WATER MANAGEMENT

Evaluating Irrigation Efficiency

Introduction

Irrigation is by far the largest user of water in New Zealand, currently accounting for 77% of water use. In Hawke's Bay, irrigation accounts for 89% of groundwater use. On the Heretaunga and Ruataniwha plains, many of the river and stream water takes are fully allocated yet the demand for irrigation water continues to increase.

Efficient use of irrigation ensures the available water resource can be used to its full potential.

Why should you have your irrigation system evaluated?

Improving irrigation efficiency saves water, energy, time and ultimately money. The savings can be very significant. Increasing a system's distribution uniformity (i.e. eveness of irrigation) from 70% to 90% can allow 50% more area to be irrigated from the same volume of water. Using the right pump can reduce your power bill up to 30%.

Centre pivot efficiency evaluation

Studies show current irrigation system efficiencies vary widely. A LandWISE commissioned study analysed 23 irrigation systems across fifteen farms in Hawke's Bay.

The main findings were:

- The quality of system designs was variable with some very inadequate systems.
- Many systems had over-sized pumps, with partially closed gate valves. This greatly increases energy use.
- Few farms had adequate records for a full and reliable analysis.
- There was a great deal of variability in the level of understanding of plant/soil/water relationships and irrigation scheduling.

Dripper efficiency evaluation

What is irrigation efficiency?

A common measure of irrigation efficiency is **application efficiency**. This looks at how much of the water applied is used for crop growth. Other

measures include profit per millimetre of irrigation or yield per cubic metre of irrigation. This Environment Topic considers irrigation efficiency in terms of application efficiency.

While the aim is for 100% efficiency, this may not be the best option. At 100% efficiency you are likely to be under-watering at least some areas of your crop and so subjecting these to drought stress.

The two main factors affecting irrigation efficiency are:

1. Distribution uniformity - how evenly the water is applied
2. Irrigation scheduling - how much water is applied and when

Distribution uniformity

Distribution uniformity describes how evenly irrigation is applied to the crop and is a critical factor in determining the potential efficiency of any irrigation system.

A typical irrigation evaluation assesses distribution uniformity by using catch cans to collect the water applied over an irrigation pass or specified time period (depending on the system being evaluated). The data is recorded and adjusted to take into account evaporation. Mathematical equations are used to calculate the Distribution Uniformity Coefficient (DUIq) or Coefficient of Uniformity (CU).

In a perfect system each plant would receive the same amount of water (DUIq = 1.00). However, the installation and running costs of such a system would be greater than the benefits gained. A compromise must always be accepted, the level of which is a decision for the farmer or grower.

Table 1 gives acceptability ratings for a range of distribution uniformities, based on guidelines for centre pivot irrigators. Some system types are able to provide greater uniformity than others.

Rating	Distribution Uniformity Coefficient (DU_{Iq})	
Excellent	> 0.94	
Very Good	0.93	0.87
Good	0.86	0.75
Fair	0.74	0.62
Poor	0.61	0.50
Unacceptable	< 0.50	

Table 1. Efficiency ratings for distribution uniformity coefficients

Irrigation scheduling

Irrigation scheduling involves balancing evapotranspiration and drainage (water losses) against rainfall and water application (water gains) using the soil's available water capacity as a water storage reservoir. Accurate irrigation scheduling requires knowledge of the soil's available water capacity and status, how fast the available water is being used up, rainfall inputs and how much water is applied by an irrigation system. The Environment Topic "Scheduling Irrigation" discusses this in much more detail.

Application rates

Incorrect application rates can also be a significant cause of poor performance. If application rates significantly exceed the soil's infiltration rate run-off and ponding will occur. This causes some areas to be under watered and others over watered. Any sign of ponding at the surface is an indication of significant efficiency loss

Surface ponding on dairy pasture

What are the benefits of evaluating irrigation efficiency?

Assessment of the design and instalment quality of systems that otherwise carry no form of system efficiency/effectiveness guarantee.

Long-term performance of the system can be checked and problems identified and fixed.

Maximise profitability by ensuring minimum energy use:

- Correct pumps used – not having to restrict water flow due to pump over capacity.
- Minimum amount of water required applied, through avoiding over-irrigating areas in order to irrigate the under watered areas (i.e. by achieving uniformity).

Maximise profitability through ensuring uniformity of crop:

- Better prices achieved as potentially better consistency and quality at harvest.
- Shorter time to harvest avoiding having to 'hang out a crop' at the end of a season because of uniformity issues.

Demonstrates to regulators, consumers and other resource users that the water resource is being used as efficiently as possible.

What is an irrigation efficiency evaluation?

An irrigation efficiency evaluation is the measurement and analyses of key aspects of an irrigation system's performance and management.

A micro-sprinkler evaluation

Irrigation performance checks may assess:

Uniformity of water distribution
Filtration
System pressure
Flow rates
Sprinkler/nozzle type & wetted radius/coverage
Leakages, surface ponding
Soil type and characteristics including infiltration rates and water holding capacities
Water supply
Pump performance and other factors that affect uniformity or add to power costs.

Irrigation management checks focus on the timing and volume of irrigation, and system maintenance. They can include seasonal irrigation efficiency estimations (water budgets and drainage loss estimates) and assessment of other key performance indicators including energy use.

A Sustainable Farming Fund project has developed the "Irrigation Evaluation Code of Practice" which establishes procedures, methods, training and a national certification process for 'system evaluators' or auditors. Evaluators use computer software to analyse the data, assess performance and identify methods to improve efficiency. The Code of Practice and certified evaluators ensure evaluations are carried out to recognised standards.

Case Studies

1. Centre Pivot Irrigator Evaluation

The irrigation volumes collected in the catch cans from the centre pivot irrigator pictured on the front page, were corrected for evaporation and the data plotted on the graph in Figure 1.

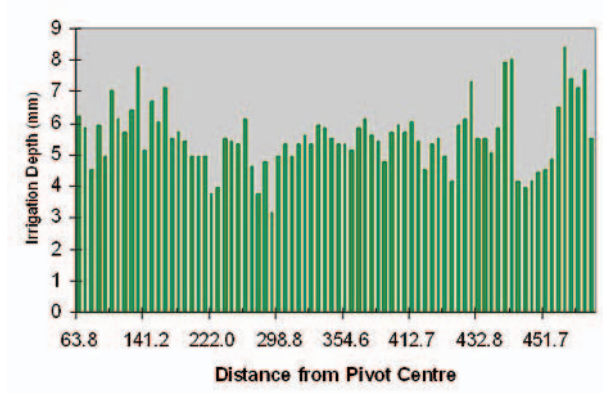

Figure 1. Graph illustrating the distribution uniformity along the length of the centre pivot. DUiq = 0.77

The graph shows the variability along the length of the pivot. This type of non-uniform irrigation results in high levels of wastage as for most of the area to be adequately watered, some parts are considerably over irrigated.

The irrigation efficiency evaluation identified that the poor uniformity was due to the design and rotators that were not set horizontally. The design had a very low number of widely spaced rotators with little overlap, which increased the problem.

2. Drip Irrigation Evaluation

Pressure readings and catch cans were used to assess the performance of the drip line system pictured on the front page.

Plugged emitters and pressure and emitter variations between blocks and along the laterals caused the system to have a poor uniformity score (DUIq = 0.70). Analysis of results allowed suggestions to be made that would help improve efficiency.

The plugged emitters were the result of one block being used for waste water disposal. Nutrient

rich waste water increases algal growth which then plugs the emitters. The implementation of a regular treatment programme will avoid this becoming a major issue in the future.

- Drip/micro irrigation can be very sensitive to pressure variation because operating pressures are very low. A small change is big in relative terms. While less important in pressure compensating cases, sprinklers and jets are typically sensitive.

Emitter performance reduced by algal growth

- Pressure variations between blocks may be caused by poor design or incorrectly set pressure regulating valves – these should be checked.

- Pressure variations along the laterals were due to long laterals (which often have high pressure losses), and in the worst case damage or constrictions to other laterals within the test site.

- The test site had two types of drip tube which caused significant emitter flow variation between blocks. The effect of this can be removed by varying run-times ensuring each block receives the same volume of water per plant.

References

Irrigation Evaluation Code of Practice. Sustainable Farming Fund Project 02-051. 2005.
Available from Irrigation New Zealand, PO Box 437, Ashburton, www.irrigation.org.nz

The Irrigation Manual: A practical guide to profitable and sustainable irrigation. A Malvern Landcare Project. 2001.
Available from Irrigation New Zealand, PO Box 437, Ashburton, www.irrigation.org.nz

LandWISE Inc - providing leadership and support for the development and promotion of sustainable crop production. www.landwise.org.nz

For further information

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