WATER MANAGEMENT

Scheduling Irrigation

Introduction

The correct scheduling of irrigation offers major benefits through cost savings, better crop quality and yield, and reduced water and energy wastage. This Environment Topic describes the principles of successful irrigation scheduling.

For comprehensive information on irrigation get a copy of the New Zealand Irrigation Manual or contact your irrigation consultant.

What is irrigation scheduling?

Irrigation scheduling is the balancing of crop water use against water application using soil water storage as a reservoir or buffer.

Managing irrigation is an ongoing task with many factors affecting the amount and frequency of water required:

- **Soil water storage** – dependent on soil type, soil structure and root depth.
- **Crop water use** - varies with crop type, crop growth stage, root depth and weather conditions.
- **Irrigation systems** - apply varying quantities of water depending on system type, settings and maintenance.

Identifying irrigation units

The key to effective irrigation management is identifying individual *irrigation units* and managing each unit separately:

- Each crop species and each crop age are separate units
- Each soil type is a separate unit
- Each irrigation type is a separate unit (e.g. dripper, mini-jet, gun).

If direct soil or plant measurements are being used to schedule irrigation, a minimum of one sampling site (station) is required in each irrigation unit. Multiple sites are better.

The example orchard in *Figure 1* has a soil change through the middle of the block, which requires the 7 year old apples to be managed as two irrigation units. Because the 2 year old apples have different irrigation systems, they must also be managed separately. Beans are also a unit on their own.

Soil water storage

The amount of water available to your crop depends on the soil's *water holding capacity* and the *effective rooting depth* of the crop.

Approximate water holding capacities for Heretaunga and Ruataniwha Plains soils are available (guides and maps by E. Griffiths available from Hawke's Bay Regional Council). However, these are an indication only – use field trials to check the water holding capacity of your soils.

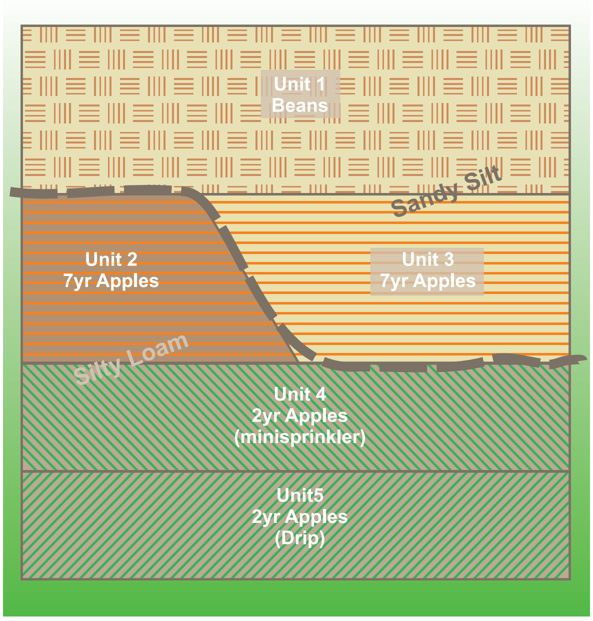

Figure 1. Selecting irrigation units

Effective rooting depth figures are available for a range of crops. However, these usually show approximate depths where root growth is unlimited, which is often not the case in the field. Soils may be shallow or have significant limitations due to wetness. Many soils that have been cropped have physical problems such as pans that can limit root and water movement. An example is a plough pan at only 200mm. Dig holes, and look for potential problems and assess your soil's *potential rooting depth*.

Soil-water measurements

There are many soil-water measurement techniques available. They are based on soil, plant or atmospheric measurements and are summarised in *Table 1* on the back page.

Currently the most common reliable techniques are soil based measurements (e.g. tensiometers and neutron probes) and budgets calculated from atmospheric measurements (evaporation pans and weather stations).

It is best to use more than one measurement technique and use multiple sites. Compare the answers gained, rather than relying on any single technique or site. With time you will develop an understanding that alerts you to unusual results.

Crop water use

Crop water use includes water loss due to evaporation from the soil and transpiration by the plants. The term used to describe these two factors is *evapo-transpiration* (ET).

Soils lose some water through drainage if they are over-watered, but the main loss is due to ET. In effect ET is 'negative' rain and like rain, it is measured in millimetres. Water use, water application and water soil storage are all measured in the same units - water depth in millimetres.

Climatic conditions and crop cover have the most impact on the variability of crop water use. As temperature, wind or crop cover increase so will water use. Due to the many variables, crop water budgets are not always accurate. Soil based measurements provide a necessary check.

Losses from the soil (evaporation)

As a rough rule, bare soil loses water at half the rate of growing plants.

Soil moisture and texture also have an effect. Moist, packed soils lose more water than dry topped, loosely packed soils, as soil-water movement is reduced and the upper layers act as mulch. However, these loose soils will be at risk from wind erosion.

Reduce soil-water loss by mulching, and by using windbreaks to slow air movement.

Losses from plants (transpiration)

Transpiration is the process where plants lose water from leaves to the atmosphere, water that must be replaced from water in the soil.

Some crops transpire more water than others and losses increase as plants grow larger. Generally, crop water use reaches its maximum once the canopy covers most of the ground or full canopy is reached.

Evapo-transpiration figures published in daily newspapers refer to the *potential* evapo-transpiration rate or 'PET'. This is the amount of water that would be lost from well watered, healthy grass that completely covers the ground, in an area away from external influences (e.g. shelter belts).

PET rates measured and calculated at Havelock North peak at an average of 5mm/day in mid-summer. This figure must be adjusted for different crops at different stages of growth. Experience has shown that actual crop water use can be much greater than PET if there are strong dry winds, especially at night.

Alternatively, on-site water use can be measured using an evaporation pan made from a cut down disused 200 litre drum. Fill the pan to a marked level and measure the mm drop after a set time e.g. 24 hours. In general crop water use is 80% of the water loss from an open pan (Epan). Therefore 5mm evaporating from a pan is equivalent to 4mm PET.

Evaporation pan

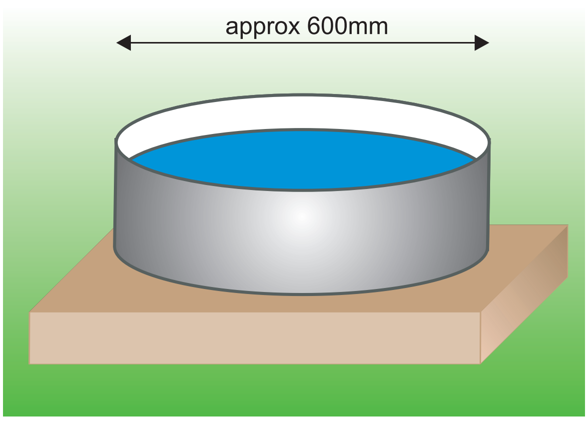

Figure 3. A simple evaporation pan can be made from the bottom half of a 200 litre drum.

Rainfall measurements

A raingauge is essential for making irrigation management decisions but is only of value when rainfall is recorded. The accepted standard is to read rainfall at 9am each day and record it on the chart for the previous day i.e. it covers the 24 hour period starting at 9am on the previous day. Record at least to the nearest 0.5mm and note the type of rain. Long, gentle, rainfall is more effective than short intense rain as more rain enters the soil .

Scheduling

Excess irrigation will cause drainage losses, while insufficient will fail to re-wet the full root zone. Scheduling allows under or over irrigation to be avoided.

A common irrigation scheduling technique uses weekly neutron-probe soil-water measurements and records of rainfall and irrigation inputs. From these, the soil's field capacity, critical deficit point and actual crop water use are determined. Irrigation timing and quantities can then be managed to maintain soil-water at the required level for the crop or return of the irrigation rotation.

If scheduling is based on atmospheric measurements (Pan or PET), irrigation begins when calculations show the readily available water has been used up. Irrigation should apply no more water than required to return the potential rooting depth to field capacity.

If scheduling is based on tensiometers, irrigation begins when the soil-water tension reaches the stress point, and continues until tension begins to drop, indicating the soil profile has been recharged.

The Environment Topic *Understanding Soil-Water* describes this terminology further and uses a simple soil-water calculation example to illustrate its use.

Water quantity and quality

The Hawke's Bay Regional Council's website has information on Heretaunga Plains Aquifer levels and seasonal irrigation restrictions on streams and rivers. Ensure you have a resource consent from the Hawke's Bay Regional Council to take water for irrigation. The Regional Council can also supply advice on the water supply reliability in your area.

Know the quality of your irrigation water. This includes sands, salts, and chemical composition. Irrigation systems may need to include filtration.

Groundwater supplied irrigation systems are designed to provide the correct amount of water at a fixed groundwater level. However, water levels fluctuate seasonally and vary with well condition. These fluctuations will affect the performance of the irrigation system, so measure and record flows and pressures.

Measure the water level once a year, in the same month, or even better, on the first day of spring, summer, autumn and winter. Ensure your well is maintained. Contract a well driller to do maintenance every 5 years.

Irrigation systems and maintenance

Best irrigation practice ensures an acceptable portion of the crop gets sufficient water without water being wasted. This requires good *irrigation uniformity,* which is the evenness with which water is applied throughout the system.

Know the potential and the limitations of your irrigation system. Measure how much water your system is applying. Consider having your system evaluated to determine its uniformity. An evaluation will tell you if your crop is getting even amounts of water, and if not, what the causes of non-uniformity are.

For irrigation to be most effective, the right amount of water must be applied to the right place at the right time.

References

The New Zealand Irrigation Manual. A practical guide to profitable and sustainable irrigation. 2001. A Malvern Landcare Project.

Available from Lincoln Environmental, PO Box 133, Lincoln, Canterbury.

Telephone (03) 325 3700 or irrigation@lincoln.ac.nz

Understanding Soil-Water. Environment Topic ET:WM2:September 2004. Hawke's Bay Regional Council, Napier.

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Soil Map of the Heretaunga Plains. E, Griffiths. 1997. Hawke's Bay Regional Council, Napier.

My Well's Gone Dry. A guide to well water problems and maintenance. 2003. Hawke's Bay Regional Council, Napier.

Well Security Worksheet – a worksheet that helps you to determine well failure. Hawke's Bay Regional Council, Napier.

For further information

For further information contact Hawke's Bay Regional Council Land Management staff for advice.

Wairoa	0-6-838 8527
Napier	0-6-835 9200
Waipukurau	0-6-858 8636
TOLL FREE	0800 108 838

www.hbrc.govt.nz

Table 1. Scheduling Techniques

Measurement method	Required instruments	Basic principles	Principle advantages	Principle disadvantages
Soil Based Measurements				
Appearance and Feel	Hand/probe	Wetter soil is darker, physical properties change	Simple, no special equipment	Unreliable, poor accuracy, approximate, time consuming. Yield loss and water wastage likely
Gravimetric analysis (weighing wet and dry)	Oven, accurate weighing equipment	Difference in weight of soil sample before and after drying show actual water content	Direct measurement of soil water content. Simple	Require multiple samples, takes 24 hours to dry sample - plants may be stressed in mean time
Soil matric potential ('soil suction')	Tensiometers (Irrometer, Quickdraw)	Soil suction increases as it dries, tension measures how hard it is for plants to draw water	Measures water tension directly, close correlation to plant 'experience'. Can be automated	Need multiple sites, careful installation, frequent readings and maintenance
Electrical resistance (conductivity of soil)	Gypsum Blocks (Watermark sensor)	Electrical conductivity decreases with less water, drier soil has greater electrical resistance	Indirect measure of soil water content. Easy to automatically record and monitor. Use same units as tensiometers	Need multiple sites, careful installation, calibration, frequent readings. Some affected by salinity, and/or soil texture
Electromagnetic capacitance	Time Domain Reflectometry (ECHO, Aquaflex, Diviner)	Water content controls the speed of an electromagnetic pulse sent through the soil	Accurate, quick measurement of soil water content. Probes cheap, permanent, no servicing required.	Control unit is very expensive. Require multiple sites, probe installation, interpretation
Neutron scattering	Neutron probe (Troxler)	Emitted neutrons are slowed by hydrogen atoms within water molecules. Number of slow neutrons = water volume	Precise measurement of soil water content by percentage	Very expensive, radioactive, require multiple sites, tube installation, calibration, interpretation
Plant Based Measurements				
Appearance	Eye	Plants lose turgidity and wilt, subtle colour change	Simple No equipment needed	Yield lost before symptoms seen
Leaf temperature (Infra-red image)	Non-contacting thermometer	Reduction in transpiration reduces cooling, leaf tissue heats up	Simple, relates to plant stress Allows remote sensing	Techniques not well developed
Leaf water potential	Pressure chamber	Measures plant hydration, a combined effect of aerial and soil environment	Correlated to plant metabolic processes	Large day/night variation, expensive, time consuming, difficult interpretation.
Atmospheric Measurements				
Pan evaporation rate	Evaporation pan	Water loss from a free water surface correlated to soil evaporation and plant water use.	Simple, cheap One site can serve large area	Requires frequent service and data collection, careful siting, calibration for each crop and canopy size
Calculations from atmospheric and crop data	Water balance models (Priestly-Taylor, Penman-Monteith etc)	Potential evapo-transpiration calculated from weather data, allows a soil-water balance to be maintained	Well developed, one calculation can serve a large area. Accurate for most crops over longer term Local data published daily	Requires considerable data and calculation, calibration factors for crop and canopy size. May not fully account for extreme conditions (e.g. strong, dry wind) in the short term