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Benchmarking Vegetable Industry water use

Bill Ashcroft
VIC Department of Primary Industries

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Final Report

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Benchmarking Vegetable Industry Water Use

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Media Summary

Vegetable production is intensive, often requiring large inputs of water and nutrients. The value of crops is high, and water has traditionally been regarded as a small component of the total growing cost. This is changing, as demand increases for this scarce resource, and the industry recognises the need to develop and implement more efficient irrigation practices. Irrigation benchmarking involves the collection of on-farm information about irrigation practices, and allows growers to compare themselves with others in terms of crop performance and water use efficiency (WUE). A pilot study was conducted during the 2004/05 growing season, to benchmark water use in vegetable crops grown in two contrasting areas of Victoria: - peri-urban Melbourne (Cranbourne, Mornington Peninsula and Werribee) and the Mallee (Mildura and Swan Hill). An approach used successfully in other horticultural crops was combined with a set of WUE indicators to collect information from a total of 25 sites. Most participants used fixed sprinkler irrigation. Crops included were lettuce, broccoli and carrots near Melbourne, and carrots, pumpkins, squash and zucchinis in the Mallee. The major focus of the study was to evaluate the benchmarking process, and the results highlighted inconsistencies and inaccuracies in on-farm methods for managing and recording water applications. The limited set of information collected, with variation in crop and irrigation type, region, planting time and climate, made it difficult to make meaningful comparisons. Averaged values for yield in the target crops ranged from 8.1 – 50.8 t/ha, for water use from 1.2 to 3.3 ML/ha, and for WUE from 2.3-28.4 t/ML. Nevertheless, this information provides useful insights into some of the issues facing farmers in the irrigation of vegetable crops across Victoria. Commitment to the benchmarking process varied, with the less experienced farmers showing most interest in participation and learning from the results. Most participants saw value in the information and were willing to take part in future benchmarking activities. Water use efficiency was not seen as a high priority for many of these growers, but most saw it as becoming more important to them. Comparisons between crops and growing districts were also of interest, despite the gaps and inconsistencies in the results. Recommendations were developed for future benchmarking activities, and for related research and extension priorities.

Technical Summary

Vegetable production is intensive, often requiring large inputs of water and nutrients. The value of crops is high, and water has traditionally been regarded as a small component of the total growing cost. This is changing, as demand increases for this scarce resource, and water shortages occur in vegetable growing areas. The vegetable industry currently lags behind other horticultural sectors in the understanding of plant water needs and irrigation best practices. Irrigation benchmarking is a proven tool for increasing water use efficiency (WUE). It allows growers to compare their performance at both local and national levels, as well as providing policy makers with sound information to use in setting realistic efficiency targets. A pilot study was conducted during the 2004/05 growing season, to benchmark water use in vegetable crops grown in two contrasting areas of south-eastern Australia: - peri-urban Melbourne (Cranbourne, Mornington Peninsula and Werribee) and the Mallee (Mildura and Swan Hill). A methodology previously used in other horticultural crops was combined with a set of WUE indicators. Results were collected from a total of 25 sites. Most participants used fixed sprinkler irrigation systems, and crops included were lettuce, broccoli and carrots near Melbourne, and carrots, pumpkins, squash and zucchinis in the Mallee. While the information on water use was a useful starting point, the major focus of the study was to evaluate the value of the benchmarking process. Inconsistencies in on-farm recording of water use cast doubts over the validity of some measurements obtained. Seasonal and market factors also influenced project results. Average marketable yields reported by growers ranged from 13.3 t/ha for broccoli to 50.8 t/ha for carrots around Melbourne, and from 8.1 t/ha for squash to 43.2 t/ha for carrots in the Mallee. The average water use reported for the target crops ranged from 1.2 (in broccoli) to 3.3 ML/ha (in carrots) around Melbourne, and from 1.7 (in squash) to 3.1 ML/ha (in zucchini) in the Mallee. Average crop water use efficiencies (measured as t/ML) varied from 9.2 (for broccoli) to 28.4 (for lettuce) around Melbourne, and from 2.3 (for pumpkin) to 24.5 (for carrots) in the Mallee. Using averaged Melbourne market prices at the times of harvest for each crop, crop values were also estimated in terms of land ($/ha) and water ($/ML). Statistically meaningful comparisons could not be made between the crops and regions due to the limited data set. Growers were provided with reports for their particular crop and region, and were then asked to comment on the value of the process and how it might be improved. Water use efficiency was generally not seen as a high priority at a time of depressed market prices and ample water supply, although most growers agreed that it may become so. The comparative results were of interest, but their accuracy and value were rightly questioned given the limited sample and obvious differences in cropping circumstances. Most growers were unaware of how much water per hectare they were applying. The application of water for environmental control - eg to prevent wind damage - arose as a significant consideration in some areas. The relative experience of farmers was also important in their engagement with the process. Those new to vegetable production were often keen to participate and learn about their water use, whereas some of the larger more established growers agreed to take part but then lacked commitment in collecting the required information. Apart from making the monitoring requirements as easy as possible (with recording tools and direct assistance), a more rigorous selection process for participants is recommended for future benchmarking activities.

Introduction

Vegetable production is intensive, often requiring large inputs of water and nutrients in the production of high value crops. Despite this, the vegetable industry currently lags behind other horticultural sectors in the understanding of plant water needs and irrigation best practices. Benchmarking can be used as a major driver for on farm improvements in natural resource management, particularly in relation to irrigation and nutrient inputs. Irrigation benchmarking is a proven tool for improving water use efficiency. It allows producers to compare their performance at both local and national levels, as well as providing policy makers with sound information to use in setting realistic efficiency targets. Peer support networks often develop from such benchmarking exercises, significantly enhancing the adoption of best management practice. The past two years have seen water shortages in many vegetable-growing areas, and focussed attention on irrigation efficiency. Irrigation benchmarking and adoption of best practices will lead growers to irrigate more efficiently and have a better understanding of crop water requirements. In turn, this will reduce growing costs, and help farmers to demonstrate responsible use of scarce natural resources.

Irrigation benchmarking is well established in Australia, particularly in Viticulture. Benchmarking techniques used in other horticultural industries could also be appropriate for use in vegetable production. This project was initiated to test a benchmarking process in vegetables that had been developed and used successfully in citrus, grapes and potatoes.

Methods

A benchmarking process for water use efficiency (WUE) was piloted with vegetable growers in two significant but contrasting production areas of Victoria with a view to extending the process to other crops and regions nationally. The two focus areas were the Mallee (Mildura and Swan Hill) and the peri-urban fringes of Melbourne – Werribee, Mornington Peninsula and Cranbourne Previous approaches used successfully in horticulture (eg Skewes and Meissner, 1997) were blended with recommended reporting indicators (DSE 2004).

Individual growers were approached to take part in the study based on their involvement in other research and extension activities. Participants were also sought in northern Victoria using advertisements in the local press. Information was collected from a total of 22 growers, monitoring 25 blocks across the two study areas (Table 1). Crops comprised carrots and cucurbits (pumpkins, zucchinis and squash) in the Mallee, and carrots, lettuce and broccoli around Melbourne.

Methods for measuring on-farm water flow rates were also discussed, and a GE Panametrics Transport PT 878 Portable Liquid Flow meter was borrowed and modified (with fittings to suit smaller pipe diameters) for use in the project. The information on output from pumps proved to be of interest to most growers.

Table 1: Vegetable blocks surveyed

Region	CROP	BROCCOLI	LETTUCE	CARROTS
Melbourne	Cranbourne	3	3	
	Werribee	2	4	
	Mornington			4

		ZUCCHINI	PUMPKIN	SQUASH	CARROTS
Mallee	Mildura	1	3	1	1
	Swan Hill	2			1

The farm questionnaire and irrigation recording sheet used in the project are shown in Appendix 1. It should be noted that one zucchini block was omitted from the report because the crop was grown between grapevine rows, making the results inconsistent with the other zucchini blocks monitored.

The following water use efficiency indicators were assessed

- YIELD (t/ha)
- WATER USE EFFICIENCY (t/ML)
- GROSS RETURN PER HECTARE ($/ha)
- GROSS RETURN PER MEGALITRE ($/ML)
- APPLICATION EFFICIENCY (%)

It was intended that the information collected be incorporated within a broader database of irrigation benchmarks for horticultural crops. The project team held various discussions with the developers of the database, and suggested modifications that would allow the vegetable data to be included. Some of these changes will be incorporated into revision of the database software. The version currently available proved too inflexible to accommodate the data set collected under this project.

References

DSE (2004) Farm Water Use Efficiency Technical Reference Booklet. Department of Sustainability and Environment, Victoria.

Skewes M and Meissner T (1997). Irrigation Benchmarks and Best Management Practices for Potatoes. Technical Report No. 265. Primary Industries and Resources, SA.

Results

A combined report, showing results in the format presented to growers, is attached as Appendix 2. Results derived from crop monitoring, farmers estimates and market information are summarised for crops and regions (Table 2) and overall (Table 3) below.
Information was also expected from an additional 4 carrot crops and one zucchini crop in the Mallee but was not supplied despite repeated requests from project staff.

Table 2: Vegetable WUE Summary by Crop and Region/Area

Melbourne Region	**Cranbourne**		**Werribee**		**Mornington Peninsula**
	Lettuce	**Broccoli**	**Lettuce**	**Broccoli**	**Carrots**
No. of Sites	3	3	4	2	4
Average Yield (t)	37.2	17.4	43.7	13.3	50.8
Average ML/ha	2.1	9.2	1.6	1.2	3.3
Average WUE (t/ML)	19.3	2.8	28.4	10.8	20.0
Average $/ha	26,477	21,718	30,231	16,628	29,282
Average $/ML	13,725	11,514	19,680	13,531	11,513

Mallee Region	**Swan Hill**		**Mildura Area**			
	Carrots	**Zucchini**	**Carrots**	**Pumpkin**	**Zucchini**	**Squash**
No. of Sites	1	2	1	3	1	1
Average Yield	43.2	20.0	17.0	8.4	36.1	8.1
Average ML/ha	1.8	3.1	2.6	10.5	3.0	1.7
Average WUE (t/ML)	24.5	6.7	6.4	2.3	12.2	4.6
Average $/ha	24,917	30,200	11,050	2,040	32,490	7,078
Average $/ML	14,141	10,414	4,185	833	10,976	7,839

Table 3: WUE Crop Summary (all regions)

	Lettuce	**Broccoli**	**Carrots**	**Pumpkin**	**Zucchini**	**Squash**
No. of Sites	7	5	6	3	3	1
Average Yield (t)	41	15.7	43.9	8.4	25.4	8.1
Average ML/ha	1.8	2.2	2.9	10.5	3.0	1.7
Average WUE (t/ML)	24.5	9.8	18.5	2.3	8.54	4.6
Average $/ha	28,622	19,718	25,515	2,040	30,963	7,078
Average $/ML	17,128	12,321	10,729	833	10,420	7,839

Figure 1: Water applied (ML/ha) on a crop basis

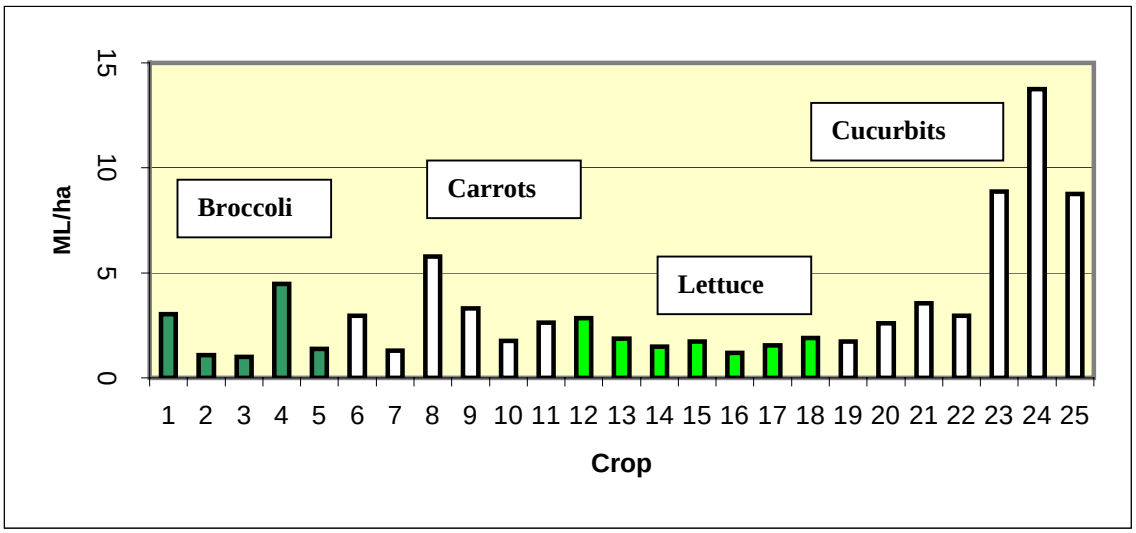
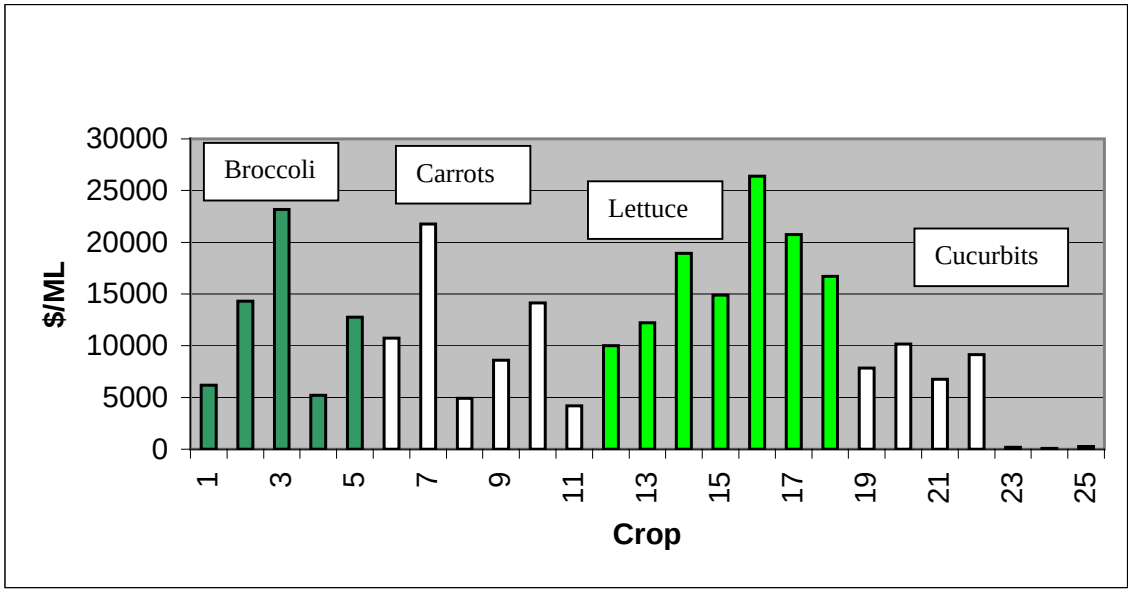


Figure 2: Returns ($/ML) for irrigation applied on a crop basis



Grower comments on the benchmarking process

Reports for each crop were delivered and explained to participating growers. They were then asked their opinions on the process and how it might be improved, with the following questions:

1: - Was the study of value to you?
2: - How could it be improved to give you greater benefit - in terms of the process (making it easier to use), or information delivered (format or content)?
3: - What, if anything, did you learn anything from the results?
4: - What issues do you have with irrigation?
5: - How do you rate yourself as an irrigator?

6: - Where do you see chances to improve?
7: - How could we help you? - eg would you like to participate in an irrigation management course?
8: - Would you be willing to take part in further development of this approach?
9: - Would you recommend it to others?
10: - Apart from watering the crop, when else do you irrigate?
11: - What percentage of your total irrigation is used for environmental control? (ie protecting the crop against damage from frost, dust or heat)

Summarised responses to these questions were as follows:

Was this study of value to you?

This project was perceived to be of value by about half of the grower participants. Growers that produced good results were more favourable in their comments. It gave them confidence and some gratification that they were on the right track. For growers that had multiple blocks this study was of value as it highlighted the differences in irrigation practices between two blocks with different pumps or systems on the same property. As the amount of water needed is mostly judged by visual analysis (experience, digging a hole, calendar), participation in the project provided a different means of measuring water. However, the accuracy of the results (responses) was a major limitation.

The growers that did not find this study of value commented that because climatic conditions were not taken into account, the true amount of water applied and its efficiency is questionable. It was expressed that water is the cheapest asset on the farm and in order to grow lettuce, you need a lot of water. Studies such as this will only be of value when water must be bought. In one case, accurate estimates of water use had already been made, so the grower found this study to be of no additional value. Other growers commented that not knowing the reason for the differences in the numbers meant they were frustrated with the results.

How could it be improved to give you greater benefit - in terms of the process (making it easier to use), or information delivered (format or content)?

Growers commented that the accuracy of the data limited the value they got from this study. When undertaking the evaluation it was stressed to the growers that the accuracy of the results is only as good as the data provided, and that each grower knows how seriously they took this study and therefore has to judge for themselves how accurate their results are. The reporting back sessions picked up errors in the estimated figures at several properties.

Some of the growers had automated sprinklers and they could have set the count to 0 to achieve more accurate irrigation duration times. However, this was not explored initially with the growers. It was also recommended that a waterproof recording sheet be used.

Comments were made regarding the way irrigation times were recorded. Growers that were committed to the process seemed to have no problems with the way the data was collected. They said the recording was easy with the only problem they found was

remembering to do it. It was recommended that small flow meters be fitted to sprinklers. This would give an accurate flow rate as well as application efficiency. In order to get greater benefit from this study, many growers commented on including rain and climate data. It was suggested that rain gauges should be on all properties.

Some growers wanted to be involved in the planning phases of future projects in order to help develop a program that would be minimally intrusive to growers.

What, if anything, did you learn from the results?

The responses varied depending on the individual results. Growers that were efficient water users and/or achieved a high yield commented that this study shows they are doing the right thing. Some growers commented that some of the results could not be true, and that other growers had provided inaccurate information about their yields. Some growers were surprised to see such differences between water use and yield, whilst others were more concerned about the ML/ha needed to achieve a good yield. Most growers found it useful to have their flow rate measured. Growers that had recorded irrigation on multiple sites, were generally surprised by the differences.
One grower on the low end of the results questioned his future in the industry when he saw how far behind he was, (something that he knew but the benchmarking process confirmed it).

What issues do you have with irrigation?

Most of the growers commented that they did not have any issues with irrigation. However, it was noted that one of the major problems is that most irrigation systems are set up so that you have to water more than one block (to utilise the output of the pump), even if it's unnecessary.

For some growers in the south, allocations have never been monitored. Most growers commented that water was the cheapest asset on the farm and that they will apply as much as they think is required. For the growers that did have irrigation issues, problems tended to be more mechanical such as blocked sprinklers.

How do you rate yourself as an irrigator?

All growers rated themselves as good irrigators, with most saying that they are conscious about the amount of water they apply and know when they are wasting it. Some growers said that during busy times, the pumps may be on for longer as there is no time to go and turn them off. One grower was looking at automating his system to overcome such problems, but was still weighing up the cost involved.

Where do you see chances to improve?

Most growers noted that their only chance to improve is by using an automated system or new technological improvements, as they are running as efficiently as they can on a manual system. All southern growers commented that drip irrigation is not feasible. In contrast the results in the north showed the drip irrigation was quite effective in gaining increased Water Use Efficiency (WUE) in cucurbit production.

The use of probes (to monitor soil moisture) was suggested by some growers whilst another grower commented that farmers need to reduce the amount that is grown and consequently reduce water requirements.

How could we help you? - eg would you like to participate in an irrigation management course?

Most growers (65%) said that if there was a free irrigation course they would participate in it. Other growers commented that an irrigation course would be pointless and that courses in monitoring and soil moisture management are more important. Most northern growers have completed an irrigation management course already.

Would you be willing to take part in further development of this approach?

All growers said that they would participate in further development of this approach. Comments regarding better accuracy and timing of the study were mentioned. A study in November would be more appropriate than January/February. There also needs to be more emphasis on what data is required. Growers would be able to provide more accurate information now that they know what they are participating in and what was expected of them.

Would you recommend it to others?

Most growers (80%) said they would recommend this study to others. Many could not give a reason why, but one grower commented that it was a very good study for the future of the industry, as every grower will be accountable for what they use. The farmers that did not see value in this study generally said they would not recommend it to others because it won't make a difference to how people irrigate and that farmers don't want to know this type of information.

Apart from watering the crop, when else do you irrigate?

- To prevent sand drift
- To maintain young seedlings
- To maintain a wet base
- To suppress the smell of chook manure to neighbouring housing estates
- To encourage weed germination (for weed control)
- To get the soil into the right condition for working and bed formation.
- To control dust, even if the ground is bare, will still water to protect other young crops
- Fertigation

What percentage of your total irrigation is used for environmental control?
Most growers commented that they watered between 1-10% for environmental control. Most growers estimated that 5% of their total irrigation was for environmental control as there are no other options at present.

Discussion

While the primary objective of this project was to evaluate the benchmarking process, the focus of participating growers was understandably on the information reported, and on their performance relative to that of others. The value of these numbers depends on how accurately figures on yield and water use have been recorded, and in some cases, this information proved highly questionable. The reasons for this varied, with some growers finding the logistics of recording yields and water applications for a single block too difficult to manage in a busy season. For others, commitment to the process fell away as other issues, such as low market prices, came to dominate their thinking. This is also seen in the evaluation responses, where many growers placed a low priority on water management as an issue in their business, and one even responded that water allocations should be cut to limit production and increase market prices. When the cost of water (generally from 0 to $250/ML) and crop returns per ML (Table 2) are taken into account, it can be seen that water is a minor economic consideration for most crops. Another report listing returns for water use by Victorian vegetable crops (ABS Census, 2001) gives much lower estimates than the figures derived from this study, but even then, economics can still be seen as an underlying factor in grower attitudes to WUE.

In other cases, growers may have felt that they were already applying best practices, and were reluctant to part with detailed information about them, despite agreeing to participate. For example, irrigation records were expected from an additional 4 carrot blocks in the Mallee but were not supplied despite repeated requests from project staff. A consultant advising two of the growers about irrigation scheduling, collected much of this information but failed to provide it as agreed when the season concluded.

The problems encountered in collecting information could be addressed by more careful selection of participants – and more attention to detail in explanations of what is required of them. More realistically, irrigation may need to be linked to benchmarking of other farming practices, providing information of greater value and impact to the farmer.

Data collected over a single season and crop when conditions may not be considered "normal" will always be open to debate. Some growers around Melbourne declined to participate in the project because water shortages meant that their current approaches to irrigation were not typical of their normal practices. All the Melbourne sites were planted from December to February, and were harvested by the end of April. Unfortunately, a delayed start to the project meant that spring plantings in the Mallee were missed (except for one carrot crop), and late summer/autumn crops were monitored instead – with some harvests extending into June.

Despite the difficulties in collecting credible information and leaving aside several outlying figures, there were some interesting results to emerge from the study (see Table 2 and Appendix 2). Around Melbourne, lettuce crops used the least water, averaging 1.8 ML/ha, reflecting a short growing season (averaging 46 days). The Cranbourne crops were given more water (possibly due to lighter soils), but produced slightly lower yields (average planting rates were higher at Werribee). Broccoli yields were reasonably consistent, with the root disease "club root" probably

responsible for the lowest yielding block. Average water use was much higher on Cranbourne broccoli crops (9.2 cf 1.6 ML/ha) – due to high values for 2 out of 3 monitored blocks. The reasons for this are unclear, as times of planting, rainfall and other information give no obvious clue to a need for higher irrigation rates. It is difficult to draw any meaningful comparisons between carrot crops, as there were too many inconsistencies between them. Average yields from the Mornington Peninsula (MP) were higher than those from the Mallee, and water use was also a little higher around Melbourne, but planting times (November for MP, August and January for the Mallee), climate and crop duration all differed. All the Melbourne carrot crops produced higher yields than those from the Mallee, although the averages are strongly influenced by one site, which performed very poorly in comparison with all the others in the study. Of the cucurbits in the Mallee, zucchinis produced the best yields, but pumpkins used the most water. Only one squash block was monitored, but it's water use was the lowest of all the cucurbit crops. Drip irrigation was used on the squash and two zucchini crops. Average water use under drip (two crops – 3.25 ML/ha) was not markedly different from that under sprinklers (one crop – 2.6 ML/ha) for the Mallee zucchini crops. The Mallee pumpkin crops were all grown under sprinklers, but one performed much better than the other two, where weeds were a problem. In terms of $/ML, none of the pumpkin blocks rated highly compared with the other crops in the study (Figure 2, crops 24-26).

A significant variable to emerge from this study is the amount of water applied to vegetable crops for environmental control. Irrigations were used to germinate weeds (presumably for post-emergent spraying), control wind-blown dust and sand, and to protect and maintain moisture under young seedlings. The extent of these irrigations was regulated by a number of factors including soil-type (with more irrigations on lighter soils) and position in the paddock (exposed blocks requiring more irrigations). One grower reported that if his crop were planted next to a bare patch, he would water that as well, to keep the dust down. Over-watering also occurred when the output of a pump was too great for one block, necessitating the irrigation of other areas, whether they needed it or not. With an abundant supply of water, these issues have not been of concern to growers in the past.

In summary, the information collected in this study provides useful insights into some of the issues facing farmers in the irrigation of vegetable crops across Victoria. Water use efficiency was not seen as a high priority for many of these growers, but most saw it as becoming more important to them. Commitment to the benchmarking process varied, with the less experienced farmers showing most interest in participation and learning from the results. Despite some early negativity towards the project, most growers were interested in the results, and were willing to participate in future benchmarking activities.

Technology Transfer

The project was directly promoted to approximately 50 growers – including industry leaders - in the target regions. A presentation was delivered through the VegCheque program to the Werribee Young Growers Group in May (2005), describing project objectives and activities. The target audience for the project included researchers and policy makers who are keen to develop better estimates of water use in horticultural crops, and to identify and promote the most efficient irrigation systems across the

Australian vegetable industry. To this end, close links were maintained with researchers on Project VG 04010: Australian vegetable crops – Maximising returns from water. This included a joint project planning meeting, held in October 2004.

Direct contact with participating growers was also a major part of the project, with initial interviews, follow-up visits/calls, and final delivery and discussion of results by the project team. Grower workshops were not considered practical, due to the size and geographical spread of the groups involved, as well as confidentiality concerns.

A reference group, initially planned for the project, was also deemed impractical due to the late project start and for the reasons outlined above.

Publications

Water Use Efficiency in the Vegetable Industry. Poster display at the Mildura Show and Werribee Field Day (May 2005).

B. Ashcroft, S. Henderson, S. Vujovic, D. Csaky, A. Boland and J.Vargas, 2005. Benchmarking the irrigation practices of cucurbit growers in Southern Australia. Abstract/presentation at the International Cucurbit Symposium, Townsville Qld, September 2005.

Articles on the project, including a call for grower participants, also appeared in the Summer Fruits and Riverlink newsletters in the Sunraysia.

B. Ashcroft, S. Henderson, S. Vujovic, D. Csaky, J.Vargas and A. Boland. Benchmarking water use in the Australian vegetable industry - a pilot study. Abstract submitted for the forthcoming Australian Vegetable Industry Conference, Brisbane 2006.

An article about the project will also be submitted to “Vegetables Australia”.

Recommendations

The benchmarking process was of value, generating information of interest to most of the participating vegetable growers, although many did not see the topic as a current priority. There is merit in developing this approach further, to better meet industry needs and benefit farmer participants. This could be achieved by linking irrigation into other benchmarking activities that target information sought by the growers.

Future benchmarking activities should also be designed to collect a comprehensive set of information – at least spanning several seasons. Factors such as region, crop-type and management system will also need to be adequately represented if meaningful comparisons are to be made.

The participation and commitment of growers is essential to the success of this process. Apart from measures suggested above, care is needed in 1) providing clear instructions for participants; 2) selecting candidates on the basis of their commitment; and 3) providing them with adequate support to ensure that the information collected is accurate and worthwhile.

Benchmarking activities should be linked with any national program for improving water use efficiency in vegetable crops, so that regions and/or issues of greatest need can be targeted and addressed. The information collected should also be incorporated into a central database, to provide a reference source to the industry, researchers and policy makers on water use in vegetable crops.

Several areas for further study also emerged from the project.

- A market study to analyse and promote the benefits of efficient water use in vegetable production will help to justify such activities to growers, and highlight the industry's efforts to other stakeholders (markets, government and the broader community).

- If accurately reported, the extent of variation in water use for the same crop, between growers and regions, suggests inefficiencies and warrants further investigation. Watering for environmental control, or to utilise excessive pump discharge are likely to be important in such studies.

- The interaction between irrigation and plant disease was identified as a priority issue by one grower, and although further details are needed, optimising irrigation and plant health (yield and quality) could be a future focus for water use studies.

Acknowledgement

The project team would like to thank all participating growers for their interest and contributions to this project.