

Research Results and Discussion

Economic analyses

Relative costs of irrigation to other inputs

All our economic studies reinforced the importance of emphasising the quality/out-turn components of the production system. In our initial modelling for the City to Soil presentation, we used the standard gross margins available for a range of crops, and compared the relative costs of irrigation to other inputs (Table 4 and 5). That particular audience was concerned with the impact of various water charges on costs and overall profitability.

NB In all these instances, values are industry averages, and do not necessarily reflect the outcomes for any particular individual enterprise.

Table 4. Relative costs of irrigation to other inputs.

	Irrigation cost per unit (\$/carton or \$/t)			Other costs per unit (\$/carton or \$/t)		
	Nil water charge	\$150/ML	\$250/ML	Planting	Package	Other harvesting & packing
Tomato	\$0.30	\$0.44	\$0.55	\$1.02	\$1.22	\$2.35
Lettuce	\$0.05	\$0.24	\$0.37	\$0.65	\$1.86	\$1.03
Broccoli	\$0.16	\$0.79	\$1.23	\$2.52	\$1.71	\$3.77
Sweet corn	\$0.15	\$0.72	\$1.12	\$0.57	\$1.22	\$2.76
Potato	\$4.44	\$21.60	\$33.60	\$43.81	\$15.60	\$54.00
Onion	\$3.68	\$18.00	\$28.00	\$15.27	\$24.75	\$34.75
Pumpkin	\$9.20	\$36.00	\$56.00	\$7.93	\$22.50	\$24.00
Grain sorghum	\$24.53	\$120.00	\$187.00	\$7.33	\$4.92	\$10.00
Lucerne	\$18.00	\$125.00	\$200.00	\$10.42	\$5.04	\$31.48

Table 5. Irrigation as a percentage of overall production costs.

	Nil water charge	\$150/ML	\$250/ML
Tomato	5%	8%	9%
Lettuce	1%	6%	9%
Broccoli	2%	8%	12%
Sweet corn	3%	12%	17%
Potato	3%	13%	19%
Onion	2%	10%	14%
Pumpkin	10%	35%	45%
Grain sorghum	40%	82%	83%
Lucerne	25%	70%	79%

From the above values, at a nil water charge, irrigation costs are only a small component of overall production costs for most of the vegetable crops (compare with grain or lucerne). Even as water charges become substantial, the costs of irrigation in vegetables are still comparative with other production costs. Contrasts with field crops, where irrigation charges quickly become orders of magnitude higher than any other significant costs of production.

Impact of water charges (or other increased costs of irrigation management) on profitability

When we plugged various water charges into gross margins for each of these crops, we can see that whilst some of the intensive vegetables can absorb the irrigation charges and still remain profitable (in a gross margin sense), the field crops cannot (Table 6).

Table 6. Impact of water pricing on crop gross margins.

	Nil water charge	\$150/ML	\$250/ML
Tomato	\$10,508	\$9,972	\$9,572
Lettuce	\$2,148	\$1,576	\$1,176
Broccoli	\$697	\$197	-\$153
Sweet corn	\$4,605	\$4,033	\$3,633
Potato	\$2,277	\$1,848	\$1,548
Onion	\$4,511	\$3,939	\$3,539
Pumpkin	\$693	\$157	-\$243
Grain sorghum	\$590	-\$126	-\$626
Lucerne	\$1,023	-\$50	-\$800

Expanding these gross margins up to whole farms, and taking into account overhead costs, debt servicing etc., many mixed farms typical of the Lockyer Valley become unprofitable once water charges are implemented (Table 7). This assumes that there are no management or output improvements associated with the increased water charges.

Table 7. Impact of water pricing on farm cash surplus.

	Nil water charge	\$150/ML	\$250/ML
Farm 1	\$17,185	\$800	-\$11,098
Farm 2	\$2,384	-\$36,174	-\$63,127
Farm 3	\$46,904	-\$8,328	-\$46,936
Farm 4	\$17,546	-\$8,102	-\$26,030
Farm 5	-\$583	-\$24,783	-\$41,700

It is self evident that a key to the whole water use efficiency concept from an economic viewpoint is to determine what irrigation management changes and outcomes will bring the greatest economic benefit.

How to pay costs of practice change

If we ask producers to change their irrigation practices to improve their water use efficiency, these changes almost invariably cost money. It was important to us to determine which outcomes best delivered producers a financial capacity to implement these changes. In early analyses, we looked at how to best pay for an increase in water charges (in this case we were investigating the prospect of using recycled water). However, the principles of recouping whatever the cause of increased irrigation costs (irrigation scheduling, amortising new application systems) is exactly the same.

For the range of crops previously mentioned, we looked at the changes in gross margin with different outcomes of changing irrigation management. The first two columns in Table 8 show the base gross margin and gross margin associated with a \$150/ML water charge respectively. The next three columns show the outcomes if improving irrigation management (a) results in a 25% water saving; (b) improves yields by 10%; or (c) improves product quality and therefore price received by 10%.

Table 8. How could we generate income to pay increased irrigation costs?

	Nil water charge	\$150/ML water charge	25% water saving	10% yield increase	10% price increase
Tomato	\$10,544	\$9,944	\$10,131	\$11,750	\$13,163
Lettuce	\$2,148	\$1,548	\$1,735	\$2,076	\$3,108
Broccoli	\$748	\$221	\$391	\$618	\$1,096
Sweet corn	\$4,325	\$3,725	\$3,912	\$4,332	\$4,775
Potato	\$2,275	\$1,825	\$1,956	\$2,245	\$2,482
Onion	\$5,184	\$4,659	\$4,827	\$5,353	\$5,591
Pumpkin	\$523	-\$41	\$146	\$71	\$214
Grain sorghum	\$590	-\$160	\$82	-\$55	-\$55
Lucerne	\$1,408	-\$167	\$348	\$66	\$96

For all the vegetables except pumpkin, saving water only improves profitability to a small extent, whereas for the field crops, it is the best way to help recover some of the water charges. In the intensive vegetables, it is much better to try and improve yields, and particularly quality/price received, as a goal from improved irrigation management. As we will show later however, in the in the special (but increasingly common) circumstances where water is a restricting resource, reducing water use per ha of crop can make an important contribution to seasonal profitability.

Determining the costs of irrigation scheduling

In developing some sensitivity models, we needed to develop reliable figures on the actual costs of irrigation scheduling. In our studies, we opted to use tensiometer-based scheduling systems, as we believed they were the least costly way of scheduling vegetable irrigation, with lowest capital outlay and expertise required.

In our scenario, we assumed a lettuce producer is turning off equal volumes of lettuce every month, by harvesting 5 ha per month over a 7 month period (April to October). Our producer was employing a farmhand to use a network of manually read SoilSpec[®] tensiometers.

We developed two different ways of costing this scheduling. In the first method (Spreadsheet 1), we simply calculated the costs of owning and operating 100 tensiometers, assuming they were each in the ground for 75% of the year. The highlighted values are entered; other values are calculated, based on those inputs. The result is a costing of about \$90 per scheduled ha of lettuce.

Spreadsheet 1. Calculating the cost of irrigation scheduling using tensiometers (% time in use method).

Irrigation scheduling costing module	Minimum cost (tensiometers)			
	Purchase price (\$)	Useable life (years)	Interest rate (%)	Annual cost (\$/annum)
Electronic reader and software	800	4	7%	\$ 256.00
Tensiometer	35	2	7%	\$ 19.95
Tensiometers per reader	100			\$ 2,251.00
Proportion of year in use (%)	75%			
Weekly tensiometer ownership cost (\$/week)	\$ 0.58			
Installation time: includes preparation, installation, retrieval, cleaning, storage (minutes/tensiometer)	10			
Installation costs (\$/tensiometer)	\$ 3.33			
Monitoring time: includes reading, maintaining, downloading and interpreting results (minutes per 100 tensiometers/ monitoring event)	60			
Labour costs (\$/hr)	\$ 20.00			
Monitoring events per week	3			
Tensiometer sets per planting (shallow and deep tensiometer per set)	2			
Planting area (ha)	0.6			
Tensiometers (/ha)	6			
Irrigation scheduling monitoring costs (\$/week/ha)	\$ 3.60			
Irrigation scheduling monitoring costs (\$/week/tensiometer)	\$ 0.60			
Irrigation scheduling period (weeks)	10			
Total ownership costs (\$/ha)	\$ 34.63			
Total installation costs (\$/ha)	\$ 20.00			
Total monitoring costs (\$/ha)	\$ 36.00			
Total irrigation scheduling costs (\$/ha)	\$ 90.63			

In a second costing method, we actually calculated a weekly cost requirement during the year for owning, installing and monitoring tensiometers (Spreadsheet 2), using the same input parameters from Spreadsheet 1, plus some additional calculations of planting and harvesting times. This method costed out at about \$105 per scheduled ha of lettuce. Both methods resulted in similar cost outcomes. In our modelling, we used the higher value, as it related closely to the planting schedule used in our lettuce sensitivity analyses.

Spreadsheet 2. Calculating the cost of irrigation scheduling using tensiometers (resource requirement method).

Total area scheduled (ha)		36.0		\$/ha				
Total irrigation scheduling costs (\$) - full use model	\$	3,262.71	\$	90.63				
Total irrigation scheduling costs (\$) - only use model	\$	3,788.40	\$	105.23				
	Annual ownership	Plantings per week	Area planted per week (ha)	Planting starts	Planting finishes	Harvesting starts	harvesting finishes	
Maximum tensiometers required	72 \$	1,692.40	2	1.2	5/02/2002	1/09/2002	9/04/2002	30/10/2002
Farm week	Area planted (ha)	Area harvested (ha)	Area scheduled (ha)	Tensiometer installations	Tensiometers operating	Scheduling operational costs		
	1/01/2002	0.0	0.0	0.0	0	0 \$	-	
	8/01/2002	0.0	0.0	0.0	0	0 \$	-	
	15/01/2002	0.0	0.0	0.0	0	0 \$	-	
	22/01/2002	0.0	0.0	0.0	0	0 \$	-	
	29/01/2002	0.0	0.0	0.0	0	0 \$	-	
	5/02/2002	1.2	0.0	1.2	8	8 \$	31.47	
	12/02/2002	1.2	0.0	2.4	8	16 \$	36.27	
	19/02/2002	1.2	0.0	3.6	8	24 \$	41.07	
	26/02/2002	1.2	0.0	4.8	8	32 \$	45.87	
	5/03/2002	1.2	0.0	6.0	8	40 \$	50.67	
	12/03/2002	1.2	0.0	7.2	8	48 \$	55.47	
	19/03/2002	1.2	0.0	8.4	8	56 \$	60.27	
	26/03/2002	1.2	0.0	9.6	8	64 \$	65.07	
	2/04/2002	1.2	0.0	10.8	8	72 \$	69.87	
	9/04/2002	1.2	1.2	10.8	8	72 \$	69.87	
	16/04/2002	1.2	1.2	10.8	8	72 \$	69.87	
	23/04/2002	1.2	1.2	10.8	8	72 \$	69.87	
	30/04/2002	1.2	1.2	10.8	8	72 \$	69.87	
	7/05/2002	1.2	1.2	10.8	8	72 \$	69.87	
	14/05/2002	1.2	1.2	10.8	8	72 \$	69.87	
	21/05/2002	1.2	1.2	10.8	8	72 \$	69.87	
	28/05/2002	1.2	1.2	10.8	8	72 \$	69.87	
	4/06/2002	1.2	1.2	10.8	8	72 \$	69.87	
	11/06/2002	1.2	1.2	10.8	8	72 \$	69.87	
	18/06/2002	1.2	1.2	10.8	8	72 \$	69.87	
	25/06/2002	1.2	1.2	10.8	8	72 \$	69.87	
	2/07/2002	1.2	1.2	10.8	8	72 \$	69.87	
	9/07/2002	1.2	1.2	10.8	8	72 \$	69.87	
	16/07/2002	1.2	1.2	10.8	8	72 \$	69.87	
	23/07/2002	1.2	1.2	10.8	8	72 \$	69.87	
	30/07/2002	1.2	1.2	10.8	8	72 \$	69.87	
	6/08/2002	1.2	1.2	10.8	8	72 \$	69.87	
	13/08/2002	1.2	1.2	10.8	8	72 \$	69.87	
	20/08/2002	1.2	1.2	10.8	8	72 \$	69.87	
	27/08/2002	1.2	1.2	10.8	8	72 \$	69.87	
	3/09/2002	0.0	1.2	9.6	0	64 \$	38.40	
	10/09/2002	0.0	1.2	8.4	0	56 \$	33.60	
	17/09/2002	0.0	1.2	7.2	0	48 \$	28.80	
	24/09/2002	0.0	1.2	6.0	0	40 \$	24.00	
	1/10/2002	0.0	1.2	4.8	0	32 \$	19.20	
	8/10/2002	0.0	1.2	3.6	0	24 \$	14.40	
	15/10/2002	0.0	1.2	2.4	0	16 \$	9.60	
	22/10/2002	0.0	1.2	1.2	0	8 \$	4.80	
	29/10/2002	0.0	1.2	0.0	0	0 \$	-	
	5/11/2002	0.0	0.0	0.0	0	0 \$	-	
	12/11/2002	0.0	0.0	0.0	0	0 \$	-	
	19/11/2002	0.0	0.0	0.0	0	0 \$	-	
	26/11/2002	0.0	0.0	0.0	0	0 \$	-	
	3/12/2002	0.0	0.0	0.0	0	0 \$	-	
	10/12/2002	0.0	0.0	0.0	0	0 \$	-	
	17/12/2002	0.0	0.0	0.0	0	0 \$	-	
	24/12/2002	0.0	0.0	0.0	0	0 \$	-	
	31/12/2002	0.0	0.0	0.0	0	0 \$	-	

These spreadsheets could be easily adapted to assess the costs of any scheduling method, as they have components for capital depreciation, installation, operating, and removal costing.

Interactions in water use, yield and price outcomes affect profitability of irrigation changes – a lettuce example

We developed and used a spreadsheet model to understand the interactions between water savings, yield improvement, product quality improvements and price gains. We used the lettuce example detailed previously. Due to issues with changing lettuce cultivars for harvesting during the Spring transitional period (see detailed lettuce experiment report for more information), there is a significant risk of lettuce tipburn occurring during the September period. Occurrence of tipburn is associated with reduced market prices, or rejection of the lettuce crop.

In this example, we are analysing the potential benefits and reasons to adopt an irrigation scheduling system. Our base lettuce gross margin, without any irrigation scheduling system, provides a return of \$1019/ha.

Similar to the previous analyses, how can we encourage producers to adopt an improved irrigation or irrigation management system; i.e. obviously it should at least pay for itself in the first instance? In Fig. 1, the red line is the base lettuce gross margin described earlier, i.e. the breakeven point. The intercept on the Y-axis is the new gross margin, assuming we have adopted irrigation scheduling at \$105/ha.

In a circumstance where our irrigation scheduling reduces irrigation required to produce the same amount of lettuce, even saving up to 40% of our irrigation requirement doesn't quite recover the costs of scheduling. This simple analysis assumes that water is not a limiting resource; (more on that scenario later).

In contrast to the benefits from irrigation saving, we can see that improving yield or price received very quickly recovers the cost of scheduling, i.e. a 2% yield increase, or a 1% price increase pays for scheduling. Greater increases in either option make irrigation scheduling very profitable indeed.

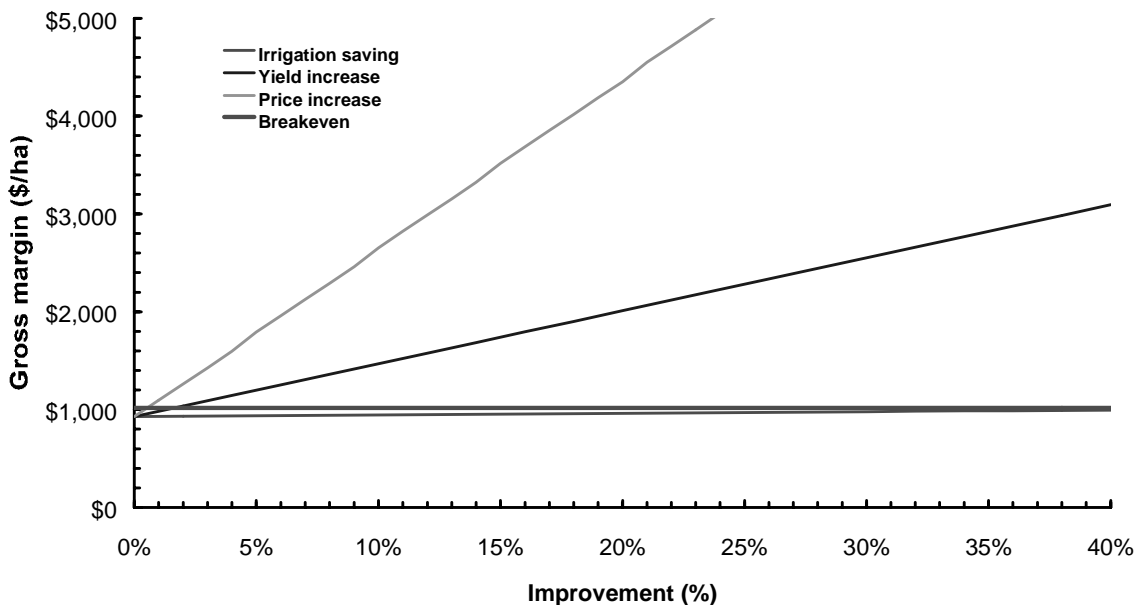


Figure 1. Impact of input or outcome improvement on lettuce gross margin.

In this lettuce exercise, we were investigating the impact of tipburn, as we believed there was an association between irrigation management and tipburn incidence risk and severity. How important is tipburn to profitability of lettuce production?

Return to our earlier lettuce producer scenario, harvesting a total of 35 ha of lettuce during the season. In this scenario we are assuming that tipburn only occurs in September, and that it does not occur every year, i.e. that there is a risk (probability) of it occurring in any one year. Lettuce can either be sold on the fresh market, or to a processor (for the salad fresh-cuts, food service or fast-food sectors). All markets will introduce a price penalty for the presence of tipburn, and severe instances will result in rejection of the crop. Processors tend to instigate more severe price penalties, and reject product at lower severity levels of tipburn, than do fresh product purchasers.

In Figure 2, we can see that our lettuce producer stands to make a seasonal profit of just over \$35,000, if they do not have any tipburn (note that this is in a system with no irrigation scheduling). As the risk of tipburn in September increases, and/or the price penalty for tipburn increases, the seasonal profitability rapidly falls. In discussions with producers and processors, most price penalties for tipburn are in the order of 20-30%, with crop rejection if the incidence is much more severe. Note the circumstance where the crop is rejected at the point of receipt (market or processor), when all the harvesting, packaging and freight costs have been incurred (yellow line). It doesn't take much risk of that happening for all the producer's profits for the season to be wiped out! It is obviously much preferred to detect a crop likely to be rejected before it is harvested, and simply leave it in the field (red line).

Assuming a tipburn price penalty of about 30% (actually equivalent to rejecting the crop prior to harvest), the cost of irrigation scheduling the whole lettuce crop (about \$3,800) could be recovered by reducing tipburn incidence in September by around 15%.

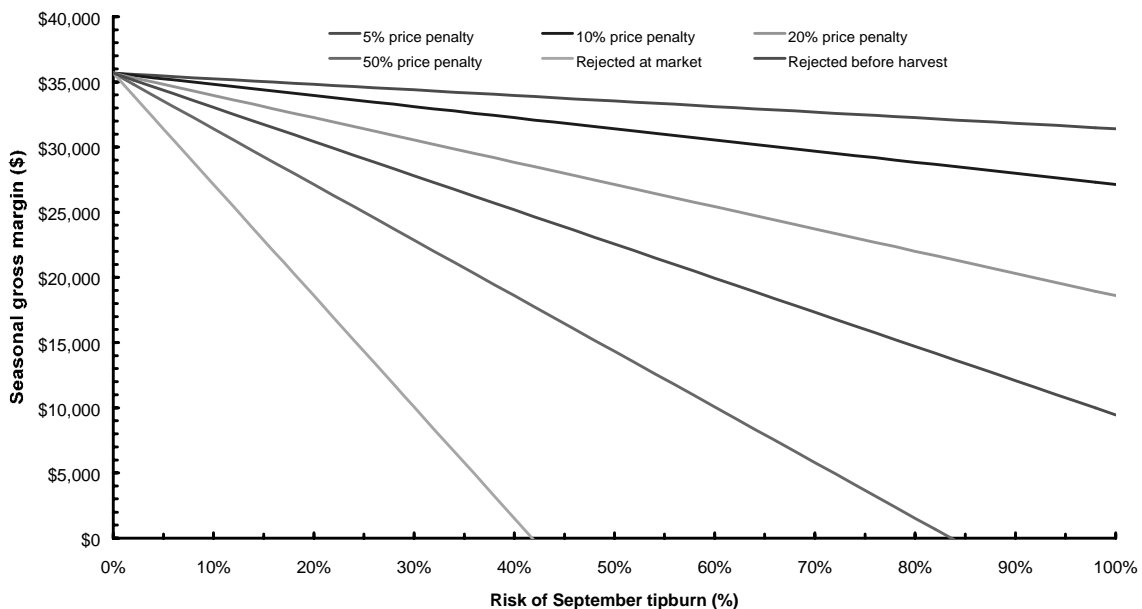


Figure 2. Impact of tipburn on seasonal gross margin for a lettuce production system.

In our economic analyses, we combined all these different scenarios into a single spreadsheet, which can examine the potential outcomes of various management changes. In the example presented below, we are investigating the question of how to pay for implementing an irrigation scheduling strategy.

In Spreadsheet 3, we show the base situation, with our lettuce producer growing 35 ha of lettuce; no tipburn risk; and irrigation scheduling costing \$105/ha. We can see that if they do not schedule, they stand to make a seasonal profit of \$35,667. Implementing irrigation scheduling, without any benefits, reduces the seasonal profit to \$31,984. Lets now start investigating some scenarios.

Spreadsheet 3. The impact of irrigation scheduling using tensiometers with no benefits.

Ask myself the question - what individual benefits would I need to pay for scheduling my lettuce crop through the season?			
Assumptions			
Months of harvesting (April - October)		7	
Harvesting area per month		5	
On-farm price penalty from tipburn (September only)		20%	
Risk of tipburn (September only)		0%	
Current seasonal gross margin without scheduling (\$)			\$35,667
Irrigation scheduling costs (\$/ha)	\$105		
Current seasonal gross margin with scheduling (\$)			\$31,984
			Individual improvements required to pay for scheduling
Percent reduction in water use	0%		62%
Percent increase in yield	0%		2%
Percent increase in on-farm price	0%		1%
Percent reduction in tipburn risk	0%		24%
Percent increase in area grown	0%		
New seasonal gross margin with scheduling and benefits (\$)			\$31,984

Introduce the reality that tipburn does occur, that the price penalty is 30%, and it occurs two years out of every five. These are conservative values. As can be seen in Spreadsheet 4, the new profit figures are \$26,595 without scheduling and \$22,912 with scheduling respectively. But hopefully the irrigation scheduling will bring about some benefit. Under the column entitled 'individual improvements required to pay for scheduling' we can see that we estimate that if we saved 62% of our irrigation requirement, or increased yield by 2%, or increased price by 1%, or reduced tipburn by 16% (i.e. to one year in every five), we could cover the cost of irrigation scheduling. Again, this assumes that water is not limiting, i.e. that our planted area is not restricted by availability of water. If irrigation scheduling has multiple benefits, then obviously the recovery in profitability is much greater.

Spreadsheet 4. Outcomes required to repay the cost of irrigation scheduling using tensiometers, in a lettuce production system with occasional tipburn.

Ask myself the question - what individual benefits would I need to pay for scheduling my lettuce crop through the season?			
Assumptions			
Months of harvesting (April - October)		7	
Harvesting area per month		5	
On-farm price penalty from tipburn (September only)		30%	
Risk of tipburn (September only)		40%	
Current seasonal gross margin without scheduling (\$)			\$26,595
Irrigation scheduling costs (\$/ha)	\$105		
Current seasonal gross margin with scheduling (\$)			\$22,912
			Individual improvements required to pay for scheduling
Percent reduction in water use		0%	62%
Percent increase in yield		0%	2%
Percent increase in on-farm price		0%	1%
Percent reduction in tipburn risk		0%	16%
Percent increase in area grown		0%	
New seasonal gross margin with scheduling and benefits (\$)			\$22,912

To demonstrate these calculations, Spreadsheet 5 shows the new outcomes if irrigation scheduling reduces water use by 15%, and increases yield by 5%. Note that the new seasonal gross margin of \$32,526 is much greater than the original seasonal gross margin without scheduling (\$26,595).

Spreadsheet 5. Scenarios that repay the cost of irrigation scheduling using tensiometers, in a lettuce production system with occasional tipburn.

Ask myself the question - what individual benefits would I need to pay for scheduling my lettuce crop through the season?			
Assumptions			
Months of harvesting (April - October)		7	
Harvesting area per month		5	
On-farm price penalty from tipburn (September only)		30%	
Risk of tipburn (September only)		40%	
Current seasonal gross margin without scheduling (\$)			\$26,595
Irrigation scheduling costs (\$/ha)	\$105		
Current seasonal gross margin with scheduling (\$)			\$22,912
			Individual improvements required to pay for scheduling
Percent reduction in water use	15%		62%
Percent increase in yield	5%		2%
Percent increase in on-farm price	0%		1%
Percent reduction in tipburn risk	0%		15%
Percent increase in area grown	0%		
New seasonal gross margin with scheduling and benefits (\$)			\$32,526

As discussed earlier, we may have a situation where availability of irrigation water is a restriction, and water saved can be used to grow a larger area of crop. In Spreadsheet 6, our irrigation scheduling has saved us 15% of our irrigation requirement, with no other benefits. Seasonal gross margin with that water saving (\$23,807) is still not sufficient to justify the cost of scheduling (\$26,595 with no scheduling and no water saving). However, if water was a restricted resource, and that 15% water saving can be used to grow 15% more lettuce (Spreadsheet 7), then the irrigation scheduling is economically justified, giving a total return of \$27,378 for the season.

Spreadsheet 6 Water saving per se does not repay the cost of irrigation scheduling using tensiometers, in a lettuce production system with

Ask myself the question - what individual benefits would I need to pay for scheduling my lettuce crop through the season?			
Assumptions			
Months of harvesting (April - October)		7	
Harvesting area per month		5	
On-farm price penalty from tipburn (September only)		30%	
Risk of tipburn (September only)		40%	
Current seasonal gross margin without scheduling (\$)			\$26,595
Irrigation scheduling costs (\$/ha)	\$105		
Current seasonal gross margin with scheduling (\$)			\$22,912
			Individual improvements required to pay for scheduling
Percent reduction in water use	15%		62%
Percent increase in yield	0%		2%
Percent increase in on-farm price	0%		1%
Percent reduction in tipburn risk	0%		16%
Percent increase in area grown	0%		
New seasonal gross margin with scheduling and benefits (\$)			\$23,807

occasional tipburn.

Spreadsheet 7 Water saving accompanied by expanded cropping area repays the cost of irrigation scheduling using tensiometers, in a lettuce production system with occasional tipburn.

Ask myself the question - what individual benefits would I need to pay for scheduling my lettuce crop through the season?			
Assumptions			
Months of harvesting (April - October)		7	
Harvesting area per month		5	
On-farm price penalty from tipburn (September only)		30%	
Risk of tipburn (September only)		40%	
Current seasonal gross margin without scheduling (\$)			\$26,595
Irrigation scheduling costs (\$/ha)	\$105		
Current seasonal gross margin with scheduling (\$)			\$22,912
			Individual improvements required to pay for scheduling
Percent reduction in water use	15%		54%
Percent increase in yield	0%		2%
Percent increase in on-farm price	0%		1%
Percent reduction in tipburn risk	0%		14%
Percent increase in area grown	15%		
New seasonal gross margin with scheduling and benefits (\$)			\$27,378

All the spreadsheets detailed above are linked, and can be quickly tailored to input individual management details and changes, and analyse sensitivity to outcomes. We have the framework for a generic model that can cope with a range of crops, which we have used to economically analyse data from our detailed experiments, as well as evaluate other scenarios from our team, or from collaborating producers.

Benefits of irrigation improvement are determined by limiting factors

In another scenario, we demonstrated that the benefits of improving price, yields or water saving are depend on the production and market circumstances operating at the time. Again, we used a lettuce enterprise, with a grower producing 3000 cartons/ha, off 40 ha annual production, and using a total of 120 ML in the process. Considering 3 scenarios, where the grower is limited by:

- (a) land available to grow the crop, or
- (b) market for his produce, i.e. they cannot profitably sell more than 120,000 cartons per annum, or
- (c) their water allocation, i.e. they only have a water allocation (or bore capacity) of 120 ML per annum.

Table 9 show how much their profits increase if they are able to achieve the outcomes shown in the leftmost column. Note that any increase in price is basically a 'free lunch', i.e. the improvement in profitability is unaffected by any of the limiting factors described above. Price increases also generate the best return per % increase of any component change.

Table 9. Increase in producer profit from cropping improvements under different resource or market constraints.

	Land limited	Market limited	Water limited
5% price increase	\$33,000	\$33,000	\$33,000
10% yield increase	\$26,000	\$15,000-\$18,000	\$26,000
20% water saving	\$1,000-\$6,000	\$1,000-\$6,000	\$54,000

This strongly suggests that any irrigation practice change that can improve price is a primary target. Improved price can be brought about by improving product quality, uniformity, or reliability of supply. This is precisely the reason that our initial project objectives had such a strong focus on quality related outcomes.

The point needs to be made that investments into irrigation management are competing in the producers mind with investments in other areas, e.g. quality assurance systems, pest management systems, marketing systems. As an extreme example, the producer may decide to invest in several lavish dinners per year with his wholesale buyer, rather than a new irrigation scheduling system!

The 10% yield increase also has a very positive impact on profitability (Table 9). It is often easier to show good relationships between improved irrigation management and higher yields, particularly by improving aspects such as irrigation uniformity, or avoiding substantial crop stress periods caused by irrigation systems that cannot cope with extreme weather. Targeting a practice change that increases yields almost invariably gives a better return on investment than cost cutting for individual components (unless they are significant cost contributors such as individual carton costs).

Note that in the circumstance where the market is limited, the profit increase from higher yields is less, because a smaller area is used to produce the same volume of product. The producer may be able to lease the land to another grower (in the Table 9 case, assuming a lease charge of \$1000/ha, this lifts the profit increase from \$15,000 to \$18,000 per annum).

If reduced water use is the only benefit from improved irrigation, the reduction in actual production costs has only a small benefit to profitability. In our scenario, the water saved by a 20% reduction in water use increases profit by \$1000 per annum, or \$6,000 per annum if the water can be sold at \$200/ML. However, during periods when water is scarce and is the principal factor limiting production, water saving becomes 10-50 times more important in a profitability sense. This assumes that any water the producer saves can be directly used to increase their planted area. This is actually the scenario in the current drought situation in southern Queensland.

The value of saving water in circumstances of restricted water availability

As indicated previously, our economic analyses suggested that irrigation practices that reduced water use whilst maintaining yields and quality could be substantially profitable when that saved water could be used to increase planted area. This assumes that the producer can sell the increased volume of product at the same price. Less water availability for irrigation can occur through regulation (e.g. reduced water allocation) or physical supply (e.g. current drought in Granite Belt and Lockyer Valley).

On the basis of feedback from adoption program staff, we re-jigged our spreadsheets to provide information on how much water saving was required to recoup a range of irrigation investments, under various price scenarios. Using this form of analysis, producers can make some risk based decisions on how much to invest in irrigation improvement, based on their estimates of price and potential water savings.

We used a seasonal sweetpotato cropping example to demonstrate how improved water use efficiency can pay for irrigation system and strategy changes. Sweetpotato prices average around \$18/carton (Loader et al. 2000), with a general market range of \$13-21/carton. In times of over-production, prices can fall to \$5-10/carton (around \$9 meaning a loss to the producer). During product shortages such as experienced over the last 6 months due to drought conditions, prices have regularly reached \$25-35/carton, and occasionally even \$40/carton.

We used a scenario where a sweet potato producer was limited in planting area by her water allocation. Thus, any water she could save in her operations was directed to increasing the planting area, to use the maximum amount of available water. To save water she is considering several options, including: (a) Using a simple tensiometer based scheduling system (\$100/ha); (b) Hiring a capacitance probe based system (\$500/ha); (c) Switching to drip irrigation (\$1,200/ha); or (d) Switching to drip, monitoring with tensiometers and trying deficit irrigation (\$1,500/ha). Figure 3 shows the water savings she needs to make (with consequent increased planting area available) to breakeven on the actual respective investments in irrigation improvement. It assumes that the irrigation improvements have no impact on crop yields, quality, or price received.

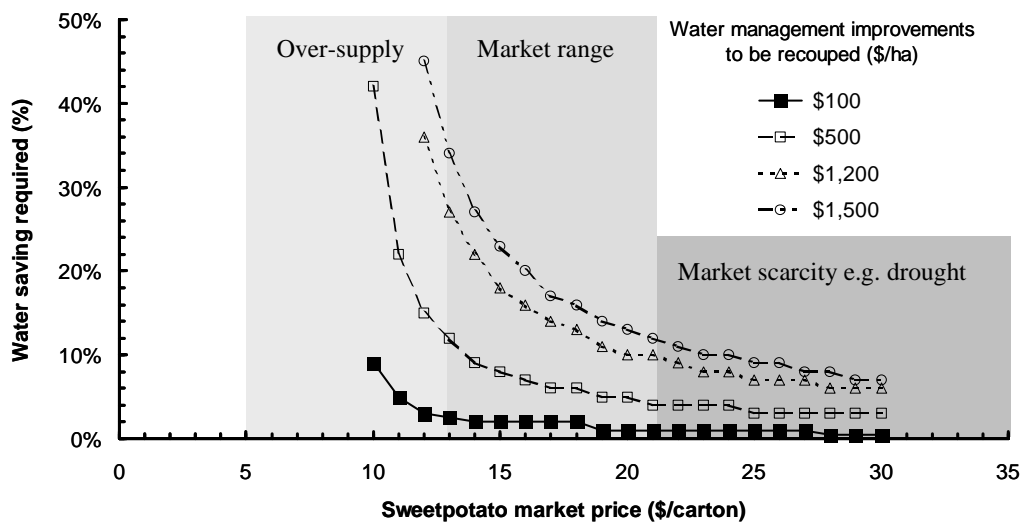


Figure 3. Water savings required to breakeven on irrigation investments, in a production environment restricted by water availability.

In these circumstances, only a very small increase in water use efficiency is required to cover the cost of tensiometer-based scheduling, less than 2% for most price ranges. Even in times of low prices, the breakeven water saving is still only of the order of 6-8%. As the level of irrigation investment increases, the breakeven water savings required becomes increasingly sensitive to price. If prices are average or above (which is highly likely, but not guaranteed, in times of water shortage), investment still looks very attractive. However, as prices fall, the risk of not getting a return on the investment sharply increases with the cost of that investment. In circumstances such as these, decisions on how much to invest in improved irrigation management involve assessing achievable water savings, impacts on productivity, likely price environments, and general attitudes to risk.

Conclusions

- Under current irrigation environments, irrigation costs are a relatively minor component of total vegetable production costs.
- Irrigation investments that lead to higher prices (through improved product quality, uniformity or reliability of supply) give the best return.
- Irrigation investments that improve yields can also be highly profitable, provided product price can be maintained. Profitability from improving yields declines significantly if the market for product is restricted.
- Irrigation investments that reduce water use only have significant economic return when water is a scarce resource, and the individual producer has control over any water saved. In those circumstances, reduced water use can have a substantial impact on profitability.
- Selecting the most economic irrigation system and irrigation strategy is very sensitive to market price for produce, and which factors are constraining returns (access to land, water or other input resources, or capacity of market to absorb produce).
- Irrigation systems and strategies that deliver superior Agronomic Water Use Efficiency, but are more expensive than current systems, are favoured by higher produce prices, restricted irrigation water supplies, and good opportunities for market expansion. Conversely, low produce prices, readily available irrigation water supplies, and restricted markets for produce, favour less investment in irrigation management, even at the expense of reduced water use efficiency.
- A framework for conducting what-if and sensitivity analyses of the economic impacts of irrigation practice change in vegetable production, using simple, linked Excel[®] spreadsheets, has been developed.