ADAPTING TO CLIMATE CHANGE

05. EFFICIENT USE AND RE-USE OF WATER

Summary

Mushroom and compost producers both use a large amount of water. The availability and cost of clean water, especially in urban areas, is likely to be affected by extreme weather events and droughts. Current industry irrigation practices have not kept up with developments in other cropping systems; irrigation water is mainly applied manually using overhead sprinklers or watering trees. There is little or no use of tools that measure moisture content or control irrigation.

The main opportunities for adapting to climate variability and change are:

1. Drip irrigation to replace overhead sprinkler irrigation
2. De-salination and purification of bore water or recycled water using solar power to reduce reliance on town water and save money
3. Potential for using moisture monitoring technology to help growers manage irrigation to improve yields and quality, and reduce water use.

Current practice

Mushroom production requires large volumes of water, both for compost production and during growing, cleaning and processing at the farm. Estimates of the water required vary widely between businesses. In the case of compost production, most estimates were between 800 to 2,000 Litres/tonne compost. Mushroom farms use about 8 to 20L per kg of mushrooms produced. This suggests that 11 to 30L of water is needed to produce one kg of mushrooms. This is substantially less than the 64L/kg estimated for mushroom production in the US.[1]

Most mushroom farms, and 3 of 7 surveyed compost producers, have access to town water. Many also use bore water, rainwater tanks or pump from surface water sources such as rivers and dams. Use of surface water is more common among compost producers.

Using town water ensures water is of suitable microbial and chemical quality for all purposes on the farm. However, one key effect of climate change is likely to be reduced availability of fresh water, or at increased cost. While most farms gained exemptions from water restrictions in the most recent drought, this represents an ongoing vulnerability for many producers. Even where bore water is available, high salt content may limit its use. Recycling is also limited by accumulation of salts and other impurities. This may be one reason why only 30% of farms recycle water, and few have installed other water efficiency systems.

"Our town water supply is limited by the size of the pipes, and means we have to truck water in occasionally. The farm can't expand further unless we can improve the supply of water."

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[1] Robinson B. et al. 2018. A life cycle assessment of Agaricus bisporus mushroom production in the USA. Int. J. Life Cycle Assess. 24:456-457.

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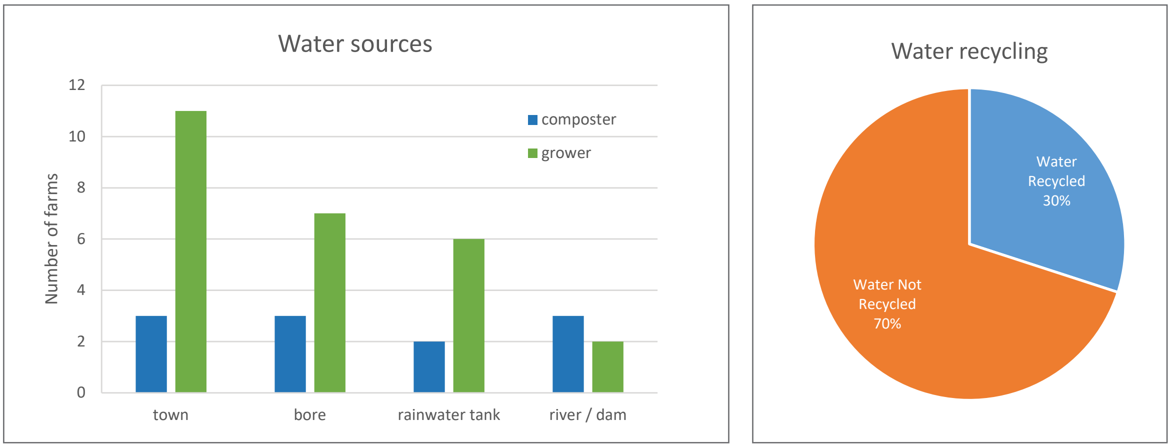

Figure 1. Water sources currently used by Australian mushroom composters and farms, and the percentage of mushroom farms recycling water for non-critical uses (e.g. cleaning).

Figure 2. Automated irrigation system with display panel.

Photo by Vullings-systemen.

Most farms irrigate mushrooms by hand, using watering trees or overhead sprinklers. Automated systems are also available which apply irrigation through fixed sprinklers or a spray arm. These are generally based simply on a timer and pressure controls, but can link with other grow room climate management systems. Examples include the Lumina 767 system by Fancom or Multiflex water supply system by Vullings-systemen. While drip irrigation systems can be installed in shelf systems, none of the mushroom farms surveyed were using this technology.

Background

Mushrooms are more than 90% water. Their production necessarily involves a considerable amount of water, much of which must be high quality. Access to water is already a key issue faced by some composting facilities and farms. Many Australian farms now use town water. While this ensures that water is of suitable microbial and chemical quality for all purposes, water restrictions during drought periods can affect farm operations.

One of the key effects of climate change is likely to be reduced availability of fresh water. While water can be recycled on-site, accumulation of salts and other impurities may limit the uses of recycled water. High salt content may limit use of bore water where this is available.

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De-salination of bore water or recycled water

New and increasingly affordable technologies are available to desalinate bore water or recycled water that contains high levels of dissolved minerals. Local desalination plants, powered by solar energy, can clean up bore water, making it suitable for irrigation of mushroom crops. There are two main types of solar desalination available:

- Reverse osmosis (RO) powered by photovoltaic cells (Solar PV)
- Thermal desalination systems using solar collectors

Reverse osmosis systems: Reverse osmosis (RO) desalinisation works by passing the water through a membrane which strips out the salts. The system produces a stream of clean, fresh water as well as one of more concentrated saline water.

Small desalination units producing up to 30 kL per day can be operated by solar photovoltaic panels. Larger plants producing 50 to 100 kL of water a day cost significantly more and require 3–phase power or stand-alone diesel generators.

A small to medium size mushroom farm (10 tonnes/week) would need about 15 – 43 kL water per day and a large farm (>50 tonnes/week) would need 75 – 215 kL water per day.

Farms would need access to a bore capable of yielding more than the daily water use by the farm, and have somewhere to send the saline wastewater, such as reject wells, evaporation basins, saline waterways and lakes.

Recycling and use of bore water can be limited by contamination with salts and organic material. Some water treatment may be required, and bore water with neutral acidity (pH), low silica and low iron require less treatment. Water chemistry will affect the efficiency of the RO membranes. Detailed water chemistry samples should be taken and analysed by an RO business. Specialist companies such as Suez supply high capacity treatment equipment for recirculating aquaculture systems which can remove dissolved salts, organic matter, bacteria and even viruses.

Figure 4. A small scale solar powered desalination unit.

Photo: Eng. P. Holi

Economic and reliability considerations are the main challenges to improving PV-powered RO desalination systems. However, the quickly dropping cost of PV panels is making solar-powered desalination ever more feasible. The cost of a solar RO desalination unit depends on the amount of water required and the quality of the input water, especially how much salt it contains. The capita cost of a small-scale desalination plant, producing 10 to 30kL of water a day is about $20,000 to $40,000 with a running cost of about 30 to 40 cents per kL. Town water in Sydney currently (2020) costs $2.11 per kL.

An example Australian provider of solar powered RO desalination system can be found at https://www.moerkwater.com.au/farming.

Thermal desalination: A good example of this technology is the Sundrop tomato farm, near Port Augusta in South Australia. The farm uses a concentrated solar power (CSP) tower plant to supply electricity, heat and desalinated seawater to grow tomatoes. The installation produces enough electricity and heat to run the 20ha glasshouse operation. It also produces 450 megalitres of freshwater by desalinating seawater each year. Visit the Sundrop farms website for more information https://www.sundropfarms.com/

FARM SIZE	PRODUCTION (TONNE PER WEEK)	SCALE OF DESAL SYSTEM REQUIRED	WATER NEEDS (KL/DAY)*	ANNUAL WATER COST ($)**
Small	< 10	Small	15 - 43	$11,500 - $33,000
Large	> 50	Large	75 - 215	$58,000 - $165,000

* Based on water consumption of 11-30 kL / tonne mushrooms.

** Based on Sydney water cost of $2.11/kL.

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Figure 3. Netafim "Mushroom Master" irrigation system

Drip irrigation

Mushrooms are usually irrigated using a sprinkler system. However, sprinklers cannot be used when mushrooms are emerging. Netafim has developed a drip irrigation system called Mushroom Master™. The drip system maintains uniform moisture levels through the compost and casing material, reducing the need for heavy watering between flushes. For more information visit: https://www.netafim.com/en/crop-knowledge/mushroom/.

It is claimed the system reduces total water use and energy costs by up to 20%, as well as reducing the thickness of the casing required by up to 30%. Moreover, as uniform moisture improves mushroom density, quality and storage life may be improved. The system is in use by at least three farms internationally.

Measurement and management of moisture levels in compost

The levels of moisture in mushroom compost and casing are high – in the range 49 – 69%. Moisture levels significantly affect yield and quality in mushroom production. The management of irrigation in mushroom production is largely manual. Irrigation is often based on operators' experience and judgement, with little reliance on technology to provide objective data on moisture levels in the media.

There are many moisture sensors used in crop production that may potentially have a role helping growers manage water. While these technologies are widely used in soils, they have not been widely tested in commercial mushroom production and in compost. Further research would be required to validate these tools for mushrooms. However, if proven effective they would facilitate better control of moisture levels in mushroom growing media. They would also work well with the drip irrigation system described above.

Two common examples of moisture sensing systems are:

- Time Domain Reflectometry (TDR) sensors
- Soil moisture capacitance sensors

Figure 5. Wildeye TDR soil moisture sensors and communications unit

Time Domain Reflectometry (TDR) sensors: These sensors measure volumetric moisture content. Moisture is measured by sending a high-speed electromagnetic pulse down a line of known length, and measuring its travel time and reflectance. TDR sensors are a well-established technology and widely used in agriculture to measure soil moisture. Recently, small portable systems have been developed that allow the data to be uploaded to a website, where it can be easily accessed by the grower. An example of a commercially available TDR system developed by Wildeye, with two sensor probes and a communications unit, is shown in Figure 4.

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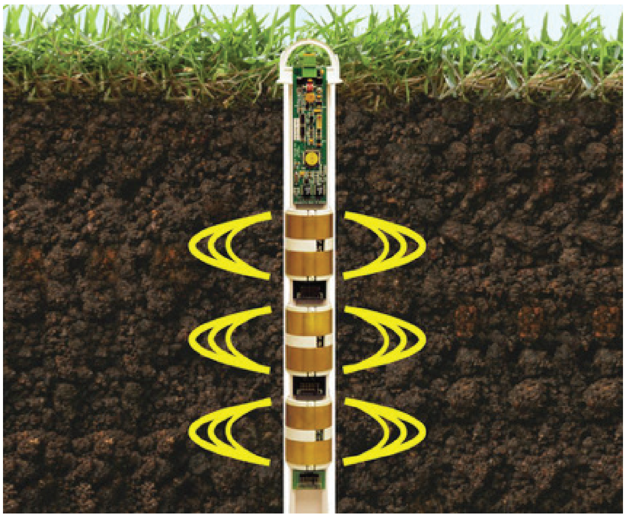

Figure 6. EnviroScan soil moisture sensors diagram showing field of measurement.

Figure 7. Standing wave sensor. Photo by ICT International

Soil moisture capacitance sensors: Capacitance sensors also measure volumetric moisture content, but by measuring the charge time for a capacitor with electrodes separated by the soil. Fast charge times indicate high moisture contents. There are many brands available commercially, with associated equipment for transmitting and storing data.

Standing wave sensors: These sensors use an oscillator to generate an electrical field along parallel needles. The signal produced by reflected signals indicates moisture content. They are less common than capacitance and TDR sensors, but are sold in Australia by ICT International.

	TDR	CAPACITANCE	STANDING WAVE
Accuracy	Excellent	Satisfactory	Good
Cost	High	Low	Moderate
Life expectancy	20 years	2 to 5 years	20 years
Needs calibration by soil type?	No	Yes	Yes
Affected by temperature?	No	Yes	No
Recommended for compost?	Yes	No	Yes

Table 1. Comparison of different types of soil moisture sensors

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