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Water Use Efficiency

Interpretation and training in the use of soil moisture data

Vegetable growers are being given the tools to improve irrigation efficiency and maximise plant growth and profits by learning when to water and how much to apply.

The bottom line

- Adequate quantities of quality water for irrigating crops is one of the critical issues growers face.
- The solution lies in learning how to use available water as efficiently and effectively as possible.
- Managing water is essential for maximising yields and profits. Future growth depends on efficiency gains rather than further allocations of scarce water resources.

Soil health management shows economic and environmental benefits

Researchers at the Victorian Department of Primary Industries are finding that a range of different soil health practices have both environmental and economic benefits to growers. By measuring biological, physical and chemical properties in soil they are identifying which methods improve soil quality, whilst providing good yields and maximum profit.

The bottom line

- To date, field trials have demonstrated that profit gains of up to $6,000/ha can be obtained by use of more environmentally-friendly fertilisers and organics.
- A computer-based tool ('C-Calc') has been developed to help estimate the amount of organic matter that is being returned to the soil from different rotations and amendments.
- A series of information leaflets on use of organic matter and soil health have been developed.

Water Use Efficiency

Introduction

The use of water in vegetable production is both highly efficient and profitable when compared to other agricultural sectors, with the vegetable industry accounting for as little as 4.6 per cent of the total water used *(ABS Water Use on Farm 2003-04)*. Sub-surface drip irrigation, computer-controlled overhead sprinklers and soil moisture monitoring equipment are helping growers to supply water only when and where it is required, however drought and increased demand for water across many growing regions has highlighted the need for even greater efficiency.

Applied Horticultural Research (AHR) has developed a training guide and series of regional-specific workshops outlining the principles of effective water management. The information is helping growers to manage crop water use for maximum returns while minimising production risks.

Water-wise

The main objective of this project is to try to reduce the amount of water used to grow vegetable crops through greater on-farm water use efficiency. This can be achieved by:

- Improving information to support irrigation choices and water management by developing real water use efficiency and water movement data in common vegetable crops from major growing regions.
- Providing training on how to use soil moisture data to efficiently schedule irrigations and maximise yield and quality based on crop water requirements and water movement in local soil types.

Data collected from previous AHR field trials and soil moisture monitoring equipment has been analysed in order to provide case studies and help demonstrate the impact and importance of effective water management. This information is in the booklet managing *Water for Yield and Profit*.

Water efficiency means applying enough water to meet the needs of the plant. No more or no less.

The publication also examines:

1. Why plants need water – impact of under or over-watering on plant physiology, crop quality and yield.
2. Water and soil – understanding the readily available water content of different soils.
3. Determining the timing and amount of irrigation – calculating a water use budget using crop coefficients and crop factors.
   Matching crop water use with the readily available water content of the soil in order to schedule irrigation events.
4. Understanding how to use the output from soil moisture sensors – examples of real data from AHR field trials using soil moisture probes.
5. A reference and resource list of other materials that cover water use efficiency training and soil moisture monitoring.

A series of workshops have been held around Australia in conjunction with the release of the booklet. Each provided a summary of the key principles and additional information available, along with a series of practical steps to help growers work through the calculations required to determine their irrigation needs. The courses not only improved the level of knowledge within the industry, but encouraged growers to evaluate their business and make positive changes.

Ways to improve water use efficiency

1. Calculate a water budget for specific crops to establish exactly how much water is required.
2. Dig soil pits in order to confirm soil characteristics and the variability of soil types across a paddock and calculate and understand the Readily Available Water (RAW) content.
3. Check the wetting pattern of the soil after irrigation to ensure that the entire root zone is wet.
4. Investigate the options for using soil moisture monitoring to manage irrigation scheduling.

The project was highly effective in terms of promoting, organising and presenting training material. Additional workshops are possible if there is sufficient industry demand.

Further Reading

The publication *Managing Water for Yield and Profit* can be obtained in hardcopy or CD format from AHR Training by telephoning 02 9527 0826. It can also be downloaded at www.ahr.com.au.

AHR Pty Ltd contributed voluntary funds to this project, VG06136 with further funding provided by HAL using the National Vegetable Levy and matched funds from the Australian Government.

Statistics supplied by AHR Training

Good news

- The vegetable industry is roughly twice as efficient in its use of water as it was a decade ago.
- The value return from vegetable production increased from $1,762/ML used in 1996/97 to $3,207/ML in 2000/01 (ABS 2001).
- The industry average water use is 4.1 ML per hectare,

compared to the national average for agriculture, which is 4.3 ML per hectare.
- The industry uses 4.6 per cent of the total water used by irrigation (ABS Water Use on Farm 2003-04).

These statistics show the vegetable industry is an efficient user of water compared to other sectors, but there are more improvements to be made.

Bad news
- Between 1983/84 and 1996/97, irrigation water use in Australia increased by 75 per cent.
- In Australia, irrigated agriculture uses 65 per cent of consumed water.
- The Australian water resource assessment for 2000 estimated that 26 per cent of Australia's river basins and 34 per cent of Australia's groundwater were exceeding sustainable extraction limits.

Water Use Efficiency

Water use efficiency is a generic term that covers a range of performance indicators irrigators can use to monitor the performance of their irrigation practices.

Irrigation water use index (IWUI) =

$$\frac{\text{Total production for farm (Tonnes)}}{\text{Irrigation water applied to farm (ML)}}$$

Operating profit water use index (OPWUI) =

$$\frac{\text{Gross return (\$) - Variable costs (\$) - Overhead Costs (\$)}}{\text{Total water used on farm (ML)}}$$

Benchmarking soil health for improved crop health and yields

Measuring & Monitoring Soil Health

Good soil health is largely driven by the amount of carbon in the soil which provides the food for soil organisms (good and bad) and helps build the good soil structure required for root growth and water storage. Agricultural practices tend to reduce soil carbon levels. The greater the intensity of cultivation, the greater the loss in soil carbon will tend to be. A range of tests (e.g. penetrometer resistance, nutrient and biomass measurements) can be used to estimate whether your soil has a health problem, and whether it is principally soil physical, chemical or biological issue. A benchmarking trial using these tests showed many growers were overusing fertilisers, with 70% of sites recording high or excessive levels of phosphorus and 90% of sites recording excessive levels of potassium.

The value and feasibility of a National benchmarking program for soil health in the Australian vegetable industry, is currently being assessed.

Field trials in Southern Victoria

Examples of some physical, chemical and biological indicators of soil health:

Soil Physical Tests	
Penetrometer resistance	Identifies potential compaction issues leading to poor root growth and water infiltration.
Water infiltration	Poor water infiltration can lead to poor root growth and poor water uptake by the plant.
Soil Chemical Tests	
Nutrient analyses	Make sure measured nutrients fall within an acceptable range for your crop as oversupply can leach nutrients into waterways.
Labile carbon	A good measure for carbon as it is the fraction of soil organic matter readily available as food for soil microbes. Particularly useful for monitoring management practices that build up soil organic matter.
Soil Biological Tests	
Biological activity (FDA hydrolysis and CO2 respiration)	Measuring total soil microbial biomass can identify soils containing high levels of microbes that can recycle nutrients from organic sources, 'glue' soil aggregates together, and may reduce some disease problems by out-competing soil-borne pathogens.
Nematode community structure	Provides an indication of the impact of management on soil microbial diversity and disturbance within soil systems.

Economic Benefits of Soil Health

A wide range of soil amendments with different soil health impacts were tested in a three year field trial. Most resulted in a positive financial impact for growers. Tests using slow release ammonium fertilisers gave average yields of broccoli 16% greater than the standard yield. These are considered beneficial to reducing nitrogen runoff. This translated to increased profits of up to $6,000/ha depending on the year and season. Adding organic amendments also had positive impacts, but due to the slower breakdown of these products, profits occur more slowly.

'C-Calc' - A tool to assist calculation of amount of organic matter added to soil

The amount of organic matter (OM) being returned to the soil is an important factor influencing soil carbon levels and soil health. This project has developed a computer tool called 'C-Calc' estimating the carbon contribution added to soil from rotations or amendments. It allows growers to compare different practices without actually growing a crop.

Soil health workshop in Devonport, Tasmania

Soil Health Management Guide

A series of steps to improve soil health are shown below.

1. Determine objective of improving soil health (eg yield, reduced inputs, profitability, poor emergence etc.).
2. Know your soil (identify and map soil type, prepare a soil pit if necessary).
3. Use soil analyses to benchmark soil health such as:
   - Penetrometer testing to identify compaction issues.
   - Water infiltration test (especially if surface is crusting).
   - Analysis for macro and micronutrients every 1-2 years.
   - Plant nutrient analysis at flowering.
   - Soil labile carbon or potentially mineralisable nitrogen tests every three years.
   - Nematode diversity testing to identify resilience.
4. Rational use of cropping inputs (refer to benchmark data for optimal plant growth):
   - Use nutrient analysis to guide fertiliser inputs.
   - Use soil moisture monitoring tools to guide water inputs.
   - Follow label recommendations for pesticides and fumigants.
5. Organic matter management:
   - Determine organic matter inputs for current rotations using C-Calc.
   - If soil carbon is low increase OM inputs by growing green manure crops, adding organic amendments, returning crop residues or growing crops with larger biomass.
6. Avoid soil compaction:
   - Implement controlled traffic (modify equipment e.g. low tyre pressures).
   - Avoid working saturated soils.
   - Consider minimal tillage practices where possible.
7. Assess the cost:
   - Benefit over the long term (3+yrs) of addressing soil health problem.

Further Information

General information on soil health is available from:

DPI Vic
www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/soil-home
Soil Health Ute Guide
www.ausveg.com.au/healthy-soils.cfm
Soil Quality
www.soilquality.org.au/
Soil Health Knowledge Bank
www.soilhealthknowledge.com.au

Further information on this project, VG07008, can be found by contacting peter.fisher@dpi.vic.gov.au or nick.ohalloran@dpi.vic.gov.au. A series of "Soil Organic Matter Info-Leaflets" have been developed by DPI Victoria to bridge the gap between general information and the scientific literature. These can also be obtained through the above contacts.

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