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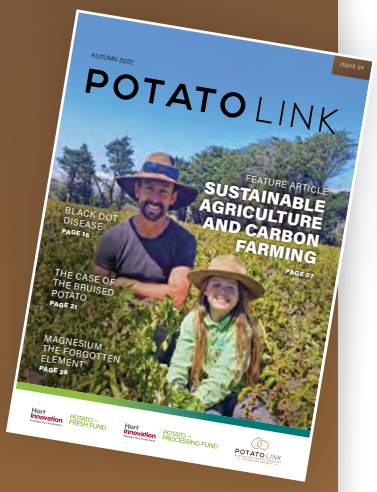
TECHNICAL CONTENT
Dr Jenny Ekman
comms@potatolink.com.au

EDITOR
Linda Drake
info@potatolink.com.au

PROJECT COORDINATOR
Peter O'Brien
peterob@potatolink.com.au

DESIGN
Jihee Park
hello@jiheeparkcreative.com



Cover: PotatoLink's Stuart Grigg and daughter Kiara in their crop of Atlantics a week before harvest
- Kate Grigg

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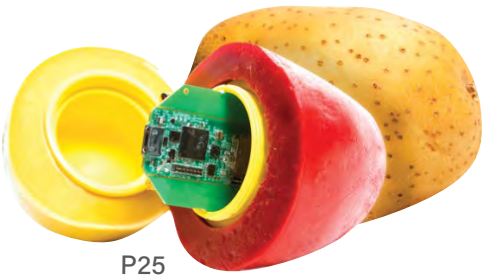

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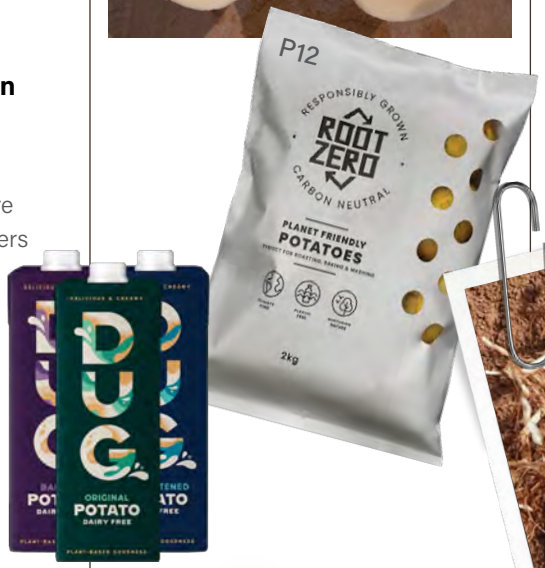

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NEW POTATOLINK TEAM MEMBERS

The PotatoLink team has expanded over the last few weeks, with new regional representatives appointed in Queensland, Victoria and Western Australia.

We also have a new staff member in our Sydney office, who will be actively involved in organizing and promoting field days, workshops and other face to face activities.

QUEENSLAND

Dr Naomi Diplock is a plant pathologist with 15 years research and university teaching experience. She enjoys working in diverse environments, from the cattle stations of the north Queensland outback, to farms in Bhutan and the vegetable production areas of the Lockyer Valley. These reflect Dr Diplock's varied research career, with projects on biological control of woody weeds, spider behaviour, mushroom production and vegetable pathology.

Now based near Nambour, Naomi will co-ordinate PotatoLink activities in both southern and northern growing areas of Queensland.

VICTORIA

Stuart Grigg, from Stuart Grigg Ag-Hort Consulting, is vegetable farming born and bred. Now a vegetable agronomist, he has nearly 20 years experience working and consulting throughout Australia (with a Victorian focus) as well as New Zealand. Originally specialised in lettuce, brassicas and babyleaf, he has more recently extended into apiaceae (celery and parsley) and potato crops.

Stuart is passionate about precision agriculture as well as sustainability and soil health. As someone who has been involved in research projects as well as responsibility for the day-to-day running of major vegetable production businesses, he has unique skills, understanding both the theory and commercial reality.

Stuart and his young family have now invested in their own 148 acre property at Bolwarrah, west of Ballarat. Here, Stuart has teamed up with potato grower Neville Quinlan, producing spuds on virgin ground alongside his broccoli crop. Stuart will run trials using their local crop of Atlantics, as well as coordinate some Victorian PotatoLink activities.

WESTERN AUSTRALIA

Regional coordination in WA will be shared between Rachel Lancaster and Mark Warmington.

Rachel has worked in research and extension with Western Australian horticultural businesses for more than 28 years.

After many years with the WA Department of Agriculture, in 2016 Rachel left to become principal of EATS (Environmental and Agricultural Testing Services) as well as consulting privately on a wide range of research projects. She has since investigated plant nutrition, disease, insect and weed management and efficient crop irrigation. With skills in implementing and analysing trials as well as working with growers, Rachel is ideally qualified to work with the PotatoLink team managing activities in WA.

Mark Warmington has worked around Australia as an agronomist in a wide variety of crops for over 30 years. After 11 years with the WA Department of Agriculture, based in Kununurra filling the role of farm manager for the research station, he recently moved south to join EATS as their Sampling/ Research Manager. Mark enjoys working with growers and will be involved with the PotatoLink activities in WA.

NEW SOUTH WALES

New recruit Stephanie Tabone graduated from the University of Sydney in 2016, with a B. Science in Agriculture with honours, majoring in horticulture and agronomy. Stephanie has since gained hands-on vegetable production and postharvest experience with a major, vertically integrated vegetable producer in South-East Queensland. She has also managed stewardship and a sales territory for a crop protection and seed supply company based in Sydney.

Stephanie was nominated for the Young Grower of the Year award and the Women in Horticulture award in 2019 and is participating in the Cultivate - Growing Young Leaders program with Action For Agriculture. She is passionate towards helping the agriculture industry to find and implement solutions to the challenges faced through crop production and the supply chain.

Stephanie will be actively involved in organising, promoting and running face to face events for PotatoLink.

REGENERATIVE AGRICULTURE OR SUSTAINABLE FOOD SYSTEM – *WHAT'S THE DIFFERENCE?*

Really, not much! The terms regenerative and sustainable can virtually be used interchangeably. They are both frequently defined as integrated production systems that:

- Produce food
- Enhance environmental quality
- Minimise use of non-renewable resources
- Integrate natural cycles and biological controls
- Promote the health and wellbeing of both farmers and communities

Views differ as to exactly what is meant by regenerative or sustainable agriculture. It may be argued that "sustainable" implies little or no change in the farming environment, whereas "regenerative" is focussed on improvement, but in reality the terms mean much the same.

Whether regenerative or sustainable, there are many different approaches. These may be characterised as "ecocentric" or "technocentric".

The ecocentric approach

This system involves little or no external inputs – including artificial fertilisers and pesticides. It is often championed by believers in organic / biodynamic production systems.

Adoption of this approach would inevitably create radical changes. To give an extreme example, in April

2021 the government of Sri Lanka banned importation and use of all synthetic fertilisers and pesticides. The stated aim was to improve both human and environmental health. The country's two million farmers, who had previously relied heavily on chemical inputs, were ordered to go organic.

Within six months rice production fell 20%. The cost of vegetables rose 5-fold and food scarcity developed. Combined with the collapse of tourism, this has resulted in fuel shorages, millions plunged into poverty and billions wiped from the economy. Although the ban has been reversed, the value of the rupee has halved, and farmers are struggling to purchase the inputs they need.

The technocentric approach

Technocentric approaches rely on modifying existing farming systems, with sustainability a goal to be reached through biotechnology and innovation. Sustainable systems can potentially use robotics, precision agriculture, soft chemistry, genetic modification, and many other new technologies.

Sustainability is hard to measure. Soil conservation and health are clearly key, with carbon capture sometimes used as a metric of success. However, the characteristics of sustainable soil management, and how much agriculture should contribute to biodiversity, remain unclear.

Key practices associated with regenerative/sustainable agriculture (Figure 1, p8) include:

- Reduce tillage and control traffic
- Keep the soil covered with mulch or cover crops
- Maintain living roots in soil
- Build soil carbon
- Reduce reliance on chemical fertilisers and pesticides
- Increase diversity through crop rotations, multi-species cover crops and long-term plantings
- Integrate livestock
- Improve water infiltration through maintaining good soil structure

Whether called regenerative agriculture, a sustainable food system or carbon farming, the outcome can be a win for both the grower and environment.

MOVING TOWARDS CARBON NEUTRAL FARMING

Growers need to prepare for the opportunities and challenges ahead that arise from carbon emission management, particularly whether they can generate carbon credits from their operations. But it all starts with basics, writes **Linda Drake**.

The unfolding carbon situation presents new opportunities to potato growers, particularly those on mixed farms.

Growers can choose between becoming more carbon neutral by reducing emissions and capturing carbon, or implementing changes on-farm to earn carbon credits.

Adrian James from Natural Resource Management (NRM) North, an independent not-for-profit organisation for NRM in northern Tasmania, has been tracking the evolution of carbon farming options through funding from the Australian Government's National Landcare Program.

He suggests that the key to making a start is understanding what you want.

"You need to know if your goal is to help the industry become carbon neutral and benefit from market access or premiums from carbon-neutral products. Or is your goal to earn money from generating and trading in carbon credits? It's more challenging, but not impossible to do both," says Adrian.

For potato growers who want to start

Figure 1. Principles of regenerative / sustainable agriculture

managing carbon but are unsure how to begin, there are some key issues to think about. These include reducing farm greenhouse gas emissions, managing wastes, capturing and storing more carbon (Figure 1), and considering whether purchasing carbon offsets make sense.

"When your farm emissions match your farm carbon capture, plus offsets, your farm is carbon neutral. This is not as improbable as it might seem, with some farms already succeeding. But earning carbon credits, without becoming carbon neutral, is also perfectly viable," Adrian says.

There are funding programs that ensure that growers get the right advice from the get-go.

The Tasmanian Government, for example, has launched a Carbon Farming Advice Rebate pilot program offering up to $10,000 per farm through Landcare Action Grants. Similar rebates are also offered in some other states.

"Making carbon projects more attractive to farmers has involved a range of pilots and improvements, especially in the mixed environmental planting methodology. If a farmer wants to plant mixed native vegetation as a carbon offset, the current rules allow for streamlined application and reporting processes, and an exemption from expensive audit requirements," says Adrian.

In addition to revegetation, other actions can also be considered for managing carbon on-farm.

Carbon offset methodologies are in the pipeline that can be used for assessing whole farm management and wetland carbon. These will happen under the Climate Solutions Fund (formerly the Emissions Reduction Fund), so monitor for announcements.

A new soil carbon methodology was released in December last year, allowing for a mix of soil testing and modelling of soil carbon

Figure 2. Cattle are a major source of methane, which is more than 25 times more efficient at trapping heat in the atmosphere than CO_2.

Figure 3. Measuring nitrous oxide emissions in a broccoli crop; nitrous oxide is an extremely potent greenhouse gas

Figure 4. Deep rooted perennial pastures improve and retain soil carbon. *- A. James*

changes. It has decreased costs but, unfortunately, also increased complexity. Farmers participating in the soil carbon methodology can be paid for carbon baseline testing in advance through the Clean Energy Regulator.

"It's a highly individual response that any grower will ultimately make, depending on location, scale, and business circumstances. For example, in Tasmania, where electricity is from renewable resources, the impact from carbon dioxide emitted from fossil fuels in tractors, utes and quad bikes is relatively high. Emissions also come from using lime, because it contains carbonate, while urea releases carbon dioxide as it turns into ammonia," Adrian says.

Potato growers who run ruminant stock need to consider managing methane emissions (Figure 2). Reducing methane from stock hinges on quality feed, high performance genetics, rapid growth for early processing, culling poor performers, early joining and supplementing feed with tannins and red seaweed.

Nitrous oxide is 280 times more potent a greenhouse gas than carbon dioxide (Figure 3), so managing nitrogen is a key factor in reducing farm emissions. While it might still be a relatively small proportion of total emissions, it may be a bigger problem to manage,

Figure 5. Planting trees boosts carbon above as well as below ground, and can earn carbon credits.

especially when soils are waterlogged and warm.

Potato production can sometimes result in high nitrous oxide emissions because they are a high-input, irrigated, warm-season crop. Adrian's tips are to accurately manage nitrogen, or use controlled release variations of fertilisers. Timing of application is critical, as is avoiding excess soil moisture through irrigation scheduling and improved drainage.

"Good soil moisture management not only reduces disease and nutrient loss, but also limits nitrous oxide emissions. Special enhanced-efficiency fertilisers can also help" Adrian says.

Capturing carbon and storing it are key steps in more sustainable agriculture, which often hinges on enhancing soil health. Improving soil carbon in areas used for growing potatoes relies largely on cover crops or pasture leys (Figure 4). Just like pastures, mixed species of deep-rooted plants often give better carbon results, because carbon lasts longer when it's stored deeper.

Addressing soil constraints, such as waterlogging, acidity, poor fertility and compaction is also critical. This includes minimising the time soil stays bare to reduce erosion. Year-round plant growth should be encouraged. If tillage is used, then organic matter can also be added. For pasture, good quality dung beetles can be useful, and grazing management aimed at maximising ground cover and pasture production is key.

Growing woody vegetation is also valuable because it stores carbon above and below the ground and can be particularly useful for offsetting high emissions on mixed farms (Figure 5). If a grower's aim is to be carbon neutral, any tree planting can work, though fast-growing plantations capture the most carbon in the near term. If trees are used to earn carbon offsets, it must use a registered project and an approved methodology.

"Under the carbon model that is used in offset projects, mature forest systems don't capture carbon as quickly as rapidly growing younger trees, and carbon captured last year doesn't balance out emissions this year," Adrian says.

In working out how many trees to plant, the short answer is, the more the better. A rolling program of newly planted zones continues to provide rapid growth as other areas mature. Working out the area of vegetation needed to balance out emissions requires carbon accounting, usually starting with a farm carbon calculator.

There is also the option to purchase carbon offsets to counter farm emissions, but that can be the most expensive option. Adrian says it's worth getting advice on eligibility before deciding on any schemes, and taking into account your individual circumstances.

Engaging a third party provider can help optimise the financial opportunities from capturing and storing large amounts of carbon. Ambitious growers with an appetite for risk (and paperwork!) may be able to take advantage of special deals in voluntary markets. However, Australian Carbon Credit Units (ACCU) are certified, so there are many rules. The largest market in Australia is currently the Australian Government, which can simplify the transaction. While revegetation projects are easier now, Adrian says that it is often better to pay a specialist to do most of the paperwork, reducing complexity and risk.

Earning carbon credits from soil or vegetation requires a 25-year minimum time frame. While increasing soil carbon is harder to achieve on cropped ground, it's not impossible to see useful carbon improvements. It's also essential that you don't start until you've registered the project. Any carbon sampling done beforehand can't be used, so register first, and use an independant contractor to establish baseline soil carbon to at least 30cm.

Carbon service providers are a growing sector, but farmers should do their homework first to ensure the deal is a fair one for both sides.

A webinar presented by Adrian in October 2021 on De-mystifying the Carbon Story contains worked examples of the costs and returns of planting shelterbelts to earn carbon credits, though note the carbon price and some methodologies may have changed: potatolink.com.au/webinars

Other resources from NRM North, including interim results from its soil carbon and diverse pasture trials can be found at nrmnorth.org.au/land/soil-carbon-project/

CARBON CALCULATORS: USEFUL BUT NOT PERFECT

Carbon calculators allow a grower to establish a baseline on their emissions. While more are being developed and refined, so far they are somewhat a blunt instrument. They give an indication of emissions but are inherently inaccurate at a farm level.

A calculator is available for farms producing beef, dairy and grains. It may have some application for potato growers with diversified interests, but is complex and takes time to enter material. A key deficiency is that the livestock calculators don't include soil carbon:

www.picc.org.au/resources/Tools

Based in the UK, the Cool Farm Alliance has developed a Cool Farm tool, for field level assessment of greenhouse gases, biodiversity and water:

https://coolfarmtool.org/coolfarmtool/

Another simple calculator, covering basic inputs:

https://www.vegetableclimate.com/tools/carbon-footprinting-tools/vegetable-carbon-calculator/

Developed some years ago by HortInnovation, this tool doesn't cover the full range of inputs that need to be considered for an accurate indication of emissions on farm but is geared to the horticultural sector.

Consultants can do the work for you, but are likely to be expensive due to the data required.

RESOURCES TO BUILD KNOWLEDGE

Understanding how the **Clean Energy Regulator** and the Emissions Reduction Fund work are essential for those looking to earn carbon credits. The Clean Energy Regulator website has key, comprehensive information on how to participate in the Emissions Reduction Fund, registering projects, steps needed to be compliant with its rigorous criteria and other resources:

http://www.cleanenergyregulator.gov.au/ERF

Meat and Livestock Australia's Carbon Neutral 2030 Program has comprehensive resources for producers on managing emissions:

https://www.mla.com.au/cn30

CSIRO's online tool to start looking at market opportunities:

https://looc-c.farm/

Elders has a soil carbon and herd management service:

https://eldersrural.com.au/tech-services/carbon-farming/

Grain Growers has produced a document that gives an invaluable overview of carbon in agriculture. *Carbon and Cropping* includes definitions and explanations of terms, soil carbon and farming practices, carbon markets, reducing carbon footprints and an extensive list of additional resources. While intended for grain growers, potato growers will find this highly useful as most material is non-specific. Either an excellent starting point on your carbon journey, or to broaden and deepen understanding of the myriad elements of sustainability, this is 40 pages of clear concise information for non-experts, with good graphic elements to aid understanding:

https://www.graingrowers.com.au/wp-content/uploads/Carbon-and-Cropping-September-2021.pdf

Rabobank Research Food & Agribusiness: It's Australia and New Zealand *podcast* features research analysts discussing what's setting the pace for global sustainability transitions, including drivers such as consumer preferences and government policy responses in the EU, US and other overseas markets. Although focused on grains, dairy and other food commodities, the perspectives in each episode are valuable to all players involved in food production, particularly on the increasing importance of carbon management for continued access to markets and finance. While rarely potato specific, sustainability issues as drivers of market changes have application to food growers, as do episodes addressing recent fertiliser and land price surges. Download from your preferred podcast supplier.

PotatoLink has hosted a series of *webinars* on sustainability related topics:

https://potatolink.com.au/

Soil Wealth is another project, with many applications for potato growers:

https://www.soilwealth.com.au/

CARBON NEUTRAL POTATOES

Potatoes and sustainability go hand in hand, not only because carbon neutral potatoes are now for sale in the UK, but because they punch above their weight compared with other food staples when it comes to environmental impact.

The first carbon neutral potatoes hit supermarket shelves in October 2021.

However, potatoes are also being recognised more widely for their lower environmental impact compared to grain crop staples.

Potatoes have proven themselves an efficient and sustainable source of calories. A World Potato Market report says potatoes will play a major role in feeding the world, using fewer resources and requiring less land than other foods.

High yields per hectare contribute to potatoes scoring well on environmental impact. Potatoes produce less carbon dioxide, leach fewer nitrates and require less water to grow than legumes, wheat or rice.

With yields commonly 50t/ha, they need about a quarter of the area required for similar volumes of rice and far less than needed for legumes.

The volume of protein produced has been estimated as between 354 kg and 417 kg/ha, based on 2.05 g of protein per 100 g and average global yields of 17.3 t/ha (EAT Forum), or 20.33 t/ha (UN FAOSTAT). However, Australian yields are up to three times this, making potatoes an efficient source of protein compared to other staple crops.

Research on environmental impact by the Barilla Center for Food & Nutrition

HUW Thomas, MD of Puffin produce UK

calculates that the carbon dioxide emission of potatoes is 1,205 g per kilogram produced, compared to 1,660 g for legumes and 3,755 g for rice. Another analysis found that eating potatoes three to five times a week results in greenhouse gas emissions of 9 kg a year, compared to 69 kg for rice, 25 kg for pasta and 12 kg for bread[11].

The analysis points to a good future for potatoes as an efficient source of nutrition, while growers are well placed to benefit from the sustainability of their crop.

Meanwhile, in Wales, the carbon neutral potatoes grown by Puffin Produce and sold under its Root Zero brand, are now available in 400 Co-op and Waitrose stores across the UK, with plans to expand further.

The potatoes are certified carbon neutral, and grown using sustainable farming practices which remove carbon dioxide from the air, create healthy soil and increase local biodiversity.

Managing director of Puffin Produce, Huw Thomas, says: "We have to act now, so we're on a mission to become carbon neutral and farm in a way that protects and regenerates our land, plants and wildlife."

Sustainability measures include consideration of power used on the farm, transport to the supermarket, eco packaging components, and even how customers cook their potatoes.

Based on its footprint assessment, Puffin Produce has set a target to reduce the carbon intensity of Root Zero potatoes by 51 per cent by 2030, including emissions from the entire supply chain as well as carbon offset investments.

[1] https://www.bbc.com/news/science-environment-46459714

THE DEVELOPING CONNECTION BETWEEN BANK LOANS AND CARBON

Agribusiness lenders are taking a keen interest in sustainability, while also looking at practical ways to support growers embarking on carbon management journeys. These factors are likely to become more important when it comes to accessing capital on optimal terms, writes **Linda Drake**.

Unless you're dealing with a loan shark, lenders will always want to know about your business before providing a loan. This information is increasingly going to include sustainability criteria.

At this stage, it's less about any action you've taken, and more about early planning on how you could either reduce emissions, or earn carbon credits.

It's yet another reason why growing sustainably will make a difference to your bottom line.

For lenders, this is seen as good business. The country's biggest agribusiness lender, National Australia Bank, holds about 30% of the Australian market, followed by Netherlands based Rabobank at 20%. They are among many banks globally now actively linking sustainability outcomes on farms to lending risk, with teams working on developing tools and resources to support clients.

RABOBANK

Rabobank's head of sustainable business development, Crawford Taylor, says: "We need to think about what we don't know about a client."

"The first step for a farmer is to understand their own emissions, and take time understanding this before formulating anything else. Establish a baseline, work out what the drivers are and what this means for opportunities."

Good record keeping, tracking inputs and keeping data that measures the farm's emissions are the absolute starting point. There is also interest in supporting emission reductions and carbon offsetting activities on farms.

"We really need to understand where the clients sit, look at solutions and take a collaborative approach," Crawford says.

Lenders are also being influenced by customers who want to know more about the carbon footprint of their food, already a strong driver in other countries that have greater commitments to being carbon neutral by 2050. Wholesale funders to banks also want information about the sustainability of their exposures. For example, there are moves to include climate risks within business financial statements.

"While it's important for investors, eventually it will track down to inside the farm gate," Crawford says.

Agriculture is expected to be a heavy lifter in Australia to reach its carbon goals, with a strong reliance on soil

Crawford Taylor, Rabobank's head of sustainable business development

Julie Rynski, regional and agribusiness executive at NAB. - ATN

carbon to meet these outcomes. Cost considerations, and concerns about climate variability, could make this challenging.

"There is so much work in where and how to implement effective and efficient farm practices," he says.

Developments such as cheaper soil testing, or appropriate carbon calculators would make this easier, he says.

In other agricultural commodities, there's already a stronger link to carbon management and access to markets, as has been seen with canola exported to Europe. It is expected that accessing capital for farming business investment will increasingly be based on sustainability criteria across many sectors.

NATIONAL AUSTRALIA BANK

NAB has partnered with the Food Agility Co-operative Research Centre, with an aim to provide practical guidance to farmers on how they can use climate and sustainability research to make science-based, commercially considered decisions about where to invest their time, effort and money.

NAB executive for regional and agribusiness, Julie Rynski, says there's a vast amount of scientific research on sustainability and adaptation, but it's difficult to translate into practical guidance.

"Many of our agribusiness customers are telling us they experience 'analysis paralysis.' When it comes to adapting their business practices, they feel overwhelmed with the research and don't know where to start," Ms Rynski says.

"We play an important role in supporting customers on ways they can improve the long-term sustainability and viability of their business".

"Many of our agri customers recognise the importance of transitioning to a low carbon economy. We want them to have practical guidance on how to use less water and chemicals, or how to reduce emissions as an example. Ultimately, it's about building resilience for the long-term."

WHY ACT NOW?

On the market driven side, food companies are among those announcing ambitious carbon targets. They will be looking increasingly at suppliers' efforts to meet their own sustainability goals.

McCain Foods says regenerative agriculture will be the foundation of its approach and by 2030 all potatoes that it turns into fries will be sourced from farms using regenerative ag practices. McCain's global sustainability report, *Together, Towards Planet-Friendly Food* says it will implement regen ag practices across 100% of its potato acreage - representing 150,000 hectares worldwide by the end of the decade.

PepsiCo says it aims to impact 2.8 million hectares of farmland and reduce an estimated 2.7 million tonnes of greenhouse gas emissions, also by the end of the decade. PepsiCo also aims to improve the livelihoods of more than 250,000 people in its agricultural supply chain and sustainably source 100% of the company's key ingredients by 2030. "Taking action in the next decade is crucial for the development of a more sustainable, resilient and inclusive food system," it says. A recent innovation in the UK includes using potato peel left over from making Walkers crisps into low carbon fertiliser for potato growers to use in their fields. PepsiCo is buying oats in Western Australia on the basis of rigorous sustainability credentials, an early example of looking towards its supply chain to meet sustainability goals.

Coles has taken the approach that customers and stakeholders want products that are sourced in an ethical, transparent and responsible way. It's strongly signalled its intent to meet robust sustainability targets on carbon emissions within its operations. Seafood and tomato production have been at the forefront of its efforts in sustainable sourcing of products so far, as well as a move towards locally grown produce.

Woolworths says that by 2022, in collaboration with its farmers, suppliers and other partners, it will carry out and publish a review of the potential for adopting sustainable and regenerative agriculture practices across its fresh food supply chain. The aim will be to improve areas such as soil health and water efficiency in high-risk areas, and it will provide an annual update on implementation actions.

Institutional investors include superannuation and overseas pension funds. They are looking for ways to meet their sustainability commitments in line with member expectations and investment mandates. With long-term investment horizons, funds are increasingly recognising the importance of sustainable agricultural production, agritech and initiatives encouraging soil carbon and soil sequestration. North American and European pension funds already view agriculture-based and natural capital assets in Australia as an important asset class with high potential for growth in future, as well as an important risk mitigation strategy by diversifying exposure to investments outside the northern hemisphere.

POTATO 'MILK' GOES ON SALE

Caption: DUG finds a niche among plant-based milk products *- Juliet Garland*

Coffee with DUG? A potato 'milk' called DUG has joined the range of plant-based milks now available in Australia.

Stocked by Panetta's Mercato in Sydney, and increasingly available through supermarkets in the UK, Sweden, and via Amazon, it sells locally for $6 for a one litre carton.

The milk is targeting consumers wanting good froth for their coffee while also having strong eco credentials.

The milk is made by combining pressed potatoes with canola oil, under a patented process developed in Sweden by Professor Eva Tornberg at Lund University.

A key quality of the product is that it can be used like any other milk and doesn't separate when added to hot drinks, including tea and coffee, which is a problem with some other plant-based milks when used for cooking or baking.

The details on how the milk is manufactured remain a trade secret, but the product is making solid inroads into the strongly growing UK plant-based milk segment where its sales have been a standout performer for premium brand focused supermarket Waitrose.

Growth has been driven by strong awareness among consumers of the carbon and energy footprints of other plant-based milks, as well as concerns about the environmental and animal welfare issues related to commercial dairying.

Founder of parent company, Veg of Lund, Thomas Olander, says: "Our choice to use potatoes as a base means we have a super sustainable drink."

DUG claims growing potatoes is twice as efficient for agricultural land use as growing oats in the same space. Oat milk is now one of the most popular plant-based milk drinks. It also claims that potato milk has a 75% lower climate footprint than dairy milk. Moreover potatoes use 56 times less water than growing almonds, which are also popular when processed into milk form. Almond milk takes about 130 litres of water to produce one glass.

The potato milk product was launched in Sweden in last year, and was initially sold online to the UK, before increasingly being stocked by retailers in other countries.

So, what does it taste like? Rachel Redman, marketing manager of Veg of Lund, says it has a balanced taste.

"DUG has a really neutral taste profile. This is one of its major strengths compared to other milk alternatives, which all have quite a distinctive taste that can affect whatever they are mixed with," she says.

The texture is similar to other creamy milk alternatives, with enough foaming potential for coffee.

"The milk is nutritious, low in sugar and saturated fat, and free from 14 of the most common allergens, like lactose, soy, gluten and nuts," Ms Redman says.

DUG is available in three versions: original, barista and unsweetened.

https://dugdrinks.com/

BLACK DOT

(*Colletotrichum coccodes*), the elusive disease

Dr Julie Pasche (North Dakota State University) calls black dot the Silent, Early Yield Robber. Silent because it is often confused with other diseases, and Early because infection that occurs early in the season has lasting effects on both yield and quality.

Black dot is a widespread disease caused by the fungus *Colletotrichum coccodes*. While known since the 1920's, it was seen as a weak soil pathogen of little economic importance. However, it is now recognised as a significant pathogen in Europe, the Americas, the Middle East, Africa and Australia.

Yield losses can be considerable, especially as early infections of black dot can make plants more susceptible to damage from other diseases. There is also a strong association between *C. coccodes* infection and early dying.

Symptoms of black dot infection may not appear until relatively late in the season, or remain hidden right up to harvest. Despite this, significant yield loss can still occur.

Infection stunts plants and can cause wilting and premature senescence. In Australia this has been shown to reduce yields by at least 12%[1], with similar results reported from the USA and Israel[2]. Not only is total yield reduced, but the percentage of small tubers tends to be increased.

While symptoms may not be visible at harvest, they can develop during storage. Fortunately, the disease does not spread between stored tubers. However latent infections can develop and expand, especially under humid conditions.

While symptoms on tubers are often superficial, infected tubers lack the smooth, attractive skin finish consumers want. This is a big problem for packed ware potatoes, which are likely to be downgraded if not rejected outright. Moreover, disease that develops during storage can penetrate deeper into the flesh, resulting in problems for processors.

SPOT THE DOT

One factor that has limited recognition of the scale of black dot related problems is that it is so easily mistaken for other diseases. Symptoms on the tubers are often mistaken for silver scurf (*Helminthosporium solani*), while rots on leaves can resemble Early blight (*Alternaria solani*) and diseased stems misidentified as Fusarium wilt.

The key to identification is the presence of tiny, dot like sclerotia (resting structures) on the tubers, stems and leaves (Figure 1). These can be seen with a hand lens and are quite different to the "Christmas tree" conidiophores of silver scurf. Other key identification factors include:

- Internal tissues in the roots turn a reddish-purple, amethyst colour (Figure 2)
- Outside of the main stem detaches from the inner core, so can be easily rubbed away
- Watersoaked lesions on leaves that turn dark brown to black
- Leaf lesions that tend to be darker than those of early blight, and lack concentric rings (Figure 3)
- Reduced growth and rotting of underground stems and roots
- Discoloured areas are frequently over the heel end of the tuber, including roundish spots >5mm diameter
- Discoloured areas / spots have diffuse edges, compared to the more sharply defined margins characteristic of silver scurf (Figure 4)
- Discoloured areas have a dull appearance, whereas silver scurf spots tend to be shiny
- Dead stems collapse, rather than remaining erect, as is typical of verticillium wilt
- Infected stems eventually turn black to grey due to the large numbers of sclerotia emerging from them

Associate Professor Julie Pasche from North Dakota State University has considerable experience in managing black dot. She recently presented an excellent webinar on the disease for the Ontario Potato conference. This included a number of the specific identifiers for black dot which allow it to be differentiated from other diseases.

"Black dot often infects tubers from

Figure 1. Black dot results in formation of tiny dot like black sclerotia (spores) on stems and tubers - *Photo left: Ontario Crop IPM*

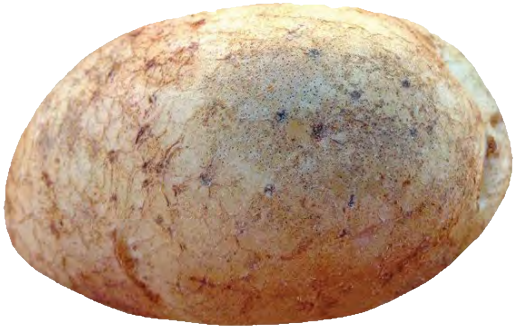

Figure 2. Roots are stunted, and both stems and roots can turn a purplish colour - *Photo: Ontario Crop IPM*

Figure 3. Leaf lesions lack the concentric rings typical of early blight - *Photo: J. Pasche*

Black dot

Silver scurf

Figure 4. Black dot lesions (left) tend to be duller and more diffuse than those of silver scurf (right) - *Photo: J. Pasche*

Figure 5. Infected stolons tend to hang onto tubers after harvest *- J. Pasche*

the stem end. The stolon then tends to hang on after harvest, like a 'piggy tail' (Figure 5). You can often see the black sclerotia on that tail, and if you cut the tuber open you can see the discolouration spreading through the tuber vascular system. Infection can exacerbate sugar end development, with dark colour at the stolon end after frying" explained Julie.

THE LIFE OF FUNGUS

The most common source of infection is sclerotia in soil. Sclerotia build up over successive potato crops and can remain viable in the soil for at least eight years. High concentrations of sclerotia in soil are associated with high rates of infection in plants. Infection can occur within days of planting, especially under moist conditions. Frequently, however, the disease is initially detectable on above ground stems, but soon spreads to all parts of the plant (Figure 6).

C. coccodes does not restrict itself purely to potatoes, or even just to Solanaceae. The fungus has more than 50 hosts from 17 plant families. While most commonly found in plants such as tomato and capsicum, it can also infect strawberries, cucumbers, mint, canola and legumes (such as soybean) among many others. Barley, maize, wheat and rye are some of the alternate crops that could be used in rotations and which have been shown to be non-hosts[3].

Even without a host, black dot sclerotia can survive for many years in the soil and are resistant to soil fumigation. The amount of sclerotia

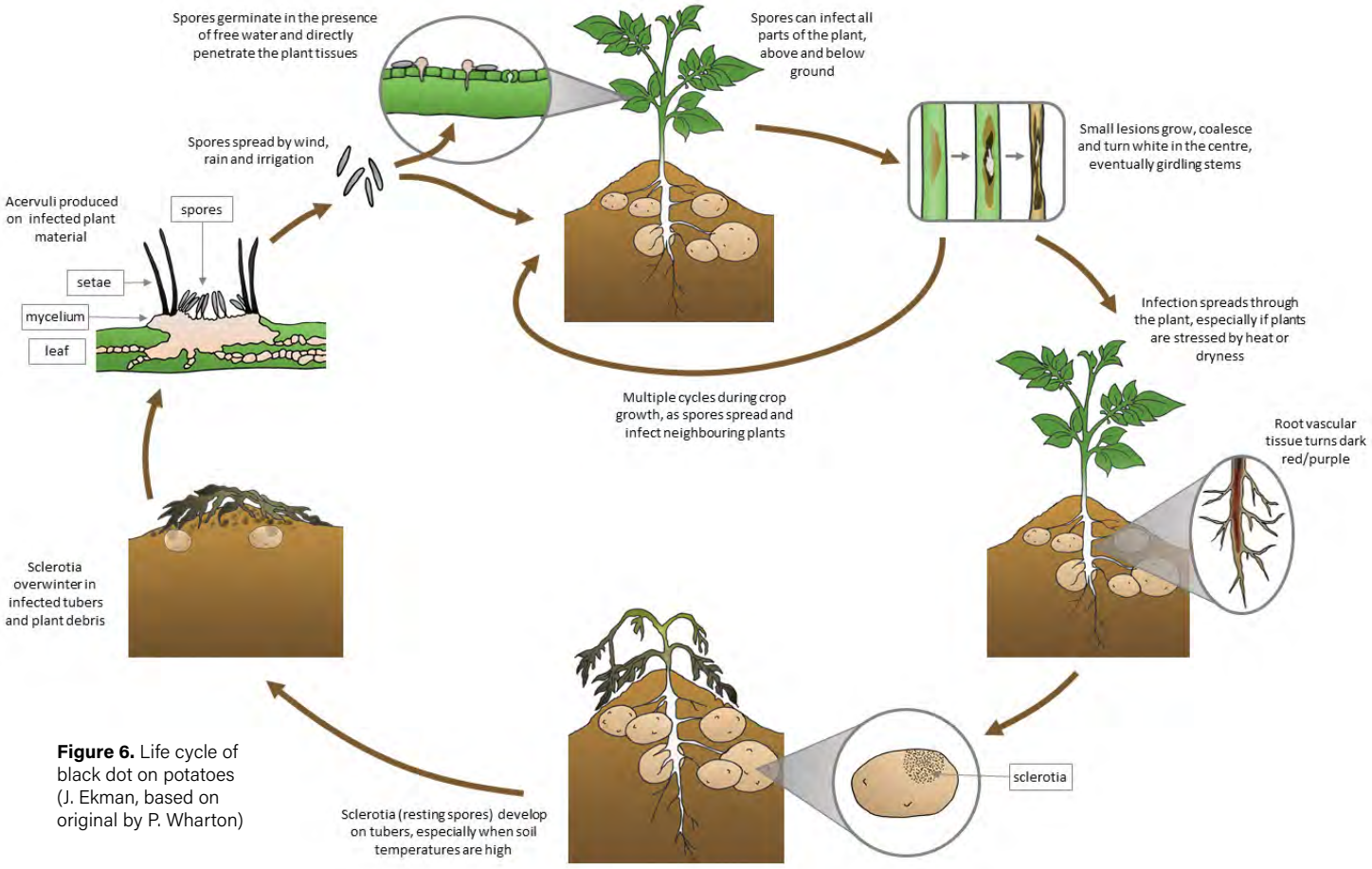

Figure 6. Life cycle of black dot on potatoes (J. Ekman, based on original by P. Wharton)

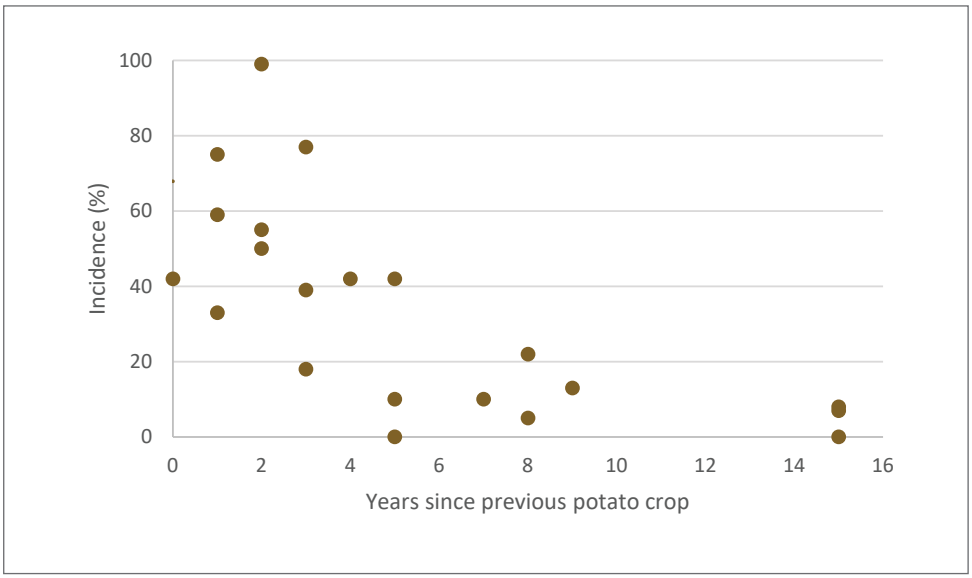

Figure 7. Incidence of detectable black dot on skins of stored Norkotah potatoes relative to the number of years between potato rotations. Data from Johnson and Cummings, 2015.

in the soil increases with continuous potato cropping, as does the incidence of infected tubers (Figure 7). While rates of infection decline if no potato crops are sown, it can take 5 years or more to reduce incidence below 40% if the soil was initially highly infected[4].

Despite this, black dot is generally a weak pathogen that may be resisted by healthy and undamaged plants. However, the presence of wounds – such as those created by windblown soil or sand – aid infection. This is most likely to occur before row closure, when stems are still exposed. The tiny sclerotia carried with the soil can then infect the plants.

REDUCING RISK

Plant stress, especially due to nutrient deficiency, makes plants more vulnerable to infection by the black dot fungus. Low levels of nitrogen and potassium are particularly associated with increased disease[5]. Stress can also be caused by excessive or uneven irrigation, both of which also increase black dot severity, as can co-infection with pathogens such as *Verticillium dahlia* (verticillium wilt) or *Spongospora subterranea* (powdery scab).

As the amount of inoculum in soil is an important determinant of infection, avoiding heavily infected areas is an important risk reduction strategy. The Predicta PT service can provide an indication of the disease risk in soil, based on DNA testing. Predicta PT is also available for seed, although in this case results indicate population density only, rather than risk.

Young plants need to be protected from coarse, blowing sand, especially if the pathogen is known to be present, as this is very likely to increase foliar infections.

In high risk situations (such as high inoculum levels in soil), early harvest can reduce both initial severity and

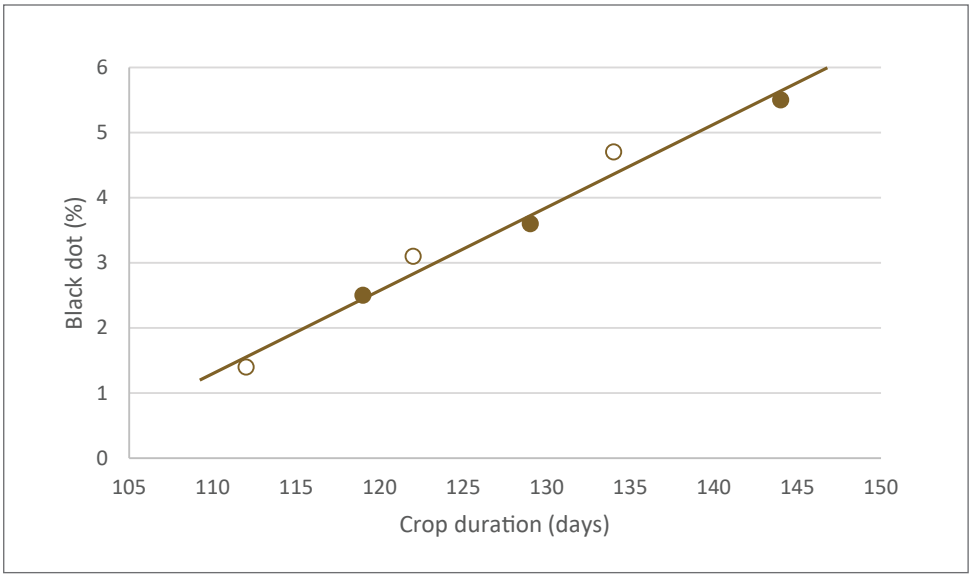

Figure 8. Mean black dot severity (% surface area) on Maris Piper potatoes harvested after different crop durations plus 20 weeks storage. Crops were harvested 21 days (o) or 28 days (•) after vine termination. From Peters et. al., 2016.

that developing after extended (20 weeks) storage[6] (Figure 8). For example, delaying harvest by 2 weeks increased the percentage of tubers with black dot by 10% to 40% in UK trials[7].

Unlike many other potato pathogens, *C. coccodes* grows well at warm temperatures. The optimum temperature range for germination and infection is 22 to 28°C. This means it is favoured by warm to hot conditions. Even in temperate regions, periods of unusually high temperatures have been associated with high incidences of black dot[3].

Dr. Julie Pasche usually recommends an application of a QoI (Strobilurin) fungicide at the mid-rate early in the season. "The key to effective control is to apply fungicides before row closure, as this will protect against infections caused by pathogen-infested soil blowing against plants. In-furrow applications of an SDHI (Group 7) fungicide may provide additional benefit under high disease pressure situations. In organic systems, the biological Serenade may be beneficial as an in-furrow application.

UK trials have also shown that application of Azoxystrobin in furrow at planting is effective at reducing incidence of black dot[7]. However, Azoxystrobin is not registered for this purpose in Australia.

"Crop rotations are a useful control strategy, so we recommend at least three years between potato crops. Reducing plant stress with an effective fertiliser program is also a good strategy. While black dot can be seed borne or soil borne, soil seems to be the most important route of infection. We don't believe that seed treatment fungicides effectively reduce black dot" she said.

In conclusion, managing black dot should not rely on fungicides alone. Rather, an integrated approach that includes risk assessment, accurate management of irrigation, fungicides and early harvest can all contribute to reducing the impact of this elusive disease.

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THE CASE OF THE BRUISED POTATO

Everybody loses if the potato bruises.

Harvest is where everything that has been put into the crop comes together. It is the culmination of months of investment in soil preparation, feeding, watering, protecting and nurturing. Harvest for many growers is the last, critical piece of the puzzle, where value is finally realised.

Damaging the potatoes during harvest is surely snatching defeat from the jaws of victory!

Physical damage not only reduces eating quality of the tubers, it increases water loss and makes tubers more susceptible to rots and disease. In some cases, damage can make potatoes completely unsuitable for the target market.

External injuries are obvious. These include cuts as well as shatter bruises, which appear as cracks on the tuber skin. The cracks can extend into the core of the tuber, making an easy entry point for fungi and bacteria.

Skinning can also occur, where potatoes are harvested before the skins have fully matured and hardened.

Rubbing by machinery, soil clods or simply other tubers removes the outer layer of skin. As with cuts, this makes it easier for pathogens to gain entry, as well as allowing dehydration.

However, internal bruising – blackspot – is harder to detect. Not only is blackspot not visible from the outside, but the damage does not appear immediately, rather developing over time.

WHAT IS A BRUISE?

Potato bruises develop due to impacts that either break the cells apart (shatter bruise) or rupture the cell membranes (blackspot).

While shatter bruises are straightforward to understand, blackspot is a little more complex.

Phenolic compounds inside potato cells are normally kept separated from reactive enzymes by internal cell membranes. If the membranes are ruptured, the two mix together and oxidise (Figure 1). Oxidation of the compounds that develop (ortho-quinones) ends in formation of the pigment melanin – essentially the same pigment that tans our skin and colours our hair and eyes. This is why bruises develop the black-brown colour we are so familiar with.

The potato skin is made up of relatively small, corky cells that resist damage. However, the swollen, starch laden cells that make up the pulp are more fragile. As the force of the impact

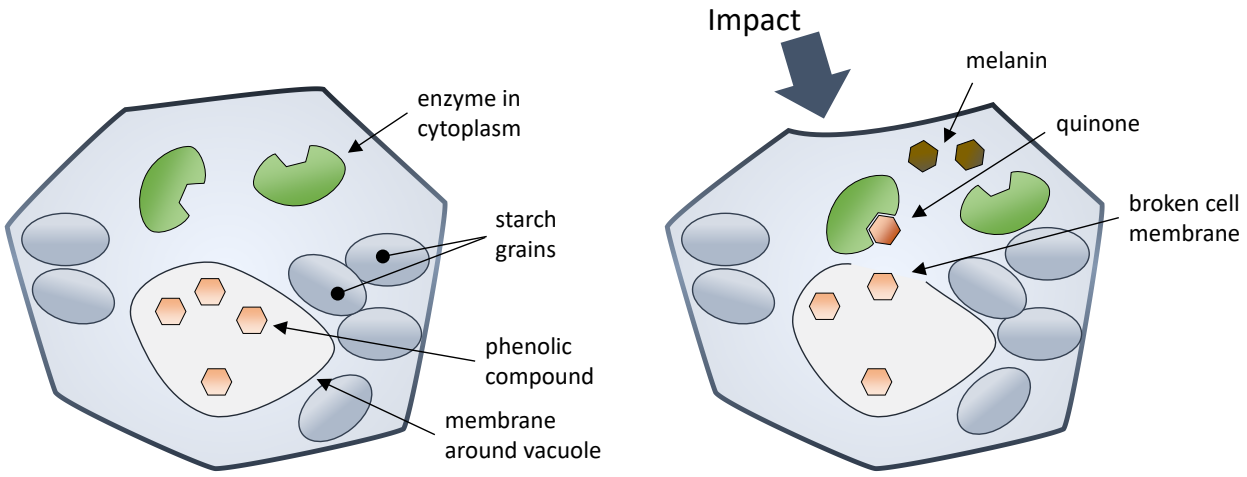


Figure 1. Intact potato flesh cells (left) contain phenolic compounds and oxidising enzymes, kept separate by internal cell membranes. An impact (right) can rupture this internal membrane, allowing mixing. Through oxidation, this eventually gives rise to the dark compound melanin, typical of blackspot.

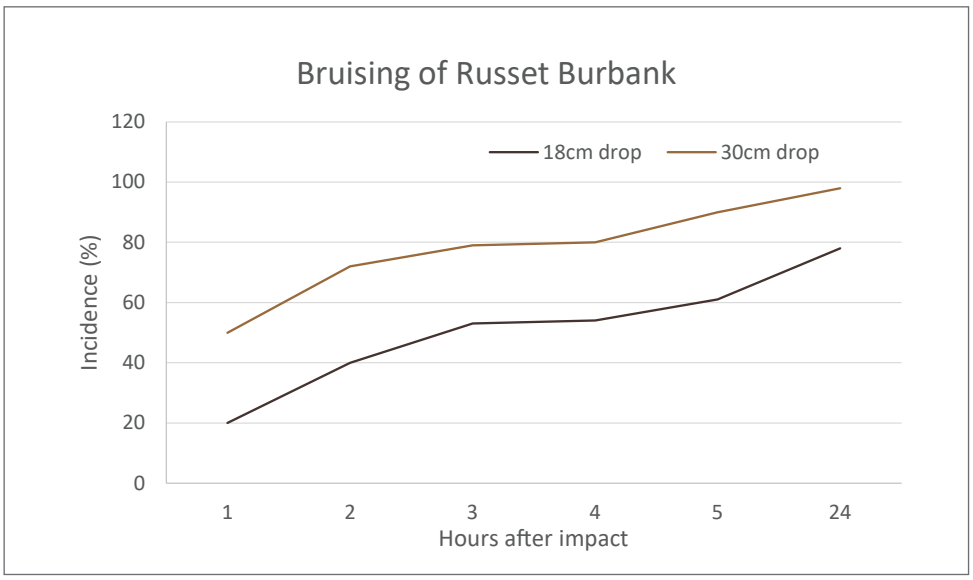


Figure 3. Blackspot development in Russet Burbank potatoes. Data extracted from Olsen and Thornton.

Figure 2. Blackspot development after 1, 2, 3 and 4 hours.

transfers from the outside to the inside of the tuber, it is the membranes of these cells that fracture most easily.

The reaction that produces melanin is not instantaneous, so bruises continue to darken over hours or even days (Figure 2). Initially, the damaged area develops a pinkish colour – possibly due to formation of ortho-quinones from the oxidised phenolics. This gradually oxidises into melanin, with the intensity of colour directly relating to the amount of phenolics and enzymes initially present in the cells.

Just as phenolic content varies between cultivars, so does the speed at which the bruise expands and darkens. Temperature and impact force also play a role. For example, Olsen and Thornton (University of Idaho)[1] found that bruises developed more slowly on Russet Burbank than Ranger Russet, and more slowly at cold temperatures than warmer ones. Despite this, most internal bruising became obvious within 3-5 hours of impact (Figure 3).

WHAT IS THE IMPACT THRESHOLD OF POTATOES?

Resistance to both shatter bruises and blackspot varies considerably between cultivars. The issue is compounded by factors such as soil moisture, temperature and specific gravity. So, for example, high specific gravity reduced bruising susceptibility in Snowden, but increased susceptibility in Russet Burbank and Atlantic[2].

Depending on their structural qualities, a variety may be relatively resistant to blackspot but susceptible to shatter, or vice-versa. For example, Russet Burbank is generally less easily damaged than Ranger Russet, while Shepody and other chipping varieties may be resistant to blackspot but susceptible to shatter bruising[3].

Temperature is also important. In general, temperatures between 12 and 18°C are often considered best for harvesting potatoes. Potatoes are less susceptible to bruising at such moderate temperatures than if they are either hot (>25°C) or cold (<12°C). This is reflected in the drops that can be tolerated.

Temperatures of dry soils are more likely to approach air temperatures; under warm conditions, soil (and the tubers it contains) can be cooled through more frequent irrigation.

Irrigating a few days before harvest also ensures tubers are well

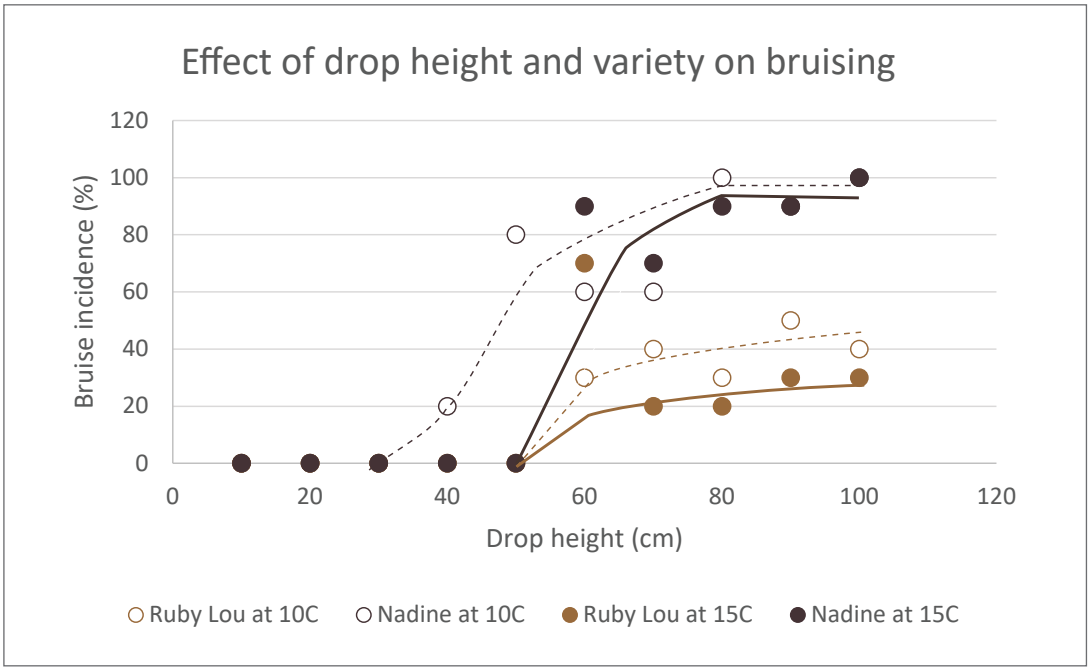


Figure 4. Incidence of bruising of Nadine and Ruby Lou potatoes dropped 10–100cm at either 10°C or 15°C. Lines indicate approximate best fit to data, except for the outlying value at 60cm for Ruby Lou. Data from Dawson and Johnstone, 2016.

hydrated, another factor that reduces susceptibility to bruising. However, there is a downside, as very high levels of soil moisture can make potatoes more susceptible to shatter bruising. The general recommendation is that soils should contain 60–80% available soil water at harvest.

Mathew and Hyde[4] estimated that the drop heights (onto steel) that were likely to cause a blackspot bruise in 10% of Russet Burbank tubers were 25, 30 and 50mm at tuber temperatures of 10, 15.5 and 21°C respectively. While this suggests that 21°C is optimal for harvest, the risk of increased disease at this temperature (and higher) likely outweighs any possible benefits from reduced blackspot.

Western Australian researchers[5] conducted similar tests on Ruby Lou and Nadine potatoes. One of the aims was to link bruise damage at 10 and 15°C to impact forces recorded using a "SmartSpud" (Sensor Wireless Inc.) datalogger. The SmartSpud contains an accelerometer and is used to record impacts during harvest and handling.

More on the SmartSpud, and other similar devices, on p25.

In the WA work, Nadine proved to be more easily bruised than Ruby Lou, with a trend to increased damage at 10°C compared to 15°C (Figure 4). One thing that is clear from these results is the increased bruising of both types, regardless of temperature, once heights exceeded 50cm. This corresponded with a value of 218G recorded with the SmartSpud. In contrast, Royal Blue tubers were more susceptible to bruising than either of these other varieties, with 10% of tubers damaged by a mere 30cm drop.

WHAT CAN I DO TO REDUCE RISK?

LOTS! There are two broad strategies for preventing blackspot:

1. Improve resistance to damage and

2. Avoid mechanical injury.

Elements of these strategies begin even before planting[6].

Improve resistance to damage

- Choose varieties with low susceptibility to bruising
- Don't over fertilise with nitrogen, especially late in the season: High vine nitrate readings are associated with increased susceptibility to blackspot
- Manage the crop to keep it as uniform as possible (e.g. through effective management of irrigation and fertiliser)
  - Uneven growth will result in under mature/overmature tubers, which are more prone to damage
  - Uniform stands also mean uniform flow through the harvester, reducing impacts on hard surfaces
- Control diseases that can cause premature vine death, as affected crops will have varying levels of maturity
- Kill tops before more than 50% of vines have died and wait at least 14 days before harvesting
- Avoid harvesting during hot conditions; consider harvesting in the early morning, when the air and soil are coolest
- Ensure soil is moist at harvest,

Figure 5. Devices for measuring impacts during potato harvest and packing: From left the Series 500 IRD (Techmark, USA), TuberLog (Esys, Germany) and Mikras (Esys, Germany)

especially if the weather is hot

- Well hydrated potatoes are less easily bruised
- Irrigation will drop the soil temperature below that of the air, cooling the tubers and reducing blackspot susceptibility
- Irrigation helps soften clods
- Damp soil will move more easily through the harvester

- If harvest must be carried out at high temperatures, consider how the tubers can be cooled to remove field heat
  - If potatoes stay warm during transport to a processing facility or storage, moisture loss can be high and diseases such as bacterial rots increase dramatically
  - Tubers that remain warm are physiologically older, reducing the quality of seed crops

Avoid mechanical injury

- Use cover crops or rotations that improve soil organic matter and deep rip to break up hard pans, as this will reduce crust formation and creation of damaging clods
- Further reduce clod formation by avoiding ploughing, discing or cultivating soil while wet
- Remove rocks and stones from the field
- Angle the digger blade at the front of the primary conveyor so that tubers are lifted onto the chain/web, not jammed into it
- Adjust the harvester speed so that the conveyors are kept around 85% full
  - If speeds are too slow, tubers will pile up and be forced against the sides
  - Too fast and tubers can roll around, hitting more hard surfaces
  - Suitable conveyor speed to ground speed ratios are estimated at 1.0 to 1.2 in sandy soil, but 1.2 to 1.5 in heavier soil[4]
  - Adjust other conveyors according to yield, increasing speed if picking up a windrow, while minimising rollback of tubers
- Cover conveyor support bars with padding to reduce impacts
- Use deflectors to divert tubers away from the sides of the de-viner, chain link ends and sorting table
- Minimise use of agitators and conveyor shakers to dislodge soil
- Minimise drops between different conveyors, particularly from the end of the boom conveyor into the truck, trailer or bins

The easiest way to find out where damage could be occurring is using an impact recorder, such as the SmartSpud already noted. Once identified, the drop may be reduced and/or cushioning added. Running the recorder through the line again can show whether the modification has been successful.

OK, I SEE THE VALUE – BUT WHAT IMPACT RECORDER SHOULD I GET?

The SmartSpud is not the only such device on the market, nor is this new technology, having been around since the 1990's.

The original impact recording device or "IRD" (Techmark USA) was a sphere designed to simulate an apple or onion. (Figure 5) This device is now sold in a range of shapes and sizes, and can be custom made to resemble anything from a blueberry to an egg to large processing potato (https://www.techmark-inc.com/impact-recording-device---ird.html).

Another option is the TuberLog (Martin Lishman) (Figure 5). Simlar to the SmartSpud, Tuberlog consists of an accelerometer embedded in a synthetic case that mimics the size, shape, density and movement of a ware potato. One difference between the TuberLog and other devices is that data is transmitted instantly via bluetooth, making it easy to see exactly where the damaging impact has occurred.

A final potential candidate is the Mikras logger (Figure 5). In this case the logger is supplied in a simple case. The user hollows out a cavity in whatever product is being handled, whether an apple, carrot, cucumber or potato. The advantage of this is that the user is measuring real impact on an actual potato. The disadvantages are that A. Not being brightly coloured, the device may be difficult to find and B. The "casing" needs to be replaced very often.

A group of German researchers compared these devices[7]. Interestingly, the IRD, TuberLog and Mikras (inserted in a synthetic case) all overestimated impacts onto a metal plate compared to the Mikras sensor implanted in an actual potato. However, the artificial potatoes were fairly accurate when dropped onto PVC or rubber cushion.

The SmartSpud recorded both fewer impacts and smaller impact values than the other devices, suggesting this device may actually underestimate potential impacts.

All of the impact recorders could provide information about where impacts were occurring during harvest and packing.

However, the authors noted that each one needs to be compared against real potatoes to understand what measured impacts could be actually causing damage.

SMARTSPUD PROVIDES QUALITY IMPROVEMENT INSIGHTS IN WA

By Georgia Thomas, Senior Project Manager, WA Potatoes

Following a successful application for funding to the Agriculture Produce Commission, Potato Producers Committee in 2020, the Potato Growers Association of WA (PGAWA) purchased a SmartSpud device for industry-wide use.

The SmartSpud is an electronic potato shaped device (pictured in a recent test) used to measure the damage caused by impacts potatoes receive during processing and transport to pinpoint and fix root causes. It does this by measuring the G-Force produced on the unit during harvest, sorting, washing or transport.

WA growers and packers are using the device to help discover where bruising, shatter damage and black spots might be occurring to assist increase potato quality and pack out.

The device was ordered from Masitek in Canada and arrived in late 2020. Upon receiving the device PGAWA staff undertook training in its use and how to interpret reports. The team then started practical training, testing the device on a wash packing line and then during harvest on-farm.

The initial trials highlighted the need for further fine tuning to troubleshoot a few issues. As such, staff have been liaising with Masitek to work through updates which are ongoing.

The trials also highlighted the wide-ranging use for the device and the opportunities for industry to make the most of the investment.

According to the manufacturers, the SmartSpud can reduce bruising and damage by up to 50%. Other benefits include:

Improve line efficiencies, targeting downtime and maintenance.

Test new equipment in quick time.

Measure levels of damage through all stages of processing.

Make data-driven decisions

Following initial testing and training a User Agreement was developed for WA potato industry members to access the device. The agreement requiring members to undertake training so they can use the device effectively.

Figure 6. The SmartSpud consists of an accelerometer mounted inside a potato-shaped urethane capsule.

The device has already been used to investigate impact points in a wash packer process, and in August this year commenced on-farm testing of the harvest process.

David Anderson, Supply Manager for Beta Spud has been running the device in a range of settings and locations.

"We have had the opportunity to use the device from the outset and have so far been running trials across several farms and in our wash packing facility. The information we have

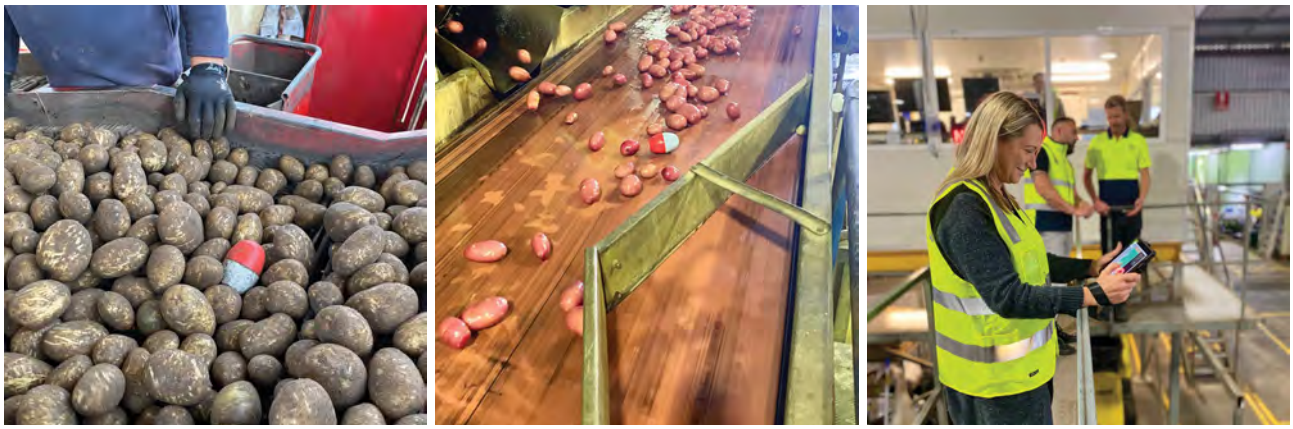


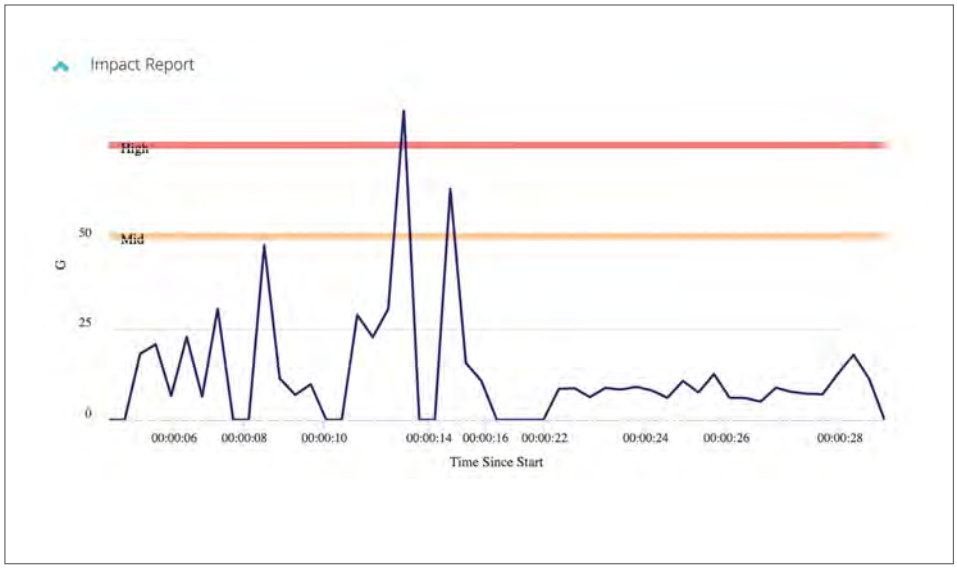
Figure 7. Initial testing of the SmartSpud on farm and at Beta Spud's packing facility, with progress monitored by Morena Perdec from PGAWA. All photos by Georgia Thomas, PGAWA.

gathered indicates that most areas on the harvester are within range. The SmartSpud has shown two minor areas that we can work on to improve quality within the packing shed," said David (Figure 7, Figure 8).

Moving forward, the PGAWA continues to support industry with training and use of the device with the goal of achieving incremental quality gains.

"As more growers take advantage of the device, more knowledge can be gathered about the specific areas of focus for industry. It is as much about ruling out issues and it is discovering where more effort should be focused to find improvements," said Potato Grower Association WA CEO Simon Moltoni.

Feedback from activities have continued to be communicated back to the manufacturer to enable improvements to be made to the device in future updates.



Read more about SmartSpud at aaggrii.com/products/smartspud

Figure 8. Example of output from a SmartSpud. The two peaks indicate points in the packline where damage may be occurring.

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Dear Spud GP

I cut open a couple of tubers the other day and found that the inside was brown and soft. What is it and why has it happened?

Patty Brown

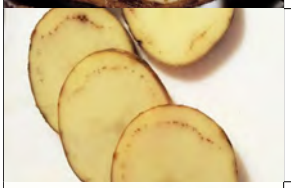
ASK THE SPUD GP

Discolouration of the internal tuber tissue is most often a disorder caused by environmental conditions. They have descriptive names such as Blackheart, Internal heat necrosis, Hollow heart, Blackspot and Net necrosis.

Some of these conditions do look similar to symptoms caused by diseases. Moreover, opportunistic microbial infections causing secondary rots in affected tubers can mask the primary cause. This means it is important to review all the field environmental conditions and clinical signs of diseases for an accurate diagnosis.

Here are some common conditions that illustrate similarities between some tuber physiological disorders and diseases.

Contact the spud GP by emailing info@potatolink.com.au

	Hollow heart – rapid tuber enlargement, moisture stress; excess nitrogen application; slight deficiency of potassium. *Photo L. Tesoriero*
	Blackheart is caused by a lack of oxygen, which can occur from waterlogging. It is also associated with temperature extremes and potassium deficiency. It may be followed by soft rot bacterial infection or Pythium Leak if symptoms develop near the stolon end or there are surface wounds. *Photo L. Tesoriero*
	Net necrosis can be caused by chilling/frost injury to the phloem tissue of the vascular ring in tubers. It can look very similar to damage caused by Potato leaf roll virus or Verticillium wilt.
	Bacterial wilt also causes necrosis of vascular tissue in tubers, but is accompanied by white ooze from affected tissue if gently squeezed. Oozing bacteria also appear on the tuber surface from eyes (called milky eye). *Photo L. Tesoriero*
	Pink rot, caused by Phytophthora erythroceptica, forms a dark line at the margin of affected tissue and has a characteristic pink colour. *Photo UNECE*
	Fusarium dry rot is often a result of damage to the tuber surface. It can occur as a secondary rot in tubers affected by Blackheart, Blackspot or Hollow heart. *Photo PotatoPro.com*

MAGNESIUM – THE FORGOTTEN ELEMENT?

Magnesium (Mg) is essential to plants. It is strongly involved in photosynthesis and transporting carbohydrates from leaves to roots, which is particularly important for tuber development. Yet, it may be overlooked within fertiliser programs focused on N, P and K.

Even if plants appear in good condition above ground, root systems are likely to be stunted if Mg levels are low. High levels of available potassium and heavy applications of calcium (e.g. gypsum, lime) can reduce uptake of Mg by the plant.

As Mg can be slowly leached, highly weathered soils are the most likely to be low in Mg. Magnesium helps to protect plants from aluminium toxicity which is more likely in acidic soils. This means that if weathered soils are low in pH, the issue is further compounded.

Getting Mg right is important to maximise yield, firmness and starch content of potatoes. Increases in starch accumulation improve specific gravity, which has direct financial benefits to processing growers. Ware growers may benefit from reductions in bruising and discolouration during transport[1].

THE POTATOLINK MG MINI-TRIAL

PotatoLinks' Marc Hinderager recently conducted a small trial on magnesium at the Canowindra demo site. The test paddock has fairly light soil (CEC approx. 8) and is under pivot irrigation.

"We applied 130 units of potassium (SOP) pre-plant and got the seed into the ground on 19 October," said Marc. "A week later I put on the first application of magnesium sulphate (Epsom salt) at a rate of 200kg/ha. This effectively added 20 units of magnesium plus 25 units of sulphur to our two 20m experimental plots".

The treatment was repeated a month later (23 November) when the potatoes were at tuber initiation

Figure 1. There were no obvious differences in growth between Mg treated and control plots (left) at tuber initiation (right)

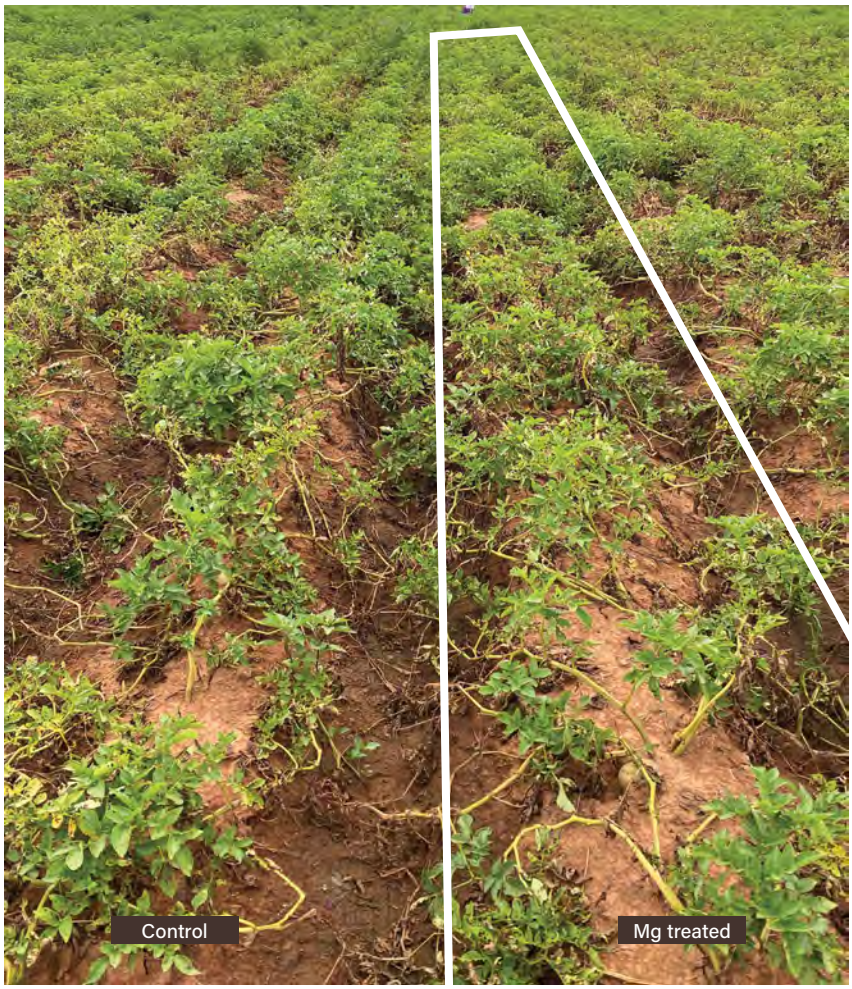
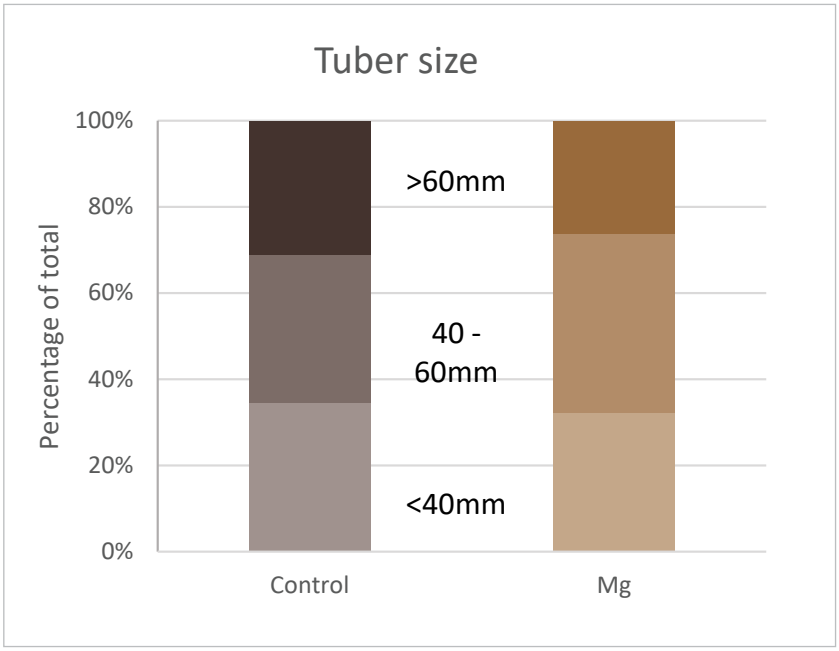


Figure 2. There were still no obvious differences between Mg treated and control plots one week before harvest



stage. This was a mid-morning foliar application with 1,500 L/ha water. While the application did not cause any foliar burn, it should be noted the weather was unseasonably cool (max 25°C).

"We harvested from our two test plots plus untreated adjacent rows on 24 January, 97 days after planting. Even though the tops had looked the same throughout (Figure 1, Figure 2), we found some really interesting differences in the tubers" commented Marc.

The total number of tubers, and the percentage of tubers within each size range, was about the same for the treated and untreated rows (Figure 3). However, reduced water rot of tubers (possibly *Pythium* or *Phytophthora*, with secondary bacterial infections) in the rows treated with Mg meant that yield was effectively increased (Figure 4).

Increased levels of Mg have previously been associated with reductions in both fungal and bacterial diseases of potatoes. Mg fertilisation has been demonstrated to improve plant tissue resistance to the pectolytic enzymes produced by bacteria, while improved transport of nutrients around the plant may enhance resistance to fungal pathogens[2].

"As you know, it's been a really challenging season with well above average rainfall" says Marc, "so the reduction in disease was great to see. Obviously, we need to repeat this on a larger scale, but still a very positive outcome."

Another interesting result was a small but potentially significant increase in specific gravity in the Mg treated

Figure 3. Effect of two applications of mag-sulphate on tuber size, incidence of soft rot, and specific gravity

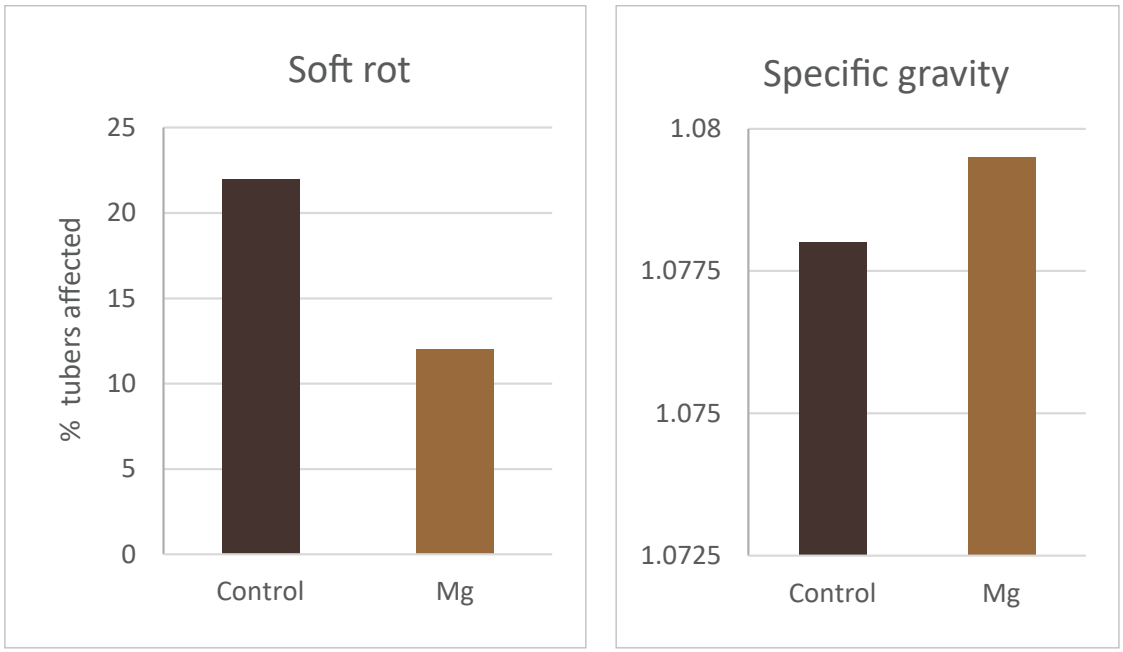


Figure 4. Effect of two applications of mag-sulphate on tuber size, incidence of soft rot, and specific gravity

rows (Figure 4). While there was a fair degree of variability between the different plots, this is consistent with published data and seems worthy of further examination.

"Mag sulphate, applied at the 400kg/ha rate we used in our demo, costs over $400/hectare, so we need to consider costs and benefits before rushing in," suggests Marc. "Depending on soil properties, other magnesium products such as calcium magnesium (dolomite), Sul-Po-Mag/K-Mag, and magnesium nitrate could be considered. However, mag sulphate is definitely the best option for foliar application."

Application of Mg is also complicated by the fact that the solubility of Mg fertilisers varies widely as does release in different soil types and bio-availability to plant roots. For example, Kieserite (magnesium sulphate monohydrate) is more bioavailable to potatoes than calcined magnesite (magnesium oxide).

In UK trials, Kieserite consistently increased both yield and % dry matter, even at sites where leaf analysis indicated Mg was within the recommended range (>0.25%). In contrast, cal-mag often had little effect, even though both products were applied at 60 kg/ha[3].

One thing that is clear is that magnesium should not be forgotten.

Rather, magnesium is essential to both yield and quality of potato crops.

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1 Senbayram M et al. 2015. Role of magnesium fertilisers in agriculture: plant–soil continuum. Crop and Pasture Sci. 66:1219-1229.

2 Huber DM, Jones JB. 2012. The role of magnesium in plant disease. Plant Soil DOI 10.1007/s11104-012-1476-0.

3 Orlovius K, McHoul J. 2015. Effect of two magnesium fertilisers on leaf magnesium concentration, yield and quality of potato and sugar beet. J. Plant Nutrition 38: 2044-2054.

EYES ON THE WORLD

Seed piece spacing for early maturing table-stock potato grown under sub-tropical conditions

Andrade MHML, daSilva ALBR, Pesantes LG, Christensen CT, Zotarelli L. 2021. Am J. Pot. Res. 98:246-254.

WHAT'S IT ABOUT?

There have been many studies comparing the effects of seed size and in-row spacing on yield and quality of potatoes. In general, planting densely increases yield, as does using a large seed size (Figure 1).

However, total yield isn't everything, and these factors interact. As seed potato spacing (SPS) increases, so do the number of large tubers. For example, research in Idaho showed total yield was relatively constant when seed size was adjusted with SPS so that tonnes seed/ha remained the same. However, the size profile shifts, with a greater proportion of small tubers at the closer planting distance.

In the Idaho study, returns on processing potatoes were maximised by planting 64g seed with 30cm SPS. In contrast, a closer SPS of 20-25cm provides the best returns for processing varieties in Florida.

However, low prices have seen many Florida growers shift to the fresh market, particularly as the spring harvest provides an advantage over other US production areas. This study examined interactions between variety and SPS on total yield and size of 6 varieties of ware potatoes (Actrice, Envol, Natascha, Purple Majesty, Red LaSoda and Satina) when grown in a subtropical climate, analogous to northern parts of Australia.

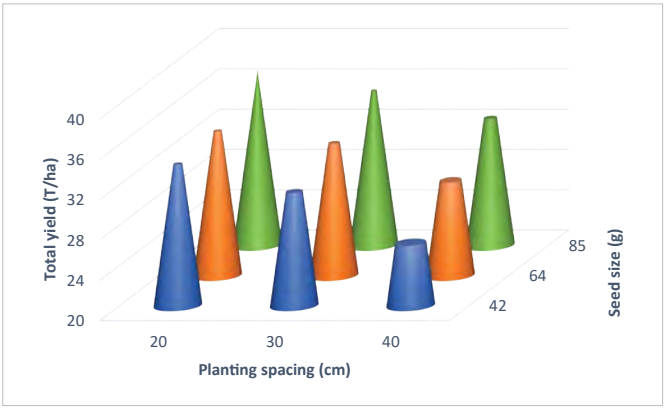

Figure 1. The effects of seed size and planting distance on total yield. Derived from Bohl et al., 2011.

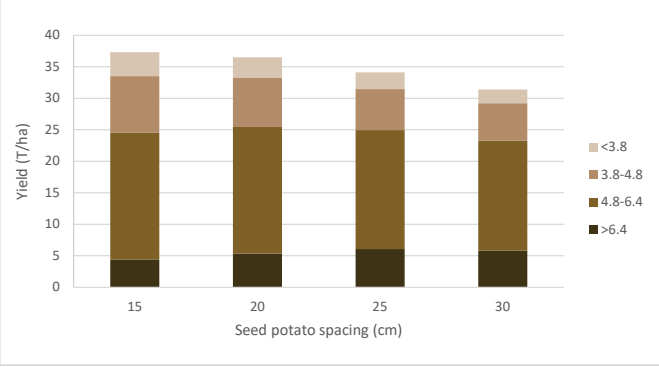

Figure 2. Effect of SPS on yield of different size grades for 6 ware potato varieties grown in Florida, USA. Derived from Andrade et al., 2021.

WHAT WAS CONCLUDED?

Only Red LaSoda and Satina had significant yields of A3 (8.3 – 10.2cm diameter) tubers. These varieties also yielded more A2 (6.4 – 8.3cm diameter) tubers.

Both total yield and the number of A1 tubers (4.8 – 6.4cm diameter) was greater at 15 and 20cm SPS than at 25 or 30cm SPS. However, the cultivars differed in the magnitude of their response to changes in SPS. For example, Purple Majesty and Natascha had mainly small tubers regardless of SPS, whereas narrow SPS's increased the number of small Satina tubers.

In general, a potato SPS of 15 or 20cm provided the highest yields of medium to small tubers, whereas the SPS of 25 or 30cm increased yields of large tubers, regardless of cultivar (Figure 2).

The authors note that potato seed represents 22% of total production costs in Florida. In this study, seed costs ranged from US$1529 (30cm SPS) to US$3,058 (15cm SPS) per hectare. The higher costs incurred by narrow SPS clearly need to be offset by increased yield and profitability.

Growers therefore need to set SPS according to market demand for smaller or larger tubers, while also considering varietal characteristics.

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