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Irrigation Benchmarking in the Murray-Darling Basin



FINAL REPORT TO WINE AUSTRALIA

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Irrigation Benchmarking in the Murray-Darling Basin

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Abstract

This project built on the framework and success of a similar project that was developed by the South Australian Research and Development Institute in the late 1990s. It reviewed the irrigation practices, yield and quality targets of over 40 selected grape growers across the Riverland, Sunraysia and Riverina regions. Information about potential drivers of irrigation practices such as irrigation infrastructure type (drip, overhead etc.) and age, diversion method, scheduling methods and production targets were compared with measured performance.

Performance against the range of indicators varied widely. For example, yield ranged from 9 to 53 t/ha, water use efficiency from 1.15 to 6.91 t/ML, cost of water per tonne of fruit from $17 to $163 /t and return per dollar of water input from $4.3 to $28.9 /$.

Comparison of potential drivers of performance indicated that water delivery method (river, pipeline or channel), irrigation scheduling method, region and system age had little impact on performance against any of the indicators. Key determinants of performance included varietal class, yield and percentage of water sourced from permanent entitlement versus the volume leased annually.

The results will inform better targeted research and extension to support the adoption of management targets and practices that improve the efficiency of irrigation use and grower profitability.

Executive Summary

A standard set of data was collected from 43 vineyard patches (contiguous management units) across the Riverland, Sunraysia and Riverina regions. The primary data set included information about the water delivery to each site, irrigation system details, a detailed record of the irrigation schedule applied to the site over the 2021/22 season and information about grape variety, yield and quality.

These data were used to benchmark irrigation performance at these sites against six indicators; yield per hectare, yield per megalitre of water applied (also referred to as water use efficiency), gross return per megalitre, cost of water per tonne of fruit, return per dollar of water cost and irrigation efficiency. Results were sorted and graphed for each indicator, demonstrating the range in performance between the best and worst sites. The performance of individual sites varied between the performance indicators.

Additional data from each site were used to group the sites into a range of categories based on irrigation water diversion method, water source, irrigation scheduling method, target market, grape variety class and irrigation system age. Performance of the sites within each grouping was compared in order to identify which of these groupings had the greatest influence on performance.

The strongest relationships were in response to grape variety class, with white grape varieties performing better than red grape varieties. This appeared to be due to a combination of higher yields in the white varieties and higher returns per tonne for white varieties in the 2021/22 season.

The proportion of water owned as entitlement versus leased annually also contributed to variation in indicators, especially those that incorporate the cost of water. Estimated water costs were significantly increased by the additional cost of leasing water.

Other designators such as water delivery method, irrigation scheduling method, target market and irrigation system age gave much weaker responses.

Six of the sites evaluated in this study also took part in a previous benchmarking exercise (Skewes and Meissner, 1997b). Comparison of data from this study with the previous study revealed large changes in the cost structures for the viticulture industry over the past 25 years. The cost of water delivery and pumping more than tripled on average across this period, while the returns per tonne of grapes declined by 36% on average, from all-time highs at the time of the previous investigations. Both of these changes were outside the control of irrigators, but directly impacted on their performance against a number of the benchmarking indicators.

Background

Irrigation is an increasing cost for most grape growers in the Murray-Darling Basin and in conjunction with poor irrigation practices, threatens the financial viability and the social license of one of the region's major horticultural industries. Almost two thirds of Australia's wine is grown in the three inland wine regions within the basin (Riverland, Sunraysia and Riverina) with an annual export value of $2.3B.

This project targeted grape growers in these inland irrigated regions of Australia. Growers in these regions rely on irrigation to supply most of their vineyards needs, as rainfall during the growing season is well below crop requirements, and is extremely unreliable.

Irrigation water is an expensive component of production costs and with increased competition from other irrigated horticulture and the potential for reduced supply due to drought, these costs are likely to increase. Better irrigation management practices to improve water use efficiency will create a more resilient industry. Improving irrigation practices will provide insulation by decreasing ongoing water requirements. It will also improve overall profitability which will improve the industry's resilience in the face of high-water prices in the inevitable drought years.

This project builds on the framework and success of a similar project that was completed by SARDI in the late 1990s (Skewes and Meissner, 1997b). The irrigation landscape has changed considerably since then, including the decoupling of water entitlements from land, the development of a water trading market, and most importantly, the decline of the position of wine grapes in the water market behind other irrigated crops. Wine grapes are no longer the largest or most profitable water user and therefore cannot set the benchmark water price. Grape growers in these regions are squeezed between increasing water prices caused by the higher profitability of other users and the international price of wine, which is largely set by supply and demand overseas.

This project reviewed the irrigation practices, yield, and quality targets of 40 selected grape growers across the Riverland, Sunraysia and Riverina regions. Well-regarded growers with efficient irrigation programs were targeted. Comparisons of performance seek to identify drivers of irrigation practices such as irrigation infrastructure type (drip, undervine etc.) and age, diversion method, scheduling methods and production targets. The results will inform better targeted research and extension to support the adoption of management targets and practices that improve the efficiency of irrigation use and grower profitability.

Project Aims

The aim of the project was to review the irrigation practices, yield and quality targets of around 40 selected grape growers across the Riverland, Sunraysia, and Riverina regions, with a focus on identifying drivers of irrigation practices such as irrigation infrastructure (drip, overhead etc.), diversion method and production targets such as maximum yield and minimum quality parameters.

Method

The benchmarking analysis followed a similar format to that undertaken by SARDI in the 1990s across a number of different crops in the Riverland (Skewes and Meissner, 1997a, b, 1998), subsequent studies in the Limestone Coast region, including in winegrapes (Binks and Christie, 2001), and multi-seasonal benchmarking by the NSW Department of Primary Industries in the Sunraysia region (Giddings, 2008).

In the present study, 40 grape growers from throughout the Murray-Darling Basin were interviewed and their vineyards assessed, with their responses collated confidentially as part of a database that allowed their irrigation performance to be readily compared.

Better performing irrigators were targeted to participate in the project and were identified with the help of regional grower representative groups and staff from the relevant state government departments of agriculture and primary industries. The interviews formed part of a validation and review process to ensure that only verified information was included in the analysis.

A range of performance metrics were calculated based on the results of the interviews including yield (t/ha), water use efficiency (t/ML), gross return per ML ($/ML), cost of water per tonne of fruit ($/t), gross return per dollar water input ($/$) and irrigation efficiency. These metrics were also compared against the grower's target markets, water supply, scheduling and infrastructure to better understand the drivers of irrigation use on a daily through to seasonal basis.

This project crossed state borders, and due to restrictions on travel due to COVID 19, SARDI outsourced some of the site selection and data collection to the Victorian Department of Jobs, Precincts and Regions (Jeremy Giddings and Maxine Schache) and the NSW Department of Primary Industries (Katie Dunne).

The initial intention was to evaluate 15 vineyards in the Riverland, 15 in the Sunraysia and 10 in the Riverina. Due to difficulties in accessing data from Riverina growers and a late withdrawal in the Riverland, the final balance of sites was 14 in the Riverland, 22 in the Sunraysia and seven in the Riverina, for a total of 43 sites. In the Sunraysia and Riverina there were multiple sites on some properties.

Sites were chosen in consultation with the property manager, on the basis of the availability of the required data. A range of winegrape varieties are represented within the samples. This range of varieties has an impact on the return data, however it allowed as wide a range of growers as possible to participate in the project, with comparison based predominantly on their irrigation performance.

Performance Indicators

The indicators of irrigation performance used in this study are the same as those developed by SARDI in the 1990s (Skewes and Meissner, 1997a, b, 1998). All indicators were quantitative, with clearly defined units. The value for each indicator was calculated at each site from the data collected in the interview. The performance of all sites for each indicator was plotted, and sites were ranked according to their relative performance.

The suite of indicators of irrigation performance is presented below, along with information on how they were derived from the basic set of data provided by irrigators. The purpose of the indicators was to determine the best performing sites over a range of parameters. They were not intended to give an accurate assessment of the total financial situation at the site. This applies especially to those indicators involving the cost of water and gross return figures.

Yield (t/ha)

Yield was collected for the 2021/22 irrigation season and expressed as tonnes per hectare over the vineyard planting unit assessed.

Water Use Efficiency (t/ML)

Yield was divided by the total volume of irrigation water applied per hectare over the irrigation season (ML/ha) as calculated from the irrigator's records, to derive tonnes of fruit produced per megalitre of irrigation applied (t/ML).

Gross Return per Megalitre ($/ML)

Gross return per hectare ($/ha) was calculated based on yield, variety and region. For each combination of variety and region, the average price published by Wine Australia in its Price Dispersion Report for the 2022 vintage (www.wineaustralia.com/market-insights/national-vintage-report) was used as the return value. The values used are displayed in Table 1.

Note that the Price Dispersion Report does not use Sunraysia as a regional designation. The values for Sunraysia in Table 1 are the average of the published values for Murray-Darling - Swan Hill NSW and Murray-Darling - Swan Hill Vic.

Table 1 Gross Return per Tonne of Fruit used for Comparisons, taken from Wine Australia's Price Dispersion Report 2022

Variety	Region	Value ($/t)	Sites
Cabernet Sauvignon	Riverina	390	037A
	Riverland	339	008A
	Sunraysia	382	011A, 028A
Chardonnay	Riverina	404	033A, 038A
	Riverland	419	002A, 003A, 009A, 058A
	Sunraysia	414	010A, 013A, 014A, 015A, 016A, 018A, 023A, 026A, 029A, 031A
Fiano*	Riverland	580	042A
Merlot	Sunraysia	396	017A
Petit Verdot	Riverland	346	005A
Pinot Gris	Riverland	556	006A
	Sunraysia	531	019A, 021A, 024A
Rhine Riesling	Riverland	357	066A
Semillon	Riverina	362	036A
Shiraz	Riverina	361	034A, 035A, 039A
	Riverland	345	001A, 012A
	Sunraysia	381	020A, 022A, 025A, 027A, 030A, 032A
Shiraz-Organic*	Riverland	1200	004A, 007A
Viognier	Riverland	500	040A

*Values for Fiano and Shiraz-Organic were estimated, as there were no figures for these designations in the 2022 Price Dispersion Report.

Returns for a small group of Riverland growers producing organic Shiraz were derived from the average of their actual returns, as they received a premium for their fruit that was not reflected in the Price Dispersion Report. However, this average figure was cross-checked against the range of prices paid for Shiraz in the Riverland reported in the 2022 Price Dispersion Report. Also, Fiano did not have a value assigned for 2022 in the Price Dispersion Report, so the actual price received by the one grower of this variety was used.

Gross return per hectare ($/ha) was further divided by the volume of water applied per hectare over the course of the season (ML/ha), to derive gross return from fruit per megalitre of irrigation ($/ML).

It should be noted that these figures were used for comparison between sites only, and do not necessarily reflect the actual returns received by the growers.

Cost of Water per Tonne of Fruit ($/t)

The unit cost of water ($/ML) was calculated from water delivery rates, the cost of any leased water and estimated pumping costs. As such, it reflects the operating costs associated with water application but does not include the capital cost associated with purchasing permanent water entitlement (a once-off cost as opposed to the annual cost associated with leasing water). Most growers in this study owned all of the water applied to their vineyards, four sites owned no entitlement and leased all of the water applied, while nine of the sites applied a mixture of permanent entitlement water and leased water.

The cost of water applied per hectare ($/ha) for the season was calculated by multiplying the unit cost of water ($/ML) by the total volume of irrigation applied over the season (ML/ha). This was then divided by yield (t/ha), to give cost of water per tonne of fruit ($/t).

Gross Return per Dollar Water Input ($/$)

Gross return per hectare ($/ha) was divided by cost of water per hectare ($/ha), to give a comparison of money returned from the sale of fruit with money spent on irrigation to produce that fruit ($/$).

Irrigation Efficiency (%)

Irrigation efficiency as defined here could also be termed application efficiency. It is similar in form to ‘Irrigation (Engineering) Efficiency’ as defined by McGowan International (1986), except that they assessed system losses (pre-application), whereas only drainage losses (post-application) are accounted for here.

Irrigation efficiency was calculated from total irrigation applied and estimated drainage for the season, by the following formula:

$$\text{Irrigation Efficiency (\%)} = \frac{[\text{Irrigation applied (ML/ha)} - \text{Drainage (ML/ha)}] \times 100}{\text{Irrigation applied (ML/ha)}}$$

This is equivalent to Application Efficiency (On-Farm Irrigation Committee of the Irrigation and Drainage Division, 1978), defined as the average depth of water stored in the rootzone divided by the average depth of water applied.

Drainage was estimated from the irrigators' irrigation records using a daily soil water balance technique. Accumulation of soil water deficit between irrigation events was estimated from crop growth stage (crop coefficient, K_C) and climatic records (Reference Crop Evapotranspiration, ET_0), and the amount of irrigation water applied at each event was compared with the accumulated deficit. Any excess irrigation applied beyond the estimated deficit was defined as drainage, and the individual drainage depths were summed to derive a total volume of drainage for the season (ML/ha).

None of the Riverina sites were able to provide detailed records of their irrigation applications, only total volume applied for the season. As a result, Application Efficiency was not calculated for these sites.

Drivers of Irrigation Performance

Additional information collected from each site was used to compare performance against the indicators, above, as follows:

- Diversion Method – Private diversion versus water delivered by an irrigation trust or authority;
- Water Source – Water accessed directly from the river or backwater, or delivered to the property via pipeline or channel;
- Scheduling Method – Low tech (calendar, climate, shovel), soil water monitoring, plant based monitoring, remote monitoring (for example aerial or satellite imagery) or unspecified;
- Target Market – Bulk, bottled, premium or unspecified, as reported by the grower;
- Varietal Class – White wine, red wine or organic red wine
- Irrigation System Age;
- Yield;
- Leased Water – percentage of the water used that was leased versus water sourced from permanent entitlement.

These comparisons highlighted which of the potential drivers was having a significant impact on performance against specific indicators.

Site Information

Table 2 summarises information about each site. Site code is a unique code that identifies each site throughout the project and is displayed on some of the results graphs. The first two letters indicate the region (RL = Riverland, SR = Sunraysia, RA = Riverina), followed by a three digit number.

The bottom six sites (RL 040A to RL 068A) indicate properties which were part of the original winegrape benchmarking project (Skewes and Meissner, 1997b), where the same numbers they had in that study have been reused. In some cases the same planting unit has been evaluated, and in other cases the original planting is no longer present so another planting has been assessed.

The size of planting units varied from 1.0 ha to 66 ha, and vine age ranged from 4 to 40 years. Water was sourced either directly from the river or delivered by pipeline for all Riverland and Sunraysia sites, while all but one Riverina site reported delivery of water to the property via channel. One site was irrigated using undervine sprays, all other sites used drip irrigation. Consequently, all of the application rates were below 1.6 mm/h apart from the undervine spray irrigation unit (4 mm/h). Irrigation system age ranged from 1 to 29 years.

Table 2 Summary data for the benchmarking sites

Site Code	Region	Area of Unit (ha)	Vine Age (Y)	Water Source	System Type	System Age (Y)	Application Rate (mm/h)
RL 001A	Riverland	1.7	20	River	Drip	5	1.1
RL 003A	Riverland	3.1	18	River	Drip	1	1.1
RL 004A	Riverland	3.2	18	River	Drip	18	1.1
RL 005A	Riverland	3.64	25	Pipeline	Drip	20	1.1
RL 006A	Riverland	10.5	5	Pipeline	Drip	5	0.9
RL 007A	Riverland	2.5	4	Pipeline	Drip	3	1.1
RL 008A	Riverland	1.5	15	Pipeline	Spray	8	4.0
RL 009A	Riverland	4.9	19	Pipeline	Drip	3	1.1
SR 010A	Sunraysia	10.0	19	River	Drip	14	0.83
SR 011A	Sunraysia	5.9	22	Pipeline	Drip	22	1.17
SR 013A	Sunraysia	4.5	20	Pipeline	Drip	1	1.18
SR 014A	Sunraysia	4.2	20	Pipeline	Drip	1	1.18
SR 015A	Sunraysia	21.5	n/a	River	Drip	5	1.19
SR 016A	Sunraysia	5.1	27	Pipeline	Drip	29	1.21 & 1.39*
SR 017A	Sunraysia	6.0	23	Pipeline	Drip	25	1.21 & 1.40*
SR 018A	Sunraysia	7.2	19	Pipeline	Drip	19	1.54
SR 019A	Sunraysia	8.0	10	River	Drip	10	1.0
SR 020A	Sunraysia	4.0	10	River	Drip	10	1.0
SR 021A	Sunraysia	12.0	15	River	Drip	15	1.0
SR 022A	Sunraysia	11.3	15	River	Drip	15	1.0
SR 023A	Sunraysia	4.0	20	Pipeline	Drip	5	1.09
SR 024A	Sunraysia	7.4	5	Pipeline	Drip	5	1.09
SR 025A	Sunraysia	1.5	21	Pipeline	Drip	15	1.8
SR 026A	Sunraysia	1.0	24	Pipeline	Drip	15	1.8
SR 027A	Sunraysia	3.8	23	River	Drip	4	2.2
SR 028A	Sunraysia	2.8	25	River	Drip	25	1.13
SR 029A	Sunraysia	9.6	19	River	Drip	19	1.13
SR 030A	Sunraysia	13.8	22	River	Drip	22	1.13
SR 031A	Sunraysia	66.0	18	River	Drip	18	1.23
SR 032A	Sunraysia	40.0	18	River	Drip	18	1.23
RA 033A	Riverina	4.7	23	Channel	Drip	23	0.673
RA 034A	Riverina	6.1	23	Channel	Drip	23	0.673
RA 035A	Riverina	9.1	27	Channel	Drip	15	0.656
RA 036A	Riverina	7.0	27	Pipeline	Drip	20	0.656
RA 037A	Riverina	8.3	25	Channel	Drip	14	0.796
RA 038A	Riverina	8.1	21	Channel	Drip	14	0.796
RA 039A	Riverina	21.1	26	Channel	Drip	14	0.546
RL 040A	Riverland	1.2	36	Pipeline	Drip	4	1.13
RL 042A	Riverland	1.7	12	Pipeline	Drip	18	1.05
RL 058A	Riverland	3.3	18	River	Drip	18	0.87
RL 064A	Riverland	6.8	5	River	Drip	5	1.16
RL 066A	Riverland	1.0	40	Pipeline	Drip	15	1.22
RL 068A	Riverland	3.7	19	River	Drip	16	1.1

*Mixed dripline product within one valve unit, variable application rates

Comparison with Previous Study

Comparison of information in Table 1 with the same information from the previous similar study (Skewes and Meissner, 1997b) indicated a major shift in irrigation system usage in vineyards over the last 25 years. In 1997, only five out of 36 sites were using drip irrigation systems (14%), compared to 42 out of 43 (98%) in the current study. In 1997, overhead sprinkler irrigation systems made up the majority of sites (64%), while there are no overhead systems in the current study, reflecting the almost complete disappearance of these systems across these regions.

The change in irrigation systems has resulted in a major change in irrigation schedules. The average number of days per season on which irrigation occurred in the 1997 study was 23, while the average for the current study was 121. With the potential for pulse irrigation during the course of the day, it is likely that the average number of irrigation events in the current study is even higher than this. This is a direct consequence of drip irrigation wetting a far smaller soil volume, and therefore the need to apply irrigation in much smaller and more frequent doses.

Irrigation system age was similar between the two studies, averaging 15.7 years in 1997 and 12.5 years in the current study. Average vine age was slightly older in the current study at 19.5 years, compared to 12.4 years in 1997.

It is interesting to note that the average vine age in 1997 was less than the average age of the irrigation systems, reflecting the predominance of overhead sprinkler systems which were long-lived and expensive to replace, and thus were often left in place when the vineyard was replanted. However, in the present study, the average vine age is older than the average irrigation system age, reflecting the shorter life span of drip irrigation systems and the need to replace the dripline more often. It is also possible that some of these vineyards have experienced conversion from overhead to drip irrigation during the lifetime of the vines.

Results and Discussion

Performance Indicators

Sites were ranked for each indicator of irrigation performance, from poorest to best performer, and plotted. The order of ranking is specific to each indicator. The colour of the bars in the graphs identifies whether a red or white wine variety was grown.

Yield (t/ha)

Yield per hectare (Figure 1) is the traditional way of representing the performance of an agricultural enterprise. While it is of immediate interest to the grower, it can sometimes give a false impression of efficiency, if other inputs are not being used efficiently.

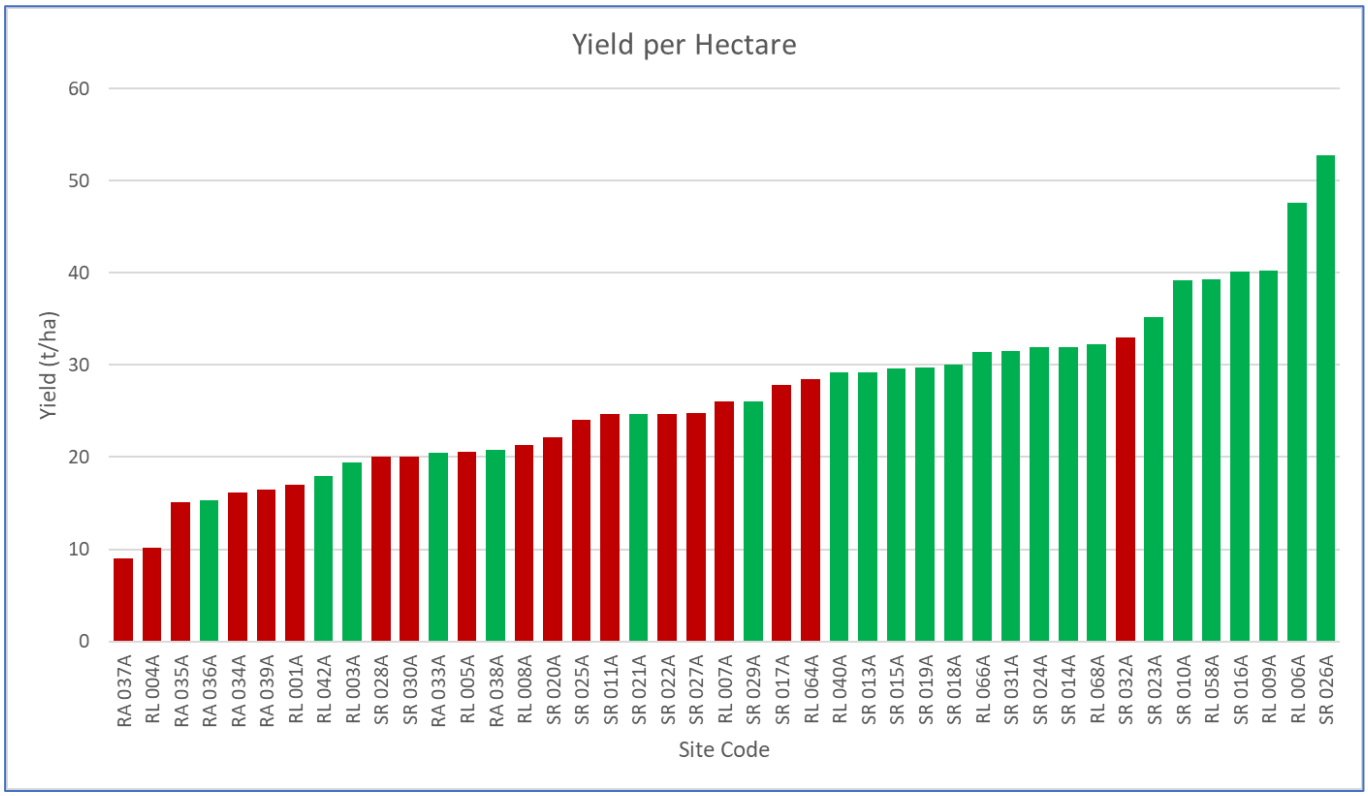


Figure 1 Yield from benchmarked sites (red bars are red wine varieties, green bars are white wine varieties)

There was a wide variation in yield across the sites, ranging from 9 to 53 t/ha. This variation was obviously not all due to differences in irrigation management, as other factors in the growing system also impact on yield. Some sites suffered hail damage during the season, with up to 50% crop loss.

Yield is sometimes restricted to improve fruit quality and value, and to increase returns. This is reflected in the proportion of red varieties with lower yields and the higher yields observed for the white varieties. Irrigation is often restricted for red cultivars in the inland wine regions to align with lower production targets designed to maintain the concentration of anthocyanins and phenolics in the fruit. White varieties do not have these requirements and the yield targets can be higher.

Water Use Efficiency (t/ML)

Water use efficiency (Figure 2) introduces irrigation water into the comparison. While yield per hectare may be high at some sites, using excessive amounts of irrigation water to achieve that high yield is not an efficient use of a limited resource.

This indicator is important because in many areas of Australia, and in particular in the Murray-Darling Basin, availability of water is the major limitation to new horticultural development. In most areas, there is sufficient suitable land available within reasonable proximity to the river, but there is no new water available to apply to that land for growing crops. It could be argued, on this basis, that water use efficiency, or yield per megalitre of irrigation, is more important than yield per hectare in making the most efficient use of the limited resources available to irrigated horticulture in the Basin.

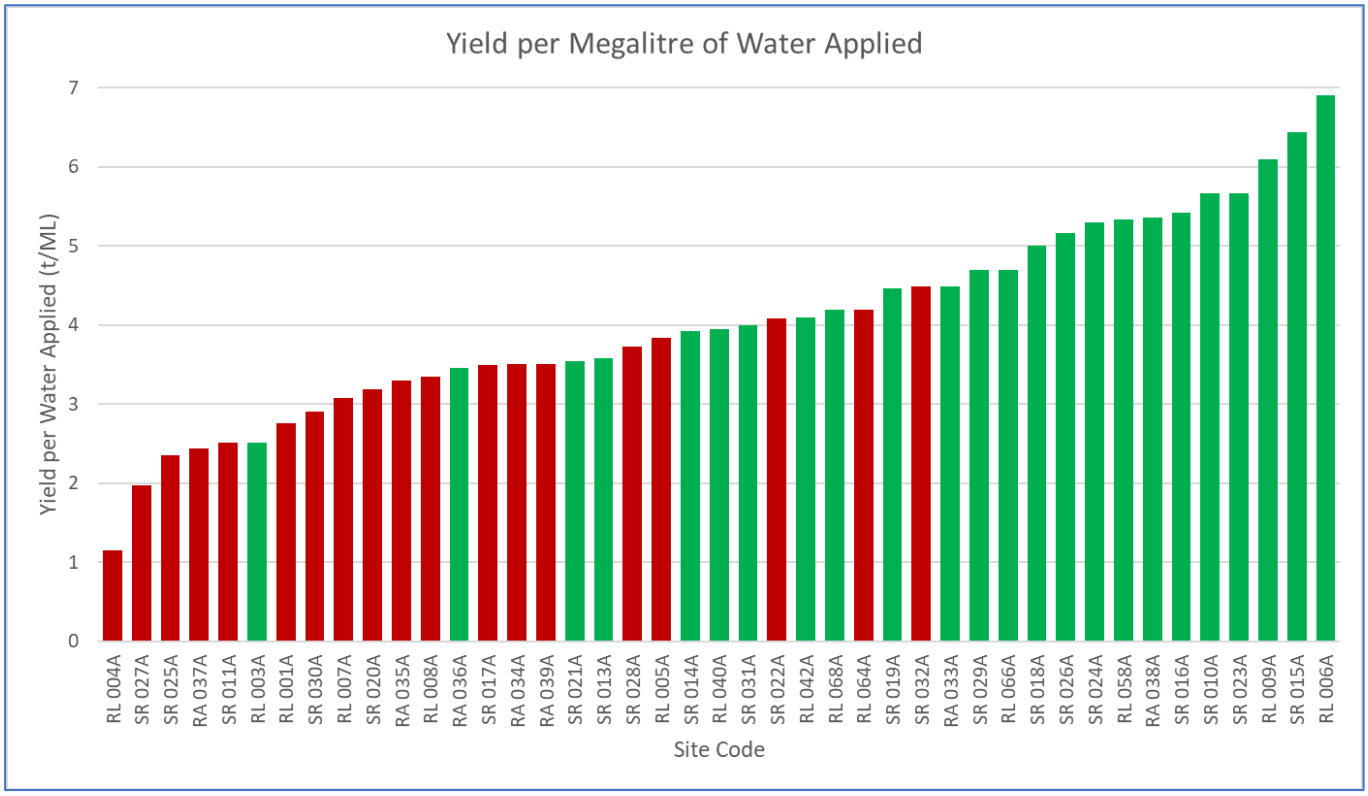


Figure 2 Water use efficiency at benchmarked sites (red bars are red wine varieties, green bars are white wine varieties)

Water use efficiency ranged from 1.15 to 6.91 t/ML. This is indicative of variation in both the yields achieved, and the volume of water used to produce those yields. The distribution of red and white wine varieties is similar to the yield distribution (Figure 1), suggesting that the average irrigation application to red and white varieties was also similar.

Gross Return per Megalitre ($/ML)

Gross return per megalitre (Figure 3) compares the relative value of the grapes produced against the volume of irrigation water applied. A standardised structure of returns was applied to the tonnages of fruit produced based on variety and yield, apart from certain specific sites where the grapes were sold for higher value (Table 1).

The value of crop produced per megalitre ranged from $784 to $3841/ML. Variety was a major influence, with the red varieties strongly impacted by lower average prices, apart from site 007 which received higher returns due to being produced organically.

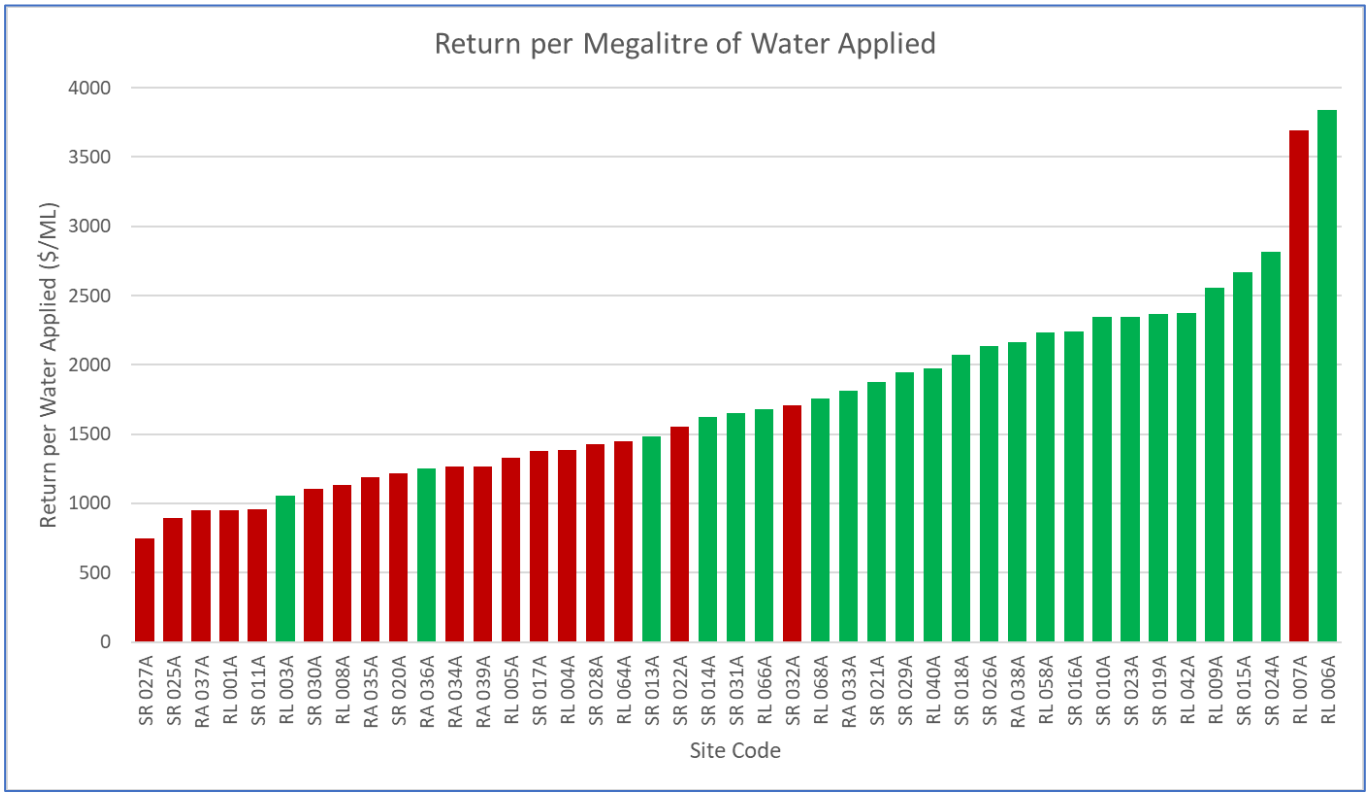


Figure 3 Gross return per megalitre of water applied at benchmarked sites (red bars are red wine varieties, green bars are white wine varieties)

As noted above, average returns for grapes in the current study were lower across most varieties compared to those used by Skewes and Meissner (1997b), with return for fruit dropping from $705/t to $448/t on average across the sites in the two studies, a 36% decrease. It is important to note that the returns offered at the time of the previous study were among the highest ever recorded in the Australian wine industry, thus emphasising the difference in returns offered in the 2022 vintage.

Cost of Water per Tonne of Fruit ($/t)

Cost of water per tonne of fruit (Figure 4) measures the delivery cost associated with irrigation water used to grow a tonne of fruit at each site. It reflects not only how much water was used per tonne of fruit, but also the cost structure of the site. There was no allowance made for the capital cost of water entitlements or pumping plant maintenance in the figures used, and the real costs to all growers would be higher than were reflected here.

The range of values for this indicator was very broad ($163 to $17/t), reflecting differences in cost structure and yield more than differences in efficiency. The distribution of varieties broadly reflects their distribution for yield per megalitre of water applied (Figure 2).

As noted above, the cost of accessing and pumping water has increased dramatically since the initial benchmarking study (Skewes and Meissner, 1997b), with the average rising from $42/ML to $153/ML, a 260% increase. This primarily reflects the increase in energy costs over this period. Private diverters pay this increase directly when pumping, and irrigation

trusts pass on their increased energy costs to their members in the form of increased water delivery costs, so both groups have suffered a similar rise in water cost.

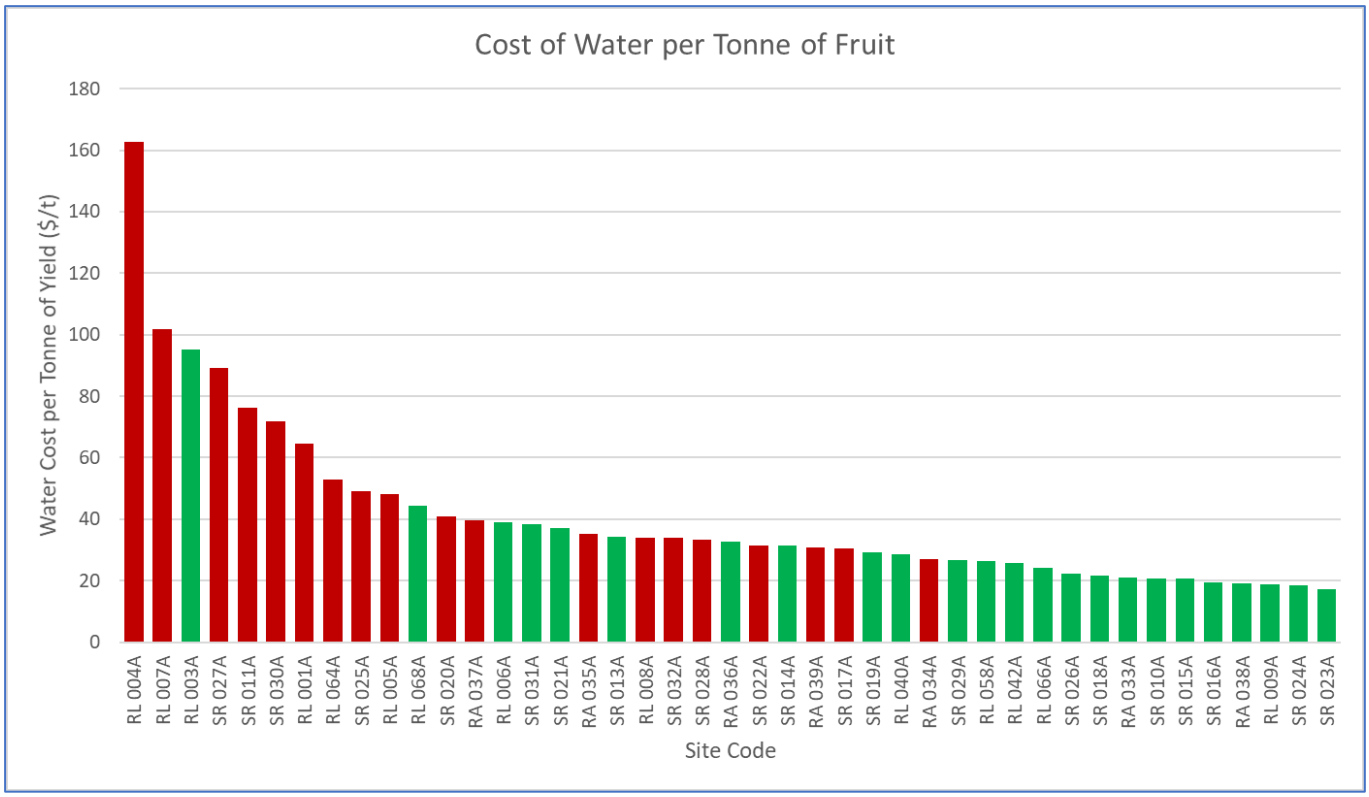


Figure 4 Cost of applying water per tonne of fruit at benchmarked sites (red bars are red wine varieties, green bars are white wine varieties)

Gross Return per Dollar Water Input ($/$)

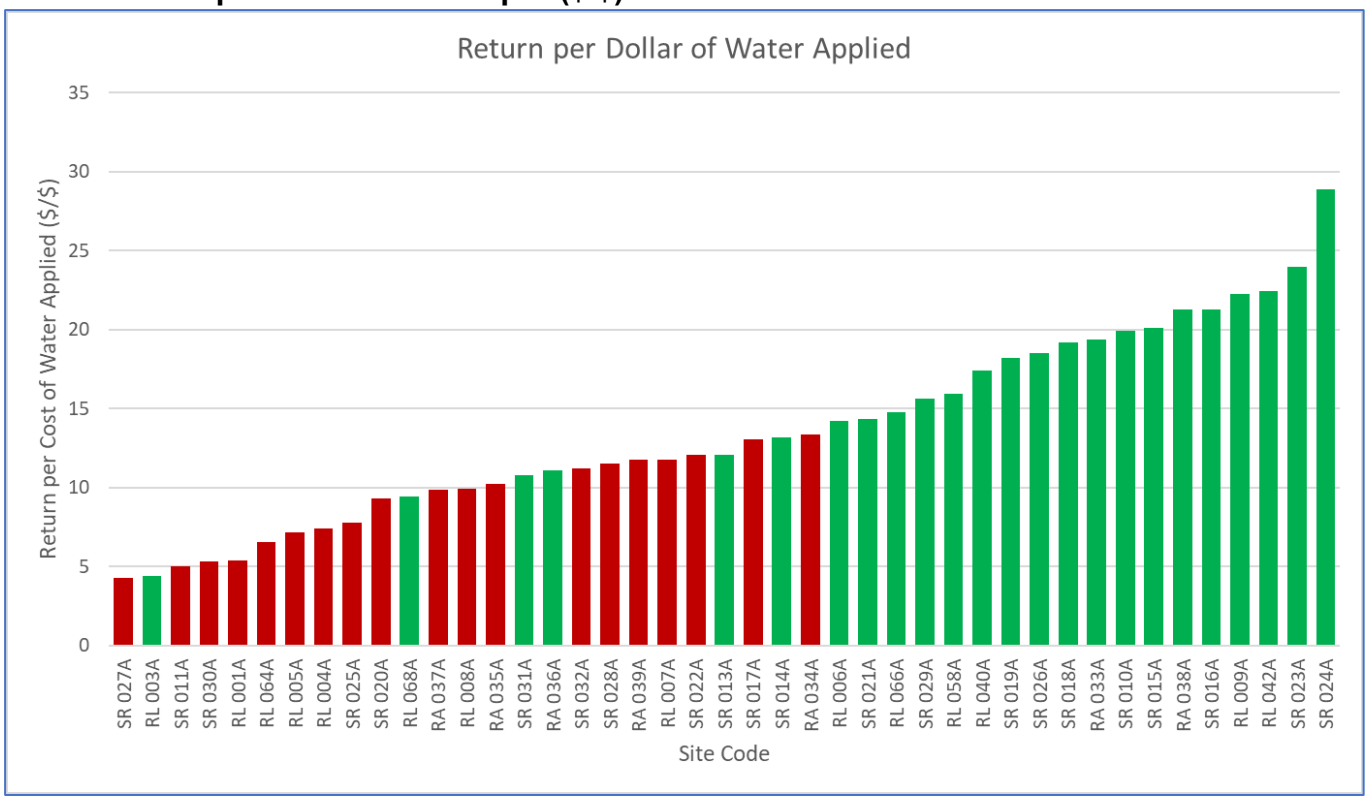


Figure 5 Gross return per dollar of water input at benchmarked sites (red bars are red wine varieties, green bars are white wine varieties)

Gross return per dollar water input (Figure 5) takes gross return per megalitre (Figure 3) a further step, by making a direct comparison of dollars spent on water with dollars returned from the use of that water. Obviously, a low gross return per dollar water input is of concern, as it impacts directly on the profitability of the enterprise.

It is particularly important to keep in mind that the comparison does not account for the cost of any of the other inputs into the growing system, such as fertilisers, chemicals, machinery costs, harvesting and transport, labour etc., and therefore this indicator does not reflect the true profitability of the enterprise.

The varietal effect is again clear for this indicator, with a similar pattern (lower returns per cost of water applied for red varieties) to that for return per megalitre of water applied (Figure 3). The exception is that the two organic properties (004 and 007) had very high water costs (Figure 4), which reduced their return per cost of water applied.

The difference between the best performer ($28.86/$) and the lowest performers ($4.40/$) was quite large, but the more outstanding observation is the difference between the average of these values ($14.41/$) and the average of the values reported by Skewes and Meissner (1997b) ($92.36/$), showing a drop of 84% between the two studies.

The timing of the previous study was during a period of record high winegrape prices, and therefore this is perhaps an unrealistic benchmark for comparison against the current situation. However, these data do highlight that, while costs have continued to increase year-on-year, grape prices have not, with the result that the grower's profit margin continues to be eroded.

Irrigation Efficiency (%)

Irrigation efficiency (Figure 6) assesses the relative percentage of irrigation water applied to the crop that was directly used by the vines for evapotranspiration. High values for irrigation efficiency reflect low volumes of drainage produced throughout the irrigation season. Actual irrigation efficiency is likely to be lower than indicated for most sites.

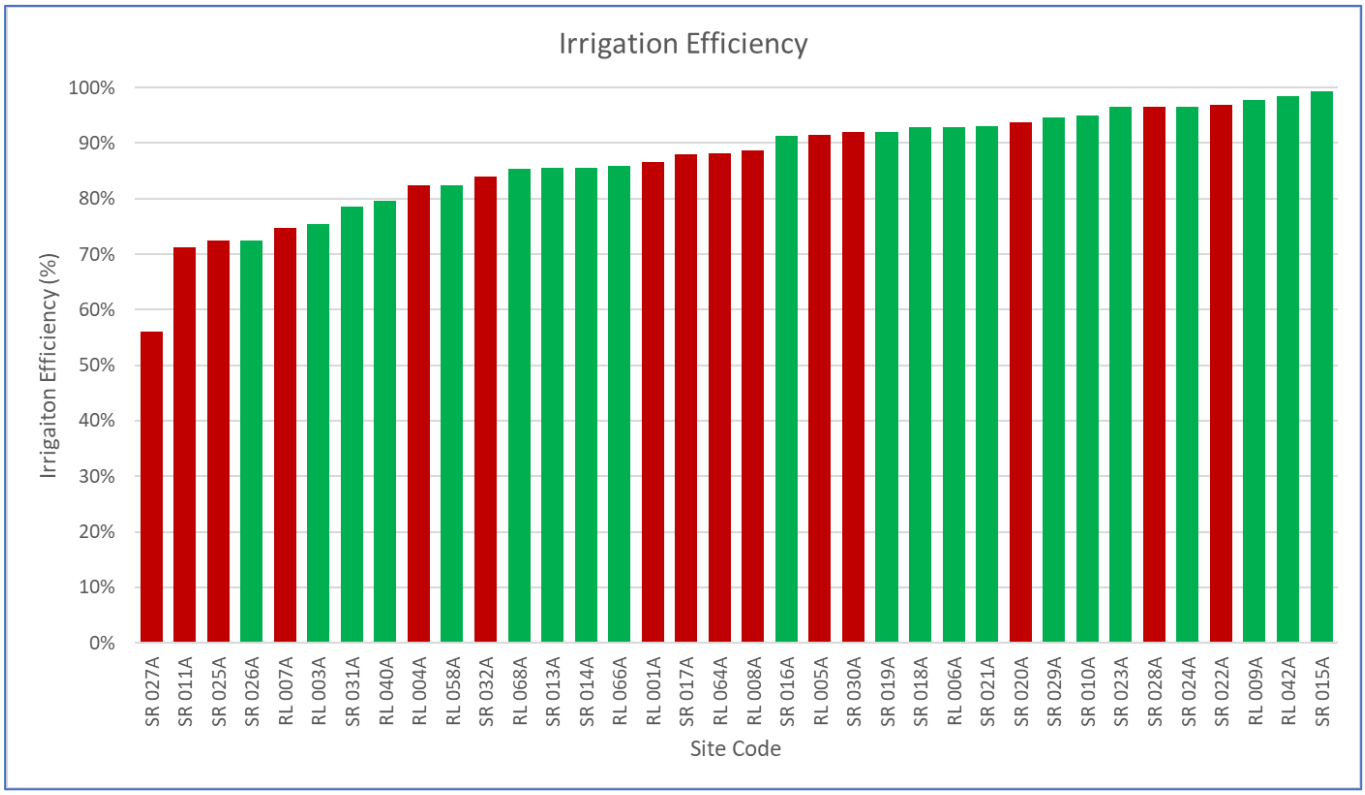


Figure 6 Irrigation efficiency at benchmarked sites (red bars are red wine varieties, green bars are white wine varieties)

A small amount of drainage almost always occurs when irrigating, and indeed some drainage is necessary, in order to leach away harmful salts that would otherwise build up in the rootzone and adversely affect vineyard performance. One hundred percent irrigation efficiency is not a recommended target.

Excessive drainage, however, is a waste of water that has been purchased and pumped, and it also contributes to problems such as waterlogging of crops (not necessarily at the site where the drainage is produced) and highly saline return drainage flows to the river system, reducing the quality of the water for downstream users.

Irrigation efficiency showed the smallest proportional variation of all the indicators. Three quarters of the sites (27 out of 36) returned an irrigation efficiency of greater than 85%. What is most interesting is that many of these sites with high irrigation efficiency have very low scores for the other indicators. The reasons for this are difficult to determine from the measured parameters, but under-watering could be occurring at some sites. This reinforces that irrigation efficiency, while an important primary indicator of efficient water use, is a poor predictor of overall water use efficiency, as measured across a range of indicators.

Variety has a limited impact for this indicator, with red and white wine varieties spread across the full range of results.

As noted in Method, none of the Riverina sites are represented in this figure due to a lack of detailed irrigation application records for these sites.

Drivers of Irrigation Performance

Most of the comparisons below utilise box and whisker plots to illustrate differences between performance of sites in different categories. In these figures, the middle 50% of data points is contained within the box, the majority of the remaining data are represented by the whiskers, and outliers are represented by isolated dots.

Diversion Method

Irrigators in the Murray-Darling Basin source water through one of two methods, either through water delivery infrastructure operated by a trust, cooperative or private/government operator, or as a private diverter.

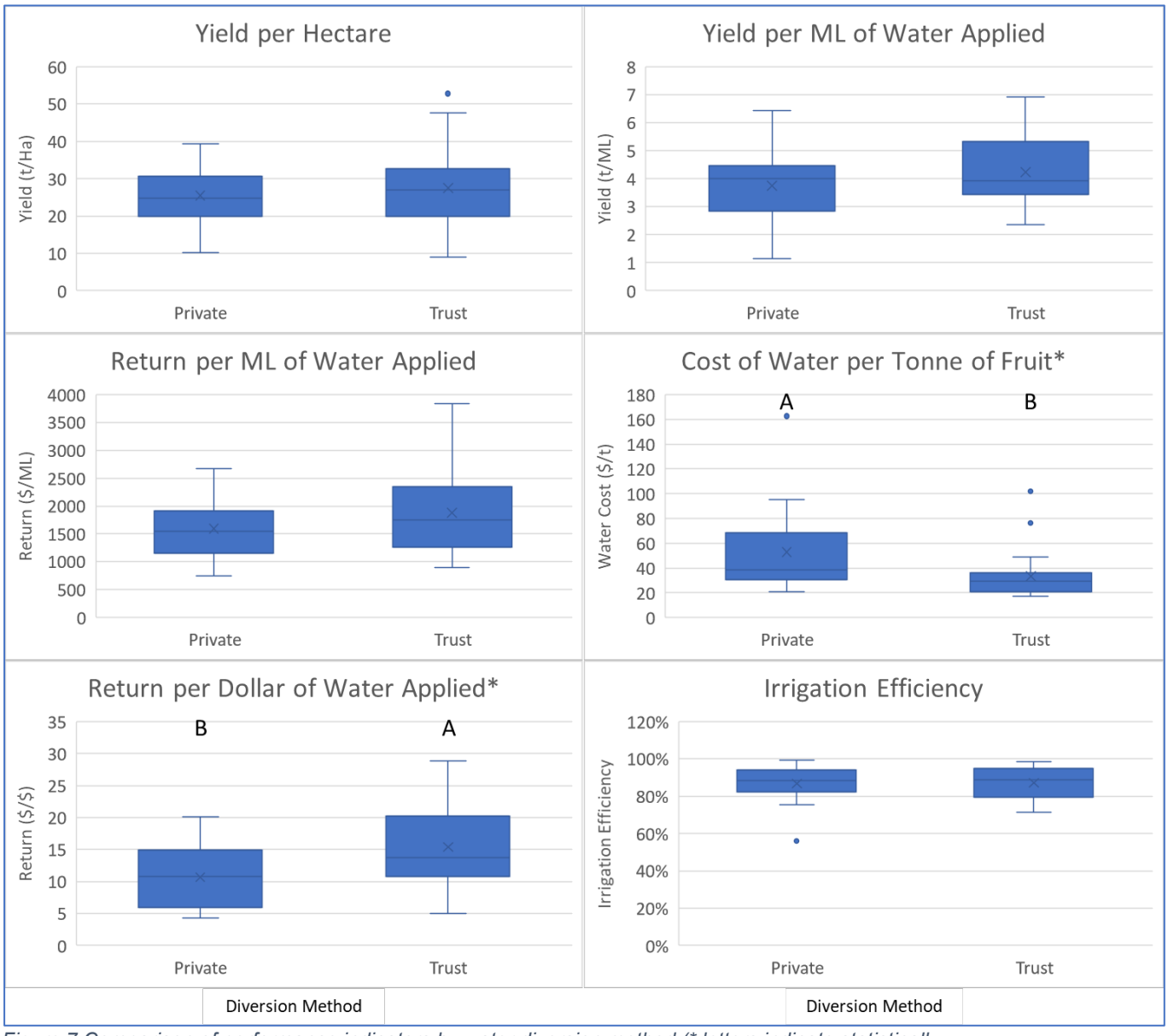


Figure 7 Comparison of performance indicators by water diversion method (letters indicate statistically significant differences)*

Irrigators on delivery infrastructure have water delivered to their property boundary through infrastructure managed by the organisation (generally pipelines or channels), under a diversion licence held by the organisation. In some cases, water is delivered at high

pressure, with no further pumping required, and in other cases, water delivery pressure is too low or unreliable, and re-lift pumping is the norm. These irrigators pay a water delivery fee to cover the costs of operation and maintenance of the pumping and distribution infrastructure, as well as the costs associated with re-lift pumping where it is needed.

Private diverters source their water directly from the river or a backwater connected to the river, under their own diversion licence. The water access cost for these irrigators is lower than for trust members, and they generally only pay an environmental levee. However, their pumping costs are much higher as they must lift water from the river to their properties, with enough residual head to operate the on-farm irrigation system.

Figure 7 illustrates performance relative to the water diversion method. There was little variation between the two data sets for most indicators. Sites sourcing water through a trust had lower cost of water per tonne of fruit and higher return per dollar of water applied.

Water Source

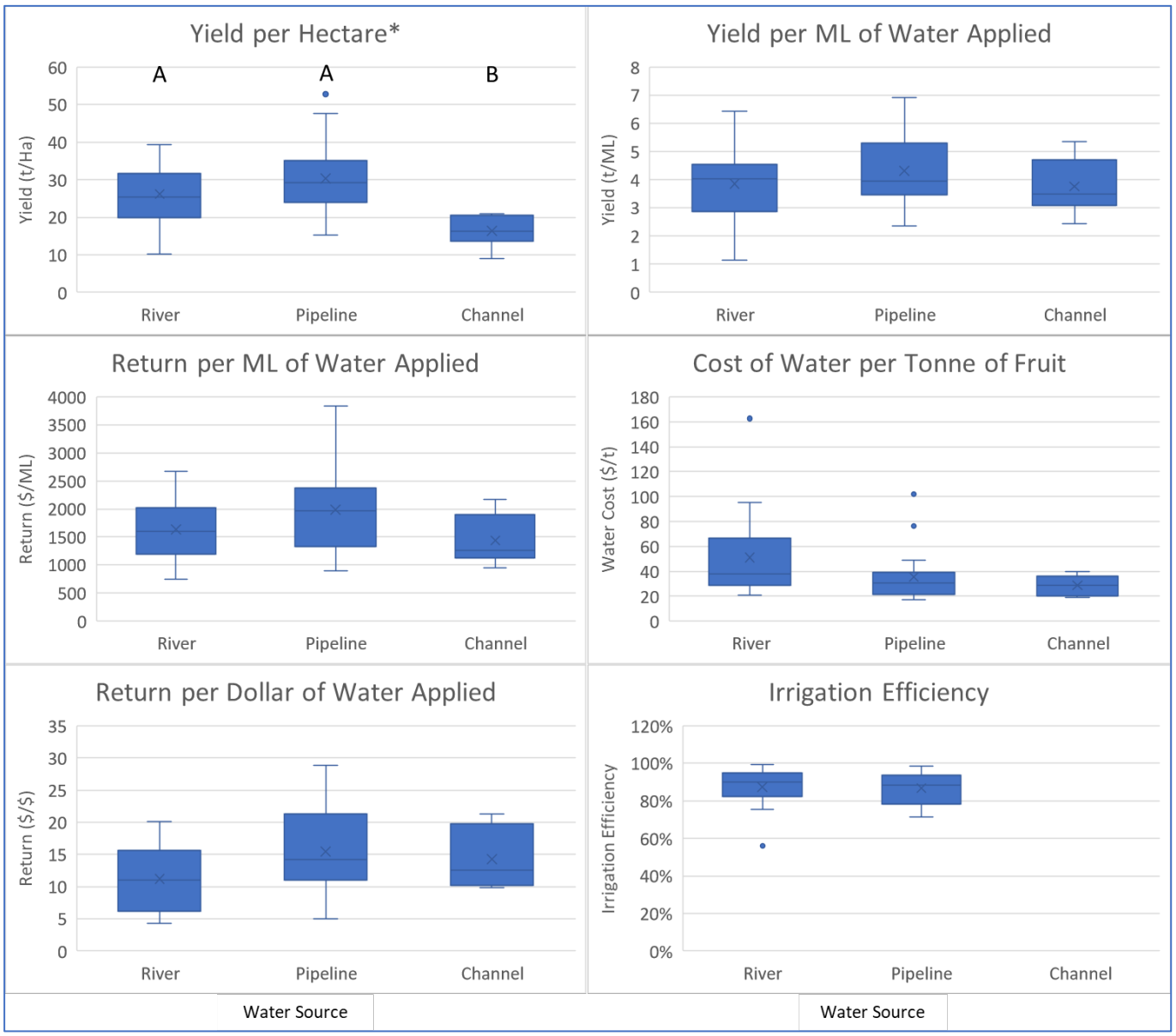


Figure 8 Comparison of performance indicators by water source (letters indicate statistically significant differences)*

Water source (Figure 8) refers to how water is accessed by each property and is closely aligned to the diversion method (Figure 7). Private diverters access water directly from the river, while trust members receive water through a pipeline or channel. In the current study, all Riverland and Sunraysia trust members received water through pipeline, while all but one Riverina grower received water via channel.

Yield per hectare is lower for channel delivery sites, but as this delivery method is exclusive to the Riverina region, it is not clear whether this is attributable to the delivery method or the growing location. As noted previously, irrigation efficiency could not be determined for the Riverina sites due to a lack of detailed irrigation schedule information, hence there is no irrigation efficiency data for channel sites in Figure 8.

Scheduling Method

Figure 9 displays data arranged by irrigation scheduling method. Many of the sites used a range of tools, the categories here represent the most advanced tools used at the site. 'Low tech' includes calendar watering, use of evapotranspiration data, digging holes and visual observations of plant condition. The other scheduling methods use quantitative measurements of soil water, plant water status or remote monitoring indices to assist with timing of irrigation events. Four sites did not provide any information about irrigation scheduling, and are shown as 'Unspecified'



Figure 9 Comparison of performance indicators by irrigation scheduling method

There were no significant differences in any of the indicators for the different scheduling approaches. This supports the conclusions of Skewes (1997), that good irrigation performance is influenced more by the management ability of the irrigator than the specific tools used.

Target Market

Figure 10 displays data sorted by target market. Yield per hectare was higher for sites targeting the bulk market than for those targeting the bottled market, but not for yield per megalitre, indicating that these sites received more water in order to achieve higher yields. There were no significant differences in any of the other indicators, including return per cost of water applied.

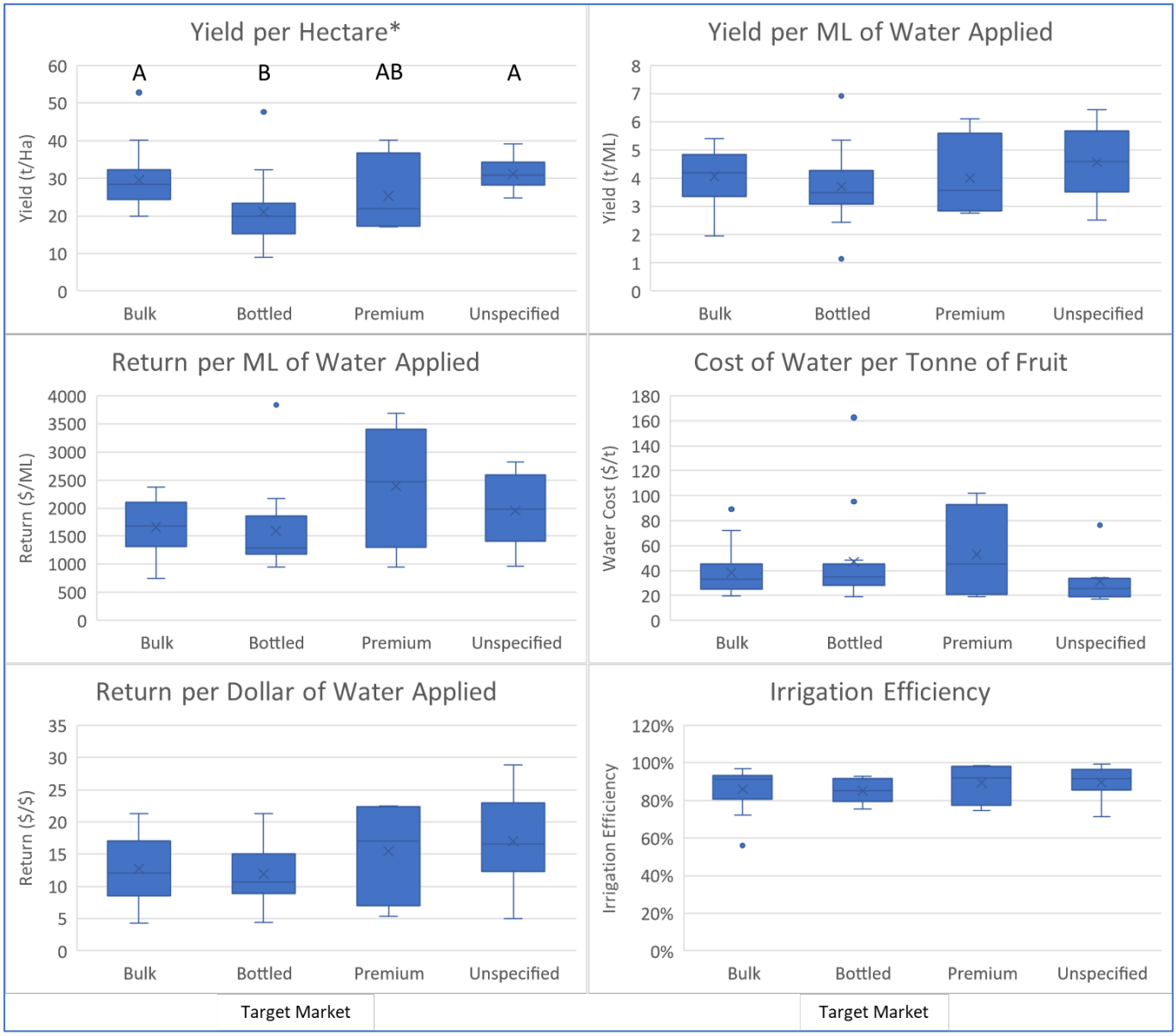


Figure 10 Comparison of performance indicators by target market (letters indicate statistically significant differences)*

Varietal Class

Comparison of data according to varietal class (red, white and organic red wine grapes, Figure 11) indicates that this had a far greater influence on performance than target market. White wine varieties had the highest yield per hectare and per megalitre of water applied, the highest return per megalitre and return per dollar of water applied, and the lowest cost of water per tonne of fruit. These results confirm the observations on the performance indicators above (Figure 1 to Figure 5).

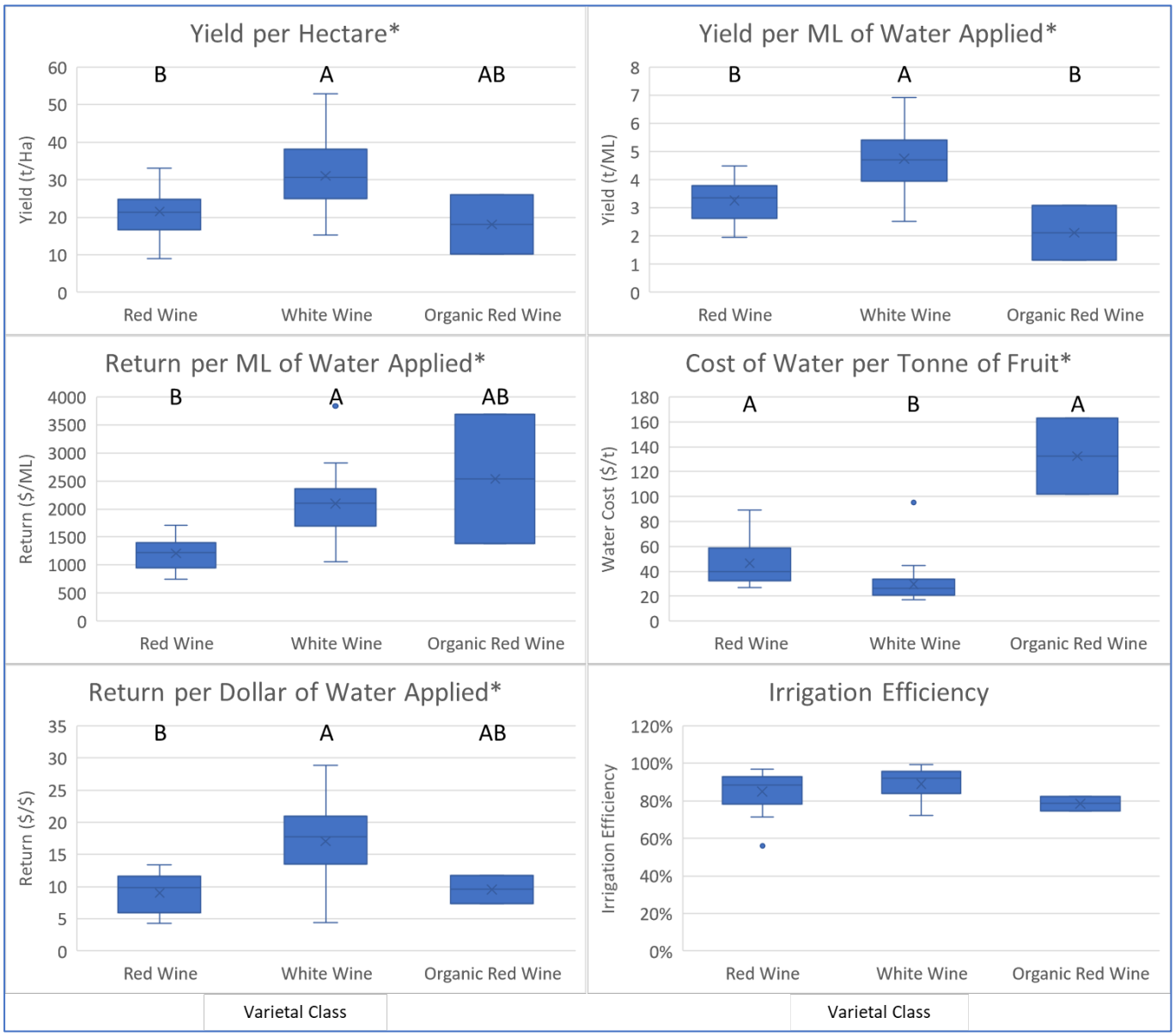


Figure 11 Comparison of performance indicators by varietal class (letters indicate statistically significant differences)*

System Age

System age was compared with the indicators as scatter graphs (Figure 12), and a trend line calculated to demonstrate the relationship (dotted line).

None of the relationships is statistically significant. The slope of the trendlines suggests a possible decline in both yield per hectare and return per megalitre of water applied with increasing system age, but this trend is not significant in the data presented.

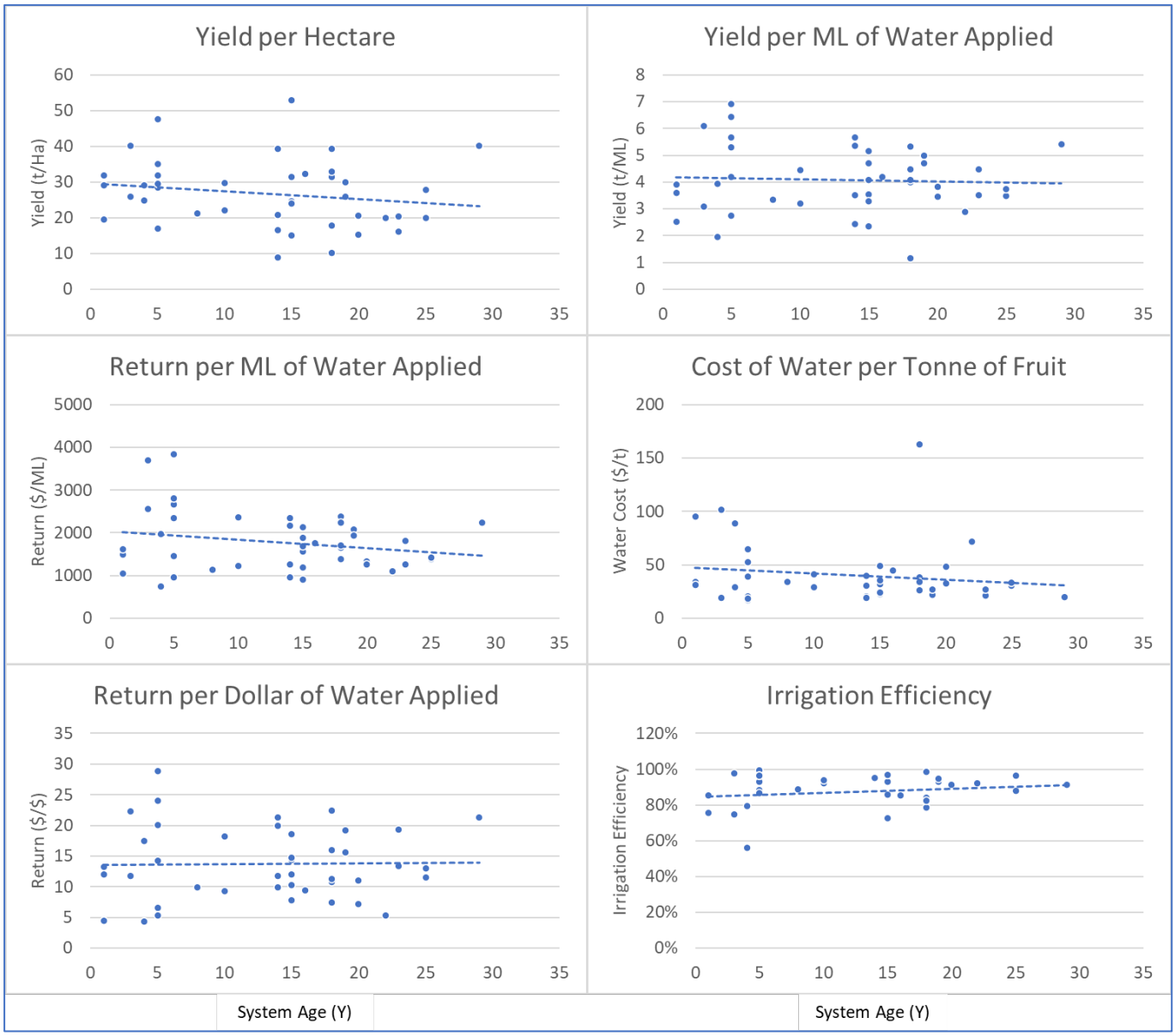


Figure 12 Comparison of performance indicators by irrigation system age

Leased Water

The percentage of water leased is compared with the performance indicators as scatter plots in Figure 13. The relationships are significant for cost of water per tonne of fruit (higher with greater percentage of water leased) and return per dollar of water applied (lower with greater percentage of water leased).

Both of these indicators incorporate the cost of water, and the response to leased water is a direct response to increased cost of water applied as a result of the increased percentage of leased water. As noted previously, the cost of water used in these comparisons is incomplete and does not reflect the full cost of applying water.

It is worth noting that allocations were at 100% of entitlement during the season when this study was undertaken. In periods of reduced allocations, irrigators who normally hold sufficient entitlement to cover their annual water needs may need to lease additional water to cover the shortfall in allocation. It is obvious that this will increase costs and put greater strain on irrigated horticulture businesses, as was the case during the Millennium Drought. During that period, with multiple years of very low allocations across the Murray-Darling Basin and low grape prices compared to other horticultural crops, many vineyards were mothballed or removed, and the water used elsewhere (Skewes, 2013).

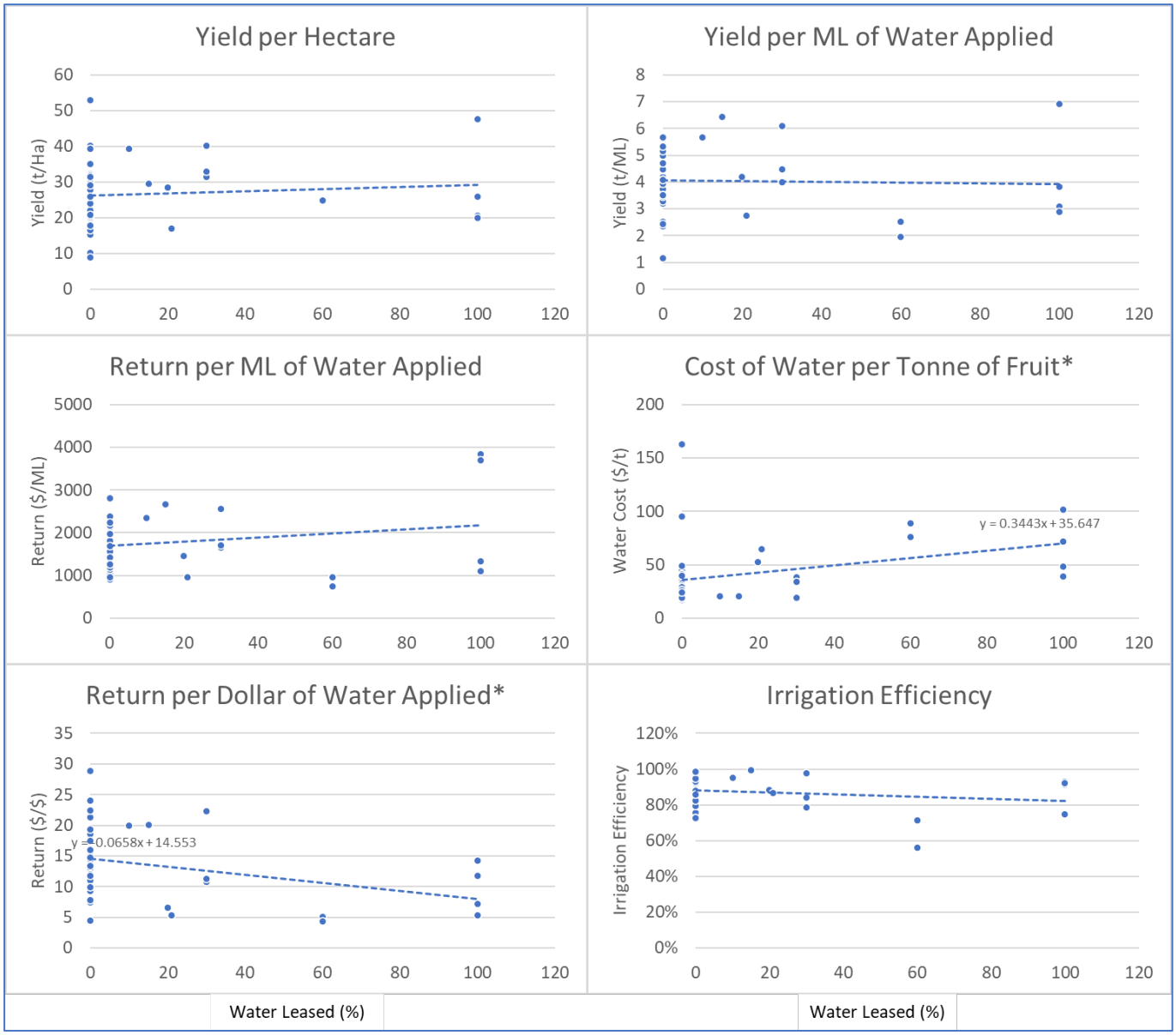


Figure 13 Comparison of performance indicators by the percentage of water that was leased (indicates statistically significant correlation)*

Yield

Although yield per hectare was one of the performance indicators, in Figure 14 yield is compared against the other performance indicators, to understand their influence on irritation performance. Many winegrape growers target a particular yield and manage their inputs,

including water, in order to achieve that target. This comparison seeks to understand the impact of the yield (or yield target) on other irrigation parameters.

There is a statistically significant relationship between yield and all other indicators apart from irrigation efficiency. Higher yield per hectare is associated with higher yield per megalitre, indicating that as the amount of water applied was increased, yield per hectare increased at a greater rate. This result was surprising, as it would normally be expected that at high irrigation volumes the yield response would begin to plateau. This implies that there is room for growers to improve their production efficiency, by increasing irrigation volume. This outcome warrants further investigation.

With yield per megalitre increasing at higher yield (t/ha), it is not surprising that return per megalitre and return per cost of water increased, and cost of water per tonne of fruit decreased. Higher yield translates into higher return, and lower water use similarly leads to lower water costs.

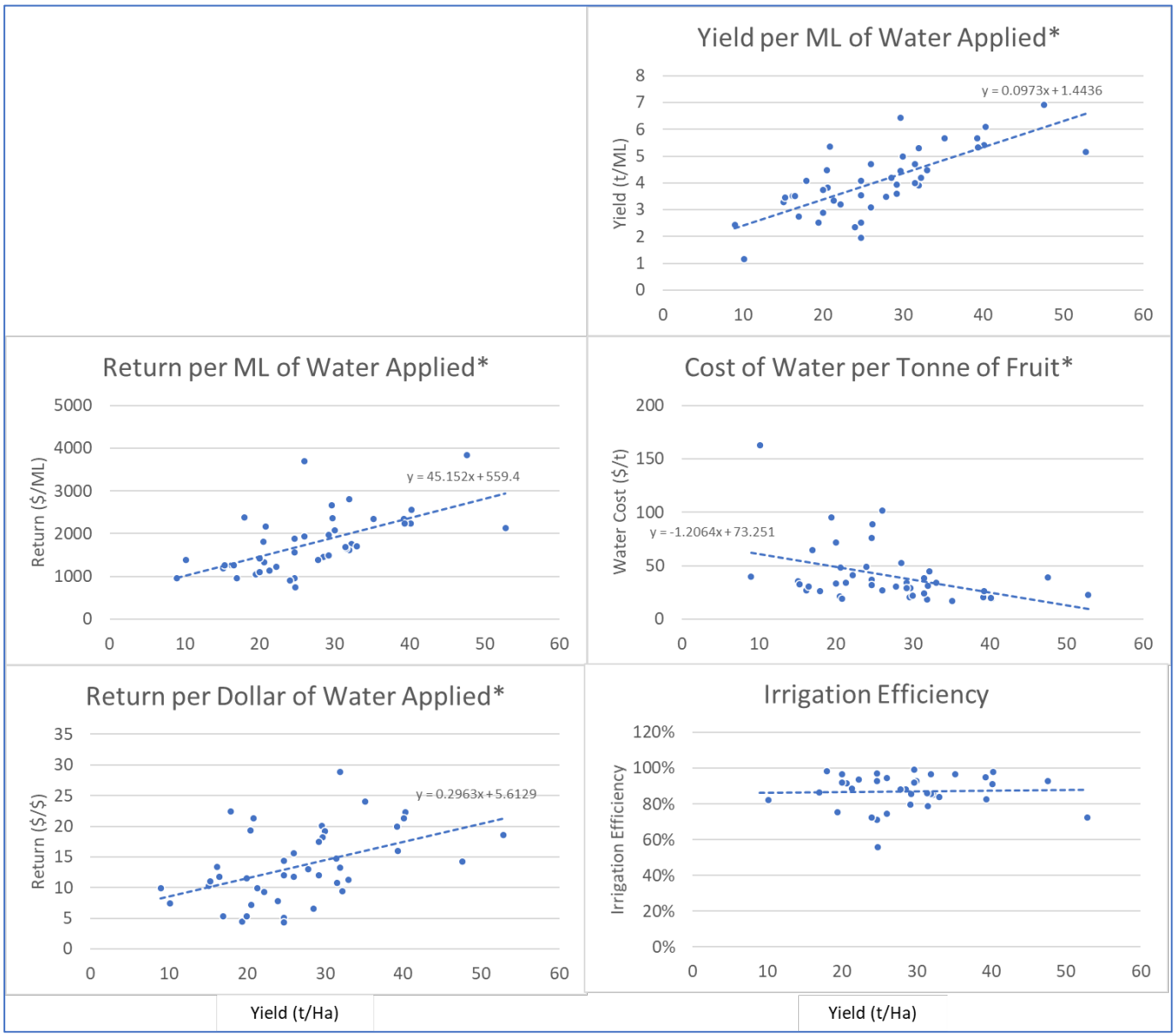


Figure 14 Comparison of performance indicators by yield (indicates statistically significant correlation)*

Comparison with the Previous Study

As noted in the Method section, six of the properties assessed in this study were also part of the original winegrape irrigation benchmarking study (Skewes and Meissner, 1997b). Table 3 shows their performance against the suite of indicators in that original study, compared with their performance in the current study.

Table 3 Comparison of performance indicators between the original 1997 benchmarking study and the current study

Site #	Year	Yield per hectare	Yield per ML of water applied	Return per ML of water applied	Cost of water per tonne of fruit	Return per dollar of water applied	Application Efficiency
040A	1997	39.2	5.44	3,267	8.47	70.80	88.6
	2022	29.2	3.95	1,972	28.72	17.41	79.6
042A	1997	20.0	2.21	1,327	27.02	22.21	79.1
	2022	18.0	4.09	2,372	25.84	22.45	98.4
058A	1997	25.6	2.92	1,751	6.79	88.34	95.4
	2022	39.3	5.34	2,236	26.30	15.93	82.5
064A	1997	13.1	3.20	1,919	9.64	62.22	87.1
	2022	28.5	4.20	1,448	42.07	8.20	88.2
066A	1997	32.1	4.19	2,511	14.53	41.30	94.8
	2022	31.4	4.70	1,678	24.21	14.74	85.9
068A	1997	35.9	4.23	2,536	7.65	78.42	77.3
	2022	32.2	4.19	1,757	44.33	9.45	85.3
Average	1997	27.7	3.70	2,219	12.35	60.55	87.1
	2022	29.8	4.41	1,910	31.91	14.69	86.7

Although many of the performance indicators show a similar range of values, the indicators reflecting costs and returns are quite different between the two studies at most of these sites, and as an average across the sites. Return per megalitre shows a slight drop from 1997 to 2022, with four of the six sites showing significant reductions and the average reducing by 14%.

The increase in cost of water per tonne of fruit is more significant, being demonstrated at five of the six sites, and averaging an increase of 158%. Return per dollar of water applied also fell significantly at five of the six sites, with the average falling 76%.

This is due primarily to changes in both the cost of accessing and pumping water, and the returns received for grapes. The average cost of water across all benchmarked sites has risen from $42/ML to $153/ML (260% increase), while the average grape price fell from $705/t to $448/t (36% decrease). The fall in grape prices is from an historic high at the time of the previous study, however, it is clear that grape prices have not risen over time to keep pace with the rising cost of power.

Conclusions

Irrigation performance was benchmarked against six indicators derived from combinations of yield, depth of water applied, cost of water, return for fruit and daily water balance calculation results. Sites performed differently against different indicators, and each indicator revealed a wide range in performance between the best and worst sites.

Sites were grouped on the basis of a range of categories and performance compared to identify determinants of performance. The strongest responses were ascribed to grape variety class, with white grape varieties performing better than red grape varieties. This appeared to be due to a combination of higher yields in the white varieties, and higher returns per tonne for white varieties in the 2021/22 season.

Other designators such as water delivery method, irrigation scheduling method, target market and irrigation system age gave much weaker responses.

Comparisons with a previous benchmarking exercise (Skewes and Meissner, 1997b) revealed large changes in the cost structures for the viticulture industry over the past 25 years. The cost of water delivery and pumping has more than tripled on average across this period, while the returns per tonne for grapes has declined by 36% on average, although this decline is from a historical high point. Both of these factors are outside the control of irrigators.

Recommendations

The current study is a snapshot in time, and the results are influenced by short-term factors such as the current cost of leased water and to a lesser extent electricity, and the returns for different grape varieties. The comparison of this investigation with the previous work (Skewes and Meissner, 1997b) highlights some of the implications of this.

This study could be repeated on a regular basis, to build up a broader picture of the factors influencing grape growers' water use decisions and outcomes. There are different ways this could be achieved:

- A consultant could be contracted to undertake a similar study every 10 years to benchmark against the current data set;
- A benchmarking tool could be developed to allow growers to compare themselves with their peers, either as a guided process using a facilitator, or as an online, unsupervised process growers undertake themselves (engagement is likely to be greater with a facilitated process).

We observed a significant correlation between water application and yield per megalitre of water applied (on average across this data set). This result was significant and not expected. It suggests that increasing irrigation will increase vineyard production efficiency. It is recommended that the relationship between applied water and yield in inland irrigated grape production is further investigated, along with how this and other factors influence growers' irrigation decisions. Potential avenues for study could include on farm benchmarking where growers are supported to evaluate the impact of varying irrigation volume on yield and performance for their own vineyards.

Appendix 1: Communication

No communication has been undertaken as part of this project as it was completed within a year and the results have only just been collated. A paper incorporating some of the results from this project has been accepted for the Irrigation Australia conference to be held in Adelaide in October 2022.

Appendix 2: Intellectual Property

New intellectual property contained in this report is shared equally between SARDI and Wine Australia.

Appendix 3: References

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Appendix 4: Staff

The Project Coordinator was Mark Skewes of SARDI, Loxton Research Centre.

Due to COVID 19 travel restrictions still being in place at the beginning of the project, the decision was made to subcontract data collection in the Sunraysia and Riverina regions.

Data collection in the Riverland was primarily carried out by Darren Graetz of SARDI, Waite Campus.

Data collection in the Sunraysia was carried out by Jeremy Giddings and Maxine Schache of Agriculture Victorian, Irymple.

Data collection in the Riverina was primarily carried out by Katie Dunne of the NSW Department of Primary Industries, Griffith.

Data compilation and analysis was carried out by Mark Skewes of SARDI, Loxton Research Centre.