Low-cost drip irrigation – representative economic analysis, Burdekin region

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Summary

The use of drip irrigation can improve the efficiency of water application and reduce water losses from runoff and deep drainage when compared to furrow irrigation. This report compares the profitability of a conventional furrow irrigated system with a drip irrigated system in the Burdekin Delta and the Burdekin-Haughton Water Supply Scheme (BHWSS) area. In particular, the report:

(1) Examines the investment required to install drip irrigation
(2) Evaluates the growing expenses associated with both furrow and drip systems in the two regions
(3) Calculates the yield improvement necessary for the investment into drip irrigation to attain the same profitability as a furrow irrigation system (break-even yield)
(4) Undertakes sensitivity analyses to examine how the break-even yield is influenced by variations in electricity costs, installation costs and cane yield decline in late ratoons.

Based on the defined assumptions, the analysis establishes that a number of growing cost differences exist between furrow and drip irrigation. For instance, drip irrigation was found to have relatively lower weed control, cultivation, laser levelling and irrigation labour expenses. In contrast, crop nutrition and irrigation electricity expenses were relatively higher for drip irrigation. A number of differences also exist between the Burdekin Delta and the BHWSS area. Overall, the drip systems growing expenses were relatively lower for both regional scenarios.

While the drip scenarios were found to achieve a higher average gross margin, the increased cash flows are not enough to recover the initial investment without realising a yield improvement. As farmers commonly install drip to improve their yields, this report examined how much extra cane yield would need to be grown for the investment to be profitable. To generate enough revenue to repay the installation costs and break-even with a furrow irrigation system, the Delta drip irrigation scenario needs to attain an extra 16.7 TCH above the yield attained by furrow irrigation. This improvement needs to be maintained during every crop class over two crop cycles. In comparison, a yield improvement of 22.7 TCH is necessary for the BHWSS scenario. The sensitivity analyses identified that the economic outcome is sensitive to variations in electricity and installation costs, while minimal yield decline in late ratoon crops would improve the economic outcome.

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Table of contents

Table of figures

Table of tables

1 Introduction

The NQ Dry Tropics Sugarcane Innovations Programme explores innovative and aspirational practices to reduce nutrient and pesticide losses from Burdekin sugarcane farms. The programme is funded through a number of organisations including: Project Catalyst, a pioneering partnership funded by the Coca-Cola Foundation through the World Wide Fund for Nature (or WWF); the Australian Government Reef Programme GameChanger project; and the Australian Government Reef Programme through Reef Water Quality Grants that allow early adoption of practice changes to ultimately improve water quality outcomes. These projects are delivered in partnership with the Department of Agriculture and Fisheries, Farmacist, Burdekin Productivity Services and the Burdekin Bowen Integrated Floodplain Management Advisory Committee (BBIFMAC).

A particular focus of the innovations programme is to foster the rapid uptake of innovative management practices and technologies that improve the quality of water leaving farms in order to alleviate the potential for adverse effects on the resilience of the Great Barrier Reef. It provides an opportunity for sugar cane growers to work closely with technical specialists to examine game changing management practices that may enhance productivity and profitability while improving environmental outcomes. The farm-based research trials undertaken as part of the programme highlight the associated costs and benefits of adoption, as well as practical improvements to management practices. They generate evidence-based research data and advance knowledge about the implications from adopting innovative practices. Moreover, the engagement process facilitates the communication of information by enabling participating farmers to learn and disseminate their experiences to other farmers, which serves as a catalyst to a sustainable farming future.

The use of drip irrigation may help Burdekin sugarcane growers to improve the water use efficiency of their irrigation systems as well as to reduce labour intensity. As irrigation can be the main conduit for the movement of nutrients and pesticides, improvements in water use efficiency are likely to reduce their loss into the environment. This report explores the economic feasibility of installing and operating low-cost drip irrigation in the Burdekin Delta and the BHWSS area.

2 Low-cost drip irrigation in the Burdekin

While furrow irrigation is by far the most widely used irrigation system in the Burdekin (Qureshi et al, 2001), drip irrigation as an alternative can provide considerable benefits. The use of drip irrigation can improve the efficiency of water applications and reduce water losses from runoff and deep drainage when compared to furrow irrigation. As irrigation can be the main conduit for the movement of nutrients and pesticides, improvements in application efficiency are likely to reduce their loss into the environment. Drip irrigation can be particularly effective at improving irrigation application efficiency on high infiltration soils such as sands or loams.

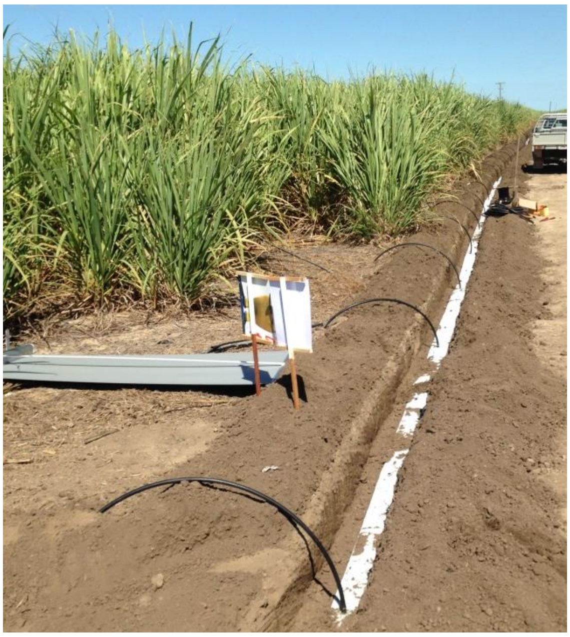
Drip tape (or Dripperline) also enables nutrients to be applied through fertigation to mimic crop requirements, as opposed to the common practice of applying large quantities of nutrients in a single application. Applying nutrients in this way also eliminates the need for a machinery operation. Labour savings are another drawcard. Drip irrigation does not require the user to monitor irrigation flow at the end of furrows. A drip system can be fully automated, allowing it to be started, run and finished remotely. Irrigation volumes and starting intervals can be based on scheduling tools, such as capacitance probes and evapotranspiration models, or prior experience.

Water applied with drip irrigation does not need to infiltrate into the bed profile. Accordingly, drip irrigation systems do not need to apply soil ameliorants (e.g. gypsum or lime) to improve water infiltration, thus requiring lower application rates compared to furrow systems. Since the soil profile is only partially wetted on drip irrigated blocks compared to furrow, the dry-down period prior to harvest is significantly reduced (usually to around five or six weeks). As a result the vigour of ratoon crops improve, which can extend the crop cycle by one or two additional ratoons. Moreover, since the soil surface is not usually wet up when irrigating, weed pressures are typically lower than what is common on furrow irrigated blocks. Consequently, weed management with drip irrigation is not as demanding and requires less control (i.e. herbicide spray operations). However, out-of-season rainfall events are likely to negate the weed control benefits (i.e. lower weed pressures) that are attainable by drip irrigated systems.

Along with the benefits already mentioned, there have been numerous instances where drip irrigation has substantially improved cane yields. See Shannon (2014) for a comprehensive review of drip irrigation on sugarcane farms in the Burdekin. Nevertheless, drip irrigation systems need to be well-maintained to function efficiently, which includes implementing preventative measures to minimise root intrusion of emitters and restricting rodent damage through the utilisation of effective pest control practices. Poor maintenance could limit benefit potential and bring about unexpected repair costs.

One constraint to the adoption of drip irrigation is that it is expensive to install. However, there are some low cost alternatives available. For example, some sugarcane growers can substitute more expensive options like gravel filters and PVC supply sub-mains with low cost options including screen filters, and sunny hose or polynet sub-mains. There are also options to reduce dripperline costs by using non-pressure compensating emitters.

Image 1: Drip irrigation (PolyNet® sub-mains).



3 Methodology

The objective of the economic analysis is to compare the profitability of a conventional furrow irrigated system with a drip irrigated system. In particular, the report evaluates the growing expenses associated with both irrigation systems, and calculates the yield improvement necessary for the investment into drip irrigation to be profitable (break-even yield).

As irrigation systems on farms within the Burdekin Delta tend to be quite different to those situated in the BHWSS (e.g. water scheme and sources, applied water volumes, infrastructure), the economic evaluation investigates two farm scenarios that have been developed to better represent both regions. The two scenarios examine common farm configurations in each region and are based on historical data, grower surveys, and advice from technical specialists about the particular characteristics of each region. Examining farm scenarios depicting both regions provides insights into the impact on profitability from installing and using drip irrigation, as well as any specific differences that could be expected.

The Farm Economic Analysis Tool (FEAT) was used to undertake a comprehensive evaluation of the implied revenues and costs of each farming system configuration. From these results, the gross margins of both systems are compared, which is calculated by taking the revenue received from the crop and subtracting the variable[1] costs involved with growing the crop.

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[1] Variable costs include fertiliser, chemical, machinery, harvesting and volumetric irrigation expenses.

Key factors in the examination include the costs to install drip irrigation as well as the relative crop growing expenses of both irrigation systems. Using these installation costs and relative growing expenses, the annualised benefit or cost associated with an investment into drip irrigation is calculated assuming that both systems yield exactly the same amount of sugar. To identify the yield improvement necessary for the investment to be acceptable, the analysis calculates how much extra cane needs to be grown by the drip irrigation scenario for it to payback the initial investment and ensure the same profitability as the furrow irrigated scenario (the break-even yield). Average cane yield and Commercial Cane Sugar (CCS) data for each region are used to calculate revenue.

The following subsections outline the parameters that were used to carry out the economic analysis and draw on a wide range of information including trial data generated from the Sugar Innovations Programme and past research, as well as advice from technical specialists and suppliers.

3.1 Farm configurations and irrigation system parameters

Table 1 lists the farm and irrigation parameters that were used to develop the scenarios for both regions. Each of the variables listed has some influence on the costs and benefits from using particular irrigation systems. For instance, the quantity of water applied may impact on water and electricity costs. Accordingly, any reductions in the quantity of water applied would generate savings in water or electricity expenses. The farm sizes represent the average farm size in each region.

Repairs and maintenance costs of the furrow irrigation system in each region incorporates spending on repairing and maintaining pumps, motors, fluming and cups and includes any necessary labour costs. Repairs and maintenance costs per megalitre (ML) are calculated by dividing the total cost by the quantity of water applied.

Table 1: Farm and irrigation parameters (furrow irrigation).

Parameter	*Units*	Delta	BHWSS
Farm size	*hectares*	100ha	200ha
Crop cycle	*number of ratoons*	3 ratoons	3 ratoons
Irrigation water applied	*ML/ha/yr*	20ML	10ML
Recycled water	*% of applied water*	0%	20%
Electricity costs	*$/ML*	$20/ML	$20/ML
Labour	*hours*	9hrs/ha	5hrs/ha
Repairs & maintenance	*$/ML*	$5/ML	~$5/ML

3.2 Costs associated with installing and maintaining drip irrigation

While it is theoretically possible to install drip over a whole farm, it is unlikely to occur due to a range of obstacles. For instance, the capital expenditure necessary to install drip across a whole farm is very high and many growers may not have access to requisite funds. Also, growers may wish to trial drip irrigation on a segment of their farm first before rolling it out over their whole farm. This way they can identify the relative costs and benefits of drip on their farm, or examine the pros and cons of a particular system. Consequently, the analysis assumes that a grower installs drip over one fifth of the farm, which is approximately equal to the fallow area on the representative farms each year.

Table 2 lists the assumed costs to install drip irrigation for each regional scenario. These prices are based on quotes from reputable suppliers as well as advice from technical specialists and growers that have installed a drip irrigation system. The largest cost component of the investment is the dripperline in both regional scenarios. Overall, the total investment needed for the Burdekin Delta scenario is approximately $5,500 per hectare, while the BHWSS scenario requires a comparatively higher investment at just above $6,100 per hectare.

Table 2: Breakdown of investment.

Item	DELTA (20ha)			BHWSS (40ha)		
	Qty.	*Subtotal*	*%*	*Qty.*	*Subtotal*	*%*
Dripperline (PC emitters, 22mm)	*DripNet™*	$56,000	*51%*	DripNet™	$112,000	*46%*
Mainline and sub-mainline	*Poly/FlatNet™*	$7,000	*6%*	PVC pipe	$25,000	*10%*
Filters	*see valve assemblies*			Sand (x4)	$22,000	*9%*
Shed[2]		$9,000	*8%*		$18,000	*7%*
Installation (Contractors/labour)		$8,200	*8%*		$17,500	*7%*
Pump, motor and VFD[3]	*15kW*	$9,500	*9%*	30kW	$17,000	*7%*
Controller	*NMC Junior®*	$5,500	*5%*	WiSA®	$14,500	*6%*
Valve assemblies	*x4 (including Disc filters)*	$6,500	*6%*	x6 (without filters)	$4,500	*2%*
Injection unit		$3,200	*3%*		$5,500	*2%*
Miscellaneous[4]		$4,500	*4%*		$9,000	*4%*
Total	*$5,470/ha*	**$109,400**		*$6,125ha*	**$245,000**	

Similarly to other pieces of farm equipment, the drip system requires maintenance to ensure efficient operation. Table 3 outlines the forecasted maintenance costs for the systems in each region.

Table 3: Estimated annual repairs and maintenance costs[5].

Item	DELTA (20ha)	BHWSS (40ha)
Repairing/maintaining water pump and motor[6] (average)	$1,000	$1,600
System flushes to disinfect/remove precipitation (e.g. algae, fert.)	$600	$1,200
Replacement of dripperline and pipe infrastructure (incl. labour)	$500	$1,000
Pest control (i.e. rat baits)	$300	$600
Filter maintenance	$100	$400
Annual total	**$2,500**	**$4,800**
$/ha	*$125/ha*	*$120/ha*

The replacement of dripperline and pipe infrastructure is dependent on effective pest control (e.g. rodents) as well as system maintenance in order to keep emitter blockages to a minimum. However, ineffective pest control or poor maintenance is likely to increase repair costs considerably. This analysis assumes that irrigators can effectively control pests and maintain the system.

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[2] A shed, or irrigation room, is needed to house the controller for the irrigation system and to store fertiliser.

[3] A variable frequency drive (VFD), or variable speed drive, can be used to optimise the speed and torque of a water pump's motor by changing input frequency and voltage. Such adjustments may enhance energy use efficiency, thus reducing input costs.

[4] Valves, meters, gauges, regulators, connections, risers and fittings.

[5] The price estimates for the capital investment items (e.g. equipment) include technical support from suppliers. Consequently, additional costs for consultants to provide assistance if the system is not working have not been taken into account. However, this may be added in the future as data are collected from trials involved in the Sugarcane Innovations Programme.

[6] For example, replacing pump packing and rewiring (electric) motors following burnout.

3.3 Anticipated costs and benefits from using drip irrigation

The key differences between each system have been estimated to determine the relative costs and benefits that a drip irrigation system in each region may deliver (see Table 4). For instance, the adoption of drip irrigation decreases the volume of applied irrigation water and quantity of labour hours required to operate the system, especially for the Delta scenario. Drip irrigating also alleviates the need to apply gypsum and to laser level blocks for irrigation purposes. In addition, the drip scenarios take into account:

- Fewer weed control operations from lower weed pressures
- Decreased nutrient use due to split fertiliser applications (improved targeting of nutrient uptake by fertigation)[7]
- An extension of the crop cycle by one additional ratoon[8]
- Zero cultivation in ratoon crops

On the other hand, drip irrigating may require additional farm operations or incur some additional costs relative to furrow irrigation. For example, the drip scenarios factor in a bedforming operation and the higher costs associated with applying liquid and crystalline fertilisers necessary for fertigation. Even more importantly, the analysis assumes that the electricity costs necessary to apply each megalitre of water more than doubles with the move to drip irrigation.

Table 4: Key differences between furrow and drip irrigation systems.

Item	DELTA		BHWSS	
	Furrow	*Drip*	*Furrow*	*Drip*
Applied irrigation water (ML/ha)	20	10	10	8[9]
Irrigation electricity costs ($/ML)	$20/ML	$45/ML	$20/ML	$45/ML
Irrigation labour (hrs/ha)	9	3[10]	5	1.8[6]
Laser levelling (hrs/ha)[11]	1 hr/ha	0	1 hr/ha	0
Soil ameliorants – applied in fallow (t/ha)	3	0	5	0
Number of ratoons	3	4	3	4
Fertiliser	100% (granular)	90% - fertigation (prilled/crystalline[12])	100% (granular)	90% - fertigation (prilled/crystalline)
Cultivation	Typical	Additional pass with bedformer but no cultivations in ratoons	Typical	Additional pass with bedformer but no cultivations in ratoons
Weed control (operations/crop)	2	1	2	1

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[7] The reduced fertiliser usage from fertigating that has been used for the analysis (presented in Table 4) maybe conservative. Shannon (2014) states that Burdekin growers with drip irrigation are generally applying around 75-80% of the nitrogen that they normally apply on their furrow irrigated blocks. Furthermore, Dart, Baillie and Thorburn (2000) and Ridge and Hewson (1995) both found that nitrogen rates around 25% lower than what was applied on furrow blocks (industry standard) maximised sugar yield potential on drip irrigated blocks.

[8] Reported yields that were achieved by drip irrigators in the Burdekin have been higher in later ratoons than on furrow irrigated blocks indicating support for extended ratooning of the crop (Shannon 2014).

[9] This decrease is predominantly due to reduced runoff that does not need to be repumped from the recycle pit. In this case, only savings in energy costs are assumed as recycled water has no volumetric water charge.

[10] Tasks include turning on pump and setting timer (for every irrigation), monitoring flow rates and system pressures, and removing and reattaching aboveground sub mainlines (Delta only) during harvest.

[11] Laser levelling is assumed to occur every second crop cycle.

[12] Liquid nitrogen products, such as Easy N®, are preferred as they are easy to inject. However, the price differential between these products and prilled Urea determines demand (Shannon, 2014).

Notably, the analysis incorporates the purchase of a new high pressure water pump and motor suited to drip irrigation applications. Recycling pumps/motors from furrow irrigation systems may not optimise pumping efficiency and using a pumping system with poor efficiency may cause a blowout in electricity consumption/costs or may be incapable of delivering the pressures required for the system to flush properly.

3.4 Other key parameters

The analysis uses ten-year average production data for both regions to estimate revenue for the economic analysis. These yields (tonnes of cane per hectare or TCH) and CCS measures are shown in Table 5. Both the furrow and drip irrigation scenarios are assumed to have the same production (yields and CCS) for the initial analysis.

Table 5: Estimated cane yield and CCS.

	Cane yield (TCH)					**CCS**				
	Plant	*1R*	*2R*	*3R*	*4R*[13]	*Plant*	*1R*	*2R*	*3R*	*4R*[7]
Burdekin Delta	143	124	115	106	97	14.5	14.5	14.5	14.5	14.5
BHWSS	132	114	105	95	85	14.9	14.8	14.7	14.7	14.7

Apart from the key differences between the irrigation systems, a number of other parameters need to be estimated to carry out the economic analyses. To focus the analysis on the specific changes in question, a number of variables are standardised so that the results are not influenced by short term changes in prices. The economic analysis uses the five-year average net sugar price[14] of $430 per tonne, while all input prices (e.g. fertiliser and electricity) are sourced from local suppliers. In addition, the analysis assumes a discount rate of 7 per cent and a labour cost of $30 per hour.

The projected life of the equipment is over two crop cycles, for which each crop cycle is prolonged by an extra ratoon (four ratoons) due to the use of drip irrigation. Assuming the drip irrigation system is installed during the fallow (year 0), the analysis assumes an eleven year investment life (a fallow is included as year six). All other expenditure on the drip system over its life becomes encapsulated within irrigation repairs and maintenance.

3.5 Risk analysis

Electricity expenses generally account for a large proportion of irrigation operating costs. Due to considerable variation in pump efficiencies and limited research into the electricity consumption/costs associated with drip irrigating in the Burdekin, it is difficult to determine the precise changes in electricity costs when shifting from furrow to drip irrigation. In particular, selecting the optimal pump arrangement for a particular drip irrigation system is imperative to effectively manage electricity costs. Accordingly, a sensitivity analysis is completed to investigate how the economic outcome is affected when electricity costs per megalitre of applied irrigation water range between one ($20/ML) and four times ($80/ML) greater than that required by an average furrow irrigation system.

The capital investment necessary to install a drip irrigation system is likely to be dependent on a range of factors (e.g. water quality, dripperline selection, block size and individual preferences). To take into account farm heterogeneity, a range of possible drip installation costs are explored.

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[13] Fourth ratoon yield and CCS measures are only used for the drip scenario. These are estimates based on the general trend in yield decline through the ratoon crops, respective of region.

[14] Using net sugar prices from Queensland Sugar Limited's seasonal and harvest pools between 2010 and 2014 (Queensland Sugar Limited, 2015).

Specifically, a sensitivity analysis is completed to explore how the economic outcome is influenced between a range of $0 and $7,500 per hectare.

An enhancement in the ratoonability of crops from drip irrigating is another uncertainty. Reducing the dry-down period prior to harvest can improve the vigour of ratoon crops. However, yield decline during late ratoon crops is likely to vary amongst farms and even on-farm (e.g. different varieties and annual climatic conditions). Hence, the influence of cane yield decline during late ratoon crops (fourth and fifth ratoon crops) on the break-even yield is considered. In particular, the case study explores the impact on the economic outcome from cane yield decline between a range of 0 and 20 TCH from the fourth ratoon onwards for both a four and five ratoon crop scenario?

4 Results

The results of the economic analysis are organised into four subsections. Firstly, average annual growing expenses for both the furrow and drip irrigation systems are evaluated followed by a comparison of each system's expected gross margins. Next, an investment analysis is completed to identify the annualised benefit of the investment into the drip system assuming both irrigation systems have identical yields. Based on this information, a break-even yield analysis is completed to identify the yield improvement necessary for the investment to be acceptable. To extend on these findings, the final subsection examines the sensitivity of the economic outcome to changes in cane yield, electricity costs, installation costs and cane yield decline during late ratoon crops.

4.1 Growing expenses

Specific growing costs that were found to be either relatively lower or higher for the drip irrigation scenarios are outlined in Table 6. A comparison of the different growing costs between the irrigation systems highlights a mix of cost savings and higher expenses.

Table 6: Differences in growing costs when drip irrigating.

Lower costs when drip irrigating	Higher costs when drip irrigating
• Weed control • Irrigation labour • Cultivation • Laser levelling • Soil ameliorants • Planting costs[15]	• Crop nutrition • Irrigation electricity expenses • Irrigation repairs and maintenance

The average annual growing expenses for the furrow and drip irrigation scenarios are examined in greater detail in Figures 1 and 2. A total of these expenses are compared in the far right column of the graphs to draw attention to the overall difference in growing costs between the two irrigation systems. A number of differences between the two regional scenarios are notable. For instance, electricity costs for both systems were more comparable in the Delta as the volume of water applied by the drip system decreased (by half) nearly enough to offset the increase (more than double) in electricity pumping costs. Another example was the higher savings in soil ameliorant expenses in the BHWSS. In comparison, ameliorants are generally applied more sparingly in the Burdekin Delta. Overall, the drip system's growing expenses were relatively lower in both regional scenarios.

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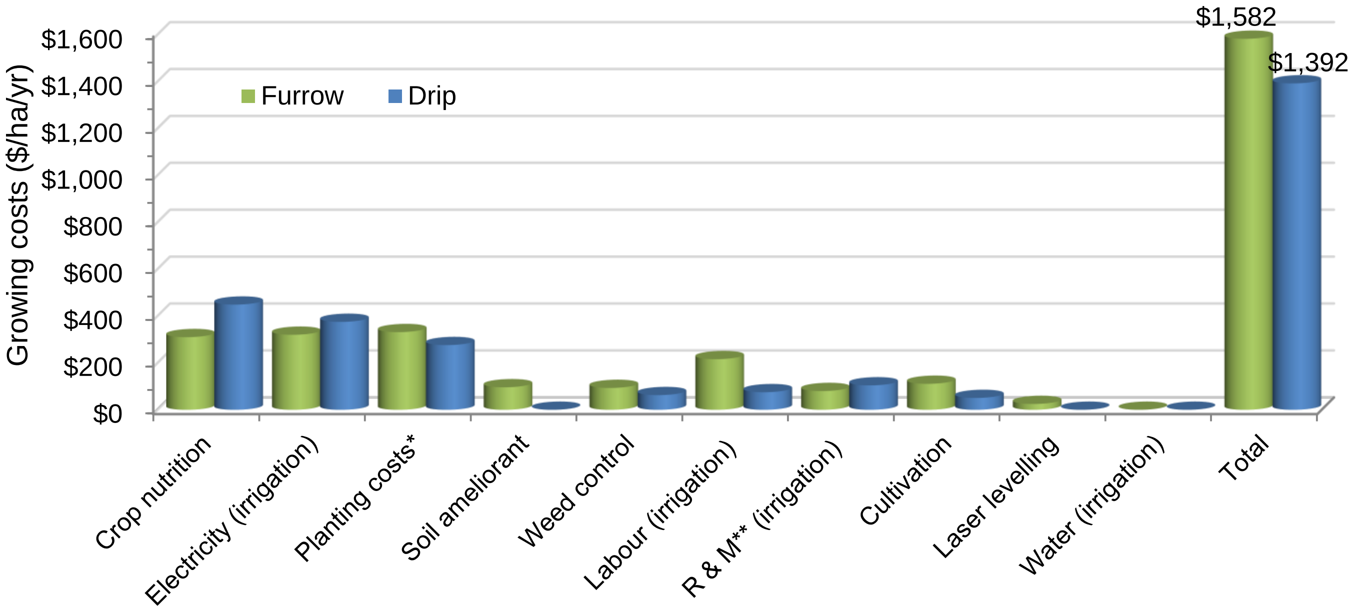
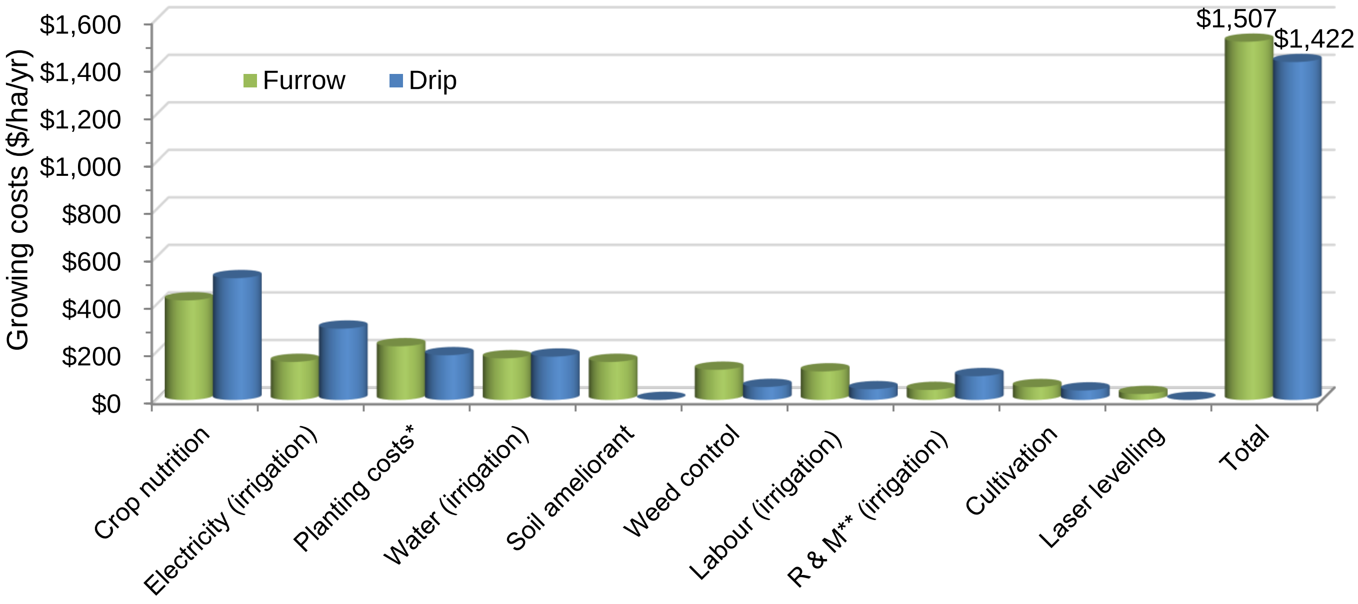
[15] The extra ratoon crop decreases the average planting cost.



* Repairs and maintenance of irrigation system
**Also includes disease and insect control (37 per cent of total)

Figure 1: Average annual growing costs – Burdekin Delta.



* Repairs and maintenance of irrigation system
**Also includes disease and insect control as well as soil testing (7 per centof total)

Figure 2: Average annual growing costs – BHWSS.

4.2 Gross Margin Analysis

Undertaking a gross margin analysis is a useful way to compare the annual profitability of different investments before taking into account the capital investment (i.e. drip installation costs) and the time value of money. Figures 3 and 4 compare the gross margins of the furrow and drip irrigation scenarios during each crop class when assuming that each treatment has the same production. In addition, the average gross margin is compared in the far right column of the chart. For the Delta scenario, the gross margin for drip irrigation is slightly higher in every crop class. In contrast for the drip irrigated

BHWSS scenario, savings made during the fallow offset relatively lower gross margins in each crop class. For both regional scenarios, drip irrigation achieves a higher average gross margin due to lower growing costs (see graphs above).

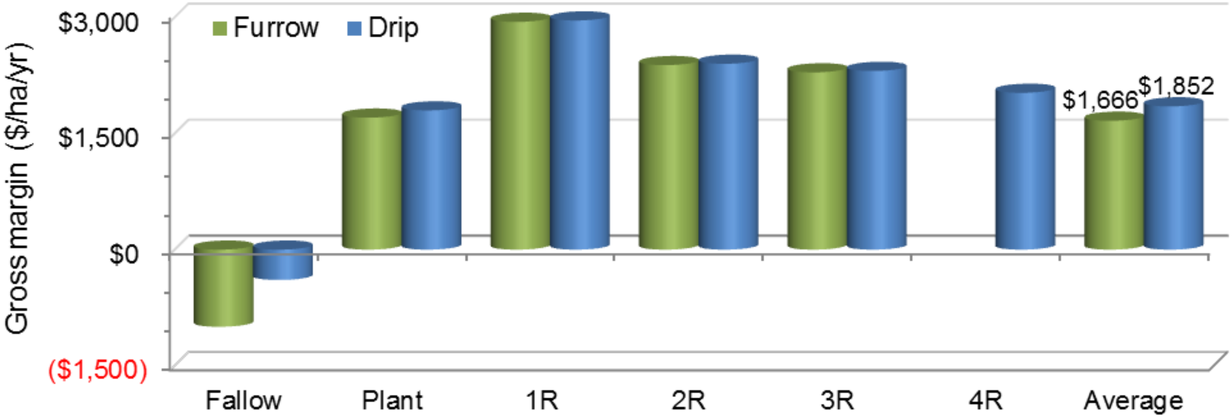


Figure 3: Gross margin during each crop class – Burdekin Delta.

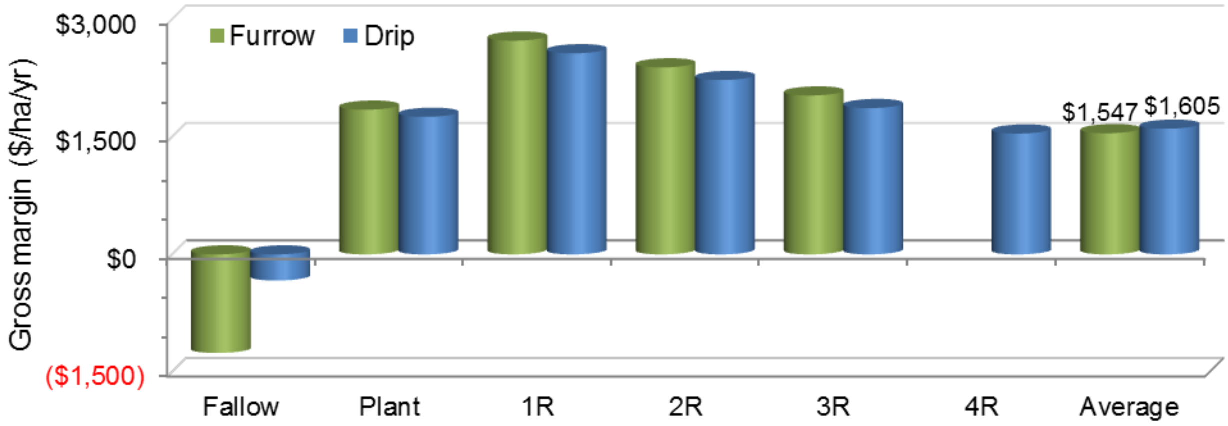


Figure 4: Gross margin during each crop class – BHWSS.

4.3 Investment analysis

Figure 5 presents the annualised benefit/cost (AEB[16]) of investing in drip irrigation for the two regional scenarios. The annualised benefit takes into account the capital expenditure into drip irrigation as well as differences in crop growing expenses between the irrigation systems. It enables the average annual return for the furrow and drip irrigation scenarios to be compared over the life of the drip investment.

The chart on the left of Figure 5 presents the annualised benefit of the investment into drip irrigation for both regions. For this initial analysis, it is assumed that drip irrigation yields exactly the same amount of cane as furrow irrigation. Under this assumption, the investment into drip irrigation delivers a large negative annualised benefit in both regions. While the drip scenarios achieve a higher average gross margin than furrow irrigation, the increased cash flows are not enough to recover the capital investment. To generate enough revenue to repay the installation costs, the drip scenarios need to attain comparatively higher yields than the furrow irrigated blocks.

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[16] The Annualised Equivalent Benefit (AEB) is a transformation of an investment's net present value. It is a useful measure to compare the performance of investments that produce benefits over different horizons.

When comparing between the two regions, not only does the Delta scenario have relatively lower installation costs ($5,470/ha compared to $6,125/ha), but it also attains more savings in crop growing expenses from shifting to drip irrigation. As a result, the investment for the Burdekin Delta scenario generates a relatively higher annualised benefit at -$507/ha, compared to -$706/ha for the BHWSS scenario.

The chart on the right of Figure 5 examines the yield improvement necessary for the drip scenarios to realise the same profitability as furrow irrigation (break-even yield). These yield increases are required during every crop class over two crop cycles (the investment's life). The analysis assumes a constant CCS level and that all other input costs remain constant (weed control, harvest costs, etc.). For the Burdekin Delta scenario, an extra 16.7 TCH is needed by drip during each crop class to break-even with furrow irrigation. Comparatively, the BHWSS scenario needs an increase of 22.7 TCH.

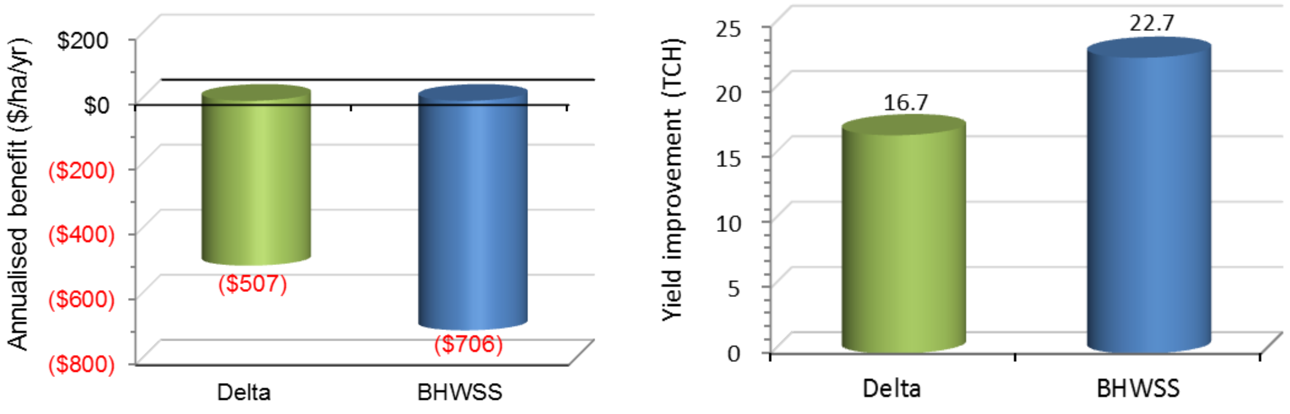

Figure 5: Annualised benefit of the drip investment (left), and break-even cane yield (right).

4.4 Risk analysis

This section extends on the preceding analysis to examine how the annualised benefit is affected by improvements in cane yield, and how the break-even yield is influenced by variations in electricity costs and installation costs. Also, the impact of yield decline during late ratoon crops on the annualised benefit of the drip irrigation investment is investigated.

4.4.1 Cane yield improvement

Figure 6 examines the annualised benefit (or cost) from investing in drip irrigation at various improvements in cane yield. It builds on the break-even yield analysis (see Figure 5) by enabling readers to examine the comparative profitability of investing in drip irrigation, based on expected improvements in cane yields above those produced by furrow irrigation. For example, assuming that a shift to drip irrigation in the Burdekin Delta boosted cane yields by 20 TCH then the comparative improvement in earnings would be around $100 per hectare every year over the life of the investment.

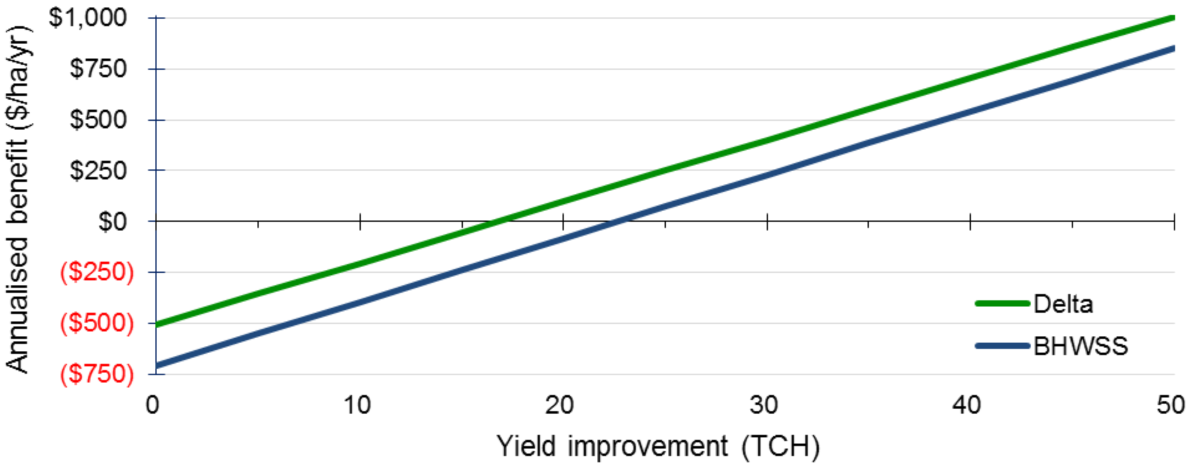

Figure 6: Annualised benefit of drip investment over a range of cane yield improvements.

4.4.2 Electricity costs

For the initial examination, the electricity cost to apply one megalitre of irrigation water via drip irrigation was assumed to be more than double the cost ($45ML) of applying water by furrow irrigation ($20/ML). However, these figures are dependent on the electricity costs of a particular farm's irrigation system and are likely to be variable between farms (due to differences in pump efficiencies, irrigation management, water sources, tariffs, etc.). Importantly, if a furrow irrigator adopted drip irrigation and was able to reduce their water use by enough to offset the higher dollar per megalitre costs (say, by half), then their electricity costs per hectare (between furrow and drip) would be similar. Moreover, growers reusing pumps/motors from furrow systems might be saving capital expenditure to the detriment of pump efficiency, which could escalate their electricity costs substantially.

To examine the impact of electricity costs on the economic outcome, Figure 7 examines the break-even yield at electricity costs ranging between one ($20/ML) and four times ($80/ML) greater than the costs required by an average furrow irrigation system. If drip irrigating in the Delta scenario incurred the same electricity costs per megalitre as furrow irrigating ($20/ML), then a 9 TCH improvement would be sufficient for the drip investment to be as profitable as furrow irrigation. On the other hand, if electricity costs increased four-fold ($80/ML), then an improvement of almost 28 TCH would be necessary. In comparison, the BHWSS drip scenario would require an improvement of nearly 17 TCH to break-even if it had the same electricity costs as furrow irrigating ($20/ML), while a four-fold increase ($80/ML) would demand just over a 30 TCH improvement.

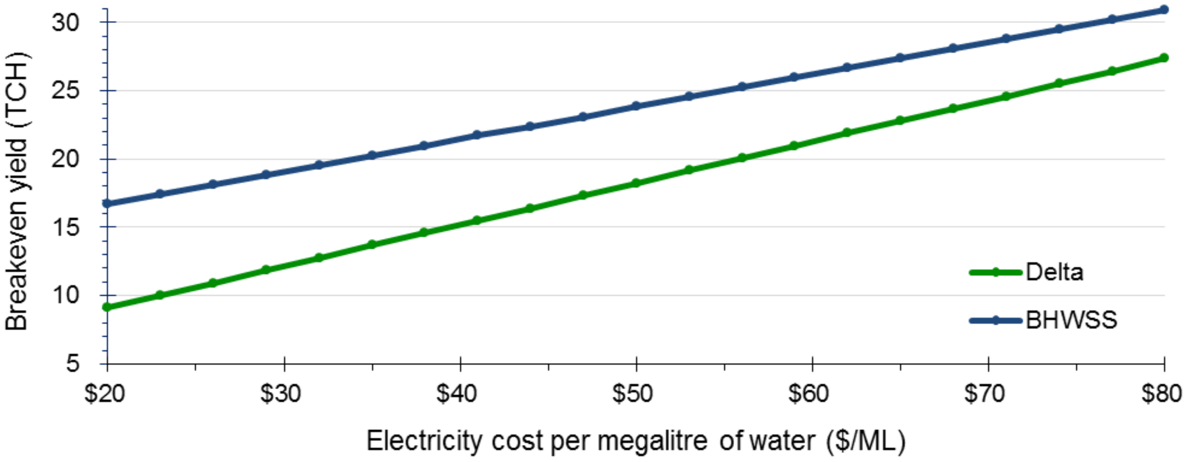

Figure 7: Sensitivity of the break-even yield to electricity pumping costs ($/ML).

4.4.3 The cost to install drip irrigation

Another factor that may vary widely between farms in the Burdekin is the cost to install drip irrigation. For instance, the choice of dripperline can impact the investment cost. Dripperline with thick walls and pressure compensating emitters has considerably higher cost (by around 100 per cent) than dripperline with thin walls and standard emitters (Shannon, 2014). On the other hand, good quality dripperline is likely to have a longer lifespan than poor quality dripperline if maintained effectively. Furthermore, the quality of water being pumped by the drip system will influence the amount spent on the filtration system. Good quality water may only require disc or screen filters, which are less expensive than sand filters. To investigate the impact that installation costs have on the economic outcome, Figure 8 examines the break-even yield at capital investments ranging between $0 and $7,500 per hectare (e.g. between $0 and $150,000 for the 20 hectare Delta scenario).

As illustrated in the graph, the size of the capital investment has a significant impact on the break-even yield. At $3,000 per hectare, a yield improvement of between 5 and 10 TCH is necessary in the two regional scenarios to break-even with furrow irrigation. Alternatively, an investment of $7,500 per hectare would require an increase of between 25 and 29 TCH. If the installation costs were as low as $1,670 and $830 per hectare in the Delta and BHWSS respectively, no yield improvement would be necessary for drip irrigation to be as profitable as furrow irrigation.

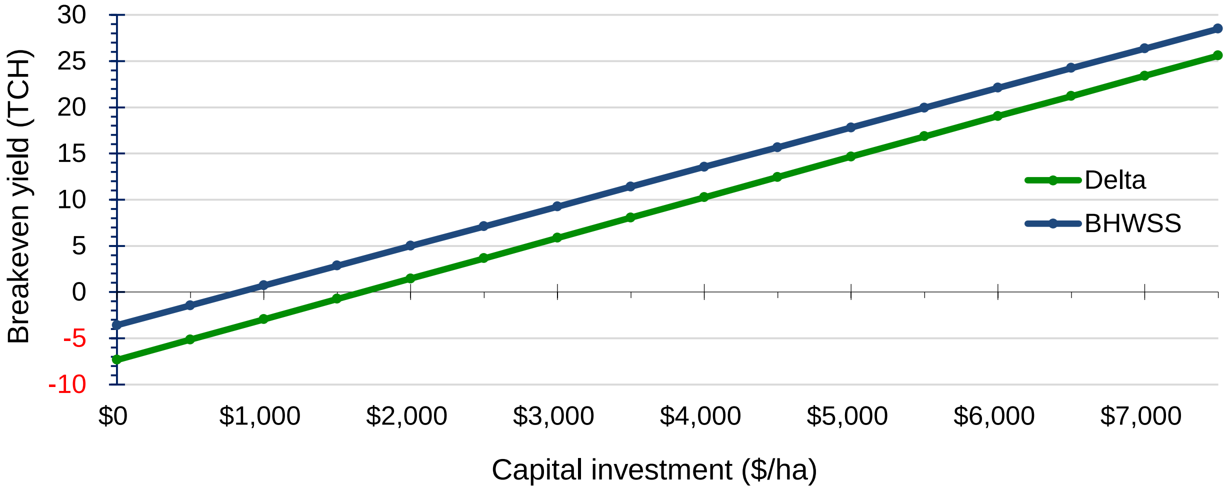

Figure 8: Sensitivity of the break-even yield to drip installation costs.

4.4.4 Yield decline in late ratoon crops

More uncertainty lies around potential improvements in crop ratoonability from a shift to drip irrigation. As mentioned earlier, reducing the dry-down period prior to harvest can improve the vigour of ratoon crops. For instance, yield data collected in 2015 shows that well-managed drip-irrigated crops harvested before mid-September 2014 yielded similarly and in some cases higher than earlier crops, provided that irrigations were well-managed and all fertiliser was applied before the end of December.

The decline in cane yield during late ratoon crops is likely to vary amongst farms and even blocks (e.g. different varieties, annual climatic conditions, etc.). Understandably, minor yield decline may permit an extension of the number of ratoons grown to offset the costs associated with planting a new crop. An obvious question here is how does yield decline affect profitability and how much yield decline warrants spraying/ploughing-out?

Figure 9 investigates the influence of yield decline during late ratoon crops on the annualised benefit of the drip irrigation investment. In particular, declines in cane yield of between 0 and 20 TCH are investigated assuming either four or five ratoon crops are grown. Logically, less yield decline improves the economic outcome by increasing the annualised benefit of the investment. Comparing the four and five ratoon crop scenarios in a given region finds that yield decline greater than 15 TCH during the fifth ratoon would decrease overall profitability. This is shown by the point where the annualised benefit for a certain five ratoon crop scenario (broken lines) crosses over and falls below the annualised benefit for the four ratoon crop scenario within the same region (unbroken lines). Alternatively, a decline in cane yield of less than 15 TCH in the fifth ratoon would improve the economic outcome.

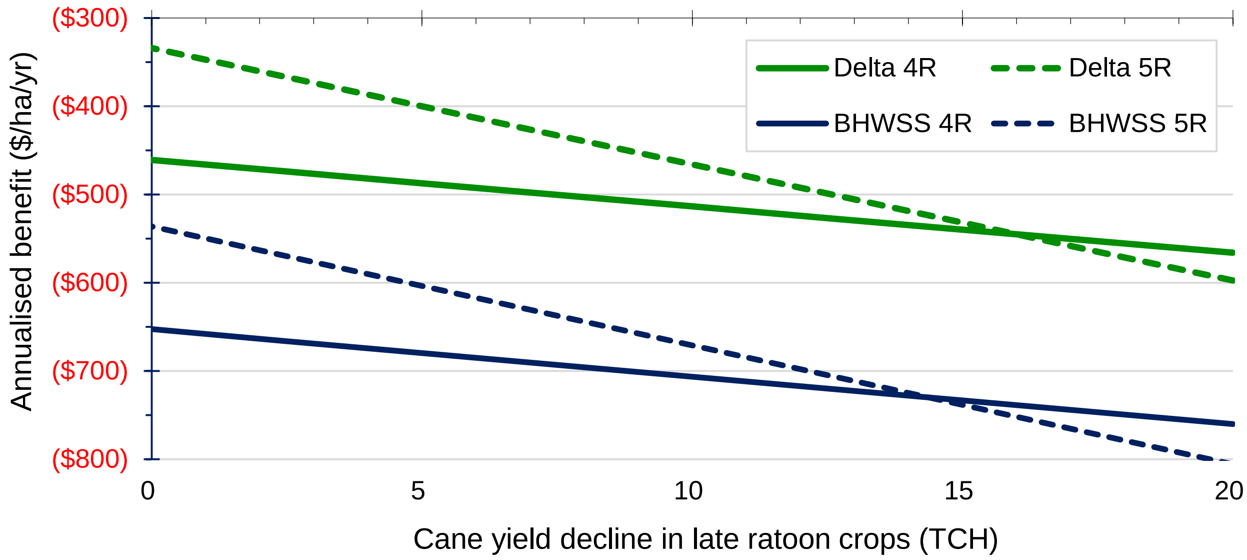

Figure 9: Sensitivity of the annualised benefit to cane yield decline in late ratoon crops.

5 Conclusion

The use of drip irrigation can improve the efficiency of water applications and reduce water losses from runoff and deep drainage when compared to furrow irrigation. As irrigation can be the main conduit for the movement of nutrients and pesticides, improvements in application efficiency are likely to reduce their loss into the environment. This report compares the profitability of a conventional furrow irrigated system with a drip irrigated system in the Burdekin Delta and the BHWSS.

In particular, the report examines the:

(5) Investment required to install drip irrigation

(6) Growing expenses associated with both furrow and drip systems in the two regions

(7) Yield improvement necessary for the investment into drip irrigation to attain the same profitability as a furrow irrigation system (break-even yield)

Furthermore, sensitivity analyses are undertaken to examine how the break-even yield is influenced by variations in electricity costs, installation costs and cane yield decline in late ratoons.

A number of assumptions were used to develop the regional scenarios and to carry out the economic analysis. Using these assumptions, the analysis established that a number of growing cost differences exist between furrow and drip irrigation. For instance, drip irrigation was found to have relatively lower weed control, cultivation, laser levelling and irrigation labour expenses. In contrast, crop nutrition and irrigation electricity expenses were relatively higher for drip irrigation. A number of differences also exist between the regions. Overall, the drip systems growing expenses were relatively lower for both regional scenarios.

While the drip scenarios were found to achieve a higher average gross margin, the increased cash flows are not enough to recover the initial investment. To generate enough revenue to repay the installation costs and break-even with furrow irrigation, the Delta drip scenario needs to attain an extra 16.7 TCH above the yield attained by furrow irrigation. This improvement needs to be maintained during every crop class over two crop cycles. In comparison, a yield improvement of 22.7 TCH is necessary for the BHWSS scenario. The sensitivity analyses identified that the economic outcome is sensitive to variations in electricity and installation costs, while minimal yield decline in late ratoon crops would improve the economic outcome.

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