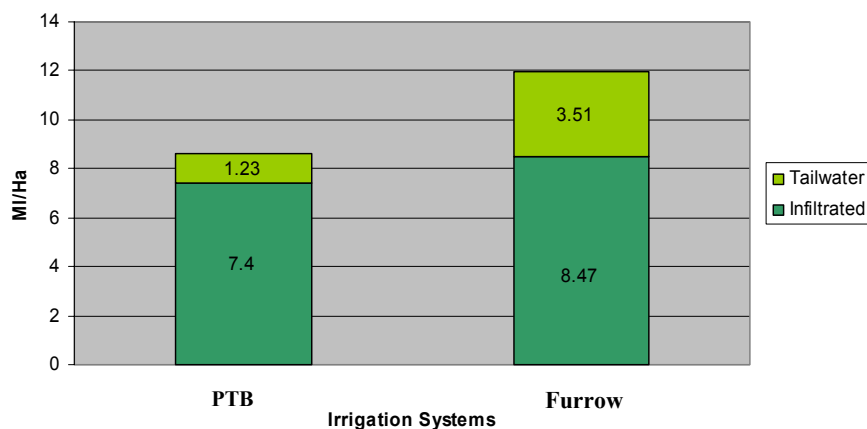


FIGURE 3: Measured irrigation events for the bank-less head ditch and comparative furrow irrigated field

