CUT 1001: AO4 – Irrigation distribution uniformity mapper

This is an excerpt from the final report CUT 1001: **Optimising industry returns from existing soil and water research.**

To read the complete version of this final report click here

GWRDC project number: CUT 1001

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Adoptable Outcome 4. Irrigation distribution uniformity mapper

Authors: Lexie McClymont, Ian Goodwin, and John Hornbuckle

1. Background

Fereres et al. (1993) considered that reductions in seasonal water application through improvements of irrigation system uniformity to be one of the four key opportunities for improving water use efficiency in agricultural systems. Compared to irrigation systems with high distribution uniformity (DU), systems with low uniformity require increased irrigation supply to ensure all plants receive adequate water and achieve maximum yields (Fereres et al. 1993, Clemmens and Molden 2007; Fig. 1). This increased irrigation leads to unnecessary water losses via deep drainage, soil evaporation and cover crop transpiration. Similarly, if growers schedule irrigation to avoid excessive vegetative growth or employ deficit irrigation strategies, the risks of yield penalties and other adverse effects of water stress are increased when DU is low.

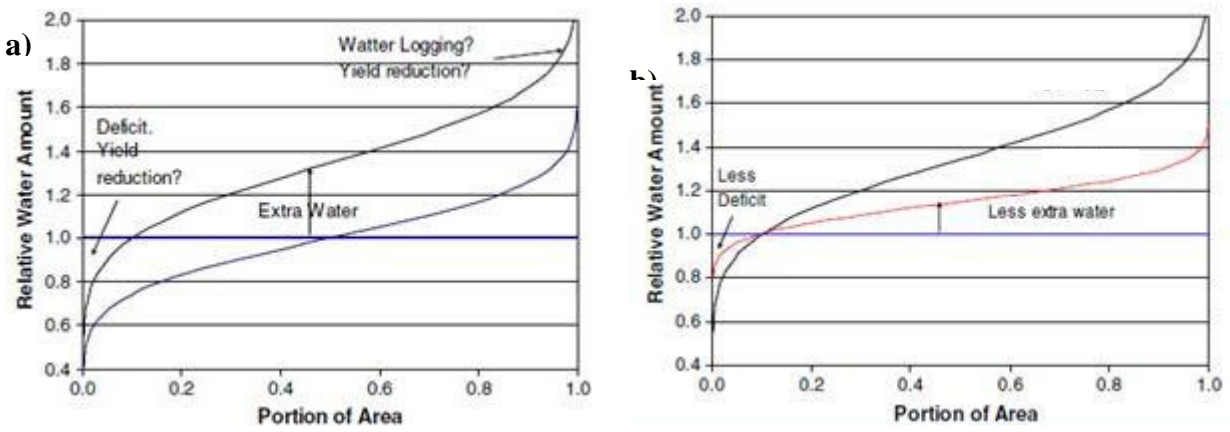


Figure 1. a) When irrigation uniformity is low (and a wide range of water is applied to different portions of a block) the risk of under-irrigation is increased. Applying extra water decreases the proportion of the area that is under-irrigated. **b)** Improving the irrigation uniformity (red line) means that less extra water is required to ensure that the majority of the area receives the desired irrigation volume. From Clemmens and Molden (2007).

Assessments of micro-irrigation system performance are rare and, consequently, little is known of typical DU values of micro-irrigation systems in Australia or their impact on efficient water management. Measurement of emitter rates at five vineyard sites revealed DU below 90 % at three of the sites (Goodwin et al. 2009), at one site simple system maintenance procedures improved DU from 85 % to 92 % while at a site with extremely poor DU (32 %) the irrigation system was completely replaced and the new system achieved a DU of 92 %. Pitts et al. (1996) assessed DU of 174 micro-irrigation systems in the USA, average DU was 70 %. A DU of 85 % was considered to be a reasonable expectation for micro-irrigation systems (Pitts et al. 1996). Three quarters of the blocks assessed had DU lower than 85 % but some blocks achieved DU greater than 95 % (Pitts et al. 1996).

Practices for measuring emitter rates and calculating DU are well established (Burt and Styles 1994, Burt et al. 1997). However, growers find the single DU value difficult to interpret in terms of actual water delivery, water use efficiency and impacts on crops. The 'DU Calculator' (www.irrigateway.net/tools/du/) provides growers or consultants with a simple and effective tool for assessing irrigation system performance and interpreting the effects of this performance in terms of water and fertigation delivery. Previously, creating maps of emitter uniformity and

visualising this across a field has been difficult. The online 'DU Calculator' takes away the need for difficult or expensive mapping software and provides the grower with a simple tool for measuring and interpreting this data.

2. Distribution uniformity

DU measurements aim to determine how evenly or uniformly plants within a system receive water. The concept of uniformity in irrigation systems has been used as a performance measure of irrigation systems for a number of years (Burt et al. 1997) and provides a standardised performance indicator which can be used to assess the capability across and within various irrigation systems to apply uniform rates of water to individual plants. DU can be calculated from the following equation modified from Burt and Styles (1994) specifically for vines,

$$DU = \frac{\text{Average discharge rate per vine of the low 25\% sampled vine emitters}}{\text{Average discharge per vine of all sampled vine emitters}} \times 100$$

where: the average of the lowest quarter of the values, rather than the absolute minimum value is used as a 'minimum' value. The highest possible value of a DU is 100 %.

Drip irrigation systems theoretically have high distribution uniformities and application efficiencies, however in commercial field systems these theoretical efficiencies can be difficult to achieve. In commercial situations, field evaluations of drip irrigation systems are often overlooked with many growers taking for granted that their system is behaving according to the design specification (Hornbuckle et al. 2007a). Furthermore, when DU is assessed, the single DU value does not provide growers with information regarding either the possible cause of poor performance or of the impact of low DU on their crop.

3. Mapping distribution uniformity

'DU Calculator' (www.irrigateway.net/tools/du/) is a practical and versatile tool developed by CSIRO to provide users of micro-irrigation systems with spatial information regarding irrigation system performance based on point measurements of emitter rates (Hornbuckle et al. 2011, submitted). Growers are provided with instructions for measuring emitter rates and recording GPS coordinates of emitters and block boundaries. This data, and basic block information, is entered in the DU website. A report is automatically generated and provides irrigators with maps of the emitter application rates, seasonal applied water, seasonal applied fertigation and the DU for their field. Spatial patterns of emitter rates revealed in these maps are of particular value in determining possible causes of poor system performance (Hornbuckle et al. 2011, submitted). For example, decreasing emitter rates at increasing distance from the supply lateral indicate a pressure problem or design flaw (Figure 2); low rates associated with a particular lateral could indicate a hole or kink in that lateral and a random occurrence of low rates throughout a block may indicate blocked or damaged emitters.

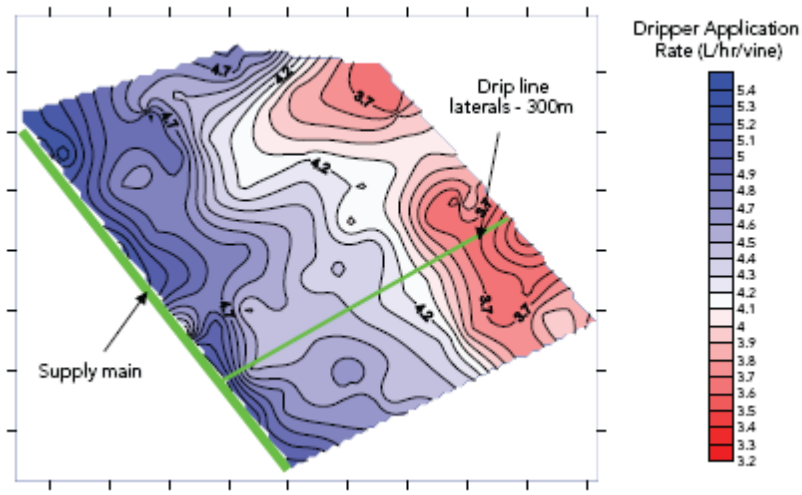


Figure 2. Map of emitter rates in a vineyard block. The emitter rates decrease with distance from the supply line indicating a problem with pressure at the site.

Once problems due to poor distribution uniformities in drip systems have been identified then mitigation measures can be undertaken to overcome these problems. Possible interventions include thorough flushing and cleaning of the system, running the system at higher or lower operating pressures, general maintenance and repair of the system or redesigning parts of the system to overcome limitations. Users have recognised the simplicity and value of the tool for providing maps of other data, for example fruit quality.

4. Future directions

A number of government and private agencies run irrigation benchmarking exercises. Expansion of these programs to include measurements of emitter rates and use of the 'DU Calculator' could be encouraged by GWRDC. Similarly, growers should be encouraged to assess the performance of new systems or to require their system designers to do so. Irrigation management guidelines should list monitoring of DU as a standard maintenance practice (albeit one that is required less regularly than other standard procedures, for example once every three to five years).

At this stage, over 40 people have used the 'DU Calculator'. Some of these have used the service multiple times, possibly for consultation services. Future monitoring of the site will retain data (anonymously) to provide an indication of typical irrigation system performance. This will enable growers to benchmark their irrigation system performance and provide feedback to system designers and retailers.

Further reading

Burt, C.M. and Styles, S.W. (1994) Drip and Microirrigation for Trees, Vines and Row Crops. Irrigation Training and Research Center (ITRC, California Polytechnic State University (Cal Poly), San Luis Obispo, California.

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Clemmens, A.J. and Molden, D.J. (2007) Water uses and productivity of irrigation systems. Irrigation Science, 25, 247–261.

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Wilson, R.F. eds *International Crop Science*. Madison, WI: Crop Science Society of America, 83–89.
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Pitts, D., Peterson, K., Gilbert, G. and Faustenaur, R. (1996) Field assessment of irrigation system performance. Applied Engineering in Agriculture, 12, 307–313.

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Distribution Uniformity – tools for measurement and understanding impacts

Presenter(s)

What is distribution uniformity?

- A measure of uniformity of irrigation applied across a field
- Yield and drainage can be affected by DU
- Poor irrigation DU = poor fertigation DU
- Important for the winegrape industry as nearly all systems will move to pressurised systems which can suffer DU problems if not designed and managed correctly
- Tools for growers to assess their irrigation systems and understand the consequences of poor DU and how to manage it

How is DU calculated?

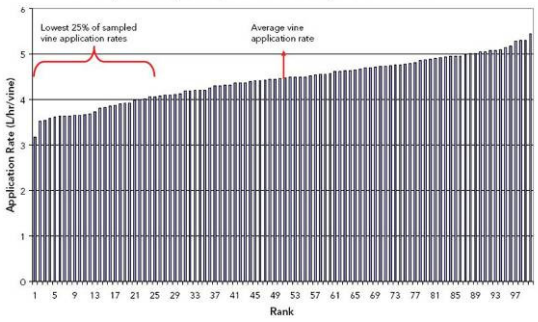
Field measurement of emitter rates

- Grid pattern – e.g. 5 emitters per line, 5 lines per block, evenly spaced avoiding edge rows and first and last emitters in lines

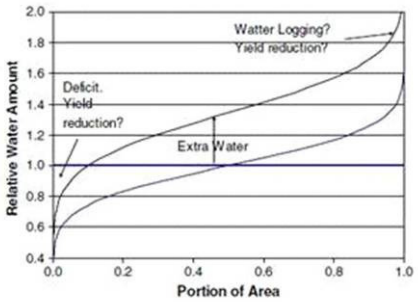


How is DU calculated?

$$DU = \frac{\text{Average discharge rate per vine of the low 25\% sampled vine emitters}}{\text{Average discharge rate per vine of all sampled vine emitters}} \times 100$$

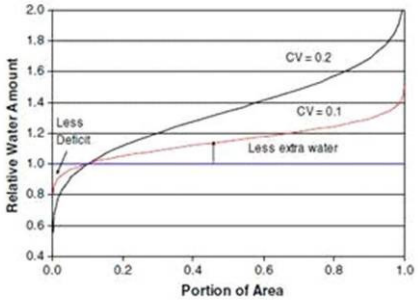


How does DU affect water productivity?



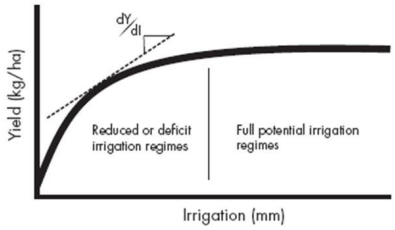
From: Clemmens, A.J. and Molden, D.J. (2007) Water uses and productivity of irrigation systems. Irrigation Science, 25, 247–261.

How does DU affect water productivity?



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How does DU affect water productivity?



What are typical DU values?

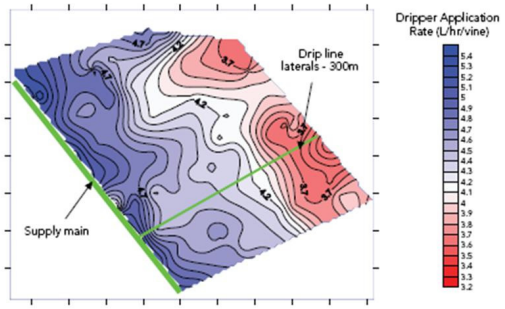
- Typical performance of micro-irrigation systems in Australia is unknown.

	n	Average DU
Hanson et al. (1996)	458	73%
Pitts et al. (1996)	174	70%
Ascough and Kiker (2002)	10	73%

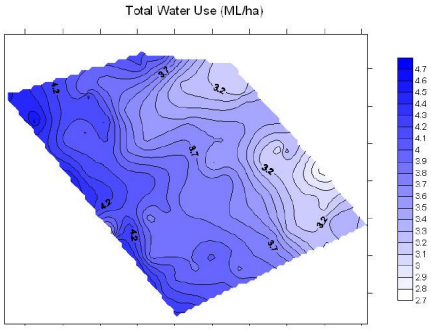
- The highest DU in a survey of five Australian vineyards was 93 %.

Interpreting DU - spatial maps

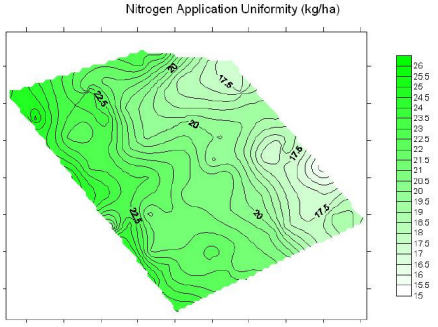
- www.irrigateway.net/tools/du



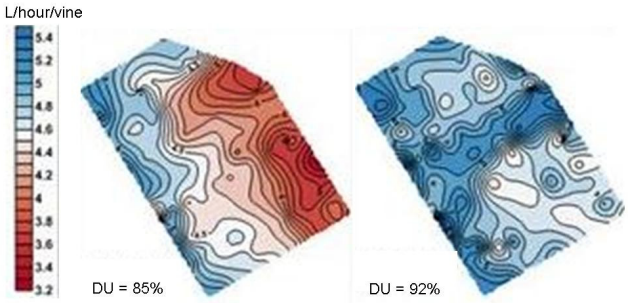
Seasonal irrigation application



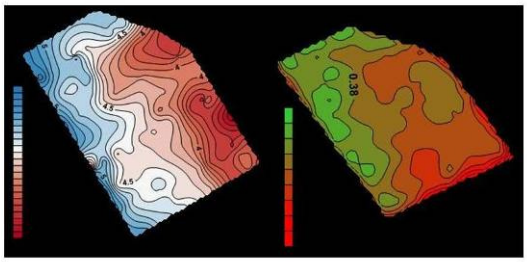
Effects of DU on fertigation



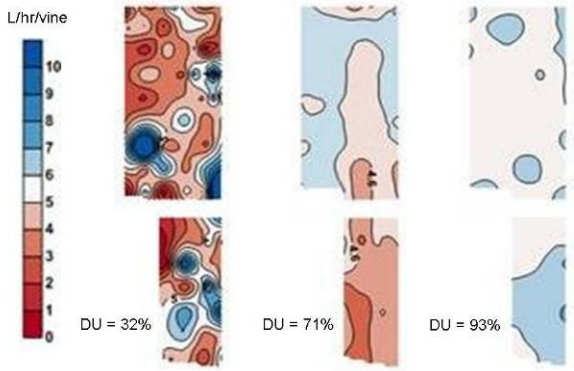
Interpreting DU - spatial maps



Effect on crop - canopy cover



Interpreting DU - spatial maps

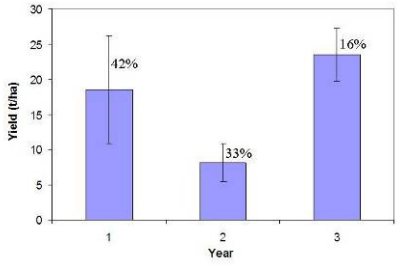


Effect on crop - canopy cover

	Year 2	Year 3
Fractional canopy cover (range)	0.11 – 0.29	0.20 – 0.30
Coefficient of variation (CV)	25 %	11 %

Effect on crop – yield

Mean yield at harvest (± standard deviation)



Tools for growers and consultants

http://www.irrigateway.net/tools/du/



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