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AUSTRALIAN POTATO INDUSTRY EXTENSION PROJECT

TECHNICAL CONTENT

Dr Jenny Ekman
jenny.ekman@ahr.com.au

EDITOR

Paulette Baumgartl
paulette.baumgartl@ahr.com.au

PROJECT COORDINATOR

Peter O'Brien
peterob@potatolink.com.au

DESIGN

Jihee Park
hello@jiheeparkcreative.com

PUBLISHER

Applied Horticultural Research Pty Ltd
www.ahr.com.au

Cover: *David Pate, from Wester Meathie Farm Scotland, shows off his superb soil structure. See p10. Photo by J. Ekman*

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Correction notice

PotatoLink Issue 8

Minor changes have been made to the article *Seed potatoes: A special feature.*

Read correction notice here

http://bitly.ws/PQB3

MANAGING POTATO CYST NEMATODE (PCN)

Potato cyst nematodes (PCN) are undoubtedly one of the world's most significant potato pests. PCN have major impacts on production in many parts of Europe and are in plague populations in some parts of Africa. So far Australia has escaped major impacts from this pest. However, forewarned is most definitely forearmed. Dr Jenny Ekman reports.

Figure 1. Globodera rostochiensis cysts on potato roots. Image: K. Walker

Potatoes are directly impacted by two species of potato cyst nematodes (PCN); the golden (*Globodera rostochiensis*) and the pale (*Globodera pallida*). PCN are particularly hard to manage because of their rapid multiplication and persistence in the soil. Moreover, at less than a millimetre long, PCN are not easy to see in soil or on roots.

Despite potentially devastating consequences on yield, symptoms are frequently subtle; the crop can just look a bit sickly or fail to thrive. With no visible pest or disease, farmers may think there is a problem with the seed, the crop needs more fertiliser, or there is some other issue.

LIFECYCLE OF PCN

The problems start with juvenile nematodes. Juveniles not only suck nutrients, but also cause physical damage to potato plants. They bore through feeder roots, leaving a trail of open wounds and destroyed cells behind them. Such wounds provide easy entry points for bacterial and fungal diseases.

Once within the vascular system the young PCN induce formation of a syncytium. This enlarged feeding structure fuses together hundreds of cells. Protected by a thickened outer wall, this feeds the nematode until it matures.

Once close to maturity, female nematodes burst through the root surface, mate with males, and then die, their body forming a cyst on the plant root. These are about the size of a grain of sand, almost impossible to see with the naked eye on roots, let alone in soil.

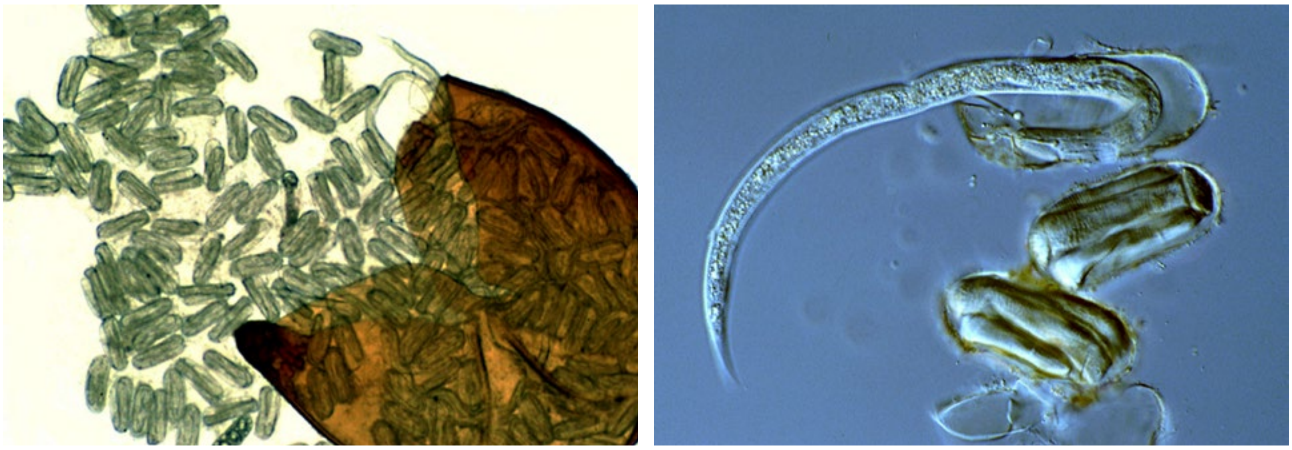


Figure 2. PCN eggs inside a cyst and juvenile PCN emerging from an egg. Images: U. Zunke, University of Hamburg, Bugwood.org

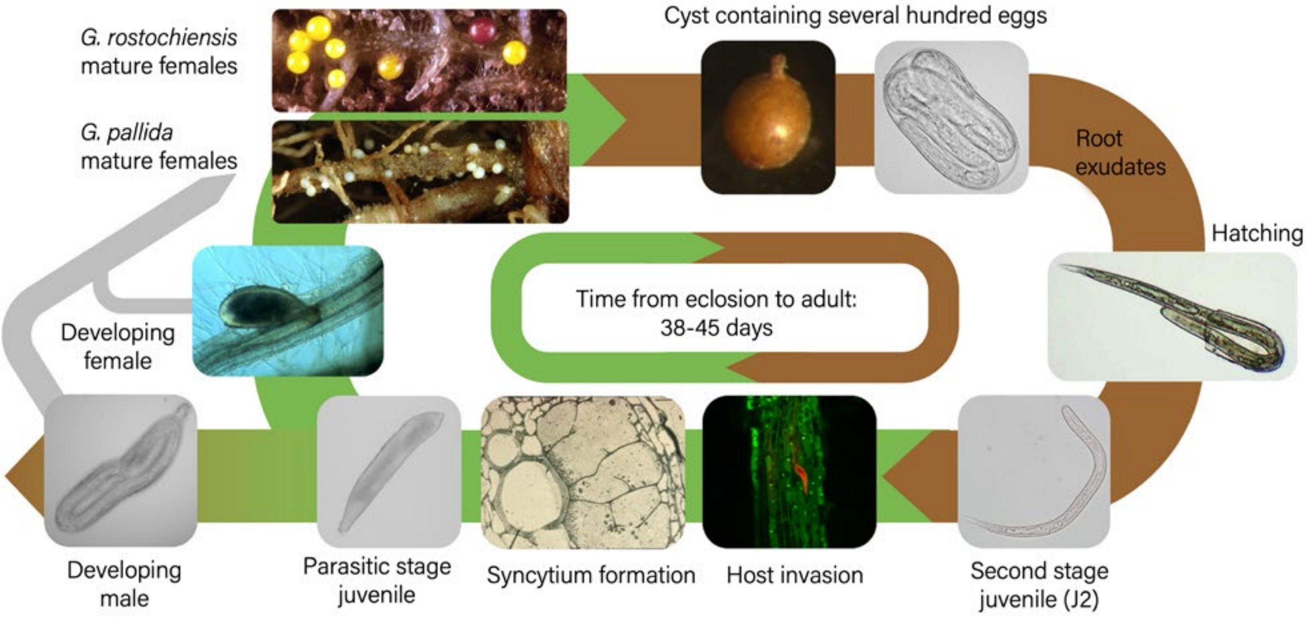


Figure 3. Life cycle of PCN. From Price et al., 2021[2].

The cyst contains up to 500 eggs. When the potatoes are harvested or the plant dies, the cysts are left in the soil. They can potentially remain dormant for at least 10 years and possibly longer, only developing in response to chemicals exuded from the roots of certain Solanaceous plants – including potatoes.

Exposure triggers a change in the outer layer of the cyst, allowing water to permeate and kickstarting metabolic activity. After using their stylet to escape the cyst, young nematodes swim through the soil along a gradient of root chemicals, finding and puncturing a suitable root and starting the cycle again.

IMPACTS OF PCN

Professor John Jones is now head of the Cell and Molecular Sciences Department at the James Hutton Institute in Dundee. However, his research passion is the genomics and host-parasite interactions of nematodes, particularly PCN. Much of his work has focussed on the factors that stimulate development of dormant cysts in the soil, as well as the proteins produced by PCN that suppress potato plant defence mechanisms.

Understanding these factors will help to develop strategies that control PCN under field conditions. "We have been working a lot in Africa, because they have terrible potato cyst nematode problems there. Kenya, Uganda, Rwanda, and likely other countries as well, have big problems," states Professor Jones.

Figure 4. Professor John Jones has spent more than 25 years researching plant parasitic nematodes, particularly PCN.

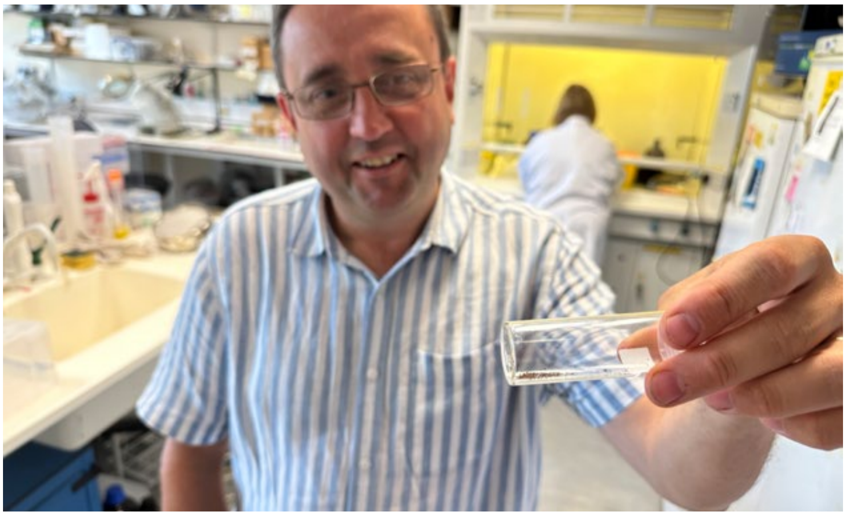


Figure 5. Although only the size of a pin head, exposure to potato root exudates can still trigger development and emergence of nematodes 10 years or more after the cysts were formed.

"Potatoes are really important in that part of the world because they are one of the few crops that smallholders grow both as food for themselves and for cash. Unfortunately, they grow multiple crops a year, with no real rotation and no winter break, so nematode populations can explode. In some cases, they may even abandon the land and clear more forest, which is clearly undesirable."

Both golden and pale PCN are found widely in Scotland, as well as parts of Europe. Golden PCN is thought to have been introduced to New York State on the muddy tyres of equipment returning after WW1, while pale PCN is present in part of Idaho as well as Newfoundland, Canada. In all these areas, spread has been contained through survey and certification requirements.

Similarly, Australia's strict quarantine regulations mean that we have prevented spread of this pest. The golden potato cyst nematode has been detected in a few, clearly defined regions of Victoria. These areas are subject to plant quarantine requirements, with permits required to move host materials. Golden PCN has previously been detected in Western Australia but now considered eradicated from that state. Pale PCN has never been detected in Australia and is more often a pest in cooler to temperate climates.

While Australian farmers appear to be managing the problem well, Professor Jones argues that there is no room for complacency. "The time to hit nematodes is when populations are low. If you have a small population but grow a susceptible potato variety you will very soon have an extremely high population. Moreover, while we can control golden PCN well with the H1 ('Hero') gene – which is present in resistant varieties – the problem is that these varieties aren't necessarily the ones consumers want."

MANAGING PCN IN SCOTLAND

One of the key control measures to managing PCN is preventing spread in the first place. This means ensuring that seed potatoes are PCN free. Any detection of PCN not only renders the seed crop unsaleable but takes land out of seed production for many years.

Detections of golden and pale PCN are therefore a major challenge for Scottish seed producers. The pest is projected to cost the local potato industry £125 million by 2024. With virgin land running out, PCN could potentially end the Scottish seed industry within the next 25 years unless new mitigation strategies are found[1].

Recognising the urgency of this issue, the Scottish Government is now funding a major project examining ways to manage PCN. The project aims to improve understanding of how some varieties tolerate PCN, as well as identifying critical genes associated with resistance. Outcomes will include IPM tools for growers, accelerated

1. Toth I. et al. 2022. Year one project report. Delivering a sustainable potato industry for Scotland through management of potato cyst nematode (PCN). http://pcnhub.ac.uk/publications

2. Price JA, Coyne D, Blok VC, Jones JT. 2021. Potato cyst nematodes *Globodera rostochiensis* and *G. pallida*. Molecular Plant Pathology 22:495-507

breeding programmes and better understanding of the costs and benefits of different approaches.

One of the keys is further developing PCN resistance and/or tolerance. While these may appear the same, tolerance and resistance are quite different things.

Dr Phil Burgess, together with field officer Kerry Leslie, is running field trials developing management strategies for PCN. He explains: "Resistant varieties can still be quite badly affected by PCN. However, the juvenile nematodes can't form feeding sites (syncytia) in the roots, preventing them reaching the adult stage. As a result, the population could be reduced from, say, 30-50 eggs/g soil to less than 2 eggs/g soil following a crop of potatoes."

"In contrast, a tolerant variety can still grow and yield well in the presence of low levels of PCN. This may seem a good strategy in the short term, but populations will inevitably increase unless the tolerance is combined with resistance. You could easily end up with 500 eggs/g soil or more the next year. Eventually, even the most tolerant variety will be unable to grow under this pest pressure."

The field trials are being run at Barnyards Farm near Forfar, the property of third-generation potato grower Neill Smith. Neill first realised he might have a PCN problem when yields started to decline despite good growing conditions. He suspects that populations had been building up over time, especially when short 4-year rotations were used in the 1970's.

Both golden and pale PCN are found on the 400 acres (~162ha) Neill uses to grow potatoes, with pale PCN the most common. While there are some varieties (Amanda and Elland) that are highly resistant to pale PCN, they are not well accepted by the market. As a result, he also grows non-resistant varieties in fields with undetectable or low nematode populations.

He also uses the granular nematicide fosthiazate (Nemathorin®) to control

Figure 6. Dr Phil Burgess (left) and grower Neill Smith inspecting a range of PCN resistant varieties at the field trial site

PCN. However, the future of this chemical is uncertain. Another nematicide (Vydate®) has already been withdrawn. In Australia there are no nematicides registered for control of *G. rostochiensis*.

What remains is an IPM approach using a range of control strategies. These include:

- Growing resistant varieties, noting that most varieties are resistant to either golden or pale PCN, with few resistant to both.
- Cover crops, particularly oil seed radish (*Raphanus sativus*). This is sown in spring, topped in early summer, then sprayed off and incorporated before preparation of the ground for potatoes.
- Application of maleic hydrazide to the growing crop. This reduces sprouting, limiting growth of potatoes left in the soil after harvest.
- Planting winter wheat (instead of spring barley) as a rotation, allowing effective control of volunteer potatoes.
- Minimum six year rotations between potato crops.

Even though a cover crop costs him a year of spring barley, Neill is convinced this is worthwhile. "The system gives me good control of free-living nematodes, as well as reducing PCN," comments Neill.

"It's an investment in the future of the farm, as nematodes are a bigger worry than the short-term cost of missing a year's cropping."

Dr Burgess, with project partners, Scottish Agronomy, is trying some other, novel approaches as well. One is the application of chitinous soil amendments. These are made from crustacean shells combined with woodchips. "Our hypothesis is that these will shift the microbial balance in the soil towards organisms that feed on chitin. PCN cysts are chitinous, so this should reduce persistence of eggs in the soil," he explained.

"We are also growing tomatoes, which may seem a surprising choice for Scotland! However, we are not growing them for fruit, but rather for their root exudates, which should trigger emergence of PCN in the soil. PCN can't reproduce on this particular variety of tomatoes, so this should crash the population."

PCN isn't currently a major problem in Australia. However, it just takes one tourist's muddy boots to introduce this significant pest to new areas, or to bring *G. pallida* into the country. Understanding the different varieties, growing techniques and other control strategies means that our industry will be prepared if and when any such incursion occurs.

SOIL PHYSICS 101

Soil health, defined as the sustainable capacity of soil to support vital living systems, often focusses on soil biology. While the role of microbes, critters and organic matter is well-documented and indisputable, we cannot only focus on the inhabitants and ignore the house. Soil structure (the house) is also critical for soil health. By Paulette Baumgartl

KEY POINTS

- Taking care of the physical properties of soil is crucial for sustainable and profitable potato farming.
- Soil physics examines the abiotic characteristics of soil and how solid, liquid, and gas components interact.
- Soil composition is key - the proportion of fine particles determines how the soil behaves.
- The composition and characteristics of soil aggregates significantly influence interactions among soil, water, and gases.
- Soil texture and structure determine the water-holding capacity and infiltration rate of the soil, impacting its ability to provide water to plants.
- **Field capacity** is the maximum amount of water that a soil can hold
- **Permanent wilting point** indicates the lower limit where water becomes unavailable to plants.
- The range between field capacity and the refill point is known as the **readily available water (RAW)** zone, which is essential for optimal plant growth.
- Infiltration, runoff, and erosion are influenced by various forces such as gravity, adhesion, cohesion, and capillary rise.
  - **Adhesion** and **cohesion** allow soil to retain water within its pores
  - **Capillary rise** enables water movement upwards in narrow spaces, particularly in clay soils.
  - Monitoring **infiltration rates** provides valuable information about soil structure and the impact of soil management practices on water movement into the soil.
- **Compaction** occurs when external forces press soil particles together, reducing pore space and increasing soil density.
  - Factors like clay content and moisture level influence the ease of compaction.
  - Compaction limits root penetration, reduces water-use efficiency, reduces nutrient retention and availability, increases fuel consumption and decreases machinery effectiveness.
  - Compacted areas can be restored through mechanical and biological approaches.

Coyne et al. (2022) compared a soil ecosystem to a neighbourhood; soil physics concerns itself with the infrastructure (aggregation) and services (aeration, hydration), while soil chemistry focusses on the catering. Microbial residents interact with, and shape, both the physical and chemical properties of the soil they inhabit.

Understanding and managing the interacting components of soil health - physical, biological and chemical factors - is essential to create robust and productive soils that are able to sustain commercial potato production.

The following article examines some aspects of soil physical properties and how they impact agricultural practice (and how agricultural practices impact soil physical properties).

SOME BASIC THEORY FOR A COMPLEX TOPIC

Soil physics studies the abiotic characteristics of a soil ecosystem and how they interact. These include the solid, liquid and gas components of the soil, referred to in science as soil phases. The interaction among these phases determines the behaviour and functionality of soil, and therefore the soil's ability to support life.

A well-structured soil under a cover crop at Mulgowie Farm in Queensland's Lockyer Valley

Soil solids include mineral and organic particles. Typically, soil solids occupy 50% of the soil volume, however solids can range from 40 to 70%.

Mineral particles are grouped into fine (sand, silt and clay, less than 2mm) and coarse (gravel, stones etc and greater than 2mm) fractions. The proportion of fine solids determines soil texture and, ultimately, the way the soil behaves.

Organic materials, including living fungi and plant residues, together with ions such as calcium, glue and bind mineral particles together to form aggregates. The composition and characteristics of these aggregates has a large impact on soil, water and gas interactions.

Soil aggregation and structure

Soils can be grouped broadly into structureless and aggregated.

Structureless soils lack visible aggregates. They are dominated by sand or clay, limiting bonding and/or resulting in poor water infiltration.

Structured soils consist of distinct aggregates that can be characterised by their shape and size.

A well-structured soil has sufficient pores (good pore volume) of differing sizes (good pore size distribution) between and within aggregates. This allows water and air to enter easily. Structured soils drain easily, while still holding enough moisture to maintain plant growth.

Poorly structured soil lacks aggregates and has few pores between soil particles.

Aggregation begins when tiny, highly reactive clay particles interact with organic residues. These bind larger sand and silt particles together to form microaggregates. Fungal hyphae and fine plant roots then bind soil micro-aggregates together into the macro-aggregates visible to the naked eye (Figure 1).

The remaining 50% of soil is pores, which are filled with water or gas. While the amount of liquid in soil can vary between <1% (completely dry) to approximately 50% (saturated, with all pores filled with liquid), in ideal conditions liquids occupy 25% of the total volume of soil, with the remaining 25% of pores filled with air.

Soil chemistry and soil structure

Just as soil biology will impact the physical structure of a soil, so too can soil chemical properties, particularly sodicity and salinity.

As the name suggests, sodicity is the presence of a high proportion of sodium relative to other cations. As sodium salts are leached through the soil, a high proportion of sodium (Na) ions (relative to other cations) remain. Some soil tests show and compare the CEC with sodium (Na^+) levels to determine whether soils are sodic.

Excess sodium weakens the bonds between soil aggregates, leading to dense, cloddy and structureless soils. Sodicity can lead to dispersion at the soil surface, causing crusting and sealing. This then impedes water infiltration and accelerates erosion.

Salinity, measured by electrical conductivity (EC) levels for salts (sodium chloride, calcium and magnesium bicarbonates) can have similar effects on soil as sodicity. High salinity disrupts the soil's osmotic potential, inhibiting the plant's ability to uptake water and nutrients.

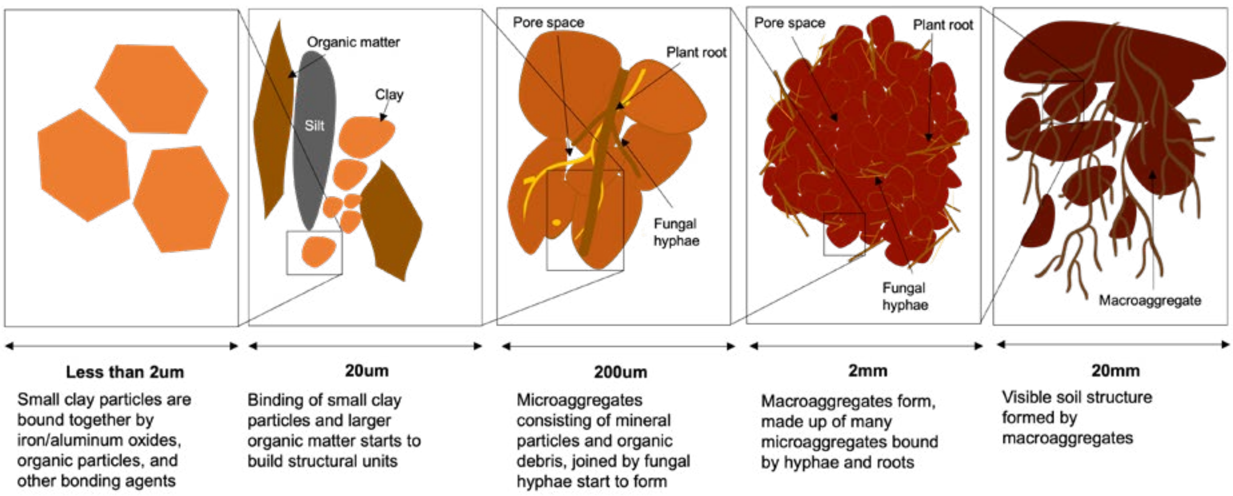


Figure 1. Aggregate formation across different scales. (Adapted from Brown et al (2021) under a creative common licence)

SOIL PHYSICS AND WATER MANAGEMENT

With their relatively shallow root zone, potatoes are very sensitive to water stress. Too much water increases disease and reduces quality, while too little water reduces productivity, yield and nutrient uptake.

The relationship between water and soil structure determines how much water is available to the plants it supports.

Like sponges, soils can only hold a certain amount of water, and absorb water at a certain rate, depending on their texture and structure.

Measuring soil water is a useful tool to understand the condition of the soil at each stage of irrigation and crop use: from **saturation point** (when all pores are filled with water, leading to anaerobic conditions, run-off and ponding), to **field capacity**, **refill point**, and finally **permanent wilting point** (Figure 2).

The maximum volume of water that a soil can hold is called field capacity, while the lower limit is the permanent wilting point, whereby the only water remaining in the soil is unavailable to plants (also known as hygroscopic water).

After saturating rain or irrigation, there is a continuous rapid downward movement of water due to gravitational force. The rate at which the water moves through the soil is related to the soil structure and texture (i.e., drainage is faster for sandy soils compared to clay soils).

After some time drainage becomes negligible. This is when the soil has reached **field capacity**. Over-irrigation that exceeds field capacity will result in drainage and/or deep percolation, wasting water.

As a plant cannot use all of the water held in the soil, irrigators must calculate the water that can be readily removed from the soil by the plant. This is called **readily available water (RAW)** and is the zone for best plant growth between **field capacity** and the **refill point**.

RAW, (measured in millimetres per metre (mm/m)) indicates the depth of water (mm) held in every metre (m) of soil depth that can be taken up by plants. RAW varies with soil type, crop, rooting depth and irrigation system and can be calculated for the total profile depth, or just the depth of the plant's effective rootzone.

Information on how to determine RAW can be found here http://bitly.ws/KZy7

The **refill point** occurs when plants have removed all RAW. The refill point is when used water needs to be replaced.

Soil moisture probes can help determine water-holding capacity and the point at which the soil profile should be refilled.

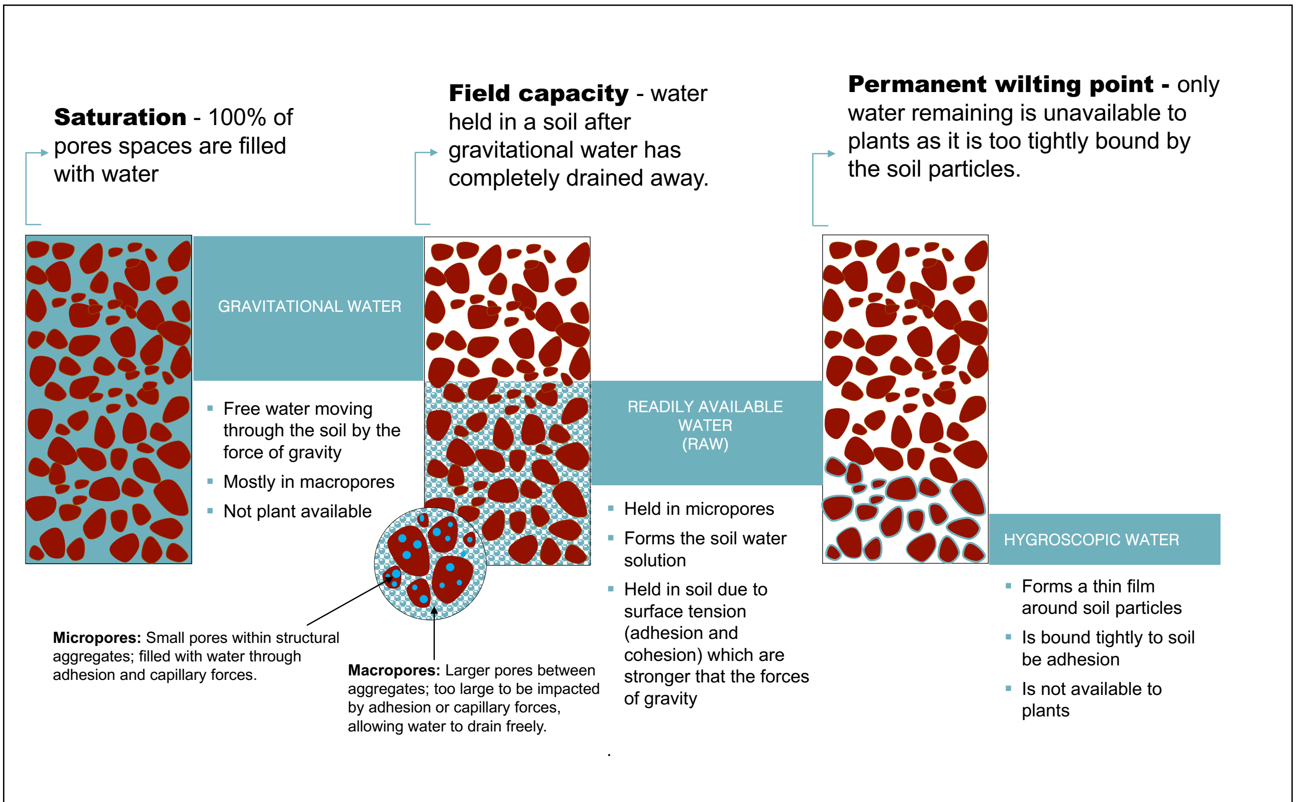


Figure 2. The different forces at play moving and holding water through the soil.

Infiltration, run off and erosion.

Gravity is not the only force at play as water travels through a soil matrix.

Adhesion, cohesion and capillary rise also play a role, impacting infiltration and how much water is available to plants.

Adhesion, the stronger of the two forces, describes the attraction between water and solid particles. Cohesion is the attraction between like materials, in this case water to water.

These forces make it possible for soil to hold on to water. Without adhesion and cohesion, water would simply drain out of the soil pores.

Capillary rise - the upward movement of a liquid through a narrow space - is another important physical phenomenon at play in the soil. As clays have smaller pores, capillary rise is higher, which is why a clay soil can also hold onto more water.

The infiltration rate is the rate at which water enters the soil and is measured by the depth (in mm) of the water layer that can enter the soil in one hour; it will vary with soil texture and structure. It is usually measured by a field test using a cylinder or ring infiltrometer.

In dry soil, water infiltrates rapidly. This is called the initial infiltration rate. As water fills the pores, infiltration slows, reaching a steady rate or basic infiltration rate.

If the amount of water entering the soil is more than what it can absorb at the time, the excess water will run off the surface. This **runoff** causes water erosion by carrying and redistributing soil particles down the slope and creating rills or gullies.

Soil management practices that degrade soil structure can adversely affect infiltration capacity, making monitoring of infiltration rates a good indicator of their impact on water movement into the soil.

Figure 2 illustrates the main forces acting on the different 'types' of water in soil as it moves through the soil profile. Figure 3 illustrates the movement of water in the soil profile.

Waterlogging

With a relatively shallow root system, potatoes have a low tolerance to waterlogging and anaerobic conditions.

While waterlogging cannot always be prevented, improving drainage of water away from the crop and improving the soil's physical structure can help the soil 'protect' itself against excessive water.

The best way to identify waterlogged areas is a visual assessment. If the surface is wet the soil is likely to be waterlogged.

However, sometimes the surface may appear dry but be waterlogged underneath. It is worthwhile to dig and examine what is happening beneath the surface. Dig a couple of holes to about 30cm - if water flows into them the soil is waterlogged.

For more information on managing waterlogging, read more in PotatoLink Issue 8 (http://bitly.ws/RujS)

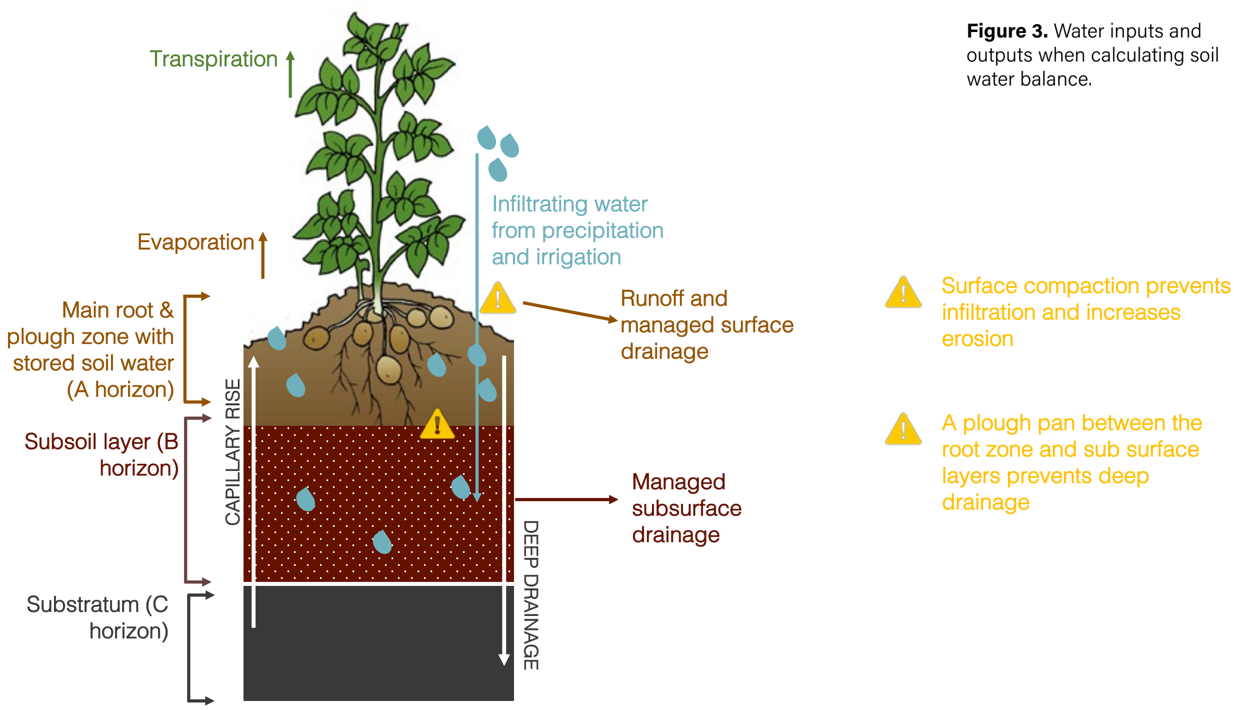


Figure 3. Water inputs and outputs when calculating soil water balance.

MAINTAINING GOOD VENTILATION

Soil holds a mixture of air and other gasses in the macropores. These should comprise the remaining 25% of the total soil volume. The composition and movement of gasses in soil are dynamic.

Pores provide a pathway for gasses to move through the soil. In the root zone good aeration is required to allow plant roots to respire, taking in oxygen and releasing carbon dioxide.

Anaerobic conditions, often a result of waterlogging, have many consequences:

- Reduces the ability of plants to take up nutrients.
- Limits the soil's biodiversity, as microbes need good aeration to efficiently cycle organic matter and nutrients.
- Lenticels on tubers become puffy and swollen as the tubers struggle to get enough oxygen.
- Plants are more susceptible to infection from a range of fungal and bacterial pathogens.
- Results in a build-up of carbon dioxide and ethylene, impacting growth.
- Leads to nitrogen loss through de-nitrification.

Not only are air and water dynamic parts of soil, but both are often inversely related. Maintaining the balance between aeration and soil water availability is a critical aspect of soil management.

SOIL COMPACTION

Compaction is caused by applying stress, for example from heavy machinery traffic, to a soil with a moisture content wetter than its plastic limit (see break out box). When soil particles are pressed together by external forces, bulk density increases and soil porosity decreases. The result is an increase in mechanical resistance or strength of the soil.

Many soil properties affect how easily the soil compacts. These include clay content, due to its ability to hold water.

Compaction has many adverse impacts on potatoes including:

- Plant roots are unable to penetrate compacted layers to access water.
- Water-use efficiency is greatly reduced; rain or irrigation water is unable to penetrate the compacted layers to re-fill the subsoil, increasing run-off and evaporation.
- Compacted soil requires more fuel to cultivate.
- Machinery can become blunt and less effective.
- Fertiliser efficiency is reduced as compacted soils provide few surfaces to retain and release nutrients for crop growth.

While most compaction occurs in the top 20–30cm of the soil, repeated tillage at the same depth can form a hardpan—a dense, impenetrable layer beneath the tilled soil.

Symptoms of surface compaction include:

- Surface clods that are hard to break apart.
- Water ponding in tracks and headlands
- Wheel tracks with a smeared appearance
- Soils that appears to have no structure.

RESTORING COMPACTED AREAS

Avoiding compaction by reduced tillage, controlled traffic, and avoiding, as much as possible, tillage when the soil is wet, is obviously preferable,

Top: compacted soils. Bottom: soil from under cover crops (left) versus intense cultivation (right) however it is not always practically possible.

Compacted areas can be restored or managed with both mechanical and biological approaches.

Biological management takes time, using cover crops with different rooting patterns that can break through the soil.

Cultivation when the soil is dry will also hasten the natural breakdown of clods. However tillage needs to be shallow to avoid compaction of deeper (and usually wetter) soil.

It is therefore important to check the soil moisture profile in relation to cultivation depth. Only cultivating dry soil ensures that it will fracture rather than smear.

Deep ripping breaks up compacted soil layers mechanically using strong tines working down to 35-50cm depth. These loosen hard layers of soil.

Before deep ripping, it is important to consider tine spacing, working depth, use of shallow leading tines or discs, soil moisture content, timing and soil type.

More information about the science of deep ripping is available here (http://bitly.ws/KZyk).

CONCLUSION

Potato cultivation, by necessity, is a constant cycle of building up a soil structure then smashing it down, undoing years of good, regenerative work.

Moreover, rarely will soil have exactly the same structure and other properties across all paddocks, complicating management further.

Being aware of the physical properties of soil in each paddock can help avoid destructive practices. It can also help identify and implement regenerative soil management strategies, keeping the potato farming enterprise sustainable and profitable.

PLASTICITY

The plasticity of a soil is its ability to deform without cracking and it is an important characteristic of fine-grained soil, especially clay soils.

At the lower plasticity limit, the soil will crumble when rolled into threads of 3.2mm in diameter.

To assess if your soil is suitable for vehicle traffic or cultivation, perform the following test:

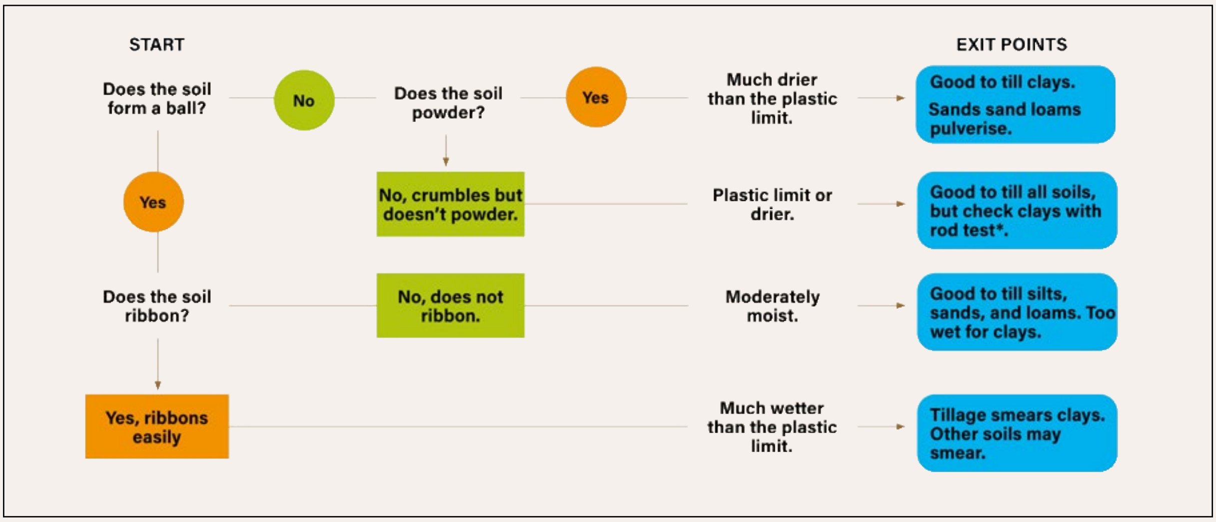
1. Rapidly squeeze a small lump of soil into a ball.
2. Attempt to roll the soil ball into a 3mm diameter rod.
3. If you can easily make a cohesive rod, the soil is too wet and should not be worked with machinery.
4. If you cannot make a rod at all, the soil is only suitable for cultivation if it is clay. If it is loam, this indicates that the soil is too dry to cultivate.

5. If you can make a crumbly rod, the water content should be suitable for cultivating all soil types.

Soil moisture test for tillage. Source: https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0020/127280/Cultivation-and-soil-structure.pdf

The ribbon test is used to estimate soil texture and the amount of clay in a soil. NSW DPI have a useful step by step guide here https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/164615/determining_soil_texture_using_-ribboning_technique.pdf

*Rod test described in the five point step.



CLAY AND ORGANIC CARBON

Keeping carbon stable in the soil is important to improve soil health. The ability of the soil to do this depends on its physical, chemical, and biological properties. Clay minerals, which are the most reactive particles in soil, play a big role in storing organic carbon (OC).

Clay soils are good at protecting OC from microbial breakdown. The clay particles and aggregates physically protect the organic matter. The organic materials can stick to clay surfaces, get covered by clay particles, or get buried in small pore spaces of clays. This makes it hard for microorganisms to break them down.

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REDUCED TILLAGE IN POTATOES

By Stephanie Tabone, Ryan Hall

KEY POINTS

- Reduced tillage can involve reducing:
    - Tillage intensity
    - Number of passes
    - Depth of tillage
    - Area disturbed, *or*
    - Complete removal of tillage from a system
- Reduced tillage is often paired with other regenerative agriculture practices such as
    - Cover cropping and pasture rotations
    - Use of compost and biofertilisers
    - Inclusion of livestock in the rotation
    - Controlled traffic
    - Promoting biodiversity
- Most of the case studies outlined in this article have focussed on reducing the number of passes prior to potatoes, combined with other regenerative practices
- Consider your unique farming system when trying reduced tillage, including rotations, crop residue management, soil type and climatic conditions
- Try reduced tillage on a small area to compare it with your conventional practices.

Reduced tillage agriculture has emerged as a sustainable and innovative approach to farming, offering numerous benefits to both farmers and the environment.

By minimising soil disturbance, reduced tillage practices promote soil health and conservation, leading to improved water infiltration, increased organic matter content, and enhanced nutrient retention. This approach also reduces soil erosion, conserves valuable topsoil, prevents nutrient runoff, and improves water use efficiency. These benefits can lead to improvements in yield, quality, and margins for growers over time.

However, for potato growers there are some challenges. Weed control can become more difficult without regular soil disturbance. Disease and pest management can also be impacted, as crop residues are not buried, potentially increasing disease carryover and pest survival.

Despite these challenges, some potato growers around the world are turning to reduced tillage, usually in combination with other regenerative practices, to improve and /or maintain soil health.

WHAT IS REDUCED TILLAGE EXACTLY?

Reduced tillage can be a reduction in intensity of tillage, the number of passes, tillage depth, area disturbed or the complete removal of tillage in a system. While reduced tillage has long been embraced in grain cropping systems, the uptake among potato growers has been slower as production systems often involve significant tillage to prepare the soil for planting.

Tillage serves multiple purposes including weed management, loosening the soil for planting and harvesting, and making nutrients more available. While tillage can appear to be a prerequisite for growing a good potato crop, there is a rising number of producers who are deviating away from conventional tillage.

CASE STUDIES AND RESEARCH

There are many challenges in adapting reduced tillage to potatoes, however an increased awareness of the importance of soil health and soil conservation worldwide has emphasised the need to consider more environmentally sensitive approaches. Over the past decade a number of studies have examined the impact of reduced tillage on yield and disease pressure, as well as soil quality parameters.

This article shares some examples of growers who have incorporated reduced tillage into their farm practice and research seeking to quantify outcomes when tillage practices are altered.

AUSTRALIA

Garry Kadwell (*Delicious* Magazine Producer of the Year, 2020) grows potatoes near Crookwell in NSW on his family farm *Fairhalt*. After taking over the family property and transitioning to potato production, Kadwell noticed that his soil biology was gradually degrading.

Of the nearly 300ha farm, 32% is set aside for conservation. The remaining hectares produce seed stock potatoes, gourmet potatoes, fat lamb production, and occasionally lucerne/silage fodder production.

Kadwell applies a minimum 5-year cycle management regime to each parcel of land on the property. Potatoes are not planted more often than one year out of every five, with the other four years involving crop rotations of lucerne and pasture grasses.

The changes

With a family history of conservation on the property, Garry was open to practice change to improve the soil health, incorporating the following changes to his farming system:

- An increase in the length of rotations
- The introduction of pastures into rotations, including legumes
- Consistent application of compost
- Rotational grazing of fat lambs to maintain ground cover
- The transition to a one-pass system to reduce tillage

The results

There has been a significant increase in tonnage/ha of potatoes since 2010. Yield has risen by a remarkable 20%, at the same time as maintaining high levels of soil carbon.

While this is the result of applying a number of regenerative farming practices, reduced tillage is a key part of this system. Fairhalt provides an Australian example where reduced tillage equals better potato production.

Soils for Life have conducted a comprehensive economic and ecological assessment, which is publicly available (https://soilsforlife.org.au/garry-kadwell-fairhalt/).

Mallee Sands of Southern Australia

Studies by the CSIRO have shown that use of minimum tillage in South Australia's Mallee region not only reduces erosion risk but supports improved soil nutrition through improving soil carbon and beneficial soil microorganisms.

A significant volume of Australian potatoes are grown in the mallee region on light sandy soils typically low in clay.

The area's Mediterranean climate, including winter rainfall and strong prevailing winds, combined with the sandy soils creates a significant erosion risk. Airborne soil and sand can cause cause abrasion damage to growing potato crops, increasing disease risk. Erosion can also

CSIRO has shown that minimising tillage of the light, sandy soils of South Australia's mallee region can reduce erosion

sometimes expose shallow potatoes, resulting in greening and postharvest grading waste.

Limiting tillage can reduce erosion risk, protecting both current and future crops.

Fairhalt Farm, showing one of the functioning wetlands that filter water runoff from the property.

NETHERLANDS

Grower Jeroen Klompe, a leading innovative regenerative farmer from the Netherlands, grows potatoes and a range of other horticultural and grain crops south of Rotterdam in the Netherlands.

Klompe grows 12 different potato varieties across 85ha (of 368ha property) for baking, baby, fresh retail, and food service markets. The diverse rotation also includes red onions, shallots, green protein crops such as kidney beans, brown beans and soya, and combinable crops including winter and spring wheat, buckwheat, oats, oilseed rape and flax, plus grass for seed.

His property hosts the Klompe Farm trials, showcasing a wide range of experimental regenerative practices, including biofertilisers, compost tea, lane cropping, biodiversity margins and strips, no till and more. Working with universities and researchers, the trials generate data on the effects of regenerative practices. These results are complemented by the farms own records – recording the adaptation of farming practices, yields, the effects of the weather on the different plots and so on.

The changes

To avoid planting into compacted soil, Klompe adopted a 3.08m working width controlled-traffic farming system: crops are never sown where machinery has trafficked.
Preparation for potato crops starts straight after the previous wheat crop. The straw is chopped and mulched and organic fertiliser – either compost or solid manure – applied.

If any remedial work is required for the soil, such as drainage maintenance, it is carried out at this point, while the ground is dry.

A cover crop is direct drilled and grown over winter. The species for the cover crop are chosen with a specific purpose in mind. This could mean planting a biofumigant for disease management, or a legume for increased soil nitrogen.

Jeroen Klompe planting into a mulched cover crop and ridging

When mature, the cover crop is mulched and cut. The potato crop is then planted directly into the cover crop residue using a one-pass system. A rotator is used to mix the cover crops and the upper surface of the soil. After the potato seed tuber is planted, the ridges are made in a single action.

Micronutrients are applied as necessary following plant sap analysis. The aim is provide the correct nutrition for crop growth and quality, but also to reduce the use of blight fungicides.

Current reductions in blight fungicide are primarily driven by decision-support systems based on moisture sensors within the crop, weather forecasting and blight detection. However copper, zinc and calcium can all play a role in improving blight resistance.

The results

Klompe has made many observations while slowly increasing the area of reduced till from about 5ha five years ago to almost half of his potato production area today.

One of the key benefits has come from combining reduced till with cover cropping. Higher organic matter has increased infiltration rates and soil water holding capacity.

Reducing the amount of irrigation applied is another way to reduce risk from blight.

Klompe hopes that the use of biofertilisers will promote growth of beneficial fungi and bacteria on the upper parts of the plant. These could potentially compete with *Phytophthora*, also reducing blight risk.

One negative is increased populations of slugs and wireworms. While damage is minor, up to 2% of the potato crop has been impacted. Klompe's agronomist advises that a balance with natural predators will keep the pest problem under control once the system adjusts, . Patience is key!

Klompe says: "In the system we are using, it's not one thing – it's the combination of lots of small things that makes the change extremely strong."

He adds that the ultimate goal is to grow the same yield but using fewer inputs.

"But we are learning that sometimes it is better to accept a slightly lower yield with a higher margin, than a higher yield and a lower margin."

To read more https://www.soilheroesfoundation.com

Wageningen University has been studying reduced tillage for many years. In 2021, the university hosted an open day outlining some of the impacts of reduced tillage on potatoes.

They noted that transitioning to reduced tillage involves some significant changes to farm operations. These include changes to crop rotation as well as management of cover crops to reduce residues as the soil adjusts.

The study

Two studies conducted by Dimitrios Drakopoulos and team at Wageningen University focused on organic potato production. The research explored the impacts of different tillage systems and fertilisation regimes on soil health and potato production (Drakopoulos et al. 2016, Drakopoulos et al. 2018).

Specifically, they assessed the impacts of a rotary hoe to 10 cm (reduced tillage - RT), compared to a rotary hoe to 10 cm followed by a mouldboard plough to 30cm (standard tillage - ST) at various weeks after planting (WAP).

Some results

- The use of RT resulted in higher soil bulk density during the first seven WAP compared to ST, while both tillage systems had similar values at the end of the growing season (13 WAP).
- Over time, soil bulk density values diminished for RT, while increasing for ST.
- The type of fertiliser had no effect on soil bulk density.
- Use of RT improved some soil quality parameters, such as earthworm activity (2–3 times higher with use of RT compared with ST at 4, 8, and 13 WAP).
- Use of RT negatively affected other parameters, with increased soil bulk density proving detrimental in terms of tuber bulking and final yield (Drakopoulos et al. 2016).
- However, over time negative effects on yield may diminish. Soil structure under RT improves due to increased depth and frequency of pores. These are created by the activity of soil biota, such as earthworms, insects and other soilborne organisms.
- As shown in the figure below, concentrations of soil mineral N (NO^{-3} and NH^{+4}) showed similar decline patterns for both tillage systems during the potato growth period (Figure 1).
- However, soil mineral N values in the top part of the rootzone (0-15cm) were significantly higher in the RT system, especially at 4 and 8 WAP
- In contrast, the bulk of soil N was in the mid to lower parts of the root zone (15–30cm) for ST.
- The study demonstrated that soil structure, drainage and soil biology all benefited from reduced tillage.
- While yield was slightly reduced, the researchers suggest yields will return to previous levels once the system adjusts.

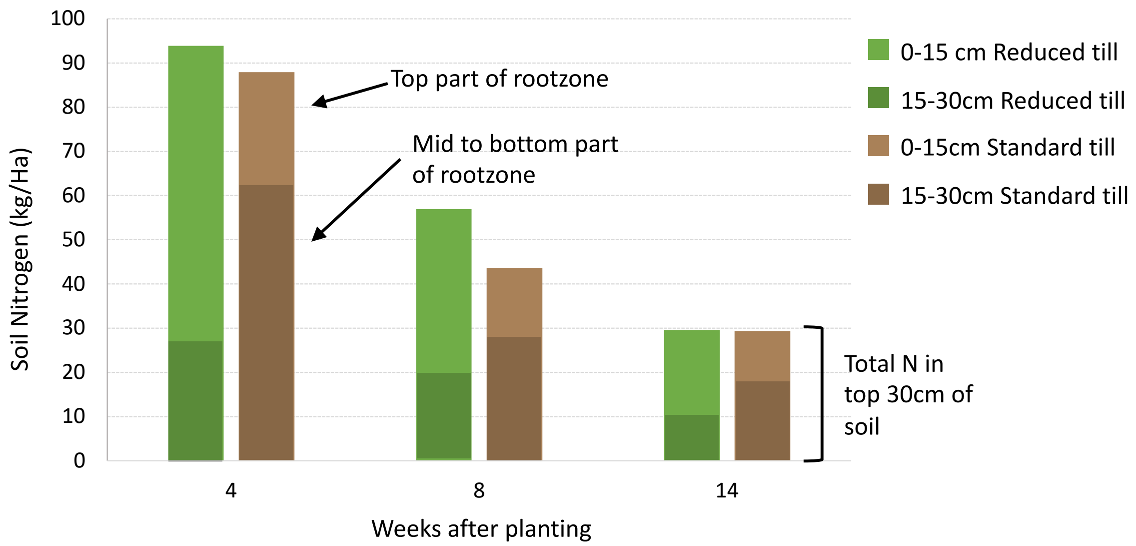


Figure 1. Influence of tillage practice (reduced tillage; standard tillage) on soil Nitrogen held in the top 30cm of soil, split into top (0-15cm) and mid (15-30cm) parts of the rootzone. Data recorded 4, 8 and 14 weeks after planting.

UNITED STATES OF AMERICA

A joint research project by the United States Department of Agriculture and Oregon State University trialled a reduced tillage system in a three-year rotation of sweet corn/ sweet corn/ potatoes. The objective was to develop a reduced tillage system for potatoes using existing field equipment with minor modifications.

The study

The reduced tillage system reduced the total number of passes from nine down to six and soil disturbance operations from seven to four. This retained crop residues as well as requiring less passes with machinery. This translated into savings in time, labour, fuel, and capital (Table 1).

Most of the soil disturbance in the reduced tillage system was caused by the bed splitter, planter, and harvester.

Table 1. Timing of field operations and equipment used in the 2003-2004 tillage trials at Paterson, WA/ Trials conducted in a three-year rotation (sweet corn/ sweet corn/ potato).

OPERATION	CONVENTIONAL TILLAGE	REDUCED TILLAGE
Residue management	Flail chop corn residues	Flail chop corn residues
Pre-planter fertilisation	Valmar™ spreader	Valmar™ spreader
Primary tillage	**2 passes** JD8760™ &13′ Sunflower™ chisel-chopper-packer	**None**
Mark-out	13-shank bed splitter	13-shank bed splitter
Plant	6 row Harriston™ pick planter	6 row Harriston™ pick planter
Drag-off	6 row rodweeder	**None**
Dammer Dike	Dammer diker	Dammer diker
Harvest	3 row potato harvester	3 row potato harvester
Total Passes	9	6

The results

- Compaction was noted as a short-term negative in the reduced tillage system, with an increase in bulk density from 1.2 g/cm^3 to 1.5 g/cm^3. However, over time the bulk density reduced.
- Yields from the conventional and reduced tillage systems were not statistically different, with conventional tillage yields higher than reduced in some years and reduced tillage higher than conventional in others.
- The main benefit noted by the researchers in the reduced tillage system was the reduction in erosion due to residue retention. Damage caused by blowing sand in the conventionally tilled plots was mostly absent in the reduced tilled plots.

For more information:

Extended report 2005
http://bitly.ws/PQ9M

Summary 2013
http://bitly.ws/PQ9S

Potato emergence from conventional tillage (left) and reduced tillage (right). Picture taken following a period of high winds. Photo by M.Seymour USDA-ARS.

CANADA

Agriculture and Agri-Food Canada study

A 10-year study by Martin Carter and team at Agriculture and Agri-Food Canada in the late 1990s and early 2000s investigated different tillage treatments on sandy loam soils (Carter et al. 2009).

The conservation tillage system consisted of one pass with a chisel plough (15 cm deep, with 36 cm sweeps) prior to planting potatoes.

The conventional tillage consisted of mouldboard ploughing (20 cm deep), followed by two or more passes (10 cm deep) with a disc and harrow prior to planting potatoes.

Both the conservation and conventional tillage treatments received the same in-row cultivation for ridging (hilling), fertiliser, pesticide applications and harvesting operations.

The Results

- Contrasting with other results, conducting reduced tillage in a three-year rotation resulted in the lowest bulk density of all treatments.
- Soil organic carbon, total nitrogen, and particulate carbon and nitrogen all increased with reduced tillage.
- Of the studies conducted by Carter's team, no significant impact was observed on yield or quality (Carter et al. 2005, Carter et. al 2009).

Grower Panel

In May 2022, the Canadian potato congress held a grower panel session with three prominent Canadian growers; Harold Perry, Homer Vander Zaag and Chad Berry, each starting to implement reduced tillage practices on their farms.

The main drivers for adoption were to build carbon, reduce erosion and to support fumigation practices for disease management. Cover crops were already used by the growers. Reduced tillage was seen as the next step to achieving their goals.

The changes

Their styles of reduced tillage differed.

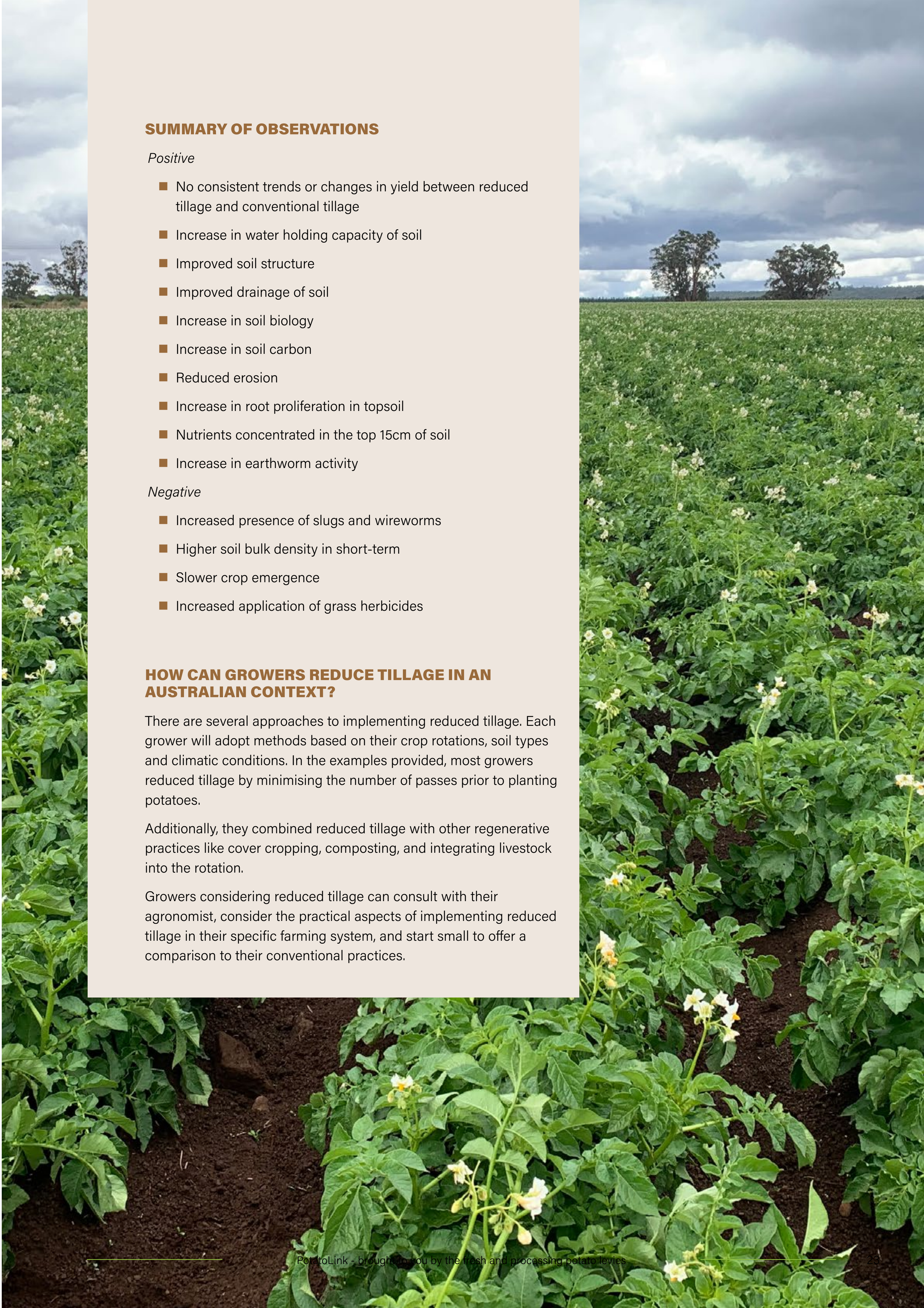
- Harold Perry has changed his practice from conventional autumn tillage to direct ridging. Ridging used to involve 2-3 passes to loosen the soil for hill formation in autumn, which was then left fallow. Now, Harold sows an early cover crop to get good growth before winter. In spring the potatoes are planted directly into the stubble in one pass, followed by a schmieser packer to promote good seed to soil contact. This approach has helped him to build carbon and reduce soil erosion, while also promoting soil biology.
- Homer Vander Zaag was facing issues with common scab and early dieing syndrome. To solve this issue he fumigated, however this required minimum soil disturbance. After practicing reduced tillage and the associated benefits, he developed a system capable of undertaking tillage, fertilisation, herbicide application, and planting in one-pass. The one-pass system was a success, offering similar results to a two-pass system and improvements in labour efficiency and soil conservation. However, it did increase the complexity of planting. Moreover, the reduction in tillage meant he had to increase application of grass herbicides. Homer observed that reduced tillage was better suited to lighter, warmer soils, with a controlled amount of organic residue.
- Chad Berry has a soil type that easily erodes. A no-till farmer of grain since the 1990s Berry has been reducing his tillage in his potato crops over the years. While erosion is a major factor leading him to reduced tillage, soil health and biology were also important. A recent demonstration on his farm trialled direct seeding potatoes into canola stubble, which offered two less tillage passes prior to planting. The results showed a reduction in fuel use with no impact on potato yields, specific gravity, disease, or other quality characteristics. Although emergence of direct seeded potatoes was delayed by several days, this did not translate into delays in harvest timing.

All three growers noted that the recent regenerative agriculture pledges by the processors have reinforced their practices. With these pledges, growers may see more support for transitioning to practices like no-till.

Harold Perry conventional autumn ridging (left) compared to direct ridging and planting (right).

Click here to learn about Homer Vander Zaag's operation: http://bitly.ws/PQa8

Click here to learn about Chad Berry's experiences: http://bitly.ws/PQab



SUMMARY OF OBSERVATIONS

Positive

- No consistent trends or changes in yield between reduced tillage and conventional tillage
- Increase in water holding capacity of soil
- Improved soil structure
- Improved drainage of soil
- Increase in soil biology
- Increase in soil carbon
- Reduced erosion
- Increase in root proliferation in topsoil
- Nutrients concentrated in the top 15cm of soil
- Increase in earthworm activity

Negative

- Increased presence of slugs and wireworms
- Higher soil bulk density in short-term
- Slower crop emergence
- Increased application of grass herbicides

HOW CAN GROWERS REDUCE TILLAGE IN AN AUSTRALIAN CONTEXT?

There are several approaches to implementing reduced tillage. Each grower will adopt methods based on their crop rotations, soil types and climatic conditions. In the examples provided, most growers reduced tillage by minimising the number of passes prior to planting potatoes.

Additionally, they combined reduced tillage with other regenerative practices like cover cropping, composting, and integrating livestock into the rotation.

Growers considering reduced tillage can consult with their agronomist, consider the practical aspects of implementing reduced tillage in their specific farming system, and start small to offer a comparison to their conventional practices.

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Growing potatoes without plowing- https://www.thecropsite.com/news/17975/growing-potatoes-without-plowing/

How to grow potatoes using minimal tillage, Jeroen Klompe- https://www.fwi.co.uk/arable/establishment/how-to-grow-potatoes-using-minimal-tillage

Low tillage potato trial showed no impact on yield and quality- https://www.potatopro.com/news/2021/low-tillage-potato-trial-showed-no-impact-yield-and-quality

2022 Ontario Potato Conference, 3 Experiences with minimum tillage on potatoes- https://www.youtube.com/watch?v=f8h4jY6D-_k

Reduced tillage in a three year potato rotation- https://landresources.montana.edu/soilfertility/documents/PDF/reports/Nutrient%20Digest_Winter%202013.pdf

Reducing Tillage but Not Quality- https://spudsmart.com/reducing-tillage-but-not-quality/

MANAGING LATE BLIGHT IN POTATOES USING A PREDICTIVE FORECAST MODEL

– A new initiative by AuSPICA

In response to a recurrence of late blight in some parts of Australia, AuSPICA, in collaboration with US expert, Emeritus Professor, Dr Steve Johnson, have developed an SMS alert system. The message, sent to members, contains spray recommendations with the aim of preventing the establishment of late blight.

By Jack Mueller[1], Prof Steven Johnson[2] and Dr Nigel Crump[1].

[1] Australian Seed Potato Industry Certification Authority (AuSPICA)

[2] Visting Scientist and Emeritus Professor Dr Steven Johnson University of Maine USA

Corresponding email: Jack.Mueller@auspica.org.au

AN INTRODUCTION TO LATE BLIGHT

Late blight, caused by *Phytophthora infestans*, is an oomycete or water mould, a fungus-like microorganism that can have a significant economic impact on the potato industry. The first visible symptom of late blight is dark brown spots on leaves. These irregular shaped lesions will develop further until the plant is killed or desiccated prior to harvest[1]. A lighter green halo will form around the lesion on the leaves (Figure 1), whilst the underside of infected leaves develop milky-white spores under moist conditions (Figure 2).

These symptoms will help distinguish late blight from other common diseases such as target spot *(Alternaria spp.)* and/or *Botrytis*.

Figure 1. (Left) Typical symptoms of late blight on upper foliage of a potato plant.

Figure 2. (Right) Underside of the potato leaf showing sporulation of the late blight pathogen.

The importance of late blight monitoring and management is demonstrated by how quickly late blight can spread. Once established and under the right environmental conditions, the pathogen will spread quickly in ring-like patterns in the crop. Ultimately the disease can progress, causing the entire crop to come to an early death, resulting in yield loss. Furthermore, spores can be spread locally by wind and infect surrounding potato crops[2]. For this reason, late blight is an industry-wide problem, requiring an industry-wide response.

LATE BLIGHT OCCURRENCE

The 2021/22 season saw the reintroduction of late blight in potato crops as a major concern in some potato production areas.

Seed crops where late blight was at its worst resulted in early death of the plants, preventing visual inspections as well as leaf sampling for PVY testing. This resulted in some seed crops being unable to qualify for AuSPICA certification labels.

Commercial potato crops were also impacted, with crop defoliation and in severe cases early crop death occurring in potato crops infected with late blight causing yield loss.

HOW WE ARE RESPONDING

In response to the previous season, AuSPICA with the assistance and expert advice of Professor Steve Johnson, worked to implement a spray recommendation system. The aim of the system is to prevent the establishment of late blight in crops. This work is funded by the AuSPICA Knowledge hub program through its membership.

Dr Steve Johnson visited Australia over the summer and during this time worked closely with AuSPICA to introduce a model of his own design, targeting the Thorpdale and Ballarat regions. These regions were used to develop the forecast model and test it under field conditions. The future plan is to identify other areas where the model can be used.

The model, used in conjunction with rainfall data recorded by the Bureau of Meteorology, can provide spray recommendations.

The recommendations are then sent via SMS to seed growers and AuSPICA Knowledge hub members. The message will recommend either a 'protectant spray' or a 'translaminar or systemic spray' to be applied at earliest convenience, otherwise no spray will be recommended. The model, time of year, days since spraying, and presence or absence of late blight in the region are all factors contributing to the final recommendations delivered by the AuSPICA certification officers.

The use of this model by AuSPICA Seed Certification Officers commenced following a meeting with growers in Thorpdale in December 2022, with a similar meeting held in the Ballarat region. At this meeting the need for a response to late blight, the way in which the model will run, timing of recommendations, and grower concerns were all discussed. In the time since the meeting in December, ten spray recommendations have been sent to seed growers and Knowledge Hub members in the Gippsland region, whilst the Ballarat region has only received four recommendations.

LATE BLIGHT IN SEASON 2022/23

The 2022/23 season saw the expected return of late blight in potato crops which were not subjected to an appropriate pesticide spray program.

Late blight has also been seen in areas this season that did not have the presence of late blight noted in the 2021/22 season.

However, growers that reacted to SMS recommendations sent by AuSPICA noted significant improvements in the longevity of their crops.

COMMENTS FROM DAVID HOTCHKIN OF HOTCHKIN POTATO GROWERS

"I've had the following thoughts on the late blight modelling developed by Dr Steve Johnson and AuSPICA.

We've been using this formula the past few years ourselves to economically control the disease. We've found that we can accurately predict when the disease is likely to affect our crops, and therefore be able to better target when to spray, and with which group of chemicals to spray, to prevent crop damage. Sometimes using this formula means that we don't spray for periods of time, meaning obvious savings and a better environmental situation.

Traditionally we have two main parts of the season when our late blight risk is at its highest in Thorpdale.

Firstly, from early November to the middle of January. If we have cool wet weather over a significant period during this part of the year, our early crops can collapse suddenly, substantially reducing yield and solids. Without early prediction and targeted spraying, the economic loss for us at this time of year can run into a six-figure sum.

The second high risk period in Thorpdale is from about middle of March through to the end of the growing season late into April. Again, cool wet conditions favouring late blight at this time of year can lead to significant reduction in yield and solids if targeted spraying to prevent the disease from taking hold has not occurred.

In summary, I have found that the Experimental Modelling works for our business.

Of most importance is the judicious use of fungicides and together with the informed knowledge of the appropriate environmental conditions, this can be used to prevent late blight establishing in a crop. We do not want to wait until symptoms of late blight develop in the crop, but rather use protectant fungicide chemistry strategically to prevent disease development in the crop. Once established in a field late blight becomes difficult to manage, particularly when the weather is favourable for the disease.

Overall benefits from the late blight forecast model include fewer spray applications than previously used for late blight and more appropriate use of chemistry modes (protectant, systemic and translaminar) to better manage late blight in potatoes. Ultimately saving money with using the right chemistry, at the right time, to achieve the right result.

For more information about AuSPICA and membership contact:
auspica@auspica.org.au or
Jack Mueller
jack.mueller@auspica.org.au

To sign up for future SMS spray recommendations:
Visit the AuSPICA website www.auspica.org.au or call the office 03 5962 0000 and sign up to the Knowledge Hub.

REFERENCES;

1. UNECE Standard S-1 concerning the marketing and commercial quality control of Seed Potatoes – UNECE Guide to Seed Potato Diseases, Pests and Defects, United nations, 2014

2. https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/plant/potato-late-blight

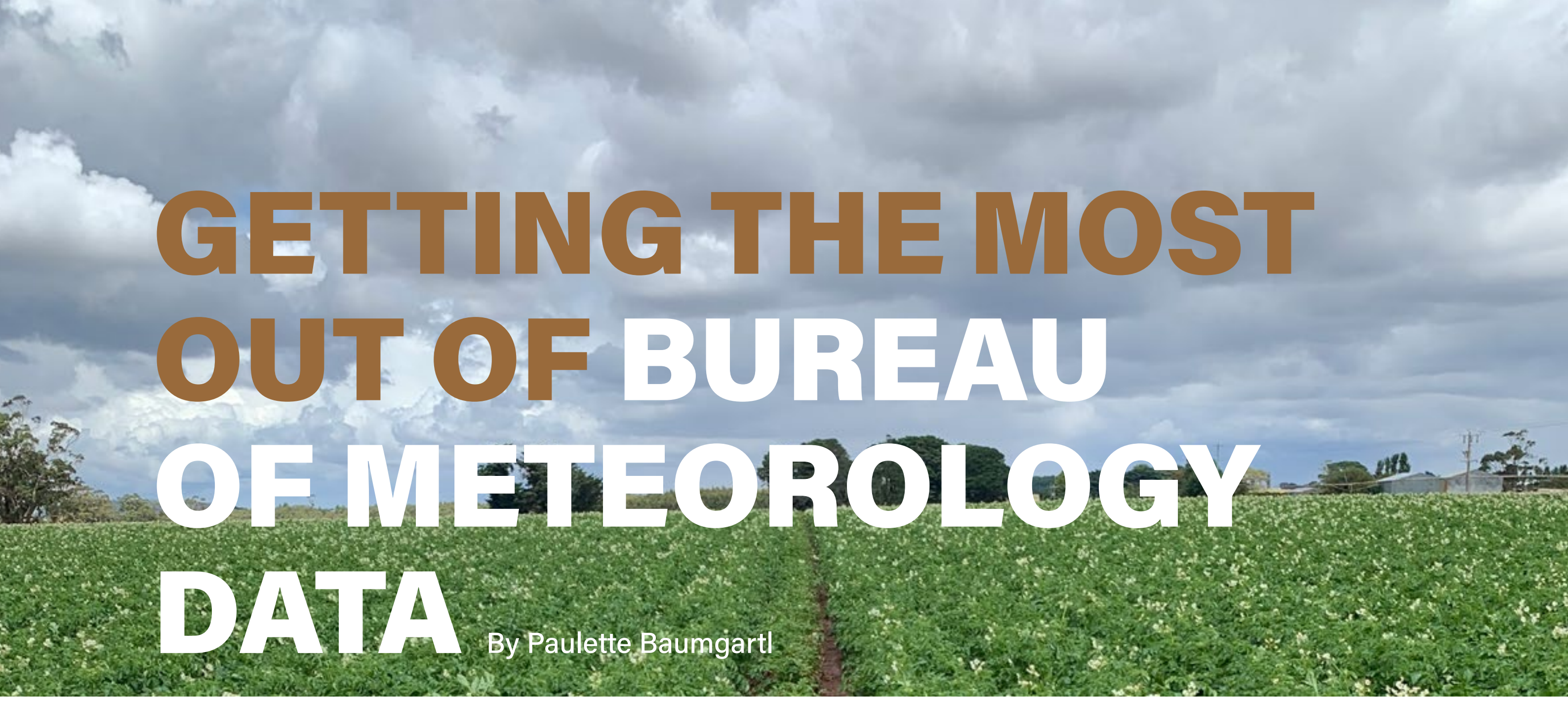
COMMENTS FROM DAVID HOTCHKIN OF HOTCHKIN POTATO GROWERS (CONT.)

I also believe AuSPICA sending out messages to its members based on the late blight Modelling Tool is great way to assist growers making their spraying decisions. During the growing season, growers tend to be very busy, and don't always have the time to keep an eye on everything, so to have Jack in the background keeping an eye on the Model and sending regular messages has been helpful. My belief is that our industry can be well served using this kind of technology, and the messaging is an important part of its uptake.

I also believe this type of messaging could be used to assist growers to better control other pests and diseases. Late blight has been particularly prevalent the last two seasons, but Target Spot is another disease not well controlled a lot of the time. We could have a hot dry year next year and run into problems with potato moth which is also not well controlled at times because of poorly targeted spraying. Hopefully this type of messaging system can be extended to other pests and diseases, such as these.

My hope is that AuSPICA can further develop this messaging technique to assist its members with pests and diseases as they arrive with the different seasons. Further development could assist pest and disease management challenges that arise with the various climatic changes that come our way from time to time.

I also hope that growers take up membership with AuSPICA to help them run these programs, because good information costs money.



GETTING THE MOST OUT OF BUREAU OF METEOROLOGY DATA

By Paulette Baumgartl

Australia's Bureau of Meteorology website (bom.gov.au), with its associated app, is one of the most well-known websites in Australia. The status of the Bureau of Meteorology among Australians is testament to the importance of weather and climate in a country famous for its extremes.

Behind the weekly temperature and rainfall forecasts, and the much-loved radar, sits an abundance of data, both raw and interpreted. If you know where to look, this data can be a useful decision-making tool.

In a recent PotatoLink online training webinar, Agricultural Segment Lead Rachel Davis and Senior Meteorologist Jonathan How guided participants through the website's many functions and useful features to help growers understand, react, and respond to their local weather.

THE BUREAU AND PRIMARY INDUSTRIES – SOME BACKGROUND

With a directive to generate more than $300 million in new economic and social value for the agricultural sector, the Bureau of Meteorology supports the agricultural industry by ensuring that weather, climate and water products meet the needs of the sector.

One output of this agenda is *Forewarned is Forearmed* (FWFA), a five-year project that concluded in 2022 aimed at helping farmers and agricultural value chains to proactively manage the impacts of extreme weather events.

Farming in one of the most variable climates in the world means that extreme weather events and climate variability have a significant impact on agricultural production and income.

KEY POINTS

- The Bureau of Meteorology provides weather observations and historical data dating back to the 1800s.
- This data helps in understanding climate patterns, optimal planting windows for crops, and potential risks associated with weather events.
- Average condition maps illustrate rainfall, temperature, sunshine, cloud cover, wind patterns, cyclones, storms, and bushfire occurrences. They are useful for quickly understanding typical weather patterns in a specific area.
- Nowcasting provides real-time weather information for the immediate future, ranging from the next minute to the next hour. Users can access the radar and satellite viewers to track rainfall, storms, cloud cover, and wind patterns.
- Forecasting uses advanced models to provide weather forecasts for the coming weeks, months, and seasons. The MetEye tool allows users to access comprehensive forecasts for specific locations and provides insights into the probability of rainfall occurring.
- Futurecasting involves seasonal and long-range forecasts. The Climate and Past Weather section offers climate outlook maps and tools to assist in decision-making for sectors like agriculture.
- The Bureau's website provides navigation instructions to access historical data, recent observations, nowcasting tools, and forecasting tools. Users can visit the specific sections under the Climate and Past Weather category to access the desired tools and information.

Watch the training session and access the links to the key tools here (http://bitly.ws/PQam).

The outcomes of FWFA include new forecast products, all freely available via the Bureau's climate outlooks website and described in more detail on p 31.

The agricultural sector can also look forward to more tailored tools in the near future, including:

- Climate Services for Agriculture (CSA) – a partnership with the Future Drought Fund and CSIRO – which will provide famers with climate information for their local area to help them better prepare for climate risks (read more here, http://bitly.ws/IuiM).
- Agri-Climate Outlooks (ACO) – a partnership with Agricultural Innovation Australia and CSIRO – which examines seasonal risks and opportunities at farm and commodity scale (read more here, http://bitly.ws/IuiW)
- ObsCheck, a weather quality control service to check private automated weather stations and unlock value from non-Bureau weather observations.

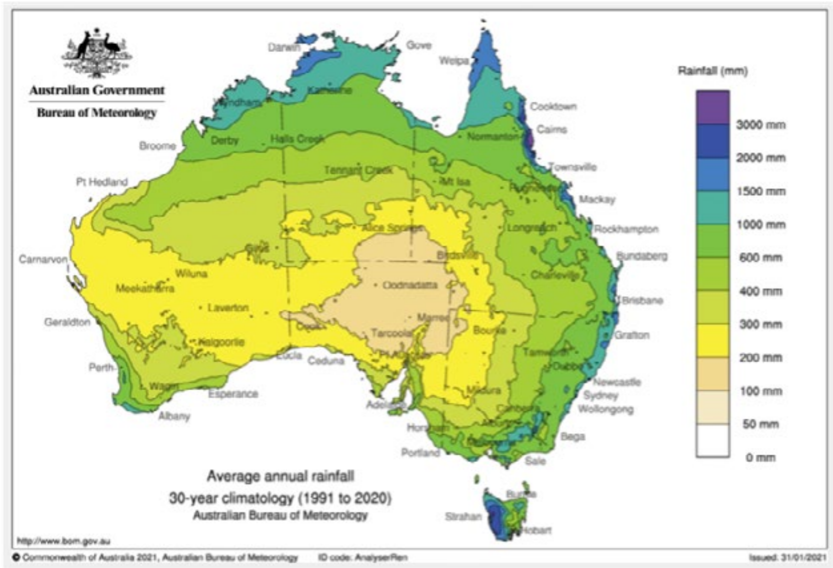
HISTORICAL OBSERVATIONS

When discussing weather, 'historical' refers from one week ago to the beginning of recorded weather records. The Bureau houses an extensive collection of weather observations and historical data on their website, dating back to the 1800s for some locations.

Historical data is particularly valuable if you find yourself in a new area. By accessing this data, you can gather essential insights about the climate patterns and conditions of the region, providing data, for example, to determine the optimal planting window for crops and understand potential risks associated with weather events.

Find historical data here (http://bitly.ws/PQIw)

In addition to the Bureau's tabulated data archive, the website contains a multitude of average condition maps. These provide a visually comprehensive overview of the aggregated weather conditions in a specific area. The maps encompass a range of parameters, including rainfall, temperature, sunshine, radiation, cloud cover, humidity, evaporation, wind patterns, cyclones and storms, and bushfire occurrences.



Example of the climate maps available. Options exists to select month and state. Image source: screen shot shared via the BOM Creative Commons Licence

Average condition maps serve as a valuable tool for gaining a quick overview of the typical weather patterns and characteristics of an area. The maps can be found here: http://www.bom.gov.au/climate/maps/averages/

RECENT OBSERVATIONS - YESTERDAY TO LAST WEEK

Each state and territory in Australia has its own dedicated **recent observations page**, which records the data from the Bureau's automatic weather stations throughout the country. The BOM app also has observations for the past 72 hours.

Most weather stations report their data every 30 minutes, providing regular updates on temperature, humidity, wind speed, and other relevant parameters. However, some stations may only report once a day, so it is crucial to keep this in mind when accessing the observations.

Not all stations accurately represent the microclimate of specific properties

Factors such as local topography and vegetation can significantly affect weather patterns.

Rainfall measurements are recorded by an extensive rain gauge network which comprises a combination of Bureau-owned and privately-owned stations.

How to find recent observations

Website: BOM home page → click on your state or territory on the map of Australia → middle column, click the first link 'All observations' → In the left column (Latest Weather) choose latest observations, observations via clickable map then navigate to

Example of recent observations as displayed on the BOM app. Image source: screen shot shared via the BOM Creative Commons Licence the weather station closest to your property.

Phone app: Search your location at the top; select 'past' on the bottom menu

NOWCASTING - NOW TO A FEW HOURS AHEAD

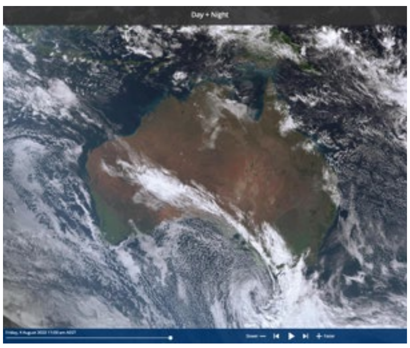
Nowcasting provides real-time weather information for the immediate future, typically ranging from the next minute to the next hour. This becomes particularly important during significant storm outbreaks or periods of extreme or catastrophic fire dangers when a wind change is anticipated.

The **radar** (http://www.bom.gov.au/australia/radar/) is the most accessed nowcasting tool, beloved by urban and rural Australians alike, and is used to view and track rainfall and storm events.

The Doppler radar (denoted by the black diamond symbol) can also capture smoke and insect swarms under some conditions.

Another essential tool is the **satellite viewer** (http://satview.bom.gov.au/), which displays fresh images every 10 minutes. While a fast internet connection is necessary, this tool plays a significant role in providing visual information.

Additionally, the BOM app offers a satellite tool that provides images every 90 minutes. While it may not capture new storm developments, it extrapolates existing weather patterns to predict their future behaviour and movement.



Satellite view of Australia, updated every 10 minutes: screen shot shared via the BOM Creative Commons Licence

Positioned below the radar on the website, the satellite tool offers users an astronaut's view of weather patterns. By correlating information from these tools, individuals can make informed decisions relating to weather. For example, anticipate the arrival of a cold front by observing cloud movement on the satellite view and track current storms using the radar.

It is important to note that not all clouds result in rainfall. It is therefore beneficial to switch between the radar, which shows rainfall intensity, and the satellite tool, which provides insights into cloud cover and storm formation. This analysis aids in accurately assessing rainfall prospects.

Warnings are another integral part of nowcasting, providing timely updates and guidance.

The Bureau's website also features a **rainfall viewer/update tool**, which visually displays the latest rainfall data on a map. Users can zoom in to their specific area, and the tool covers a daily period up to three years. Additionally, users have the option to view the data in a tabular format for a more detailed analysis.

Find the rainfall tool here

(http://www.bom.gov.au/climate/rainfall/).

FORECASTING AND FUTURE CASTING - NEXT WEEK TO NEXT SEASON

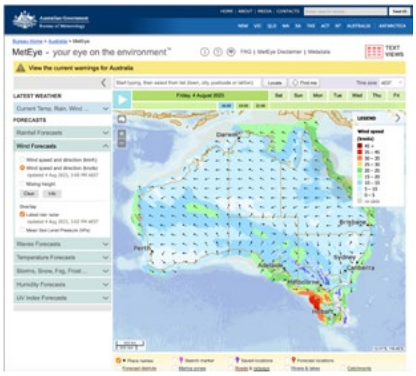
Have you ever wondered what lies ahead in the coming weeks, months, or even seasons? Weather

Visual presentation of recent rainfall. Image source: screen shot shared via the BOM Creative Commons Licence

forecasters rely on advanced modelling techniques to provide insight into future weather patterns. In Australia, the Bureau uses the Australian Community Climate and Earth System Simulator (ACCESS) model, specifically developed by their scientists to cater to the unique needs of the Australian climate.

These models are continually refined and improved over time, ensuring that the forecasts generated are accurate and reliable.

MetEye (http://www.bom.gov.au/australia/meteye/) provides a summary of these predictions. By default, the tool displays wind information but can be customised to show other parameters of interest.



Met eye map displaying wind forecasts. Image source: screen shot shared via the BOM Creative Commons Licence

Users can zoom in on specific locations or search for a particular area to obtain a comprehensive forecast for the next seven days, offering useful insights on whether the conditions will be suitable for on-farm activities like planting, spraying, irrigating, and harvesting.

The percent chance of rain displayed in the forecasts represents the likelihood of precipitation based on the consensus of various weather models. This information offers valuable insights into the probability of rainfall occurring in a specific area.

Future casting looks ahead to seasonal and long-range forecasts. These forecasts play a vital role in decision-making in agriculture. The Bureau's Climate and Past Weather section offers climate outlook maps, empowering users to gain a deeper understanding of future climate trends and anticipate any potential extreme weather events.

Climate outlook maps visually illustrate the modelled three month forecast. Image source: screen shot shared via the BOM Creative Commons Licence

Within the Climate and Past Weather sits the outcome of the **Forewarned is Forearmed** project. This provides additional tools to help producers prepare for extreme weather conditions.

The **Chance of Extremes** function enables users to determine the severity of dry periods by comparing historical records, helping to plan and mitigate potential risks. Similar analysis can be conducted for temperature data, and three-day rain events with rainfall probability maps displaying the likelihood of exceeding 3-day rainfall totals, ranging from 15mm to 75mm in the weeks and fortnights ahead.

For those interested in the **accuracy of the model's forecasts**, the Bureau offers an accuracy map. Generally, the model exhibits higher accuracy during winter months, providing users with a reliable estimation of future weather conditions.

How to find the forecasting tools

BOM homepage under → Climate and Past Weather →long range forecast.

EVAPOTRANSPIRATION

The Bureau offers evapotranspiration forecasts via its Real-time Data Services, which are subscription-based services.

Registered users can access the evapotranspiration grids, based on the Australian digital forecast database, via an FTP (file transfer protocol) system (Product ID IDBZ0003, Product Name, ADFD Evapotranspiration Grids – Australia (state-based) – Bundle).

The gridded evapotranspiration forecasts are updated twice daily, and include one to seven day forecasts.

More information on this service is available at http://reg.bom.gov.au/reguser/reguser.shtml

A service catalogue and charges for registered users at http://reg.bom.gov.au/other/charges.shtml

A user guide can be downloaded at http://reg.bom.gov.au/catalogue/Gridded_Evapotranspiration_User_Guide.pdf

Modelled data on evapotranspiration is also available through the Bureau's free to use **Australian Water Outlook** (https://awo.bom.gov.au/products/historical).

This interactive website offers comprehensive information on various components of the landscape water balance, including soil moisture, runoff, evapotranspiration, and precipitation across Australia.

The Australian Water Outlook allows users to access information over different timescales. For historical data, daily gridded outputs of precipitation, soil moisture, runoff, and deep drainage are available from 1911 until the previous day.

Seasonal forecasts, covering a range of 1 to 3 months, provide monthly outputs for root-zone soil moisture, evapotranspiration, and runoff. These forecasts are updated monthly to provide the most accurate information. Additionally, the website offers projections of changes in precipitation, soil moisture, evapotranspiration, and runoff for aggregated periods extending until the end of the century.

These projections are based on different greenhouse gas concentration pathways, multiple Global Climate Models (GCMs), a downscaled Regional Climate Model (RCM), and are corrected for bias.

THE BUREAU'S DATA ARCHIVES

Access for past weather and climate information is available from the Bureau's vast data archives, including data on temperature, humidity, rainfall, air pressure, sunshine, wind speed and direction, cloud and visibility.

Much of the information is free to download, although some charges may apply for specific services.

More information is available here:

http://reg.bom.gov.au/climate/data-services/

For any questions on the tools outlined, please contact agriculture@bom.gov.au

IMPACT OF SEED SPACING ON POTATO YIELD AND SIZE:

A demonstration by PotatoLink

Potato growers know that seed is an expensive input not to be wasted. Yet inefficient planting and spacing, including skips and doubles, can be costly. Optimising seed spacing provides a real opportunity to minimise inputs while maximising yield. To evaluate the economic impact of poor planter performance, PotatoLink conducted a demonstration on the impact of seed spacing on potato yield and size.

Figure 1. Example skips and doubles, 21.12.22

Planting seeds further apart than intended, for example when spaces are skipped, is a poor use of paddock space and leads to an uneven crop, with varying plant and tuber sizes. Uneven crops need uneven inputs and water, which quickly becomes a management headache.

Doubles, in contrast occur, when two seeds are dropped in the same space, leading to competition for nutrients, light, and space, and ultimately also an uneven crop (Figure 1).

There are many factors that can influence successful, even planting including:

- Speed of the planter - 5.8-6.1 km/hr is ideal
- Seed uniformity
- Seed shape
- Cut versus whole seed
- Planter functionality
- Best practice, for example planter should always be calibrated prior to planting

Generally, the optimal seed spacing distance is determined by several factors. Seed age, variety, end use market (for example seed crop vs processing crop), and disease management (for example closer space results in smaller tubers which helps with the management of hollow heart) all need to be considered.

THE DEMONSTRATION SET UP

For this trial, potato processing variety FL 2215 tubers were planted in November 2022 on a paddock that had a long history of growing lucerne crops (Figure 2). Seeds, planted in November, enjoyed an ideal growing season.

The soil was light textured. It was the first time that the paddock was planted with potatoes, so volunteers and disease did not present a problem. *A Grimme 6 row* planter was used with spacing set to 26cm between seeds and a planting speed of 6km/hr.

To assess seed spacing variability and the efficiency of the planter, the team opened the furrow after the planter had planted the crop (on the same day of planting) to confirm the actual distance. Space between seeds was manually measured and recorded. By

Figure 2. Planter on day of planting – 21.11.22

Figure 3. Demonstration layout, precision spacing, demonstration area (22 cm spacing left row, 30cm spacing right row) – 21.12.22

Figure 4. Crop at flowering in demonstration area

way of comparison, a small test area was then planted with three different seed spacings: 22cm, 26cm, and 30cm, which could then be compared to the control (26cm by the planter) (Figure 3 and 4). Please note this demonstration was not a replicated trial.

The crop and demonstration area were grown under usual conditions, with data collected from the demonstration as the crop neared harvest. Data collected included:

- Number of plants
- Number of stems per plant
- Number and size of tubers (<40mm, 40-60mm, 60-90mm, >90mm)
- Weight of tubers from the control (machine planted) and demonstration (hand planted) areas

RESULTS

The degree of variance of the planter was assessed by analysing a 10m row. On average, the planter planted at the desired rate (26cm) of seed per hectare. However, the average deviation between seed spacing was 8.8 cm or 33%. The Potato Manual provided an example where a spacing of 25cm should have 40 seed pieces within a 10m area. It suggests that +/- 2/40 seed pieces (5% variability) in 10m is an acceptable variability. The planter performance, including planting speed, has room for improvement, and economics justify it.

In this demonstration, the 30cm spacings returned the highest **yield**, outyielding the closer spacings (26cm and 22cm) by around 4% for this variety (Figure 5). All precision plantings outyielded the planter. However, it is important to note that tubers <40mm and >90mm were excluded from yield calculations as they are not accepted by the processor. Also, yield from the '26cm planter' was calculated from a low number of repetitions.

Tuber size by count revealed a greater number of larger tubers in the 30cm and 26cm spacings, highlighting that bigger spacings returned larger potatoes. 30cm = 61% at 60-90mm, 22cm = 54% at 60-90mm (Figure 6)

The 30cm spacings also returned a greater average number of tubers per plant (Figure 7). 30cm = 11 tubers/plant, 22cm = 9 tubers/plant - which concurs with expectations.

Also as expected were the results for Tubers/m (Figure 8). Total tubers per metre was greater for 22cm = 39 tubers, compared to 30cm = 37 tubers - i.e. smaller seed spacing = more plants in a given space = more total tubers.

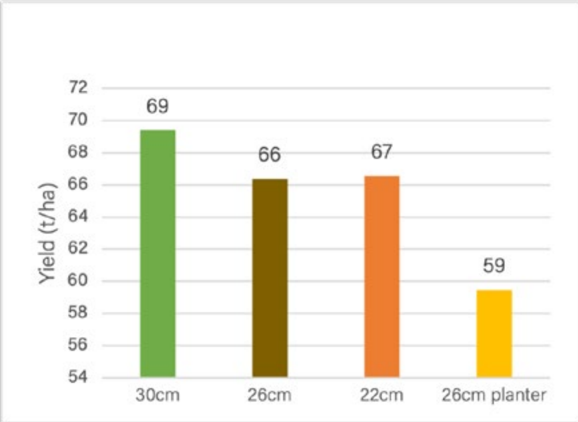


Figure 5. Marketable yield

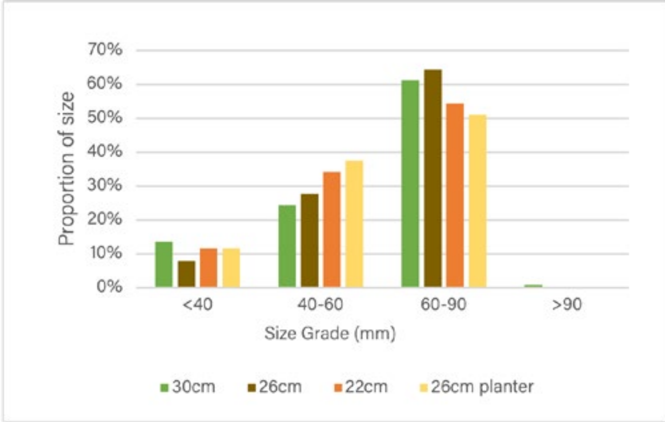


Figure 6. Tuber size at different spacings

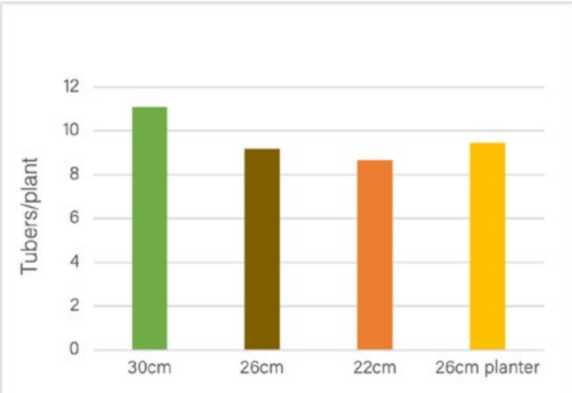


Figure 7. Tubers/plant

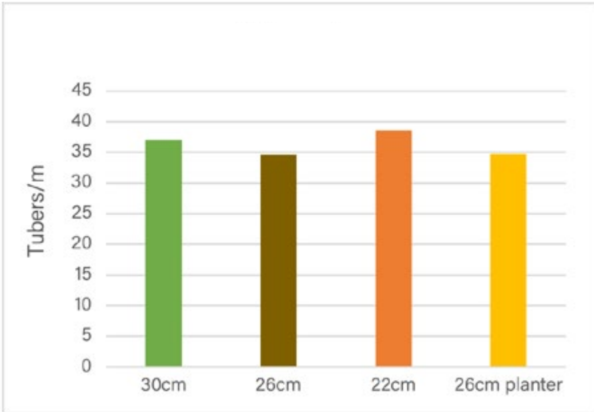


Figure 8. Tubers/metre

THE ECONOMIC BOTTOM LINE

Calculations in Figure 9 are based off an average seed size of 65g, costing $1000/tonne of seed.

For this particular crisping variety in this situation, 30cm spacing returned the best yields, greatest tuber size and lowest cost of seed/ha.

The 59t/ha of yield obtained in the 26cm planter area of the demonstration was lower than the 64t/ha predicted by the grower, highlighting the importance of seed spacing on potato yield and size. An increase in seed spacing can significantly reduce the overall amount of seed required and cost, however it is important to consult with your seed supplier on the optimum spacing, as it will vary from variety to variety.

The Potato Manual suggests calibrating the planter before planting and conducting regular in-paddock checks to ensure seeds are placed at the correct spacing in the row. This can help to reduce costs and improve yields and quality.

Figure 9. Number and cost of seed/ha

EYES ON THE WORLD

RECENT ADVANCES IN POTATO RESEARCH AND INNOVATION

The effect of concurrent elevation in CO_2 and temperature on the growth, photosynthesis, and yield of potato crops

Lee YH, Sang WG, Baek JK, Kim JH, Shin P, Seo MC, Cho JI

PLoS One. 2020 Oct 21;15(10):e0241081. doi: 10.1371/journal.pone.0241081.

WHAT IS IT ABOUT?

In 2016, global CO_2 concentrations passed 400 ppm for the first time since the Pleiocene Era, 3 million years ago. This was a time when forests retreated, giant ground sloths grazed on spreading grasslands, and the first humans stood up on two legs and surveyed the savannah around them.

CO_2 now stands at 419 ppm and rising.

The effects of high CO_2 on plant growth has been a research focus since the 1990s. Potatoes today are growing with 25% more CO_2 than they were then.

One of the positive impacts of high atmospheric CO_2 is that it is easier for plants to assimilate carbon. It also reduces 'stomatal conductance' – that is, the amount of water plants lose by keeping their stomata open to capture CO_2.

Much early research focussed on wheat and rice. High CO_2 was found to increase yield – mainly due to an increase in grain size, rather than number – but also to reduce nutritional value. However, grasses (C4 plants) are already more efficient at getting carbon than plants such as potatoes (C3 plants). This suggests that the effects of high CO_2 on potatoes could be greater than those on grain crops.

This South Korean study from 2020 examined how elevated temperature and/or CO_2 concentration impacted potato plants. The researchers used controlled chambers that allowed them to regulate temperature and CO_2 levels under daylight conditions.

The plants were exposed to normal temperatures, normal temperatures elevated by 4°C, increased CO_2 (800ppm), and elevated temperature and high CO_2 combined.

The researchers measured various plant parameters including stomatal conductance, chlorophyll concentration, and nutrient uptake. They also analysed CO_2 gas exchange rates to determine the rate of photosynthesis and carbon accumulation in the plant. Yield, including both the total number of tubers and size range, was also recorded.

WHAT WAS CONCLUDED?

Plants grown at elevated day/night temperatures of 25°C/19°C had lower stomatal conductance and reduced photosynthesis. As a result, they were smaller than those grown at 21°C/15°C. Effects were strongest during the late stages of growth, as daily temperatures rose.

Unsurprisingly therefore, higher temperatures significantly reduced yield. Each plant averaged only 6.4 tubers weighing a total of 342g, compared to 10.2 tubers weighing 502g when plants were grown under the ambient temperature range.

Increasing atmospheric CO_2 to 800ppm (combined with ambient temperatures) also reduced leaf chlorophyll and stomatal conductance (and potentially, therefore, water use). Despite an increase in mid-size tubers (30-80g), total yield was not significantly affected.

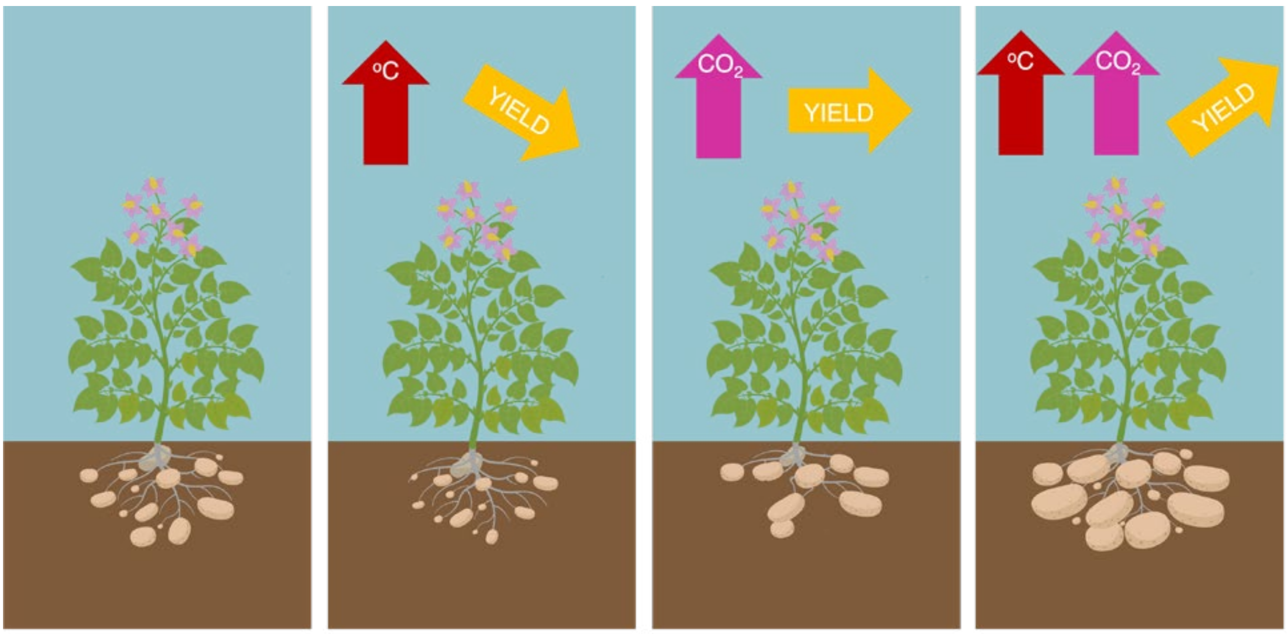
However, the most dramatic effects occurred when high CO_2 was combined with high temperatures. These conditions significantly increased growth, development, and photosynthetic rate during tuber formation and bulking. The result was a 20.3% increase in tuber yield, with a total of 604g/plant. This was mainly due to larger tuber size rather than an increase in the number of tubers/plant.

Despite increases in the C:N ratio, there is some evidence that the efficiency of nitrogen use increases as CO_2 rises. Unfortunately, elevated CO_2 also affected nutrient concentrations, reducing chlorophyll, magnesium and phosphorus levels in the plants.

Although mineral concentrations in the tubers were not measured, these results are consistent with previous work finding lower nutritional quality in grain crops grown under high CO_2.

Overall, the study suggests that the negative impacts of high temperatures on potato growth and yield, especially during the later stages, are mitigated by high levels of CO_2. When the two occur together, the balance between source (CO_2) and sink (tuber) means there is a positive effect on potato productivity and quality.

This is not to say that climate change is good for potatoes. Increased frequency and severity of negative weather events is going to challenge our ability to grow all crops. Moreover, high temperature will inevitably create major challenges for growers, as will the dry conditions that often accompany heat. However, this study does demonstrate the adaptability of the potato plant, and its ability to make the most of the atmosphere around it.



NORMAL TEMPERATURE (21/15°C), AMBIENT CO_2 (CONTROL)

AMBIENT CO_2, ELEVATED TEMPERTURE +4°C (25/19°C)

NORMAL TEMPERATURE, ELVEVATED CO_2 (800ppm)

ELVEVATED TEMPERATURE, ELVEVATED CO_2

DISPATCH FROM ... VICTORIA

This issue, our dispatch comes from PotatoLink regional rep Stuart Grigg in Victoria.

EVENTS

Professor Andy Robinson from North Dakota State University visited the Ballarat region to conduct a presentation and field walk with growers on weed management and herbicide damage. Despite the wild, wet, and cold weather, forty-five brave growers and industry representatives participated in the event. The discussion during the field-walk included more general concerns regarding the impact of the cool and short summer on this year's yields, as well as the delay in planting due to a wet winter and the dry summer, which put pressure on irrigation resources.

Trials on the local Quinlan property (thank you Tom and Neville), included one on mycorrhizae treated seed, harvested in late April. Local growers attended the field-walk to observe any visual differences and discuss the results, which will be shared in future PotatoLink communications.

Additionally, a second study was carried out on the Quinlan Farm on remote moisture sensing probes, which highlighted the importance of monitoring soil moisture after a rain event.

An Integrated Pest Management (IPM) trial was conducted to study the benefits of 'bug-scouting' for economic thresholds versus regular pesticide added in a tank mix.

The trial resulted in a zero-pesticide application in one season without any loss of yield.

CHALLENGES

Growers in the region cite the current costs of production a major challenge. The added uncertainty of the short and cool summer could make this a difficult year for some local growers... but everyone is spudermistic!

EXTRA RESOURCES

- Case study Mycorrhizal fungi at the Bolwarrah Victorian demonstration site (http://bitly.ws/Ruim)
- Feature article Managing herbicides and herbicide injury (http://bitly.ws/Ruiq)

CONTACT

For more information about PotatoLink activities in Victoria, contact Stuart

stuart.grigg@potatolink.com.au

HORT INNOVATION PROJECTS

Project name	Code	Lead organisation	Description	Fund	Start and end date
Potato industry minor use program	PT16005	Hort Innovation	Used to submit renewals and applications for new minor use permits for the potato industry.	Fresh & Processing	Ongoing
Australian potato industry communication and extension project (PotatoLink)	PT20000	Applied Horticultural Research	Supports growers in adopting improved practices on-farm and communicating new information, research and technology.	Fresh & Processing	08/12/2020 – 30/11/2025
Management strategy for serpentine leafminer, Liriomyza huidobrensis	MT20005	Queensland Department of Agriculture and Fisheries	Delivering targeted R&D specifically for serpentine leafminer in response to the incursions detected in late 2020.	Multi fund including Fresh & Processing	19/03/2021 – 30/11/2023
Regulatory Support & Response Co-ordination	MT20007	AKC Consulting Pty Ltd	Provides key information regarding domestic and international pesticide regulation	Multi fund including Fresh & Processing	30/06/2021 – 01/07/2024
Consumer behavioural data program	MT21004	Nielsen	Provides regular consumer behaviour data and insight reports, through the Harvest to Home platform (www.harvesttohome.net.au)	Multi fund including Fresh	20/01/2022 – 20/11/2026
Feasibility/scoping study: Surveillance and diagnostic framework for detecting soil-borne pathogens in vegetable industries	MT21016	NSW Department of Primary Industries	Examining the potential to develop a national surveillance and diagnostic framework for soilborne pathogens of vegetable crops including potatoes	Multi fund including Fresh & Processing	11/10/2022 – 31/08/2023
Generation of data for pesticide permit applications in horticulture 2022	ST22001, ST22003 and ST22004	Agreco, Eurofins Agroscience Services and Kalyx	The generation of pesticide residue, efficacy and crop safety data to support label registration and minor use permit applications and renewals made to the APVMA.	Multi fund including Fresh	16/05/2022 – 15/12/2025
People development strategy for the vegetable, potato, onion, and banana industries	MT22002	RMCG	Building a People Development Strategy to guide future investment in building capacity and capability within a range of industries including potatoes	Multi fund including Fresh & Processing	12/12/2022 – 01/07/2023
Horticulture trade data	MT22005	IHS Global	Provides Hort Innovation with a subscription to the Global Trade Atlas Database.	Multi fund including Fresh & Processing	14/12/2022 – 01/12/2025

Potatoes Australia Ltd is proud to host the

12th WORLD POTATO CONGRESS (WPC 2024)

Adelaide, Australia, 23 - 26 June 2024

The next World Potato Congress will be hosted by Potatoes Australia in June 2024.

The congress gathers potato professionals from all over the world to meet and share ideas and knowledge.

World Potato Congress Inc. is a non-profit organisation supported by a group of volunteer directors representing potato jurisdictions around the world.

GET INVOLVED

Information on sponsorship opportunities, registration, social events and tours, exhibitors and a preliminary program is now available.

Scan the QR code for more information.

POTATOES AUSTRALIA

The Voice Of The Potato Industry Value Chain

WPC 2024