IRRIGATION INSIGHTS

Participant Manual

October 2025

Australian Government
Department of Agriculture, Fisheries and Forestry
Future Drought Fund
TAS FARM INNOVATION HUB
UNIVERSITY of TASMANIA
TIA
Tasmanian Institute of Agriculture
pinion ADVISORY

This program received funding from the Australian Government's Future Drought Fund.

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Acknowledgments
This project received funding from the Australian Government's Future Drought Fund, via the TAS Farm Innovation Hub. Thanks to James Curran, Sarah Castine, Ella Roper and Lauren Rowlands for reviewing the text.

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History and importance of irrigation

1.1 WHAT IS IRRIGATION?

Water is an essential element for plant growth. Different plants need different amounts, but there is no known plant species that can exist without water.

Irrigation can be defined as the replacement of water storage in a plant root zone by means other than natural rainfall (or snowfall in some areas).

1.2 ANCIENT IRRIGATION

There is archeological evidence that irrigation has existed for 4,000 – 5,000 years. Unsurprisingly, it began in areas where there was not enough natural rainfall to support crops, but there was fresh water nearby that could be channelled into cropping areas. For example, farmers in Mesopotamia (modern day Iran and Iraq) built channels to take water into fields. The ancient Egyptians channelled water from the River Nile into fields surrounded by small walls.

Figure 1: Ancient Egyptian irrigators channelling water from the Nile River into fields (*Picture*: (International Commission on Irrigation and Drainage, 2016))

1.3 HISTORY OF IRRIGATION IN AUSTRALIA

Australia is a dry continent, and therefore irrigation is practiced widely. Even so, growing crops without irrigation is still widely practiced in some parts of Australia, for example, most grain production.

The first large scale irrigation schemes were introduced in Australia in the 1880s in response to drought, with an irrigated farm at Mildura being developed by Californians George and William Chaffey from 1886. In 1915 the River Murray Waters agreement was signed, which set out basic conditions for the use of water from that river, and was Australia's first major irrigation policy or agreement. Over 70% of irrigation in Australia occurs in the Murray-Darling river system.

Figure 2: Centre Pivot irrigator in NSW using water from the River Murray (*Photo: Pinion Advisory*)

Water for irrigation in Australia either comes from rivers or on-farm dams, or from underground water storage called aquifers. The great artesian basin is an example of an aquifer and covers areas of Queensland, Northern Territory, South Australia and NSW and is the largest and deepest artesian basin in the world. The word "artesian" means that water will rise to the surface without pumping, because it is under pressure underground. Most of the other aquifers in Australia are smaller and more localised and may or may not be refilled every year by rainfall.

In 2021-2022 (the latest figures) Australia used 9,981 billion litres of water for agriculture, forestry and fishing. In comparison, the total consumption of water by households and other industries in Australia was 13,449 billion litres (Australian Bureau of Statistics, 2025).

Of the 9,981 billion litres used by agriculture, forestry and fishing, 7,336 billion litres of water were distributed from irrigation schemes, 1,046 billion litres was from self-extracted surface water (dams and rivers) and 1,509 billion litres was from self-extracted groundwater. Interestingly, 90 billion litres of water use for agriculture, forestry and fishing was reuse water.

1.4 HISTORY OF IRRIGATION IN TASMANIA

There were some irrigation systems set up along the Derwent, Macquarie and Clyde Rivers in Tasmania in the late 1800s, but it was not until the mid-20th Century that larger irrigation schemes began in the midlands and northern Tasmania. In 1974, the Cressy-Longford scheme began, the South East Districts scheme in 1986 and the Winnaleah scheme in 1987. Irrigation of vegetable and industrial crops began on the North West Coast in the 1960s, mainly out of creeks or on-farm dams, while perennial horticulture, primarily apples in the Tamar or Huon areas, began irrigation around this time, also out of creeks or farm dams.

Today, Tasmania has an enviable network of irrigation schemes. Tasmanian Irrigation Pty Ltd manages 19 schemes that deliver irrigation water to farmers. Figure 3 shows the area covered by these schemes.

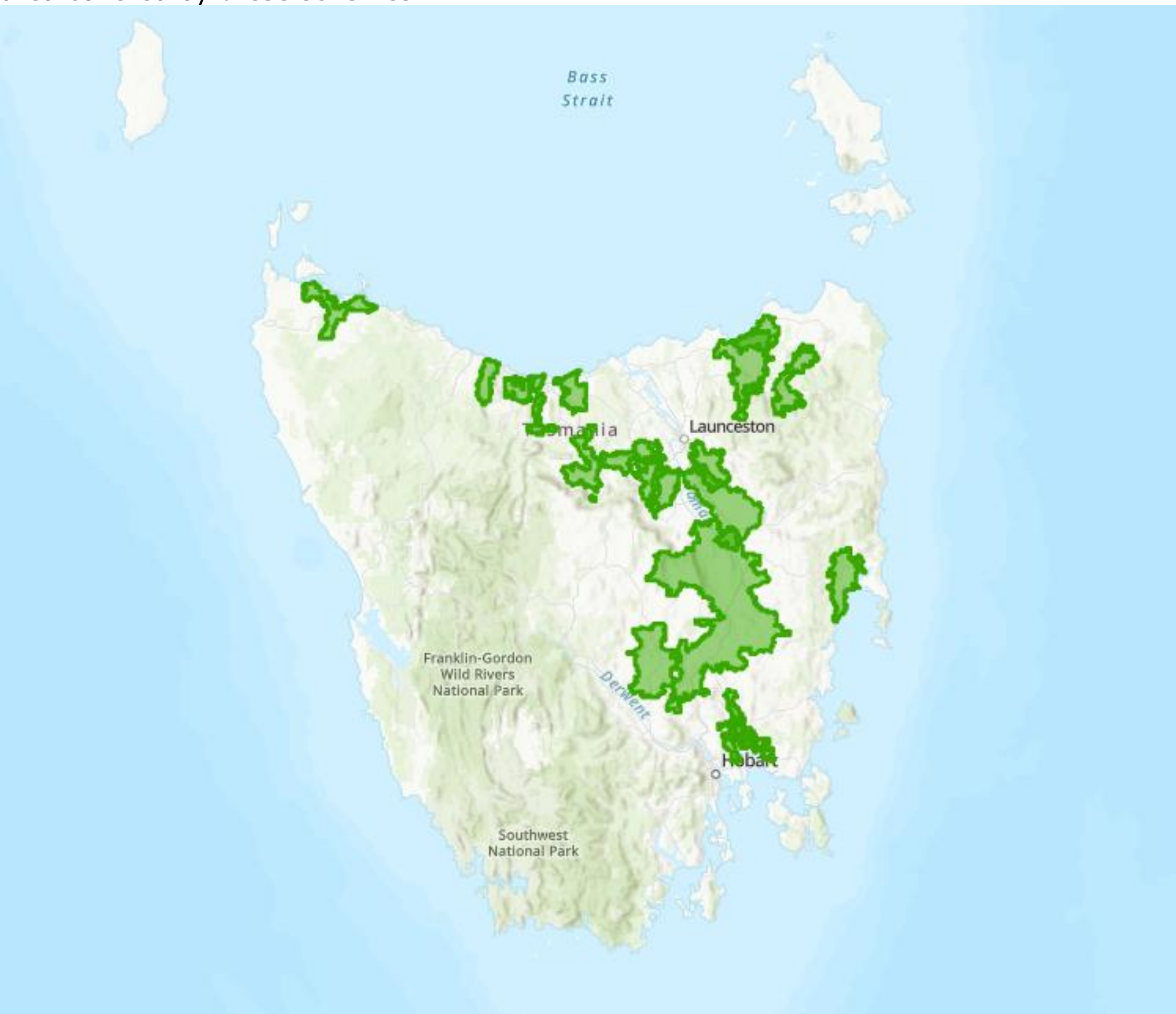

Figure 3: Area of Tasmania covered by irrigation schemes (*Source:* (Tasmanian Irrigation, 2025))

Early irrigators in Tasmania used flood irrigation, but in later years pressurised water systems using sprinklers or travelling irrigators became popular.

Today, Tasmania is one of the highest per-capita users of centre pivot irrigators in Australia. Drip and micro-irrigation systems are now used extensively in perennial horticulture and small fruit production. Irrigation is important to Tasmania's $2 billion dollar farm gate value agricultural industry (AgriGrowth Tasmania, 2022), with potatoes, vegetables, berries, fruit, wine and field crops relying primarily on irrigation, with a portion of beef, dairy and lamb / mutton production also relying on irrigated pasture production.

Figure 4: Prime lamb production under centre pivot irrigation in Northern Tasmania (*Photo: Pinion Advisory*)

Figure 5: Micro irrigation of raspberries in Southern Tasmania (*Photo: Pinion Advisory*)

Exercise

- What is the source of irrigation water where you work?

- Is it part of an official irrigation scheme? If so, do you know the name of it?

Types of irrigation systems

2.1 BASIC CLASSIFICATION OF IRRIGATION SYSTEMS

There are three basic types of irrigation systems. These are:

Surface irrigation
Surface irrigation, where water is channelled onto a field and allowed to spread across the surface in a controlled manner. It is still used worldwide, especially in the cultivation of rice, where the water also acts as weed control. In Tasmania, surface irrigation was used in the dairy industry for many years but has largely been superseded by methods that apply water more accurately. The advantage of surface irrigation is that it can be powered by gravity and therefore can be cheap to run. The disadvantage is that it can be difficult to control the distribution of water, and a lot of water can be lost to deep drainage or runoff. High efficiency surface irrigation is generally restricted to relatively flat land where land planning can be undertaken to allow for very controlled water distribution and minimal losses. Figure 6 shows surface irrigation in Emerald, Queensland.

Figure 6: Surface irrigation of soybeans in Emerald, QLD. Notice that this land is particularly flat. Water is siphoned out of channels into the soybeans using the pipes shown (*Photo:* (Commercial real estate, 2025))

Spray irrigation
Spray irrigation simulates rain, in that water is applied onto the soil surface or plant itself as fine droplets. To do so requires water to be pushed under pressure through various

types of nozzles. Common techniques using spray include travelling irrigators, centre pivots, linear move, solid set sprinklers and micro-jets. The advantages of spray irrigation are even water distribution, even on land that is not flat. Spray irrigation can also be controlled and precise, so that water is used as efficiently as possible. Figures 7-13 show these different techniques.

Figure 7: Soft hose travelling irrigator, NW Coast Tasmania (*Photo: Pinion Advisory*)

Figure 8: Soft hose travelling irrigator in action (*Photo: Pinion Advisory*)

Figure 9: Hard hose travelling irrigator (*Photo: Pinion Advisory*)

Figure 10: Centre pivot irrigator (*Photo: Pinion Advisory*)

Figure 11: Hose pull linear move irrigator (*Photo:* (Cadman Power, 2021))

Figure 12: Solid set irrigation system (*Photo:* (Nelson, 2025))


Figure 13: Micro sprinkler in an orchard (*Photo:* (Irrigear, 2025))

Micro irrigation
Micro irrigation includes system such as drip (inline and button drippers) and micro sprays system. Drip irrigation is just like it sounds, water is released very slowly as drips to the surface of the soil or substrate at a controlled rate. Sometimes, the water is released underground, and not on the surface. The pressure needed for these systems are much lower than sprinklers, because the water is not spread long distances from the point of release. Drip systems are good where plants can be targeted easily in rows or as individuals. Drip is particularly useful in hydroponic systems, for instance, in Tasmanian berry farms. Figure 14 shows a drip irrigation system.

Figure 14: Micro irrigated lettuce. The integrated dripline has emitters regularly along its length that release water onto the surface of the soil (*Photo:* (Kelemwork Trading, 2025))

Exercise

What irrigation system do you use on your farm or the farm where you work?

What are the advantages and disadvantages of that system?

Irrigation system components

3.1 INTRODUCTION

The main components in a berry irrigation system are:

- Water supply including quality protection
- Pumps and power units
- Filtration systems
- Fertiliser infrastructure
- Pipes and conveyance systems
- Valves and filters
- Sprinklers, emitters and micro-irrigation components.

All these components are important to efficient running of an irrigation system.

3.1.1 Water supply

Water supply might be from an official supply scheme, a river, farm dam or bore. For berry production, the quality of water is very important. Most water in Tasmania is of very high quality, meaning low salinity and turbidity.

For enterprises using substrate as the growing medium, it is necessary to have water storage on farm that can be used to supply water in the case of an outage of the main water supply (Figure 15). These may be evident as tanks on farm. These are needed as substrate has little water storage (hours) for plants, while by comparison soil may have several days storage.

To ensure the water supply is free of microbes or disease, many substrate-based farms have a method to sterilise water. This might be chemically (using chlorine, hydrogen peroxide, ozone) or ultraviolet (UV) light.

Figure 15: Tanks are used as backup water supply in substrate based production (*Photo*: (NPI Water Storage, 2025))

3.1.2 Pumps and power units

For pressurised systems, the pump is the centre of the system, like the operation of the heart (pump) in the human body it critical for life (Figure 16). The pump, in turn, requires energy to move the water to the place where it is applied to the crop or pasture. The force in which water is delivered is called pressure. Pressure is measured many ways, but pounds per square inch (psi) or kiloPascals (kPa) or metres (m) of head are common measures of pressure.

Pumps are commonly powered by either electricity, or, where there is no electricity available, by fuel (commonly diesel). Supply of electricity or fuel is expensive, so pump design should supply water to the irrigator at the right pressure level and flow rate, while using as little energy as possible.

Figure 16: The pump is the critical energy centre of an irrigation system (*Photo: Pinion Advisory*)

Pumps have limited working ranges of pressure and flow rate, so it is critical that the right pump is selected for each system. Poor system performance is often due to a mis-match between the pump and the irrigation system.

There are many types of pumps, including centrifugal, turbine, piston and diaphragm. What is best will depend on system requirements. It is important to design a layout of the pump that is simple and safe (Figure 17).

Electronic pumps are preferable to diesel or fuel powered pumps, as they have fewer moving components, need less maintenance and should last for longer periods of time if installed correctly.

Figure 17: It is important to have a neat and simple design layout for pumping systems for ease of maintenance and safety (*Photo: Pinion Advisory*)

Other factors to consider when selecting a pump and power unit are:

- Will it deliver the flow and pressure required?
- How efficient is it (energy per litre of water delivered)?
- Suction performance
- Reliability
- Cost of ownership (common brand vs unusual brand).

Exercise

What is the power source for pumps on your property?

Where are your pumps located? What do you think are the reasons they are put there?

What are the maximum and minimum flow rates and pressures for the pumps on your property?

3.1.3 Fertiliser infrastructure

For substrate-based systems, there is a need for a system to add fertiliser to the irrigation water for the plants to use as their mineral "food". This can be called fertigation (a contraction of "fertilisation" and "irrigation") or, alternatively, hydroponics.

Concentrated fertiliser is kept in separate tanks, as the minerals in them can form solids if they are mixed (Figure 18). There are usually "A" tanks and "B" tanks, and sometimes an acid tank to keep the balance of acidity and alkalinity in the mix in a range that plants can grow.

Figure 18: Fertiliser infrastructure (*Photo*: (Kynoch, 2025))

3.1.4 Filters

Filters are installed in irrigation systems to remove particles from the water. This is especially important for micro sprinkler or drip systems that have very narrow nozzles that can be easily blocked.

Filters have various designs, depending on the requirements of the systems. Screen filters include a fine mesh that filters out particles as water moves through the mesh. Disc filters have a series of grooved rings, that form a cylindrical filter with each groove crossing the other in different directions. Media filters consist of sand, gravel or other media that cleans water as it flows through.

All filters need to be regularly cleaned to continue to have good operation. This can be done manually or automatically depending on the sophistication of the filter.

In berry systems there may be filters close to the source of water and the main pump, and extra filters throughout the system as well, for instance, where the secondary pipes enter each tunnel.

Figure 19: A bank of disc filters in a complex irrigation system (*Photo: Pinion Advisory*)

Exercise

What type of filters are used in your irrigation system (if any)?

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___

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3.1.5 Pipes and conveyance systems

Pipes are used to transport water from the pump to the emitter. Most pipes these days are made of plastic, such as polyethylene (Figure 20) or unplasticized poly-vinyl chloride (uPVC Figure 21). Metal pipes are sometimes used but they can be expensive and labour intensive to install.

Figure 20: These pipes are made of polyethylene (*Photo: Pinion Advisory*)

Plastic pipes have pressure ratings. Pipes must be able to carry water at working pressures needed to operate the irrigation system. Polyethylene and uPVC pipes are rated on the pressures that they can safely operate. Table 1 shows the classifications. In this instance, pressure is measured in "head" (metres).

Table 1: Pressure ratings for PVC and polyethylene pipes

PVC		**Polyethylene**	
Head (metres)	Class	Head (metres)	Pressure Nominal (PN)
45	4.5	40	4
60	6	63	6.3
90	9	80	8
120	12	10	10
150	15	125	12.5
180	18	160	16

The classifications above are for water of 20°C or less, adjustments are needed for water at higher temperatures, as pipes can handle less pressure at higher temperatures. This might only be the case where warm or hot artesian water is used.

Polyethylene pipe is more flexible than uPVC, and it is sometimes more expensive. Joiners and other fittings are sometimes more expensive with polyethylene compared to uPVC.

Figure 21: The pipe in this photograph is made of PVC. It comes in fixed lengths and joins are often via rubber rings or solvent welds (*Photo: Pinion Advisory*)

Exercise

What material are your irrigation pipes made of?

Are there different diameter pipes made of different material?

Do you know the pressure rating of your pipes? Why is it important to get the pressure rating right?

3.1.6 Valves

Valves are devices that control the flow of water or air in an irrigation system. Valves are used to open and close pipes, regulate pressure or start / stop irrigation. Sometimes they may be referred to as "taps".

There are many types of valves in irrigation systems, and they are used for different purposes. These are detailed on the following pages:

Air release valves
These valves are located at high points in a pipeline to release air, but not water. Removing air from the pipeline is important as air can restrict flow and also compress under pressure and cause pressure surges in the pipeline (Figure 22).

Figure 22: Air release valves (*Photo:* (Bermad Water Technologies, 2018))

Backflow prevention valves
These valves are used to stop backflow of irrigation water in systems connected to potable (drinkable) water supplies (Figure 23). This is so that any contaminants from the irrigation pipes and fittings or nutrients from a fertigation system are prevented from flowing back into the water that people use for drinking. These valves are mandatory in Australia for any system connected to a potable supply.

Figure 23: Backflow prevention valve (in light blue) (*Photo*: (Sydney Water, 2025))

Ball valves
These valves contain balls within them with holes. As they rotate, they open or close flow. They are simple, low maintenance and easy to use (Figure 24).

Figure 24: Ball valve (*Photo*: (Irrigation Express, 2025))

Butterfly valves
These contain a disc that rotates to provide an on/off function (Figure 25).

Figure 25: Butterfly valve (*Photo: Pinion Advisory*)

Check valves
These are one-way valves, that is, water can only flow through them in one direction (Figure 26).

An example of when they are used is to stop water flowing back to the pump when the irrigation system is not operating. There are special check valves called **foot valves** which are placed at the end of a suction line to ensure that the suction pipe always remains full of water (i.e. remains primed).

Figure 26: Check valve (*Photo:* (Valve Warehouse Australia, 2024))

Float valves
Float valves are, like they sound, a valve connected to a float (Figure 27). When water levels decrease (for example in a tank as water is used), the angle of the float changes and water is release through the valve. As the tank fills, then the angle of the float flattens to the horizontal and the valve shuts off.

Figure 27: Float valve (*Photo*: (Land and Water Technology, 2025))

Pressure reducing valves
These valves create a constant water pressure downstream of the valve, by reducing the pressure from upstream of the valve (Figure 28).

Figure 28: Pressure reducing valve (*Photo: Pinion Advisory*)

Gate valves

Gate valves control the flow of water by lifting a barrier (gate) out of the path of the water (Figure 29). When fully opened, there should be no restriction in flow.

Figure 29: Gate valve. In this example the valve is thrust blocked with concrete (*Photo: Pinion Advisory*)

Globe valves

Globe valves are a type of valve used for regulating the flow of fluids in a pipeline, that is, they can let more fluid through or cut off fluid flow. They consist of a movable plug within a spherical body (Figure 30).

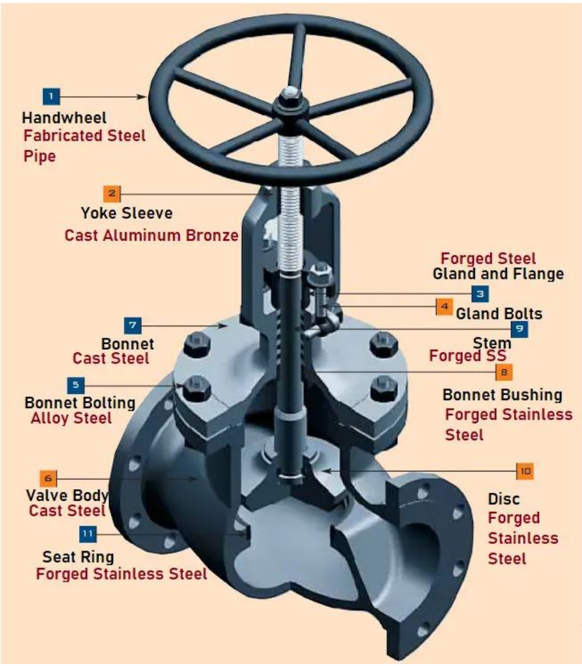


Figure 30: Typical globe valve (*Picture:* (Day, 2025))

Ratio valve
Like pressure regulating valves, they create a reduced pressure downstream of the valve at a preset ratio to the upstream pressure (Figure 31). They are installed to make certain that pressures in the pipes in certain parts of an irrigation system remain below a set value.

Figure 31: Ratio valve (*Photo:* (Irrigation Box, 2025))

Pressure relief valve
These valves allow water to escape if pressure builds up in the system to a certain value (Figure 32). These valves are important if there is a blockage in the system which causes a pressure build up, and therefore the system is protected against breakage.

Figure 32: Pressure relief valve (*Photo:* (Indiamart, 2025))

Solenoid valve
These are diaphragm valves that can be controlled electronically (Figure 33). They are often used in domestic and commercial irrigation systems with controllers that turn water on and off automatically.

Figure 33: Solenoid valve (*Photo:* (Baldivis Water, 2025))

Exercise

What valves have you encountered in your irrigation system?

What are they used for?

3.1.7 Flow meters

Flow meters are placed in pipes to measure the flow of water moving through that pipe (Figure 28). They are often used in situations where the volume of water used by a farmer is restricted through a licence.

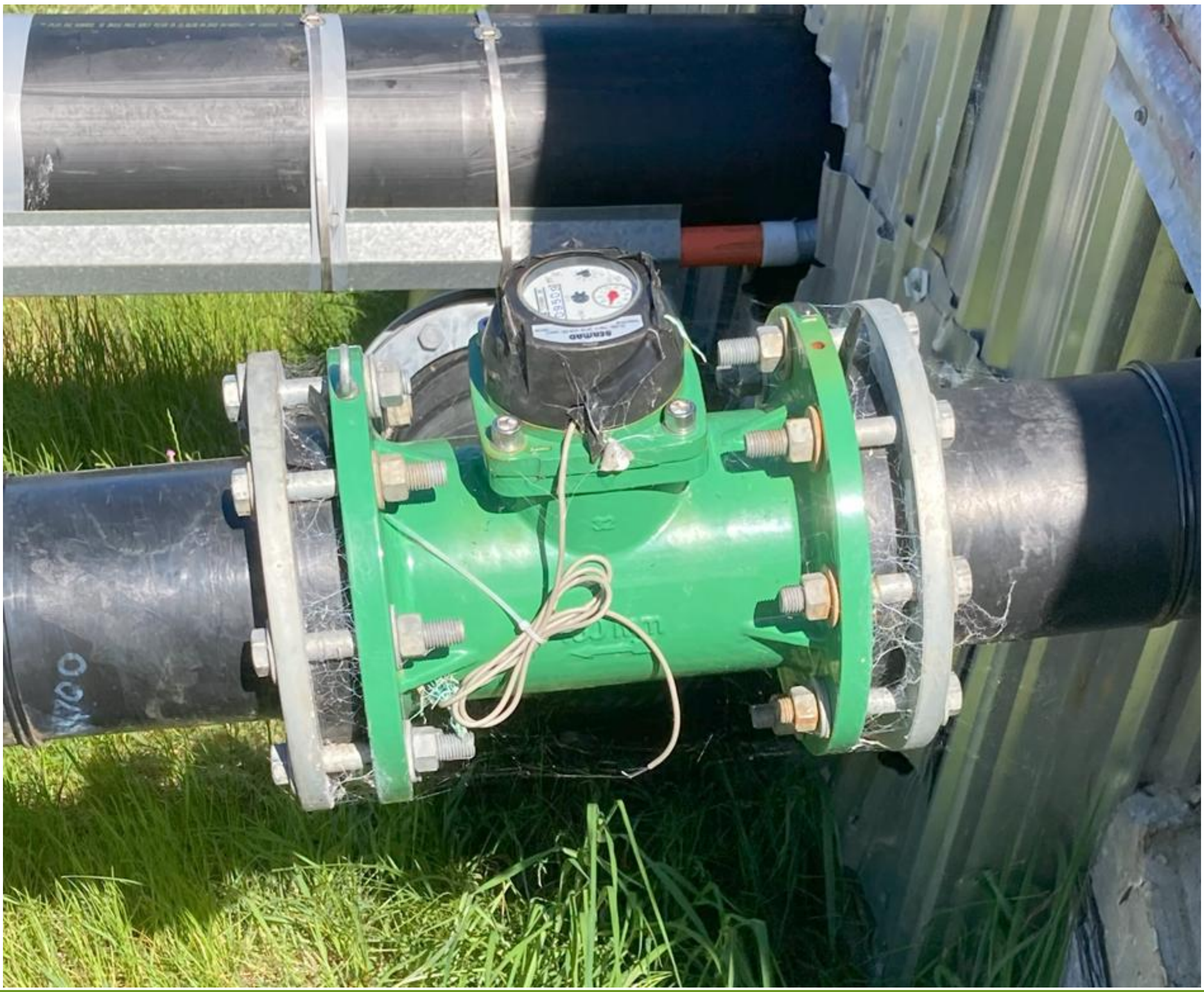


Figure 34: Flow meter (*Photo: Pinion Advisory*)

3.1.8 Sprinklers and emitters

Sprinklers, emitters and micro irrigation components are a small part (approximately 7%) of the capital cost of an irrigation system, but are responsible for up to 70% of performance, therefore it is important that quality is not compromised.

The goal of selection of these components is to be able to apply water uniformly. This depends on the:

- type of sprinkler and/or nozzle
- type and size of hole or orifice
- position and spacing of where the sprinkler is mounted
- pattern of the sprinklers or embitters
- operating pressure.

Figure 35: Sprinkler designed to work at high pressure (*Photo:* (Rain Bird, 2025))

Sprinklers

Sprinklers typically work at high pressures (around or above 50 psi or 350 kPa) (Figure 35) and throw water a large distance in a circular pattern. The diameter of the circle that a sprinkler wets is called the wetted diameter. To ensure uniformity, the distance between sprinklers is approximately half of the wetted diameter at the normal operating pressure.

Developments in sprinkler technology in the past few decades has improved sprinkler performance, meaning that they can work at lower pressure, and therefore use less energy. This is especially true of sprinklers that are attached to centre pivot irrigators. System pressures can be as low as 10 psi (145 kPa) and with a sprinkler comprising moving plates or similar mechanisms.

Modern sprinklers typically have pressure regulating valves fitted as standard upstream of the sprinkler, ensuring uniform flow delivery regardless of pressure above the set value. These assist with uniform water application (Figure 36).

Figure 36: Low pressure sprinkler with pressure regulator for centre pivot irrigator (*Photo: Pinion Advisory*)

Emitters or drippers
Emitters (or drippers) are devices that are either integrated into a drip tube or attached to a small pipe that controls the rate of water application to a crop in drip irrigation systems. It is important that emitters match the irrigation system. Emitters can be of varying quality, it is recommended reputable brands are used.

Drip irrigation systems operate at lower pressures than sprinkler systems, therefore are less costly to run and use less energy.

Emitters can be pressure compensating or non-pressure compensating. Pressure compensating drippers, like sprinklers with pressure regulators, have constant outputs over varying pressure, provided the pressure is above the minimum required. Non pressure compensating drippers have increased output as system pressure increases.

Aside from filters, emitters have design features like self-flushing diaphragms, and zig-zag water flow paths to cause turbulence and keep particles suspended, to ensure they do not become clogged by particulate matter.

Drip systems are typically used for perennial horticulture where the crop root zone is in distinct rows, with large spaces between the rows that do not require water. They are also useful in systems that use pots or containers, where medium volume is very limited (Figure 37).

Figure 37: This raspberry crop uses drip irrigation (*Photo: Pinion Advisory*)

Exercise

What sprinklers or emitters / drippers does your irrigation system use?

What pressure do they operate at?

Maintenance, troubleshooting and safety

4.1 INTRODUCTION

Even with well-designed systems, with time, there is bound to be problems that develop. These can often be avoided with good maintenance systems. If problems do occur, they can sometimes be easily fixed without contacting irrigation professionals if a simple troubleshooting process is followed.

4.2 MAINTENANCE

All irrigation systems need to be maintained regularly. Regular checks on operating parameters can be instructive, that is, if the numbers are not what they are meant to be, something is wrong that needs investigation. There should be an adequate system to check:

- operating pressure
- flow rate.

Simple checks of leaks and blockages should be done routinely, to make sure water is not wasted and system performance is optimal.

A simple maintenance checklist is given below. It covers:

- pump station and pump
- main line
- specific checks for a dripper or micro-irrigation system.

4.2.1 Pump station

SAFETY TIP **Before completing any checks at the pump station ensure all electrical isolator switches are OFF (tagged/ locked) in the Switch Board**

Electrical

☐ Visually inspect all wiring for damage and condensation. This should include both wiring in cable trays and in cabinets

☐ Check for any sign of shorting, burnt cables, hot terminals

☐ Test starters / drives, ensure they are working

☐ Test priming system – reprime priming pump if applicable

☐ Test control systems i.e. pressure switches by shutting valves etc.

Mechanical

☐ Clean and inspect foot valve (if applicable)

☐ Check adequate submergence of foot valve to ensure that vortexing / cavitation is not occurring

☐ Inspect suction and discharge piping for corrosion and leaks

☐ Fully close and open all valves to ensure they are still functioning

☐ Ensure air valve on discharge is functioning and sealing

☐ On systems drawing from a water source below the pump, ensure the suction assembly rises to the pump flange i.e. ensure there is no high point above the pump flange, this includes the fitting bolted to the pump flange

☐ Ensure system is primed / priming pump or system working if applicable
☐ Spin the pump by hand if possible to ensure it is free
☐ Grease pump and motor as per the manufacturer's guidelines (Important)
☐ Belt drive is tight (as applicable)

Run the pump
☐ General check over the pump and motor to detect any visible issue, leaks, cracks etc
☐ Check flow meter and pressure gauges are working and replace where necessary
☐ Check the pump runs up to pressure and note the pressure
☐ Check the water meter is functioning and check flow rate
☐ Healthy pumps and motors should be running cool and quiet, if there are strange mechanical noises and excess heat generation this warrants further investigation by a trained technician.
☐ Check pump rotation direction – phase switching might occur with work outside the property

4.2.2 Main line

☐ Drive the main line and check for leaks and damage (particularly after floods)
☐ Check air valves

- Ensure the isolation valve below the air valve is open
- Make sure the air valves are working – listen for air escaping while the line is filling
- Remove and clean the air valves if they are leaking

☐ Check for animals and nests in hoses and delivery pipes.

4.2.3 For drip or micro irrigation systems

The biggest issue with drip and micro systems are blockages, because the emitters of water are so small. Systems that are flushed, cleaned and have adequate filtration should perform well.

Flushing
☐ Flush the mainline while the sub-main and lateral flush valves are closed for at least 2 minutes or the water runs clean.
☐ Close the mainline flush valve and start flushing the submains for at least 2 minutes or until the water runs clean.
☐ Close the flush valve of the sub-mains and flush the drip laterals patch by path for at least 2 minutes or until the water runs clean.
☐ Close the laterals in consecutive order and check that all drippers are working.

Disinfestation
Organic matter can block emitters. Chlorine (in the form of sodium or calcium hypochlorite) is used to clear out organic matter.
The procedure is:
☐ Flush the system as per the instructions above
☐ Inject chlorine until it reaches the last dripper (divide the distance to the last dripper by 20 to give the time in minutes)
☐ Run the pump for another 10-15 minutes
☐ Shut the system down for 24 hours
☐ Flush the system again.

4.3 TROUBLESHOOTING

Table 2 is a summary of common irrigation problems, possible causes and solutions.

Table 2: Common irrigation problems, causes and solutions

Problem	*Possible causes*	*Solutions*
Uneven crop	Blocked or broken nozzles	Unblock nozzles or replace if broken. Clean filters.
	Spacing between sprinklers or emitters is too high	Add more sprinklers or emitters and ensure overlap is adequate.
	Poor pump performance	Conduct a system evaluation to ensure pressure and flows are adequate.
Insufficient water flowing into the pump	Clogged screen or filters	Clean screen or filters

4.4 SAFETY

It is important to maintain a safe working environment while conducting irrigation activities. The key safety risks related to irrigation and ways to mitigate those risks are shown below in Table 3.

Table 3: Managing safety risks associated with irrigation

Safety risks in irrigation	Risk mitigation
Slips, trips and falls	Wear sturdy, waterproof footwear.
Injuries due to water pressure	Keep your face as far away as possible from valves when adjusting a pressurised system. Wear safety goggles.
Splash when mixing fertilisers	Wear safety goggles and overalls / apron.
Electrocution	Before completing any checks at the pump station ensure all electrical isolator switches are OFF (tagged/ locked) in the Switch Board. Adhere to tag outs / out of service signage.
Hearing damage from loud noises	Wear earmuffs.

Principles of plant-water relationships

5.1 PLANT WATER NEEDS

Water is essential for plants to grow and survive. Water is needed by plants for photosynthesis, nutrient transport, to keep cool, to maintain structural support through turgor pressure.

Most plants that are important to agriculture take in most of their water through roots. There are some other plants like orchids, ferns and moss, that can absorb water directly through their leaves or other above ground parts.

Different plant species have different water needs depending on a few different factors. These include:

- The root system: some plants have bigger or deeper root systems than others, and therefore can access more water from the soil.
- Leaf size: plants with bigger leaves generally need more water because there is a bigger leaf surface area for facilitating water loss.
- Leaf structure: plant water loss through leaves is affected by the number of pores (called stomata) on the leaf, and the thickness of layers of wax on the leaf surface (Figure 38). Also, some leaves can be curly in shape, which may restrict the loss of water from their surface.
- The way that some plants convert sunlight to energy: Some plants have special chemical pathways that use water more efficiently in the process of converting sunlight to energy (called photosynthesis). For example, some plants like cacti have a system called CAM (Crassulacean Acid Metabolism) that allows them to close their pores (stomata) during the day, therefore minimising the loss of water.

Figure 38: Onions are a common Tasmanian crop. Because of their waxy leaves, they use less water that other plant species (*Photo:* (Pixabay, 2025))

5.2 HOW DOES WATER MOVE THROUGH PLANTS?

Plants get water from the soil or other growing medium (in the case of hydroponic production) through their roots and this water moves through the plant and is lost from stems and leaves. This process is called *transpiration.*

Transpiration starts at the roots, where water is absorbed from the soil or growing medium. It is then pulled upwards by loss of water at the leaf surface through tiny pipes called *xylem*. At the surface of the leaf, if the tiny pores (stomata) in the leaf are open, water escapes to the atmosphere as a gas. For most plants, these stomata are only open during the day, and closed at night, therefore most plant water loss through transpiration is during daylight hours. The process is pictured as Figure 39.

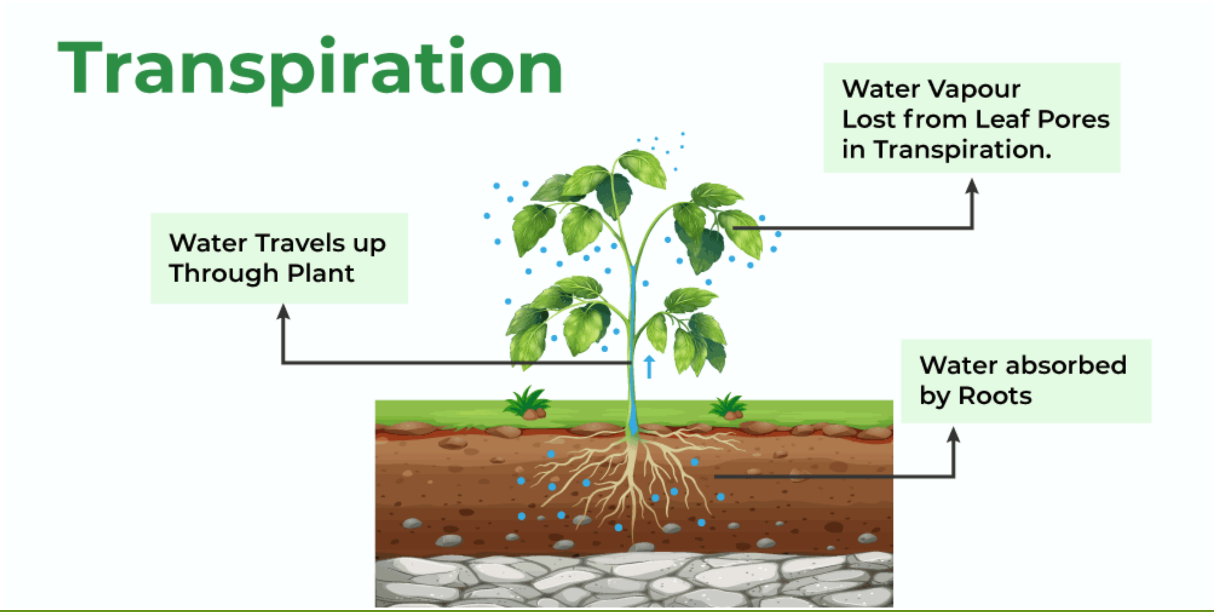


Figure 39: The process of transpiration in plants (*Image spurce:* (Geeks for Geeks, 2025))

As mentioned above, because of the differences between plants in the way they use water, their transpiration rates are different. For example, the water use of onions is approximately 60% of a perennial pasture over the same area due to differences in transpiration.

There is another process called *evaporation* where water is lost from any other surface other than the plant. The process of drying clothes on a clothesline is an example of evaporation. Evaporation can be measured using pans filled with water. In Australia, the Bureau of Meteorology uses a Class A evaporation pan, and measures the mm of water lost from the surface of these pans daily (Figure 40). This measure of evaporation can be used as an indication of the amount of water that plants are using. As can be seen from Figure 40, they are covered with mesh to minimise loss of water from consumption by birds or other animals.

To tell how much water is being lost from an area of land, transpiration and evaporation are added together. The result of this addition is called *evapotranspiration*.

Evapotranspiration can be measured by putting an area of land or potted plants on a set of scales called a lysimeter (Figure 41). As evapotranspiration occurs, the weight of land or pots decreases. This is impractical in most farming situations but is used in intensive horticulture like berry production. To make things easier the Bureau of Meteorology calculates evapotranspiration using a formula that considers solar radiation, temperature and windspeed (Figure 42). Conveniently, evapotranspiration is measured in mm of water, therefore can be matched with mm of water applied through irrigation or rainfall.

Figure 40: Class A evaporation pan, used to measure daily evaporation in a standardised manner (*Photo: Pinion Advisory*)

Figure 41: Lysimeters are weighing scales that contain portions of land or pots that grow crops, and are used to directly measure evapotranspiration (*Photo: Pinion Advisory*)

The weather profoundly affects evaporation and transpiration. Both increase with:

- higher temperatures
- higher wind speed
- more sunlight
- lower humidity.

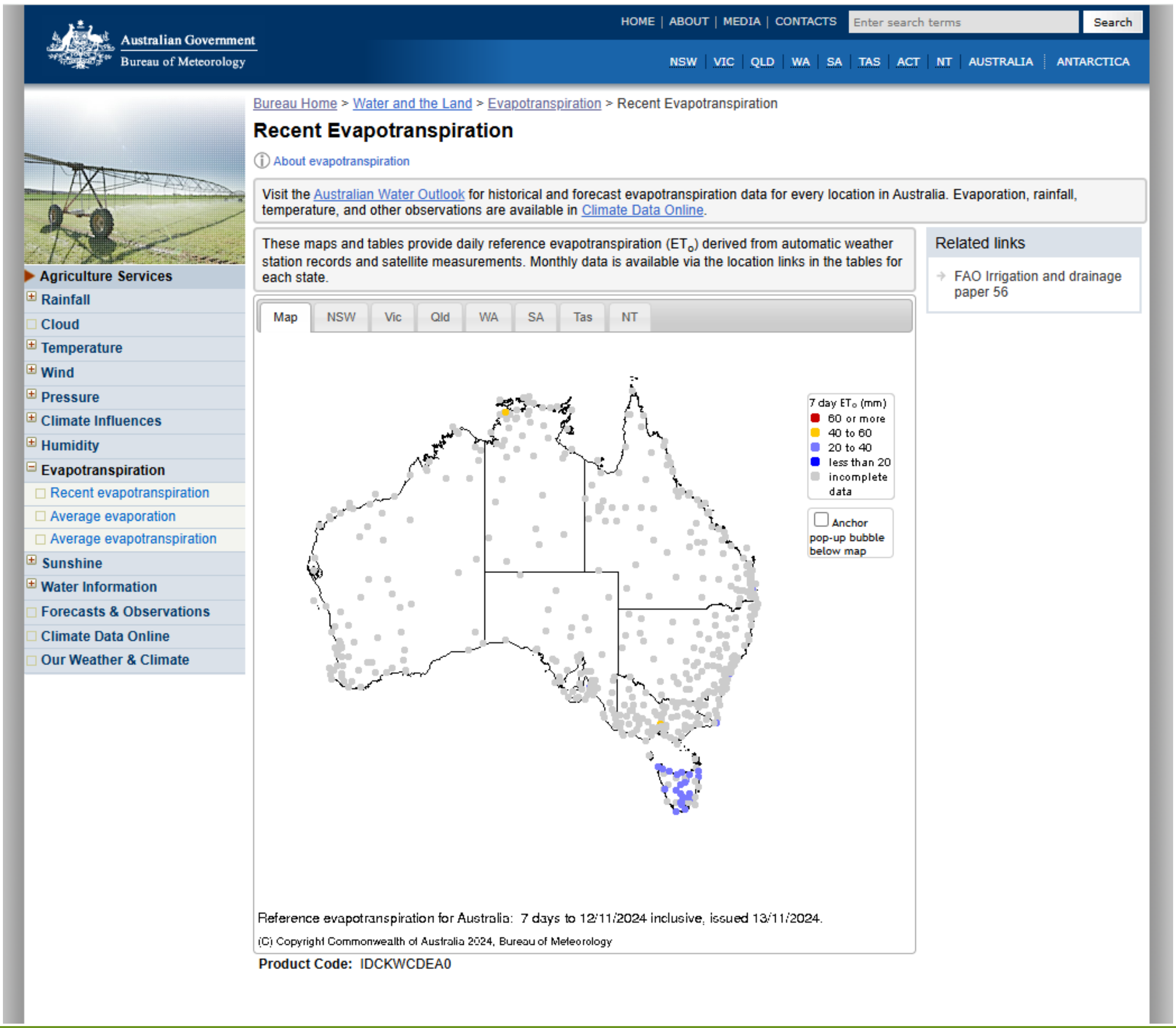


Figure 42: Evapotranspiration is reported by the Bureau of Meteorology (*Source*: (Bureau of Meteorology, 2025))

Exercise

- Go to the Bureau of Meteorology website and find the evapotranspiration in your area over the last seven days.

- From the website, can you find out what has the greatest influence over evapotranspiration?

Soil and irrigation

6.1 IMPORTANCE OF SOIL TO IRRIGATION

As mentioned in Section 5.1, most, if not all, plants that are important agriculturally obtain their water through their roots, and these roots grow in either soil or other growing media (in the case of hydroponics). From now on, the word *soil* can be taken as meaning either soil or growing media, as they perform in very similar ways.

Once water enters soil through rain or irrigation, its availability to plants will depend on the characteristics of the soil. Furthermore, as the level of water changes in the soil from wet to dry, the availability to plants also changes. This means that some thought is necessary to determine when to irrigate so that the optimal amount of water is in the soil and therefore available to cropping plants.

6.2 SOIL TEXTURE

Not all soils are the same. They have different soil *texture*. Texture refers to the size of the particles that soil is made from. Particles of different dimensions have different names. These names are clay, silt and sand. The size range for these particles is in Table 4.

Table 4: Soil texture types and particle size

Soil texture type	Particle size
Clay	Smaller than 0.002 mm diameter
Silt	0.002 – 0.05 mm diameter
Sand	0.05 – 2 mm diameter

Soil is usually a mixture of these particle sizes, and these mixes have other more specific names, like loams, light clays, or loamy sands, for example.

The importance to irrigation is that different particle sizes cause soil to react in different ways towards water. For example:

- Clays absorb and hold onto large amounts of water, but can be slow to drain, as they hold the water very tightly.
- Sands allow water to enter soil more quickly that clays, and drain easily, but do not hold as much water as clays.
- Silt is intermediate between clay and sand.

6.3 EFFECT OF SOIL TYPE ON WATER AVAILABILITY TO PLANTS

Soil acts like a sponge with regards to water. It can only soak up a certain amount, and after this it cannot hold any more. If there is more water applied than a soil can hold, then excess water will drain because of gravity. At the point when this drainage through gravity stops, the soil is said to be at *field capacity*.

As the soil dries out, plants can use the water in soils between *field capacity* and another point of dryness called *permanent wilting point*. At this point, no more water can be extracted from the soil by the plant, even if there is water remaining in the soil. This is because the water left in the soil is held strongly between soil particles, and the force needed to extract this water is too much for plant roots.

The amount of water in soil between *field capacity* and *permanent wilting point* is called *available water*. Figure 43 shows the amount of *available water*, in mm water per metre of soil depth, for various soil types. For example, for the column on the far right (self mulching clay), the amount of water that the soil holds is quite high (a little over 400 mm per m of soil at field capacity). As the soil dries out, water in the soil becomes impossible for plants to extract at about 200 mm / m soil (*permanent wilting point*). The *available water* is therefore around 210 mm / m soil.

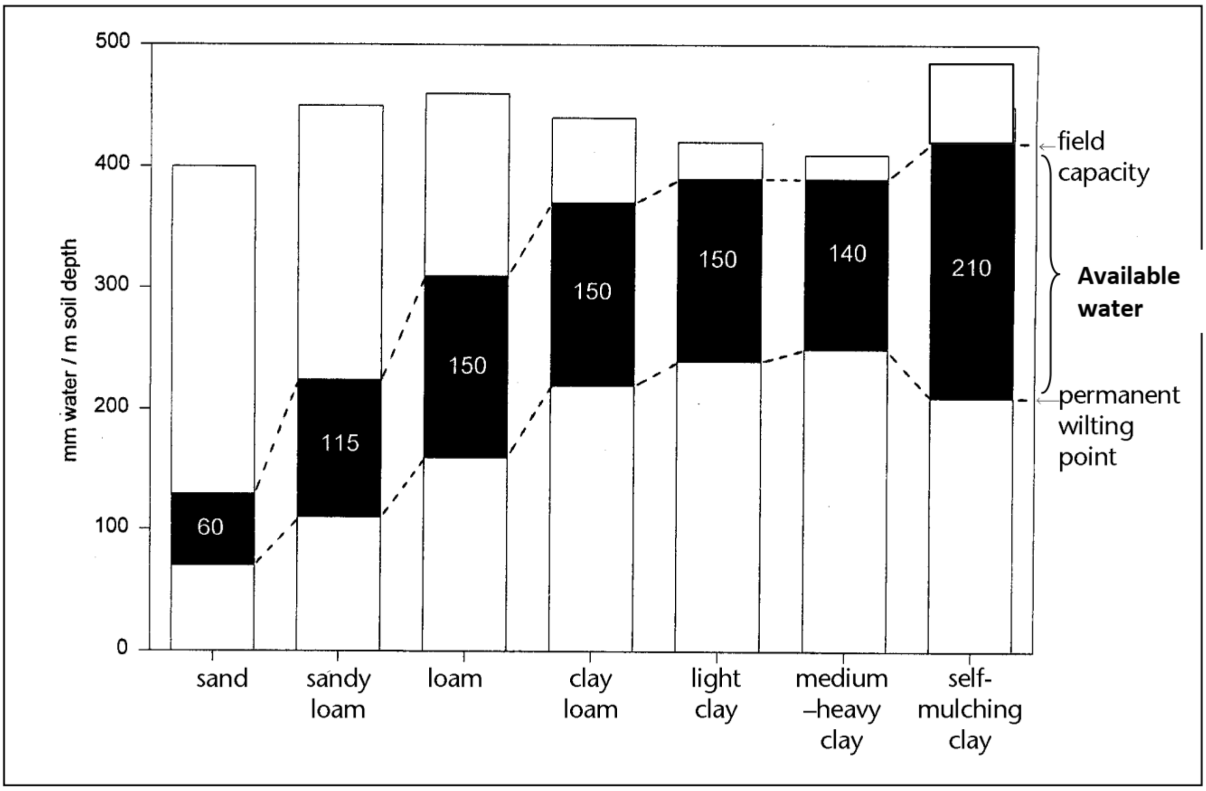


Figure 43: Effect of soil type on water storage (Source: (Cotching, 2011a))

Exercise – soil ribbon

Using soil from your farm, or supplied, mix water and soil in a small handful into a lump about the size of a golf ball in your hand. Keep kneading the lump for a couple of minutes, ensuring the lump remains wet. Using your thumb and forefinger, press it out into a ribbon around 2 mm thick and 1 cm wide. Do this a few times and measure how long the ribbon gets before it breaks. Use the information in Figure 44 to determine your soil texture. This is the same method that soil scientists use in the field.

How long was your ribbon?

What is your soil texture?

Soil texture	Ribbon length	How the soil feels/behaves	Approx. clay content
Sand	nil	Coherence nil to very slight, cannot be moulded; sand grains adhere to fingers.	< 5%
Loamy sand	5 mm	Slight coherence; sand grains of medium size; can be sheared between thumb and forefinger.	5–10%
Clayey sand	5–15 mm	Slight coherence, sticky when wet, many sand grains stick to fingers, discolours fingers with clay.	5–10%
Sandy loam	15–25 mm	Coherent bolus but very sandy to the touch; dominant sand grains are of medium size and readily visible.	10–20%
Loam	about 25 mm	Loams can form a thick ribbon. Soil ball is easy to manipulate and has smooth spongy feel with no obvious sandiness. May be greasy to touch if much organic matter present.	about 25%
Silt loam	about 25 mm	Coherent bolus; very smooth to silky when manipulated.	About 25%
Sandy clay loam	25–40 mm	Strongly coherent bolus, sandy to touch; medium sand grains visible in a finer matrix.	20–30%
Clay loam	40–50 mm	Strongly coherent and plastic bolus, smooth to manipulate and slightly sticky.	30–35%
Silty clay loam	40-50 mm	Coherent smooth bolus; plastic and often silky to the touch.	30-35%
Sandy clay	50–75 mm	Plastic sticky bolus, fine to medium sand grains can be seen and felt.	35–40%
Light clay	50–75 mm	Plastic behaviour evident; smooth feel; easily worked, moulded and rolled into rod. Rod forms a ring without cracking.	35–40 %
Light medium clay	75–85 mm	Plastic bolus; smooth to touch; slight to moderate resistance to ribbon shearing.	40–45%
Medium clay	> 75 mm	Smooth plastic bolus; handles like plasticine; can be moulded into rods without cracking; resistant to shearing and sticks to thumb and forefinger.	45–55%
Heavy clay	> 75 mm	Smooth, very plastic bolus; firm resistance to shearing; will mould into rods. Handles like stiff plasticine. Very sticky and strongly coherent. Rods will form a ring without cracking.	over 50%

Figure 44: Field characteristics of different soil textures (*Source*: (Cotching, 2011b))

6.4 READILY AVAILABLE WATER

Figure 43 shows the *available water* for plant growth from various soil types. However, as the soil dries out, it becomes difficult for plants to extract water. Therefore, for practical purposes, there is another measure of soil water called *readily available water* or RAW for short. Only 25-60% of the total available water (the black section in Figure 11) is RAW. Once all the RAW is used in a soil, irrigation should be applied. If irrigation is applied at this point, the plants will then have a new source of water that they are easily able to extract from the soil, therefore their growth will not be hindered due to lack of water. Table 5 shows RAW for a range of soil textures. RAW is measured in mm of water per m of soil.

Table 5: Readily available water (RAW) for a range of soil textures (Cotching, 2011a)

Soil texture	Readily Available Water (RAW) mm/m
Sand	30
Loamy Sand	50
Sandy Loam	70
Loam	90
Clay	50
Clay Loam (Ferrosol)	80
Well-structured clay	60

6.5 EFFECTIVE ROOT DEPTH

Different crops have different root depths in the soil from which they can effectively and easily extract water. This depth is typically around two thirds of the maximum root depth that will be found in these plants. Some effective root depths can be found in Table 6.

Table 6: Effective root depth for a range of crops (Cotching, 2011a)

Crop	Effective root depth (m)
Strawberry	0.2
Raspberry	0.3
Blackberry	0.3
Green beans	0.5
Lucerne	1.2-1.8
Stone / pip fruit	1.0
Wheat	0.8-1.1
Oats	0.6-0.8

6.6 WHEN TO IRRIGATE

The above information can be pulled together to form a simple model of irrigation scheduling. The ingredients needed are:

1. Daily evapotranspiration
2. Soil texture, and therefore readily available water (from Table 5)
3. Effective rooting depth (from Table 6).

Example: Calculating RAW for raspberries.

The effective rooting depth of raspberries is 0.3 m (from Table 6).
The RAW in a sandy loam is 70 mm / m.
Therefore, the RAW for raspberries is 21 mm for 0.3 m (RAW x effective rooting depth).

Therefore, if a soil is at field capacity, there is 21 mm available for the raspberries before they experience some level of water stress.

If evapotranspiration is 5 mm per day, and no precipitation occurs, the crop will need to be irrigated in around 4 days' time (5 mm x 4 = 20 mm = RAW in the effective rooting depth for raspberries).

Exercise

Calculate the RAW for strawberries on a well-structured clay at field capacity.

If evapotranspiration is 4 mm a day, and the soil that is growing the strawberries is at field capacity, how many days will it be before the peas would need to be watered again?

6.7 INFILTRATION RATE

One of the most important characteristics of a soil is the speed at which it can absorb water. This speed is called the *infiltration rate*.

Infiltration rate is measured with an instrument called an *infiltrometer* (Figure 45).

Figure 45: Infiltrometer measuring speed of water absorption into soil (*Source:* (Trade India, 2025))

Infiltration is measured in mm/hour.

The rate of infiltration into any soil changes depending on the initial moisture level in the soil, the number of cracks that water can move down, how compact the surface is and the soil texture. In some soils, infiltration rate can be changed dramatically by application of gypsum, for example, sodic soils (soils that contain clays that have a high proportion of sodium attached). To further complicate matters, soil texture may change throughout a soil profile with depth, therefore different layers of soil may have different infiltration rates.

Challenging soil types may include:

- water repellent sands – water runs off the surface of these sands
- heavy clay soils with very low infiltration rates
- cracking clays that have high infiltration when dry (due to cracks) and then become very impermeable when wet.

6.8 APPLICATION RATE

Infiltration rate is important to irrigation in tandem with *application rate*, which is the speed at which water is applied to the soil surface by irrigation. This, like infiltration, is measured in mm/hr.

The goal of irrigation is to manage infiltration rate and application rate, with the aim for the application rate to be less than the infiltration rate. If application rate is greater than infiltration rate, then water runs off the surface of the soil, or if it is flat, will pond on the surface.

Table 7 shows maximum application rates for various soils in mm/hr.

Table 7: Estimated maximum water application rates in mm/hr (Dairy NZ, 2011)

Soil type	0-8° slope (level to undulating)	9-12.5° slope (Undulating to low hills)	>12.5° slope (low – steep hills)
Sands and light sandy loams uniform in texture	31.8	25.4	20.3
Sandy loams overlying a heavier subsoil	20.3	16.5	12.7
Medium loams to sandy clays over a heavier subsoil	16.5	12.7	10.2
Clay loams over a clay subsoil	12.7	10.2	7.6
Silt loams and silt clays	10.2	7.6	5.1
Clays	6.4	5.1	3.8

Exercise

A sandy soil in Southeast Tasmania is growing blueberries. An infiltrometer has measured the soil infiltration rate as 25 mm/hour. Which of the following irrigation systems would be best for these blueberries?

- Drip irrigation (application rate 12 mm/hr)
- Sprinklers (application rate 24 mm/hr)

Why?

Do you know the application rate for the irrigators on your farm?

Do you know the infiltration rate for the various soils on your farm or the farm where you work?

What do you notice from these numbers? Does the application rate match the soil types?

Substrate and irrigation

7.1 PRINCIPLES OF PLANT GROWTH

Irrigation is applied to crops to meet their water requirements of the plants for water and nutrients. Plants require water for photosynthesis, respiration, transport nutrients throughout the plant and to cool themselves. The turgor pressure within plants is the internal hydrostatic pressure within the plant cells that results from the movement of water into the cell and the cell's rigid cell wall. It is essential for plant structure and growth. It gives fruit its firmness and plants their structural strength.

Plants absorb water through their roots by root pressure pushing water into the roots and by the negative water potential drawing water into the roots. Water then moves through the plant through the xylem by capillary action and cohesion tension. These forces work to move water from an area of high concentration to an area of low concentration. The concentration gradient is developed under pressure (turgor) or solutes (osmosis) to create a gradient across the plant to support the uninterrupted flow of water. The water moves through the soil into the roots then through the xylem in the stem, out through the stomata on the leaves as vapour into the atmosphere. This is known as transpiration (discussed also in section 5.2).

The rate of transpiration and photosynthesis is determined by the levels of light, temperature, relative humidity, leaf wetness, wind and rain. Evapotranspiration, growing degree hours and vapour deficit pressure combine a number of environmental factors to measure the rate of plant activity and water use.

7.2 GROWING MEDIA

Berries have traditionally been grown in soil like all crops but in recent years have moved to alternative substrates, particularly coir. Coir is a cheap substrate that is available in large quantities to supply many greenhouse and protect cropping systems. Coir is relatively free draining, retains nutrients and moisture to provide to the plants. The root system area is more concentrated in a coir bags or pots than the soil. Plants are trellised for support and canopy management. Nutrients are provided with each irrigation and along with moisture levels are monitored closely.

Irrigation operators play an important role in the growing team to monitor the plants throughout the day to ensure that the irrigation schedule meets the plants water and nutrient needs.

As opposed to soil where the water buffer can last days and the nutrient buffer longer, substrate buffers are shorter relative to the size of the pot. Under summer conditions in the heat of the day, plants in substrate can wilt within hours without water.

Understanding the physical characteristics of soil and substrate assist irrigation operators and agronomists to effectively deliver water and nutrients to the plant to support plant growth, development, yield and fruit quality. The characteristics of texture and particle size dictates the water holding capacity, air-filled porosity and nutrient holding capacity. Substrate characteristics operate under the same principles as soil. For example, the particle size of sand is more similar to coir and the wetting pattern of coir is similar to sand, the pattern under the dripper is long and thin (Figure 46).

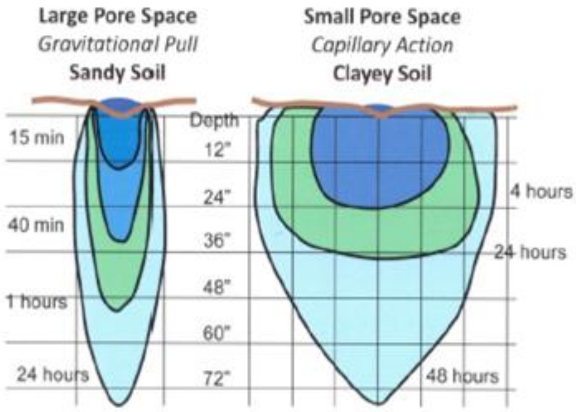


Figure 46: Comparative movement of water in sandy and clayey soils (*Source:* (Alhammadi & Al-Shrouf, 2013))

7.3 IRRIGATION SCHEDULING

Irrigation water needs to be delivered to the coir at a rate equal to or less than its infiltration rate. If the application rate exceeds the infiltration rate water will pool or run-off on the substrate surface. As coir ages and the plants roots populate the pot the infiltration rate decreases, particularly at the top surface of the substrate. The irrigation water moves down into the substrate primarily influenced by gravitational pull. Sideways or capillary movement of water is poor due to the large pore sizes in coir.

Capillary movement of water in substrate is aided by short, frequent irrigations. Each irrigation establishes a wetting front further into the pot. Soil on the other hand with small pores, like clay soils, can be irrigated for long periods, less frequently to deliver water to the depth and width of the active root system (Figure 46).

In substrate, it is important to establish the wetting fronts to the edges of the pots daily during the "wetting up" cycles in the morning. Substrate irrigations normally start 1-2 hours after sunrise. These "wetting up" irrigations in the morning:

- establish a wetting front in the pots after the overnight dry back,
- develop positive root pressure to push water into the plant prior to transpiration pressures and
- establish a substrate at field capacity before the maximum water use throughout the middle of the day (Figure 47).

Figure 47: Substrate irrigation to match daily crop water use requirements (*Source*: (Priva, 2025))

As plant water use reaches a maximum through the middle of the day, the irrigation frequency increases to maintain high pot moisture and achieve draining from each irrigation. These irrigations target non-limiting water availability in the pot and enough drain to remove excess nutrients and manage the pot Electrical Conductivity (EC).

Later in the afternoon, irrigations become less frequent to dry the pot back before dark. This allows the pots to cycle through a period of the day where air is allowed back into the substrate. These 3 irrigations phases are illustrated in the diagram above (Figure 47).

The daily irrigation cycles supply the plants need for water, nutrients and air to be supplied to the root system for active and healthy growth (Figure 48). At saturation to flush nutrients through the substrate; to field capacity and wilting point where the plants can readily access the water; to the wilting point where the remaining moisture is too tightly retained by the substrate for the plant to take up.

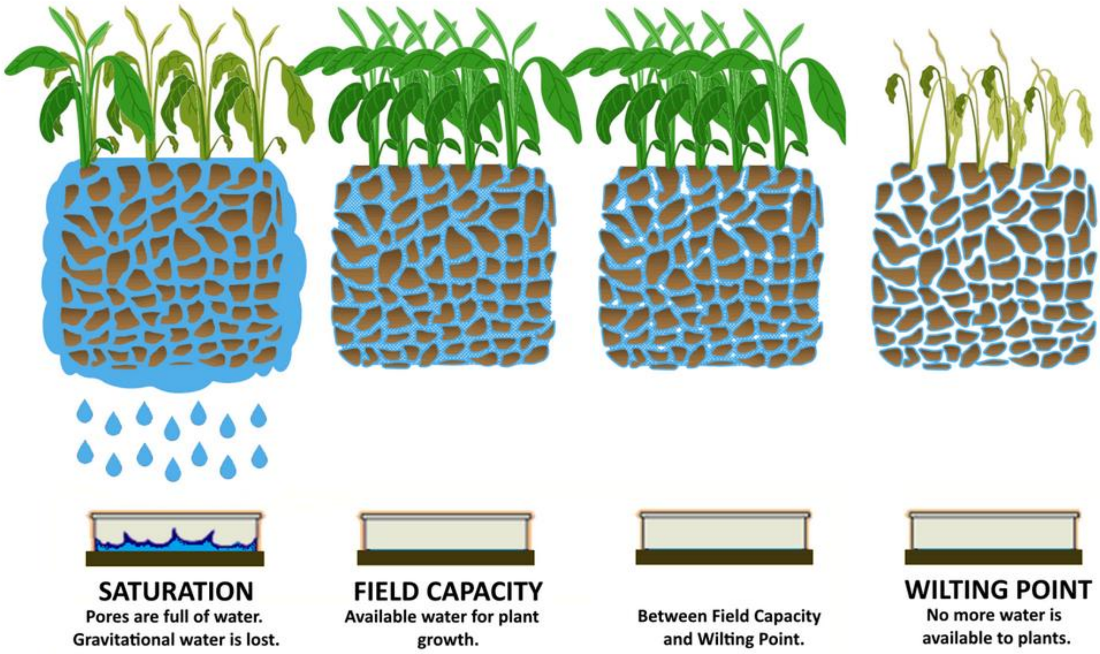
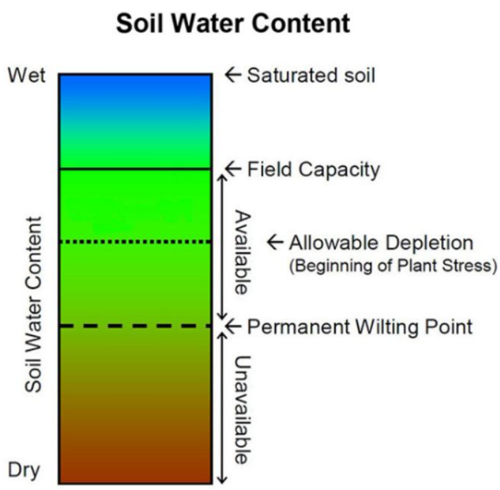


Figure 48: Water status of soil and substrate (*Source:* (Gould, 2024))

The curve in Figure 49 illustrates the pressure or ease at which the plant can take up the water from the substrate. At saturation the plant cannot take up water until it drains out. At wilting point it becomes increasingly difficult for the plant to draw water up out of the substrate, both soil and coir.



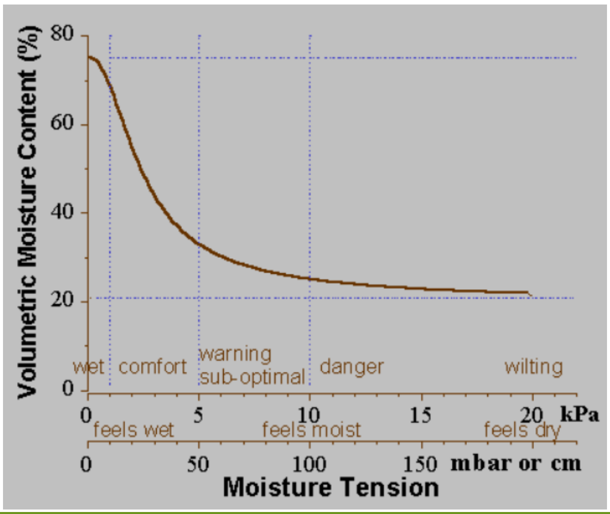


Figure 49: Soil water content and the tension the plant must overcome to obtain water (*Sources:* (Maughan, et al., 2015) (Lieth, 1998))

In protected cropping systems, understanding the tunnel management effect on the growing climate is important. Tunnel management can increase the temperature and relative humidity increasing the plants water use and increase the risk of wilting. Tunnel management decisions should always be communicated to the irrigation operators and factored into the irrigation scheduling strategy. The conditions in a protected substrate growing system can change quicker than the plants can respond to protect themselves by closing their stomata when the substrate moisture levels become too low/pressure too high for the plant to move water from the roots to the leaf resulting in wilting.

7.4 NUTRITION MANAGEMENT

Maintaining the substrate moisture within the target range and achieving target drain percentages not only meets the water needs of the plant but also manages the levels of nutrients supplied to the plants and the nutrient environment in the substrate. Nutrient levels are measured as EC (Electrical Conductivity). In soil, EC is a measure of salinity or the quantity of dissolved salts in the soil solution. Salts including Sodium Chloride dissociate into ions readily in soil that results in salinity.

Salinity adversely affects plant health and growth. In substrate however, EC measures the total dissolved salts concentration, which are primarily plant nutrients. EC measures inorganic ions (N, P, K, Ca, Mg etc). Organic molecules (i.e. urea) do not contribute to the EC readings.

Nutrient uptake is highest in the morning and afternoon when temperatures are moderate to cool. Under the warm temperature through the middle of the day nutrient uptake is lower as the plant absorbs more water for transpiration. Ensuring the EC does not build through the heat of the day is critical and if drain EC or substrate EC thresholds are exceeded, the substrate needs to be flushed to remove the excess or unused nutrients.

Nutrients are mixed into concentrated stock fertiliser tanks. The nutrients are separated into an A and B tank to keep incompatible fertilisers separate. Calcium must be kept mixed in the A tank and if added to the sulphate or phosphate fertilisers will settle out and block up filters. Iron is commonly added to the A tank but is also compatible with the fertilisers in the B tank. When mixing fertilisers ensure that each fertiliser is accurately measured out and added to the correct tank.

The irrigation unit then doses the fertiliser from the A and B tanks at the target EC into the irrigation water.

Table 8 lists the fertilisers that can be used in each tank to make up the feed recipe:

Table 8: Fertilisers used for "A" and "B" tanks

A Tank	B Tank
N, K, Ca, Fe	*N, P, K, S, Mg, Fe, B, Cu, Mn, Zn, Mo*
Calcium Nitrate	Potassium Nitrate
Iron	Potassium Sulphate
	Magnesium Nitrate
	Magnesium Sulphate
	Sulphate of Ammonia
	Mono Ammonium Phosphate
	Mono Potassium phosphate
	Manganese
	Copper
	Zinc
	Boron
	Sodium Molybdate
	Iron
	Trace elements as sulphates or chelates

Specialised hydroponic fertiliser manufactures have B tank fertiliser mixes that can be paired with Calcium Nitrate in the A tank, thus simplifying the fertiliser mixing.

7.5 IRRIGATION SUBSTRATE MONITORING

Irrigation and nutrient levels need to be monitored to provide feedback to the irrigation team.

Methods for monitoring are:

- daily drip and drain monitoring
- spot substrate checks with a WET Sensor or similar
- continuous substrate monitoring.

Daily drip and drain monitoring are set up in stations, in each irrigation block. Water is collected directly from the drippers and from a tray collecting the drain water from a number of pots. The drip and drain water volumes and EC are measured and recorded. The drain percentage and sum EC are then calculated. An example drip and drain recording sheet is shown in Table 9.

Table 9: Drip and drain recording sheet

	Drip		Drain			
Block	**Volume (ml)**	**EC**	**Volume (ml)**	**EC**	**Drain %**	**Sum EC**
A	900	1.4	300	1.6	33%	3
B	1100	1.5	250	1.8	23%	3.3
C	1200	1.5	150	2.2	13%	3.7
D	800	1.2	400	1	50%	2.2

Spot substrate EC and moisture checks are used to look at individual pots. The wetting and EC patterns can be detected as well as sampling more widely to confirm trends in entire blocks. When readings are taken across a block, record the results to establish high, low and average readings. These can be compared to the daily drip and drain readings to confirm a trend or the reliability of the data.

Continuous substrate moisture monitoring is a valuable tool to monitor the irrigations and observe the trends the irrigation strategy is influencing. Always cross check this information with the WET sensor and coir squeeze test to confirm the full and wilting points to establish the readily available water parameters.

The coir squeeze test is a simple test where a handful of coir is taken and squeezed to see how hard it is to get water out of it. Plant available water should be easy to squeeze out, saturated water will drip without much if any pressure. If it is hard to squeeze out water, there is not enough moisture in the substrate for the plants. Field checking the moisture establishes confidence in the levels and trends on the continuous substrate moisture data.

7.6 IRRIGATION OPERATIONS

Every irrigation operator needs to understand the operation of their irrigation system including its capability to deliver water and its limitations. Be proactive in managing the system and its maintenance. Maintenance checks should be carried out on a schedule to help catch issues early and avoid any significant down time. Review the irrigation strategy daily with the agronomy and crop management team based on the monitoring data and weather data and forecast. Discussing the strategy each morning will ensure everyone knows what is happening and provide feedback from the crop throughout the day, flagging any changes as they are seen.

Mixing fertiliser accurately, calibrating and checking sensor performance are regular tasks. Ensuring the fertiliser stock is managed proactively and stocks are not exhausted is also important.

Be proactive and across the details. Make one change at a time and assess the feedback before continuing to adjust the strategy. Watch the plants as well as the data to complete the feedback loop.

Further reading

For further information and resources, go to https://www.tasfarmhub.com.au/water-use-efficiency-project/

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