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POTATO LINK AUSTRALIAN POTATO INDUSTRY EXTENSION PROJECT

POTATO LINK
AUSTRALIAN POTATO INDUSTRY
EXTENSION PROJECT

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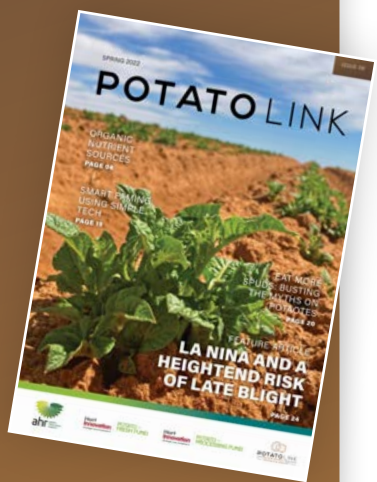
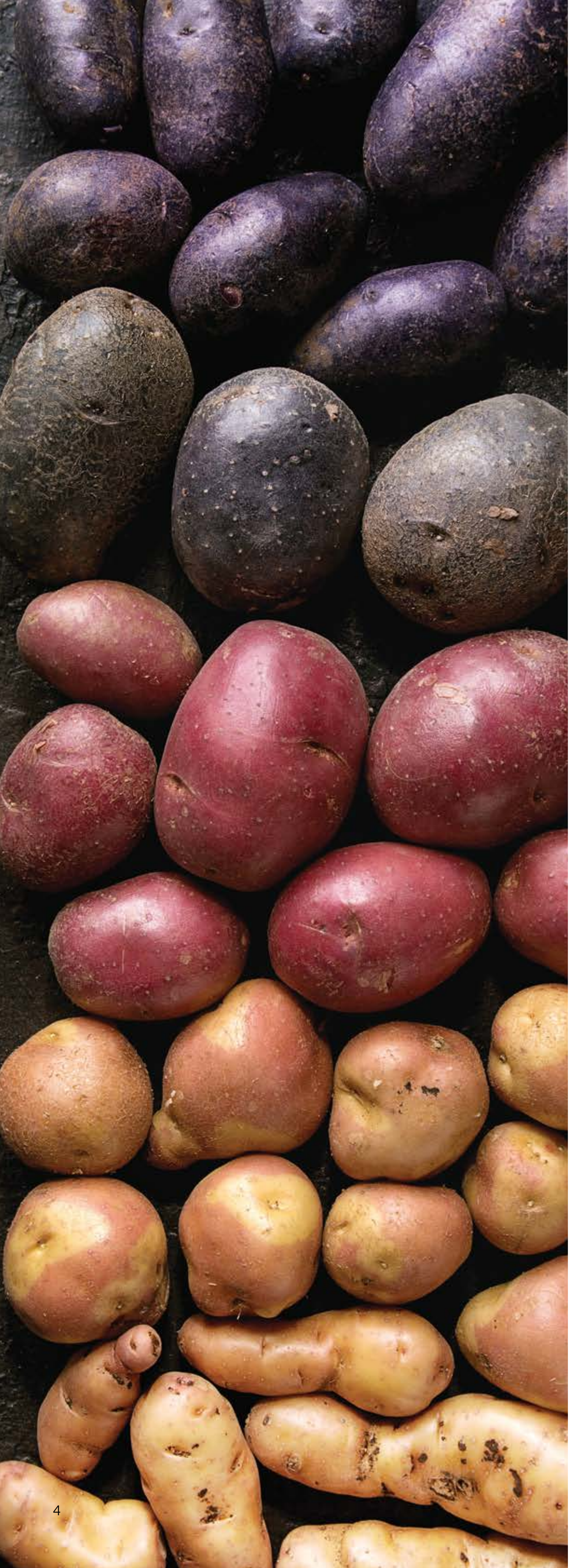


Cover: Young potatoes in South Australia

- Photo by Dr Jenny Ekman



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ORGANIC NUTRIENT SOURCES

- Finding new ways to fertilise

Potatoes are a hungry crop. Maximising yield requires good plant nutrition. However, skyrocketing fertiliser costs have seen many growers search for ways to use inputs more efficiently. Another potential strategy is to supplement the potato plant diet with organic nutrient sources such as composts, green waste and manures. However, while these can provide benefits above and beyond nutrition, they are not without their own risks. Dr Jenny Ekman investigates.

RECYCLED ORGANICS AND COMPOST

What is compost anyway?

In the broadest sense, compost is any mixture of different organic materials that has been broken down by naturally occurring organisms. These include bacteria and fungi as well as larger organisms such as mites and worms.

However, there is much debate about the various terms used to describe composted materials. Recycled organics, green waste, FOGO and compost can all be used to refer to slightly different mixtures and processing methods.

Recycled organics

Recycled organics (RO) can include a wide range of different materials, such as commercial green waste from landscaping, grass clippings, wood residues and sometimes the contents of kerbside collection bins. However, RO products generally do **not** include manure, other animal products, or food waste. This means they can be used freely without affecting certification to food safety programs such as Freshcare and HARPS.

The materials used to make RO products are usually shredded, mixed, stockpiled for up to six months and finally screened to remove contaminants before use. Recycled organics are often very high (>60%) in carbon, which means they are an excellent way to improve soil health. They are also usually cheap, with councils frequently keen to dispose of green waste this way (Figure 1).

There is no requirement for RO products to be high temperature pasteurised (heated through) as they are unlikely to contain human pathogens. While this makes them simple to produce, it means that weed seeds and other plant propagules may not be destroyed during the ageing process. There have also been issues with RO products containing physical contaminants, such as fragments of glass and plastic – especially if the raw materials include kerbside collections (Figure 2).

If the material has a high carbon:nitrogen (C:N) ratio (>30:1) this

Figure 1. Delivery and spreading of recycled organics at a vegetable farm in Cowra, NSW.

Figure 2. Any delivery of RO or compost must be checked to ensure it is free of contaminants such as plastic and glass.

can increase drawdown of nitrogen from the soil. This is most likely if the RO is immature (still breaking down). The C:N ratio will depend on the materials in the mix (Table 1).

Compost

Compost can include all of these ingredients, plus manures and other materials of animal origin (e.g. blood, bone and carcasses).

The high nutrient content of manures increases activity of microbes, so composting occurs more rapidly. Some high intensity 'in vessel' systems can turn organic materials into compost in only a few days. However composting more often takes several weeks or months.

Composts may also contain food wastes: some councils have introduced collection of food organics and garden organics (FOGO) within the same bin. Unfortunately, contamination rates in this material are relatively high; a 2020 study found that 8 to 32% of FOGO bins contained contaminants such as plastics, glass

Food safety programs allow compost to be used freely *IF* it is certified to Australian Standard (AS) 4454. This standard is not just about microbial food safety, but includes details about particle size, levels of contaminants, biological stability and nutrient content.

It also prescribes a minimum of five turns and at least 15 days above 55°C for mixtures containing materials of animal origin (Figures 3, 4). This is to ensure human pathogens and weed seeds are destroyed. If the mixture does NOT include any materials of animal origin, this is reduced to three turns and 9 days above 55°C.

Products which contain products of animal origin but have not been, or cannot be, certified against AS4454, are considered to be the same as untreated manures under most food standard codes. This means exclusion periods may apply between application and harvest.

Compost has higher nutrient values than recycled organics / green waste

Table 1. The C:N values of some common compost ingredients. An ideal ratio for composting is approximately 30:1.

Material	C:N
Wood chips	>600:1
Sawdust	500:1
Paper and cardboard	200:1
Straw	90:1
Corn stalks	50:1
Nut shells	35:1
Garden waste	30:1
Fruit and vegetable wastes	25 to 40:1
Grass clippings	15 to 20:1
Seaweed	20:1
Weeds	20:1
Cattle manure	20:1
Chicken litter (broiler)	10 to 20:1
Chicken manure	7:1

(Table 2) and generally contains around 40 to 50% organic matter.

The cost of compost is commonly $50 to $80 per cubic metre, although larger volumes are likely to attract a discount. Freight costs are clearly location dependant, while the cost of spreading is in the order of $140/ha.

Application rates are usually 20 – 30m^3/ha, although some intensive vegetable producers apply up to 50m^3/ha. High rates are particularly beneficial in sandy soils, as the organic material stabilises the soil, helping raised beds retain their structure.

Figure 3. . To be considered truly compost, the material needs to be turned regularly (left and centre, Images J. Ekman and V Brunton) and heat to at least 55°C in between turning events (right, Image: Rodale Institute).

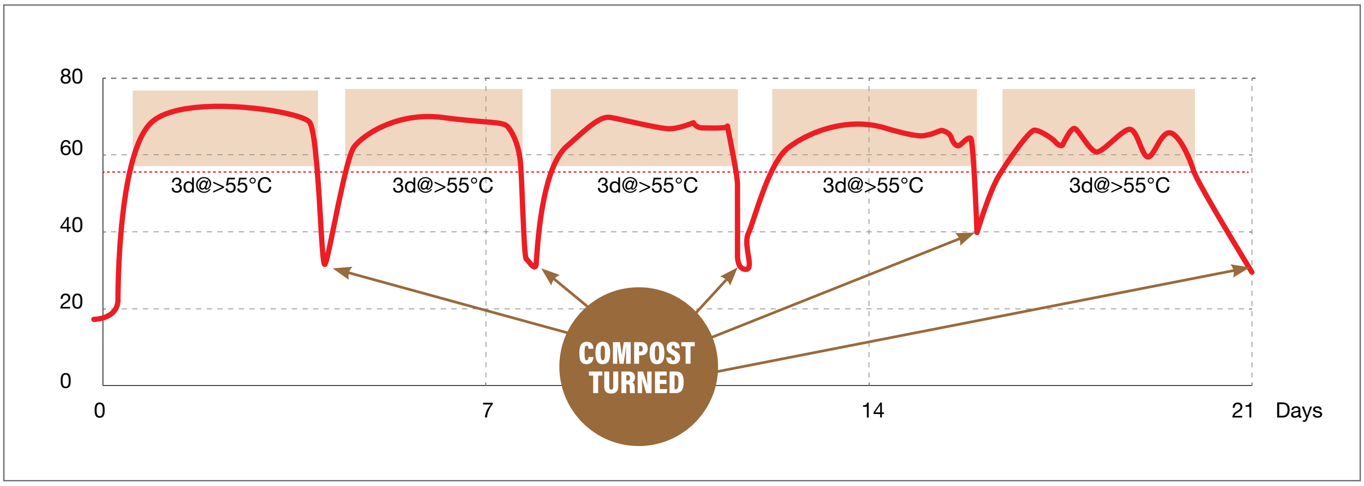


Figure 4. Temperatures inside a compost pile containing manure. The core temperature needs to exceed 55°C for three consecutive days on five occasions, with the pile being turned after each heating event, for it to be considered properly composted in accordance with AS4454.

Other costs and benefits of compost / recycled organics

In addition to nutrients (Table 2), the key benefits of adding either recycled organics or compost to soil include:

- Increased organic matter, and therefore improved soil structure and soil health
- Improved water infiltration and soil water holding capacity
- Increased soil biological activity
- Potential reduction in some soil-borne diseases.

POULTRY LITTER - MORE THAN JUST A NITROGEN SOURCE

Poultry litter is surely proof that one person's waste is another's windfall. Poultry litter is a relatively compact and cost-effective source of nitrogen. It also provides other nutrients, organic matter and carbohydrates that can improve plant and soil health.

Poultry litter sourced from broiler sheds is not just manure, but contains bedding material, feathers, blood, and potentially dirt or other materials. Litter from barn-based egg production and turkey manure can provide bulk organic material, but tends to be lower in nitrogen than litter from broiler sheds (G. Martin pers. com.).

	Green waste compost	Conventional compost
Organic matter	65 – 75%	30 – 50%
pH	6.8 – 7.7	6.0 – 7.6
C:N ratio	25:1 – 35:1	15:1 – 20:1
Nitrogen	1.2 – 1.6%	1.5 – 2.0%
Phosphorus	0.2%	0.6%
Potassium	1.0%	1.0 – 1.4%
Sulphur	2 – 3 kg/tonne	4 – 5 kg/tonne
Calcium	3.0 – 4.0%	3.0 – 4.0%
Magnesium	0.6%	0.6%

Table 2. Typical analysis of a recycled organic product (green waste) and a conventional compost. All values by dry weight. N.B. compost commonly contains 25-35% moisture. Data summarised from multiple sources.

What goes in affects what comes out

Modern broiler chickens are incredibly efficient converters of feed to body mass – approximately 1.5kg of food produces 1kg of chicken. High feed use efficiency equals less waste, especially of the carbohydrates which could potentially nourish soil microbes.

Despite this efficiency, feed still accounts for up to 70% of the cost of raising chickens. The type of feed used is clearly going to affect the attributes of the manure. For example, broiler chickens were once fed mixtures of maize, soya, meat meals, offal, feather meal and tallow. However, modern mixes are predominantly grains plus vegetable proteins and oils. This predominantly vegetarian diet affects the nutrient balance within the litter.

Moreover, the life of a broiler chicken may be as little as six weeks, compared to 10 weeks a few decades ago. This factor, combined with dietary changes, has reduced average nitrogen levels in manure from 5.7% to approximately 3.5%. Modern litter also has 30% less phosphorus, lower levels of fats, carbohydrates, uric acid and enzymes than it once did[1].

Bedding materials matter

Chicken litter consists of both manure and bedding, at a ratio of about 55:45. The type of bedding material used

Figure 5. Adding compost to soils low in organic matter can increase root growth, as shown in these sweet corn seedlings grown with (left) and without (right) compost.

FOOD SAFETY AND MANURES

Manures have been used to improve agricultural soil since the very start of human civilisation. As well as nutrients, manures add organic matter, increase soil bulk density, enhance structure, improve water holding capacity and stimulate soil biodiversity.

Unfortunately, manures can also contain human pathogens such as *Escherichia coli* (*E. coli*), *Salmonella* spp., *Listeria monocytogenes* and others. Products grown in manure amended soil can be contaminated by these bacteria, potentially causing severe illness or even death.

Fortunately, potatoes are always eaten cooked. This process kills any bacteria that may be on the skin or even inside the tuber flesh. As a result, potatoes are usually considered **low risk** with regard to potential contamination by human pathogens.

Human pathogens such as *E. coli* and *Salmonella* spp. are relatively poorly adapted to the soil environment. As a result, their populations in manure amended soil usually die-off over a matter of days or weeks, especially if temperature and UV intensity are high[5]. To take advantage of this decline most, if not all, food standards mandate an exclusion period between application of untreated manures and harvest of fresh produce, including ware potatoes.

Recently released Food Safety Guidelines by the Fresh Produce Safety Centre (fpsc-anz.com) recommend exclusion periods based on maximum air temperature. If the mean maximum (monthly) temperature during the growing period is above 20°C, then 45 days must elapse between application of manure and harvest. If the mean maximum temperature is below 20°C, then this exclusion period doubles to 90 days.

However, other standards are more restrictive. For example, GLOBALG.A.P. stipulates 60 days between application of manure and planting for all vegetable crops.

It is therefore important that before applying manures, or other amendments containing animal products, check the requirements of your food safety certification body, as well as local regulations.

It is also important to practise good hygiene when handling or spreading litter. This is to protect the health of workers and ensure it does not accidentally contaminate neighbouring crops or waterways.

Figure 6. Chicken litter from broiler sheds is not just manure, but includes feathers, bedding, blood, feed and other organic materials.

is likely to significantly alter the C:N balance and nutrient levels in the waste product. For example, litter from wood shavings has lower nitrogen content than that from rice hulls (G. Martin, pers. com.).

Another change is the more frequent recycling of the litter by re-use, layering or mixing. In the past, about 70% of Australian broiler chickens were grown on new bedding, with the remaining farms practicing partial re-use[2].

In the US, litter may be re-used for up to 2 years before the sheds are fully cleared out. The bedding is windrowed inside the shed, allowing it to partially compost, before re-spreading for the next batch of birds[3].

Australian growers appear to be recycling litter more frequently, altering both the volume and composition of material available (Table 3).

Availability of nutrients

In addition to nitrogen, poultry litter contains phosphorus, potassium and micronutrients such as sulphur, calcium, magnesium, manganese, zinc and copper.

About 25% of the nitrogen (N) contained in litter is ammonium, which is readily plant available. The rest is uric acid, protein and urea. In the months following application an additional 25-35% of the nitrogen in the litter is converted to ammonium, making it available to plants.

Importantly, poultry litter needs to be incorporated into soil as soon as possible in order to preserve nitrogen held in the manure. Ideally, manure should be incorporated within 12 to 24 hours after spreading (Figure 9).

It is also essential to keep litter moist; piles should be kept covered to prevent drying out and protect the material from UV light, both of which increase volatilisation of ammonia.

If litter is not incorporated, either mechanically or with irrigation, then a significant portion of the available ammonium will be lost to the air. This may be up to 50%, especially if the soil is dry and/or the weather is warm.

Phosphorus (P) is relatively immobile in the soil, so it needs to be placed where crops need it. Surface application may not make P available in the plant root zone. Between 30-80% of the P in chicken manure is inorganic, which also limits its availability; the phosphorus in chicken litter may be more tightly bound than in chemical fertilisers (e.g. DAP), reducing availability during early crop growth.

In contrast, potassium (K) in litter is readily available and mobile in soil. As a result, 90% of the K in poultry litter is available to plants, compared to 30 to 80% of P.

How much litter is good litter?

Chicken litter is usually sold and applied by the cubic metre. However, nutrient analysis is reported as % dry weight, so it is important to know moisture content. At typical levels of 20-30% moisture, a tonne of litter will weigh approximately 2.5m^3.

This allows calculation of the nutrients in a m^3 of litter, and comparison with synthetic fertiliser.

For example, a cubic metre of litter that is 4% N, 1.3% P, 2% K, 26% moisture and weighs 400kg/m^3 will contain:

0.04 (N) x 0.74 x 400kg = 11.84kg N

Using this same calculation, it will also contain 3.85kg P and 5.92 kg K.

The trace elements in litter, as well the organic matter it contains, are useful as well, but harder to value monetarily. Note that 50% of N may be lost if the material is not used promptly.

According to Wiedemann (2015), an application of 2.5m^3 chicken litter is roughly equivalent to a 50kg/ha application of DAP (di-ammonium phosphate) or 70kg/ha application of CK 66 fertiliser, in terms of N and P supplied.

Once nutrient content has been estimated, application rates per hectare can be calculated. While spreaders can distribute down to about 2m^3/ha, it is difficult to apply evenly. Rates of 4-5 m^3/ha allow for better distribution.

Figure 7. The food that chickens eat affects the nutrient mix of their manure. (Image: Australian Chicken Meat Association).

Figure 8. Broiler chicken litter is generally piled up for a day or two, allowing some composting of the material even before it is removed from the shed (left, Image: Australian Chicken Meat Association), after which it is delivered to the farm for spreading (right).

Table 3. Typical nutrient values in chicken litter with different bedding materials. Values by dry weight. From Wiedemann, 2015* and Griffiths, 2011**.

	Chicken litter single use			Chicken litter multi-use*	Turkey litter**	Layer manure**
	Straw*	Sawdust*	Wood shavings*			
Moisture (%)	20	25	26	21	32	41
Total carbon	30 to 40%, lower in multi-use litter				39	33
Total nitrogen	4.0	3.8	3.9	4.0	3.8	5.8
Total phosphorus	1.1	1.2	1.3	1.7	1.7	2.2
Potassium	2.2	1.8	1.9	2.4	1.9	1.7
Magnesium	0.43	0.44	0.44	ND	0.46	0.49
Sulphur	0.63	0.5	0.5	0.6	0.49	0.45

Litter contains low levels of chloride and sodium. A high application of 10m^3/ha will add around 12 kg sodium, which will not influence salinity. However, repeated high applications can start to have negative impacts – as has been observed on some vegetable farms.

FEEDLOT FERTILISER

Growers located close to feedlots may be able to access feedlot manure. Compared to poultry litter, fresh livestock manure is somewhat lower in nutrients, containing around 2.4% N (compared to 4% in poultry litter) and 0.75% P. It also contains approximately 0.5% sulphur and 0.02% zinc.

However, it is relatively high in potassium (K). Feedlot manure (semi-dry) contains approximately 2.6% K, which is similar to the levels found in chicken litter. Moreover, it remains stable during ageing and composting.

Potato plants need huge amounts of potassium, taking up over 4 kg/ha/day during tuber bulking. While this is the period of greatest demand, it is also essential to have ample potassium present during stolon growth and tuber initiation. Feedlot manure added before planting can therefore be a good source of potassium for potato crops.

Release of ammonia and nitrous oxide (NO) is much less from livestock manure compared to chicken manure. Despite this, as with chicken litter, it is important to incorporate the manure into the soil as soon as possible to maximise avoid losing N to the air.

Most of the N in feedlot manure is in an organic form, but it is released more slowly than from poultry litter. According to a report by P. Wylie (2008) approximately 30-50% of N in feedlot manure becomes available to the plant over the first 12 months of application. This extended release may be useful for potato crops.

Distribution of feedlot manure is more difficult than poultry litter because of its lumpiness. It is collected by yard scrapers which lift manure compacted by many hooves and dried in the sun (Figure 10). The manure may therefore need to be aged and screened in order to be evenly distributed, especially if it is applied at relatively low rates e.g. 6 t/ha.

Feedlot manure has a C:N ratio of around 10:1, suggesting it is significantly lower than manure from free ranging, grass fed animals. As a result, it breaks down relatively rapidly. For comparison, chicken litter may be as high as 20:1. However, this also means it is a good source of organic matter, being rapidly absorbed into the soil.

Like chicken litter, cattle manure is a potential source of human pathogens.

Figure 9. Chicken litter should be kept moist and both spread (left) and incorporated (right) as soon as possible after delivery in order to minimise loss of nitrogen to the atmosphere (Images: L. Southam-Rogers).

It should be considered that the bacteria *Listeria monocytogenes* has occasionally been found in feedlot manure. *L. monocytogenes* is a natural soil dwelling organism, so is more persistent in soil than *E. coli* and *Salmonella* spp.[ii]. Risk of persistence can be minimised by composting the manure then incorporating thoroughly into the soil. *L. monocytogenes* populations decline most quickly in sandy soils at temperatures over 21°C[4].

PIGGERY SLURRY – *NOT FOR POTATOES*

Piggeries produce effluent, manure and used bedding materials. Unlike poultry litter and feedlot manure, most piggery wastes are collected and transported as either liquid effluent or sludge.

Piggery slurry is NOT RECOMMENDED for application to land used for horticulture. As it is liquid, it runs off more easily than solid wastes, potentially contaminating other crops and water sources. It can contain higher populations of human pathogens than other manures, as well as parasitic viruses and cysts, both of which can survive for extended periods in the environment. Slurry is also a poor carbon source, typically being only 4 to 5% dry matter.

Piggeries also periodically dispose of bedding materials, including sawdust, rice hulls, barley straw or wheat straw. These materials can add organic matter, but are generally low in nutrients.

Figure 10. Feedlot manure can be hard to distribute as it has been hard-packed by hooves (left). The material is scraped and mounded before removal from the pen (right) (Images: Meat and Livestock Australia).

REFERENCES

1 Griffiths N. 2011. Best practice guidelines for using poultry litter on pastures. NSW DPI Primefact 534.

2 Chinavasagam HN, Tran T, Blackall PJ. 2012. Impact of the Australian litter re-use practice on *Salmonella* in the broiler farming environment. Food Res. Int.45:891-896.

3 LeBlanc B. et al. 2005. Poultry production best management practices. Louisiana Ag Centre.

4 Roser D et al. 2011. Managing the contaminants in feedlot wastes: Development of realistic guidelines. Final Report for Meat and Livestock Australia. FLOT.333B. ISBN: 9781741918311.5 Ekman J et al. 2021. Persistence of human pathogens in manure-amended Australian soils used for production of leafy vegetables. Agriculture. 11, 14; https://doi.org/10.3390/agriculture11010014

SMART FARMING USING SIMPLE TECH

Not all technology is complicated or expensive. One of the best things to emerge from the digital revolution is the accessibility and mobility of technology. With vastly improved user interfaces, compact devices, and simplified apps, technology can be used almost anywhere, anytime, by anyone in thousands of applications. This includes agriculture, writes Ryan Hall.

KEY POINTS

- A range of easy-to-use tools is available to growers to help with scouting and keeping track of crops
- Drones do not need to break the bank to be useful; simple applications can yield large savings of time and money
- A variety of smartphone applications are available to help potato growers
- Applications using satellite imagery can be used to optimise irrigation, monitor growth, and provide a historical record of an area

Figure 1. A drone being used to scout a potato crop in NSW

DRONES/REMOTE SENSING

That small drone that has been sitting in the shed since it was unwrapped last Christmas could save you significant time and money, and could be an excellent tool for monitoring and assessment.

Drones have varying levels of use. Drones with multispectral cameras and other capabilities can provide significant information to a grower about how well a crop is growing, or help to quantify areas where growth is below expectations. However even a smaller drone with a decent camera (20-megapixel) can be useful to keep an eye on things.

Back in January of 2021, John Coulombe of Drone Training Solutions conducted a webinar with the Soil Wealth Integrated Crop Protection team. In his seminar, John outlined the various considerations and uses of drones on agricultural properties.

One of the major benefits of drones is that they are not limited by wet soil. Looking at your crop, or spotting trouble spots in the irrigation system, without trudging through miles of mud, is one great advantage. Drones are also fast. What might take an hour to walk through will only take 5 minutes with a drone.

"A great example of this is monitoring irrigation. It's super easy to turn the irrigation on and send up your drone to make sure it's all working properly," John said.

"Need to check the levels on your dams? Send the drone out and have a look. Saves you fuel and time, and it can be a bit of fun at the same time."

So, what are some of the important things to know about drones?

John noted that there are some restrictions on use, including laws on where, when, and how you can fly.

"Insurance is also another thing to consider; check to see if your liability insurance covers things in the air. Most don't. It's important to be covered in the event something goes wrong and someone is hurt", John said.

As John points out, costs can be variable.

"A good drone with a 20-megapixel camera is a fantastic starting point. These can cost around $2000. This is an investment that will soon pay for itself given the potential savings from identifying a problem early."

Drones are part of a set of management tools, best used in combination with satellite maps, soil maps, electromagnetic (EM) surveys, and historical knowledge.

It is also important to be aware of the rules and regulations of flying

Figure 2. Image captured by a drone highlighting a problem area and its extent. It still requires ground truthing to determine the cause of the problem

drones on your property. In most cases licenses are not required for small drones , but it is important to be across the rules and regulations. Find the most up-to-date information on the Civil Aviation Safety Authority (CASA) website.

The importance of 'ground truthing'

Ground truthing, a term favoured by the ABC's Dr Karl, involves checking conditions with your own eyes and ears. In this context, it means going to a site identified by the drone to check the situation. The drone can identify potential issues quickly and easily, but will not necessarily reveal the exact problem.

What about bigger drones?

There are several issues to consider before upgrading to a more serious drone. Drone restrictions are related to weight classes, which determine cost, function and importantly, licenses. The drones used for spraying are massive, with their 30 L tanks making them very heavy. As a result, extra training and licensing is required to operate them. While useful, these drones are expensive, costing upwards of $20,000.

Further information on this is available on the CASA website (https://www.casa.gov.au).

So why not a satellite?

The use of drones and satellites is not mutually exclusive. Satellites have their own advantages and disadvantages. One of the main limitations is cloud cover. If a satellite passes on a cloudy day no information can be captured. Depending on the frequency of passes this can mean days or even weeks until the next pass, which may be cloudy again. Drones mitigate this by flying low.

IrriSAT, which has been discussed previously by PotatoLink, is a free, satellite-based irrigation scheduling app that combines satellite images with weather data to estimate crop water use. With weekly satellite image updates and weather reports, crop water requirements can be predicted up to seven days in advance, helping to manage irrigation.

As with drone monitoring, ground truthing is also important when using satellite tools. Combining soil moisture probe data with IrriSAT facilitates ground truthing of estimated crop requirements against actual soil moisture levels. With this information about the water budget, when to irrigate and by how much, can be calculated.

While an important part of the tool, there is more to IrriSAT than water budgeting. The normalised difference vegetation index (a measure of different wavelengths of light) or NDVI can be used to identify areas of problem growth.

Interpreting satellites requires some practice but tools like IrriSAT are a great help. For more information, see the PotatoLink website for a webinar and case study on IrriSAT. You can read about IrriSAT in the first edition of PotatoLink magazine, also available on the PotatoLink website.

APPS

Ironically, most of us barely use our smartphone as a phone. Apps are what we want and there seems to be one for everything, including for the agricultural sector. While some are specific to potato crops, others are for broader use.

Two apps that caught our attention are DiagPOT and xarvio™ SCOUTING.

DiagPOT is a free smartphone application available on both IOS and Android platforms. The app was developed from the *Practical guide on diseases, pests and disorders of*

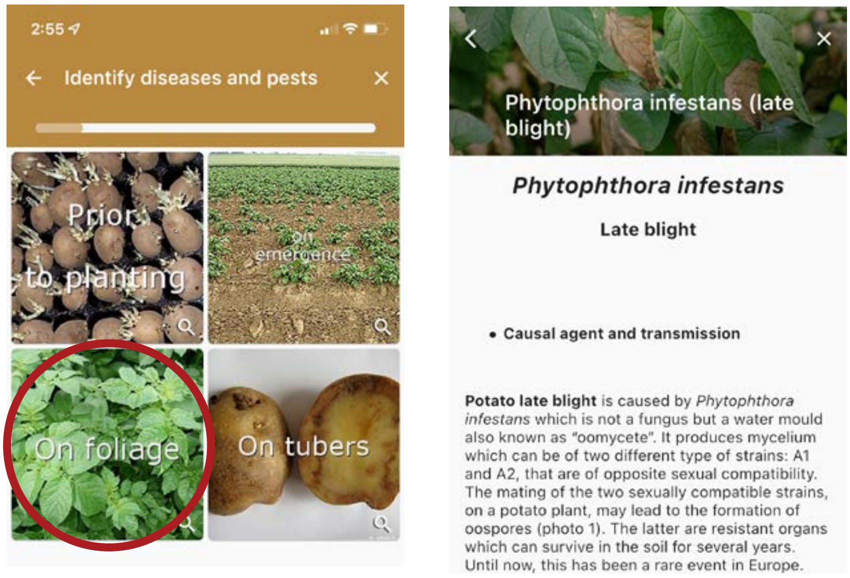


Figure 3. An example of how the app can be used. NOTE the information for late blight in this context is for France. For effective management of diseases and pests please ensure Australian resources are used.

the potato, and created and edited by a range of French organisations including the French Federation of Seed Potato Growers (FN3PT), French Association for Seeds and Seed Potatoes (GNIS), French Technical Institute for Cereals Forage and Potato Crops (ARVALIS-institut du Végétal), and the French Institute for Agricultural Research (INRA).

The application, which has an English language option, boasts a broad range of photos of pests, diseases, and physiological disorders. One of the best uses of the app is as a diagnostic tool, with 400 photos to help identify issues with plants or tubers. The app also includes an index of 150 diseases, pests, and disorders and 94 datasheets that cover causes, symptoms, risk factors and management of diseases, physiological disorders, and nutrient imbalances.

It should be noted that while the app is useful, it has been developed for French conditions; information may be less accurate for an Australian context. Nevertheless, it is a fantastic tool for that first step in recognising or understanding a problem. Consult an agronomist or another relevant professional before making decisions based on the app.

The free app, **xarvio® SCOUTING**, developed by BASF Digital Farming, uses advanced image recognition technology and machine learning to identify more than 400 weed types, as well as damage caused by more than 400 different diseases, pests, and nutrient deficiencies.

In Australia, the focus of the app has been on its application to support the management of broadacre grain crops including canola, barley, and wheat. While it does not currently offer analytical features specifically for potato crops, growers are already finding it useful, with its functionality increasing as more users add to the database.

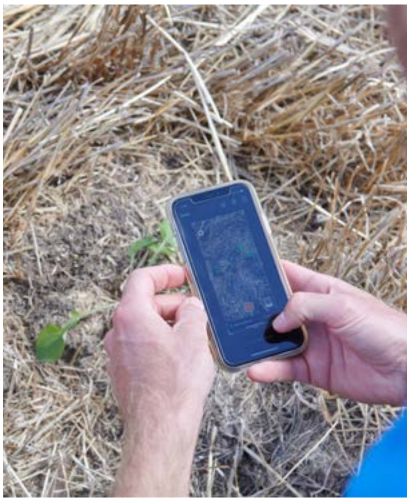


Figure 4. David Brunton using the Xarvio app to identify a weed

To identify weeds, the app compares a photo taken within the apps' camera function with photos already loaded to the app's ever growing image database. If xarvio SCOUTING does not recognise a weed, users can easily record information about that species to enhance the apps' 'knowledge.'

Disease identification works the same way. The more the app is used in Australia, the more accurate it will become.

xarvio SCOUTING also has a feature that documents images and results from local scouting trips. This information creates a local area history that can be reviewed at any time, helping alert users to emerging in-field problems.

Users can decide whether to share the in-field problems identified on their property as part of the anonymous collection of local area data. This information is made available to other local growers and agronomists via the app's unique radar function and in-app notifications. This can help them to take preventative action to protect their crops from a potential risk. This feature could be particularly useful for diseases such as late blight, where a community approach greatly improves overall disease management.

CONCLUSION

Digital agriculture is no longer an idea of the future. It is here and available now, with new technologies and systems emerging every year. While the next 10 years will see major changes to the way potatoes are produced, it is important to remember that not all new technologies are complicated and expensive. Simple digital tools can have a great impact.

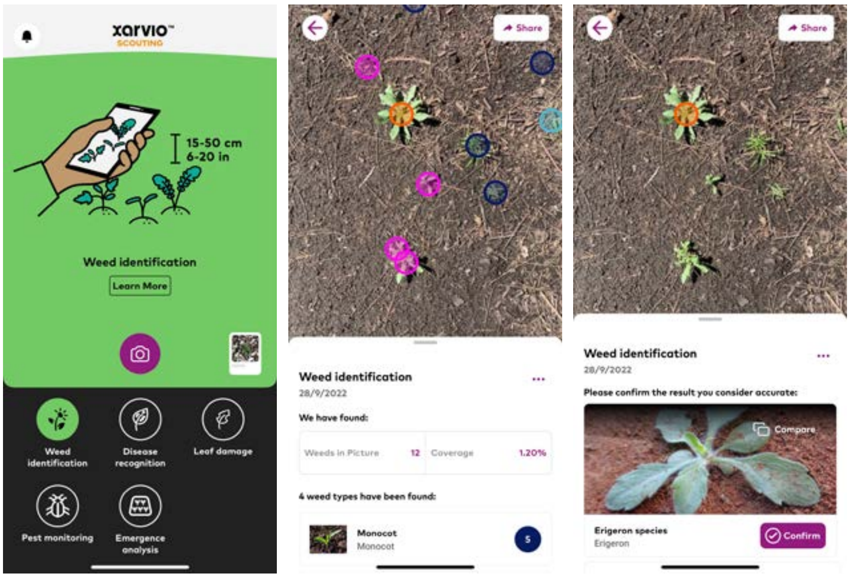


Figure 5. an example of Xarivo SCOUTING app being used to identify weeds

UPDATE FROM THE BOLWARRAH, VICTORIA, DEMONSTRATION SITE

Rising prices, unreliable supply and the importance of using inputs as efficiently as possible, are top of every grower's mind. Reducing use of fertilisers and pesticides is not just good for sustainability, but also for farm profitability, reports Stephanie Tabone

THE BOLWARRAH SITE

Bolwarrah is 30 km east of Ballarat. The soil is generally rather low in nutrients, especially phosphorus. As the site had previously been used for grazing and forestry, it was virgin ground for potato production.

These factors made it an ideal candidate for addition of mycorrhizal fungi. Naturally occurring populations were likely to be low, and nutrients were potentially limiting. Mycorrhizal fungi develop symbiotic relationships with their host plant. The plant provides food for the fungi (photosynthates), in exchange for the fungi supplying nutrients from the soil to the plant.

Many species of mycorrhizal fungi are well adapted to colonise potato plants. The product EndoPrime by Sumitomo Chemical contains four such species.

Processing potato grower Neville Quinlan, with the support of agronomist and PotatoLink regional representative Stuart Grigg (Stuart Grigg Ag Hort Consulting), decided to trial EndoPrime in the 2021/2022 potato growing season. The product was applied to most of the paddock at planting in late October 2021, with a central area left untreated (Figure 1).

Mycorrhizae act as an extension of the plant's root system, effectively increasing the surface area of the roots. This is particularly useful for uptake of nutrients which are immobile in the soil, such as phosphate.

Application of a mycorrhizal product is most likely to provide benefits during the first 6-8 weeks of crop growth. This helps the mycorrhizae to establish and colonise the roots more quickly. As the crop progresses, naturally occurring mycorrhizae are likely to colonise untreated cropping areas, so long as environmental conditions are suitable.

Sap tests conducted on 16 January and 1 February provided a snapshot of the plants' nutrient status. Interestingly, phosphate levels were 15-20% higher in the EndoPrime treated area compared to the control (Figure 2).

This result suggested that the potato plant roots had been successfully colonised by the fungi. To test this, root samples were collected from the treated and untreated areas of the crop three weeks before harvest and processed for microscopic examination. This revealed that mycorrhizae had indeed colonised the roots, with both fungal hyphae and vesicles (bladder-like structures formed by the fungus) clearly visible within the cells (Figures 3, 4).

Crops are considered colonised when the percentage of roots with

Figure 1. Areas of the field treated with EndoPrime or left as untreated control.

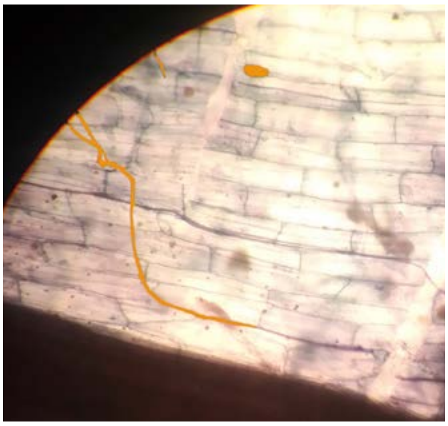


Figure 3. Potato roots observed under a microscope showing colonisation of the cells by mycorrhizal hyphae and vesicles. These structures have been coloured orange in this image.

mycorrhizal fungi exceed 10%. Both treated and untreated plants exceeded this level. However, the rate of colonisation was higher in the area treated with EndoPrime (Figure 4).

While biologicals can provide great results, some farming practices may need to change to create an environment in which they can thrive.

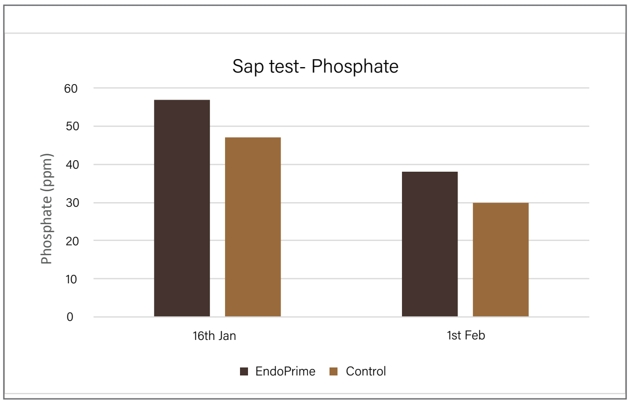


Figure 2. Potato crop sap tests from 16 Jan 2022 and 1 Feb 2022, indicating phosphate levels in the EndoPrime treated area compared to the untreated control.

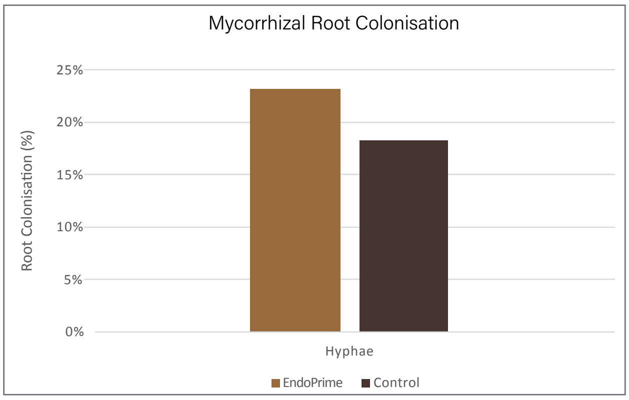


Figure 4. Percentage of mycorrhizal root colonisation of hyphae in EndoPrime treated and untreated control plants three weeks before harvest.

Products containing mycorrhizal fungi are usually applied at planting. If a fungicide is also required, then it is important to check compatibility with your supplier. For example, Sumitomo advises that EndoPrime can be used at the same time as several common fungicides. However, not all products and biologicals will be compatible. In some cases, results may be improved by applying fungicides at a different time, or in an area separated from the root zone, so as not to compromise efficacy of the biological.

It is also important to consider that full application rates of fertiliser will provide the plant with all the nutrition that it needs. If the plant does not need additional nutrients, it is less likely to form a strong association with the fungus.

While products such as EndoPrime may still provide a yield increase under a normal fertilisation program, results are likely to be most dramatic if nutrients are limited.

GETTING BEST RESULTS FROM PRODUCTS CONTAINING MYCORRHIZAL FUNGI

When to apply?

- When growing a crop that responds strongly to mycorrhizae – such as potatoes
- After using a soil fumigant
- When soil nutrition is not ideal or limited
- If the field has been empty of vegetation for 6 months or more
- If crops have been grown which do not host mycorrhizal fungi, reducing natural populations in the soil
- When soil constraints are present such as sodicity or salinity
- After any significant cultivation
- When growing legumes, as mycorrhizal fungi and rhizobium are highly complementary

How to use?

- Ensure the spray, dip or drench solution is well agitated
- Apply at planting, or as early in the crop cycle as possible
- Ensure good contact between the inoculant and potato seed
- If applying through the irrigation system after planting, ensure enough water is applied to wash the material into the root zone
- Do not over fertilise the crop
- Apply enough to ensure colonisation; you can't 'overdose' with mycorrhizal fungi

EAT MORE SPUDS FOR A HEALTHY GUT!

Busting the myths on the nutritional benefits of potatoes.

by Paulette Baumgartl

A bowl of roast potatoes, a cooling potato salad, or smooth mash are all favourites of the Australian table. Yet, many dated misconceptions continue to linger about potatoes and their health benefits.

Far from being a mere comforting and economic staple, potatoes pack a nutritional punch and are a healthy carbohydrate choice.

The Hort Innovation project (PU190002), *Educating health professionals about Australian potatoes*, set out to bust some of the myths about potatoes.

Instead, the aim was to deliver evidence-based nutritional information about Australian potato products to dietitians, nutritionists, naturopaths, GPs, students of health-related disciplines, as well as other health professionals such as personal trainers and health coaches.

Although primarily targeted to these groups, potato growers and the broader potato industry can also access all the data, resources, and information via the project's online platform (https://www.powerpackedpotato.com.au) for their own business development.

HIGH IN FIBRE, LOW IN CARBS

To provide clear and evidence-backed information, an essential part of the project was to generate new, current data. The project team carried out nutrient testing (July to September 2020 with analysis performed by *Agrifood Technology)* on six varieties of potato (Crème Royale, Royal Blue, Sebago, Desiree, Cremoso, Dutch Cream) sourced from growing regions in South Australia, Western Australia, Tasmania, and Queensland. Potatoes were steamed before testing. Samples tested while hot for all nutrients, except resistant starch (RS). To test for RS the potatoes were steamed as usual, then chilled at 4ºC for 2 hours and tested cold.

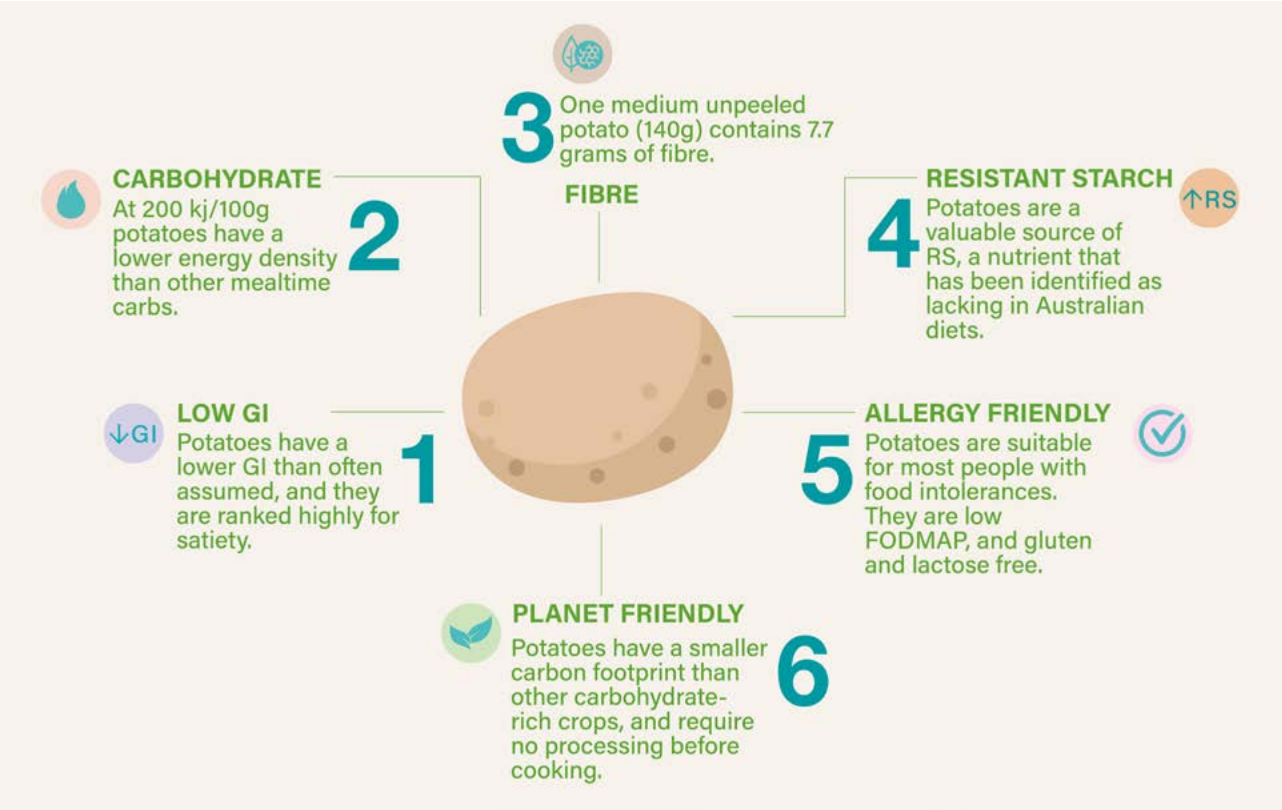
Potatoes are a greatly misunderstood vegetable. They are often dismissed as 'too fattening' by career dieters and banned from the *five a day* list because they are considered a starch.

KEY POINTS

- This project generated new data on the nutritional vales of potatoes and forms the basis for evidence-based education for health, nutrition, and sports professionals
- Potatoes are much higher in fibre than previously believed, especially resistant starch
- When cooked and then cooled, resistance starch increases and GI decreases
- Potatoes are the main intake of resistance starch in Australian diets
- The full suite of resources generated from this project is available online

However, the new nutritional values obtained demonstrate that their nutrient profile is a lot more favourable than broadly perceived. Two particularly notable outcomes were **energy density** and **fibre content**.

Potatoes have a much lower energy density (or KJ value) and are much higher in dietary fibre than assumed. Critically, the fibre in potatoes is



high in resistant starch, which in turn lowers the glycaemic index of potatoes. Win, win and win!

Fibre

As most Australians currently fall short of the recommended daily intake, understanding sources of dietary fibre is all-important.

Currently, dietary fibre values for potatoes are sourced from the Australian Food and Composition Database (AFCD). Examination reveals some incongruities with the AFCD data, and no comparative data for resistant starch in cooked and cooled potatoes. Information from this project therefore provides a valuable contribution to understanding the nutritional qualities of potatoes.

Compared to AFCD data, results for this project showed higher values of dietary fibre, as shown in Table 1.

These new insights into the value of potatoes will support health professionals in recommending the inclusion of potatoes into diets.

Resistant starch and pre-biotics

Resistant starch has been identified as lacking in Australian diets. Resistant starch is considered a pre-biotic fibre because it cannot be broken down by usual digestive processes in the small intestine. It reaches the large intestine intact, where it is fermented by gut bacteria. It is excellent for gut health, providing the gut with lots of useful microbiota. There are many health benefits of prebiotics including:

- reduces prevalence and duration of infection and antibiotic-associated diarrhoea
- reduces inflammation and symptoms associated with inflammatory bowel disease
- helps protect against colon cancer
- enhances bioavailability and uptake of minerals, including calcium, magnesium and possibly iron
- lowers risk factors for cardiovascular disease, and
- promotes satiety and weight loss

Currently potatoes, followed by bananas, are Australian's primary source of resistant starch. We need to eat more potatoes!

MYTH NO. 1 – POTATOES ARE BAD FOR BLOOD SUGAR

The glycaemic index (GI) is a ranking from 0 to 100 based on how quickly the carbohydrates in food are broken down into glucose. It is based on how much different foods raise blood sugar after they are eaten.

The lower the GI, the more slowly the energy contained in that food is released. This helps manage diabetes, as well as keeping us energised and feeling fuller for longer. Not the dreaded peaks and troughs of sugary foods!

Most people know that whole grain foods have a lower GI than their processed counterparts (that is, they are broken down more slowly). However few would realise that

FIBRE	Serving size: 1 medium potato, unpeeled (140g)					
	AFCD data			Project data		
	Average quantity per serve	% daily intake per serving	Average quantity per 100g	Average quantity per serve	% daily intake per serving	Average quantity per 100g
Total	2.7g	9g	2g	7.7g	26%	5.5g
Soluble				2.6g		1.9g
Insoluble				5.1g		3.6g
Resistance starch				2.2		1.6g

Table 1. Dietary fibre data from this project and AFCD data

potatoes are a low carbohydrate food, lower even than brown rice (Figure 1), and when prepared properly, can be a low GI food.

However, calculating GI in any food is harder than it seems. This is particularly true for potatoes, which have widely variable GIs, more so than any other food. Potatoes are often represented as high GI; however, it isn't that simple. The GI of potatoes is influenced by many factors. Variety, storage, age, and preparation can all affect the GI of potatoes.

While there is no clear pattern between the GI of potatoes cooked using different methods, cooling cooked potatoes for at least two hours increases the level of resistance starch (RS), which is associated with lower GI. Some studies have reported that GI after cooling is 28% lower, and if eaten with vinegar (hello European potato salad), GI is 31-43% lower than that of freshly boiled potatoes.

MYTH NO. 2 - POTATOES ARE FATTENING BECAUSE THEY ARE HIGH IN CARBOHYDRATES

Despite many associating weight loss with no carb/low carb food, heathy carbohydrates are essential to a balanced diet. Potatoes are often sacrificed at the altar of rapid weight loss, or unfairly plonked into the 'sometime food' basket.

This is where the project team busted myth number 2. Potatoes contain less carbohydrate and have a lower energy density than other mealtime carbohydrates such as pasta and rice. Because of their high water content, potatoes are far and away not a high carb food.

This is great news for calorie counters who can literally have their (oven baked) potato cake and eat it too!

MYTH NO. 3 - POTATOES ARE BAD FOR THE ENVIRONMENT

Potatoes are not just good for us, they are also good for the planet. Potatoes are the world's fourth largest food crop and with a smaller carbon footprint than most other staples. Potato crops are less resource intensive than other carbohydrate-rich crops and require no processing before cooking. Furthermore, as potatoes are grown in from Atherton in the north to Tasmania in the south, all fresh potatoes available for purchase are grown in Australia, meaning that their carbon miles are also low.

Australians typically eat fewer potatoes per person per year than culturally and economically similar countries. Promoting the nutrition and environmental merits of this not-so-humble vegetable could shift consumption upwards.

Good for the industry.

Good for our health.

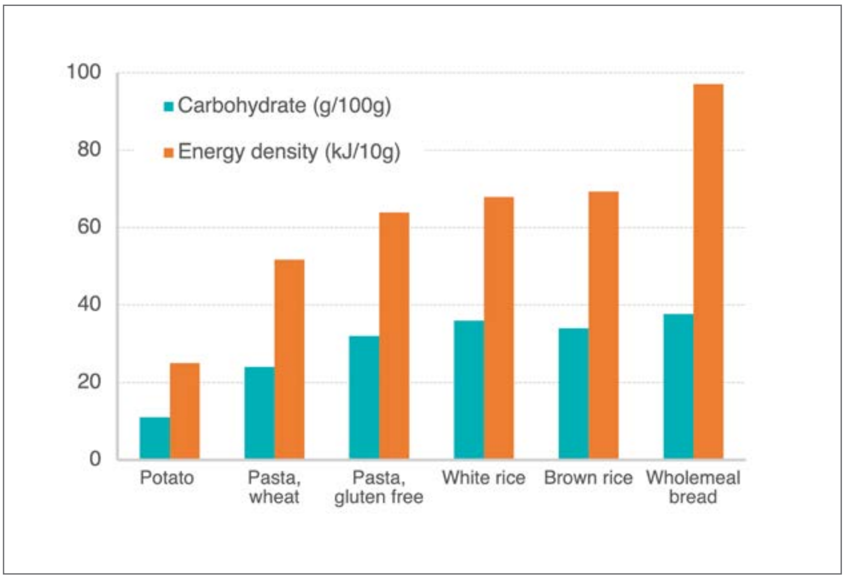


Figure 1. Energy density and carbohydrate content of common mealtime carbohydrates.

POTATOES POWER PERFORMANCE

Every athlete knows that carbohydrates are essential fuel for top performance as well as post workout recovery. Potatoes provide the carbohydrates, potassium, and energy that strength and endurance athletes need to perform at their best.

At the recent World Potato Congress in Ireland, Dr Katherine Beals gave an inspirational talk into the benefits of potatoes for exercise. Dr Beals is an Associate Professor in Nutrition at the University of Utah, as well as holding a PhD in exercise science, so she has professional expertise on both topics.

Dr Beals gave several examples of studies where potatoes have been compared against artificial sports supplements as fuel for athletes.

In one trial, twelve cyclists were given either water, PowerBar Gels, or potato puree during a two-hour ride followed by a 10-mile time trial. Both the potato and the gels significantly improved their time trial performance compared to water alone, there being no difference in results between the two supplements[1].

The researchers concluded that *"potato ingestion during prolonged cycling is as effective as carbohydrate gels to support exercise performance in trained athletes"*

In another experiment[2], 16 recreational cyclists were given either potatoes or sports supplements after 90 minutes of cycling. The researchers measured levels of glycogen (glucose used for energy) in their muscles during a four-hour recovery period. The cyclists then completed a 20km time trial. Once again, potatoes were just as good as the sports supplements in helping muscle recovery as well as supporting time trial performance.

Other new research asked young men to do leg presses and knee extensions until they could do no more[3]. Potato protein and milk protein were identical in helping muscle recovery but, of course, potato provides a plant-based, environmentally friendly option.

According to Dr Beals, potatoes are simply the best fuel for exercise. Not only do they contain the carbohydrates needed for energy, but an average potato contains 3g of complete protein. This has high biological value, supporting muscle synthesis and tissue repair.

Many will be also surprised to learn that potatoes contain more potassium than a banana (approx. 620mg vs 450mg). Potassium is essential for correct muscle function, and must be replaced after sweating.

Perhaps that is why pro-rider Toms Skuijns, champion of Latvia and member of the Trek Segafredo cycling team, is an official potato ambassador of the World Potato Congress. Toms is a true believer in the power of potatoes; check out his YouTube video on the Potato Man of the Peleton (www.youtube.com/watch?v=NSbg_HzdhiY) and website (https://www.tomsskujins.com/potato) for favourite potato recipes and tips, as well as his pride in being able to promote potatoes.

So clearly there is nothing humble about potatoes. Next time you're out exercising, don't reach for that sugary sports drink, choose a potato.

Ed. – I have tried this myself; on a recent bike ride, I pulled a couple of baked potatoes out of my jersey pocket while my buddies sucked on their gels. Sure, they looked at me strangely, but I found it a lot more satisfying than the sticky, sugary substances they were forcing down...

Toms Skuijns, the potato ambassador

1 Salvador AF et al. 2019. Potato ingestion is as effective as carbohydrate gels to support prolonged cycling performance. J. Appl. Physiol. 1:1651-1659.

2 Flynn S et al. 2020. Males and females exhibit similar muscle glycogen recovery with varied recovery food sources. Eur. J. Appl. Physiol. 120:1131-1142.

3 Pinckaers PJM et al. 2022. Potato protein ingestion increases muscle protein synthesis rates at rest and during recovery from exercise in humans. Med Sci Sports Exerc. 54:1572-1581.

Research undertaken as part of this project was detailed and extensive. Full reports are available via the Hort Innovation website and at https://www.powerpackedpotato.com.au.

Article based on: *Final Report: Educating health professionals about Australian potatoes - Project leader: Rachel Bowman; Delivery partner: Seedbed Media; Potato Nutrition: An evidence-based Approach, Compiled by Dr Jane Watson.*

LA NIÑA ALERT – THE HEIGHTENED RISK OF LATE BLIGHT

Plant diseases can change the world. The English took to drinking tea when their coffee plantations in Ceylon (now Sri Lanka) were wiped out by coffee rust in 1869. Both the Salem witch trials and – more arguably – the French Revolution have been blamed on ergot infection of rye, the toxin of which causes muscle spasms, mania and hallucinations. By Jenny Ekman

However, there is surely no plant disease which has had as big an impact on human history as late blight – *Phytophthora infestans*. We are all familiar with the terrible story of the Irish famine (1845-1849). The disease caused at least 1.5 million deaths from hunger and more than a million permanent emigrations, spreading the Irish people around the globe. The population of Ireland has never recovered.

Late blight remains one of the most destructive and costly plant diseases around the world today. It can cause complete crop loss within weeks, as well as have significant effects on quality and yield on surviving crops.

According to Agriculture Victoria senior research scientist Dr Rudolf (Dolf) de Boer, more pesticides are used worldwide for control of late blight on potatoes than for any other plant disease. There are also major issues with fungicide resistance, making it ever more difficult to control.

WHAT IS *PHYTOPHTHORA INFESTANS?*

P. infestans is not actually a fungus but belongs to a group of organisms known as the oomycetes. These produce mobile, swimming spores called zoospores.

In most of the world there are two forms of *P. infestans*; the A1 and A2 'mating types.' The sexual stage of the life cycle occurs when compatible strains of A1 and A2 mating types both infect a plant. The two strains merge, producing oospores with recombined DNA. These oospores are very robust, potentially surviving many years in the soil without a host.

In Australia we only have the A1 type, a relic of the original Irish late blight pathogen. This means that the lifecycle occurs solely through asexual growth and division. As robust oospores are not produced, the pathogen can only survive in living host material.

This means that *P. infestans* can be more readily controlled through crop rotation here than in many countries. Lack of genetic variability also makes it more difficult for resistance to develop.

However, it does not mean the fungus does not present challenges. There are a number of highly aggressive strains of the A1 (and A2) mating types. For example, an A1 strain present in Papua New Guinea would likely create major issues if introduced here, potentially replacing our existing strain. Similarly, a very aggressive A2 strain has become dominant in Scottish crops. Although it can potentially produce oospores, this strain still mainly spreads through infected materials, possibly due to incompatibility with local A1 types.

HOW DOES IT SPREAD?

The late blight pathogen was introduced to the Australian colonies on infected seed potatoes sometime in the 1840s. However it was not until the early 1900s that major epidemics occurred, the infection spreading from farm to farm on infected seed potatoes. These days the pathogen is most likely to survive in small pockets, most likely as latent infections in old tubers and pre-emergent sprouts.

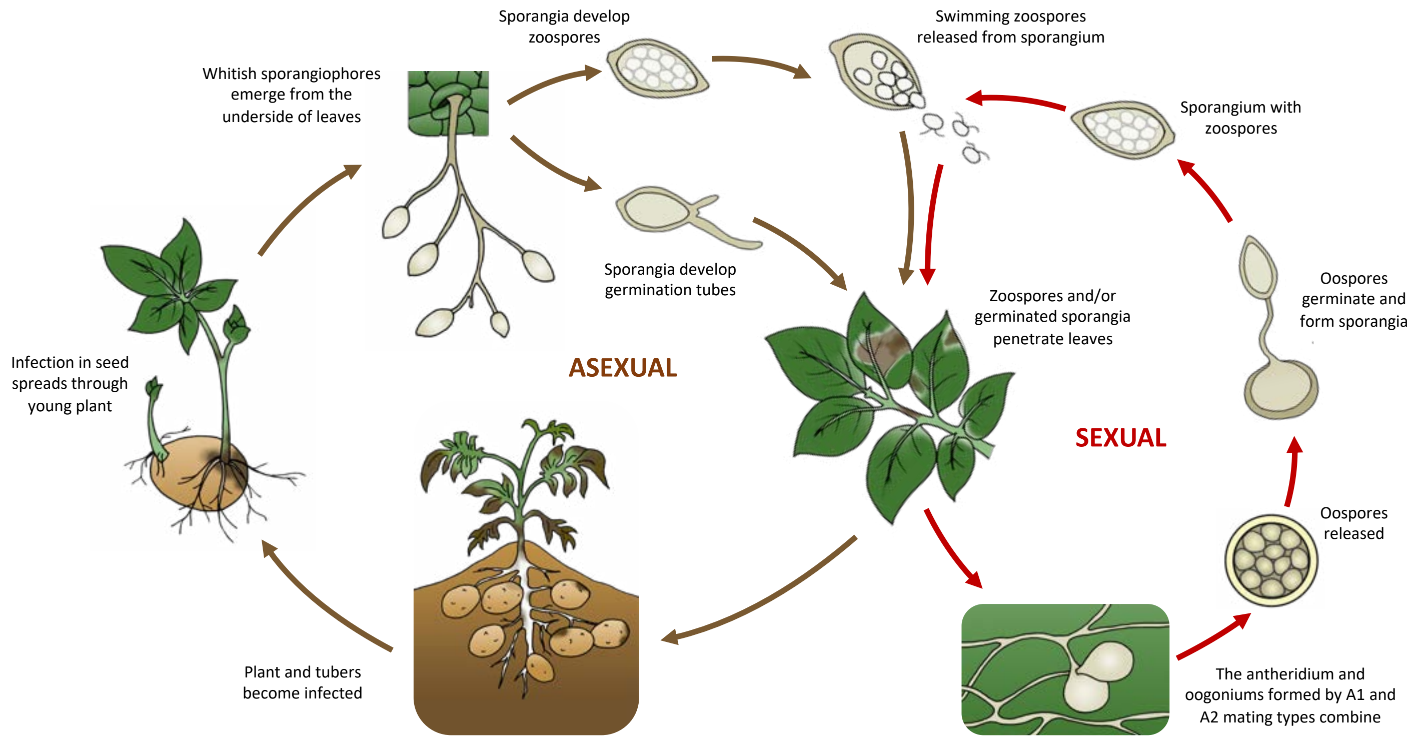


Figure 1. P. infestans lifecycle. Note that only asexual reproduction occurs in Australia as the A2 type is not present.

After emergence, the pathogen follows the growth of the plant from the tuber to the young stems. Here it spreads onto the new foliage and sporulates. What look like upside-down trees of whitish sporangia emerge from leaf lesions and through the leaf stomata. The sporangia are then spread by wind, or in rain or irrigation water to neighbouring plants, fanning out into the crop.

While sporangia can germinate directly, they can also release swimming zoospores. The zoospores actively move through water films on the leaves down the stems, to be further spread by wind and rain.

Sporangia can also be washed down into the soil to infect tubers.

Modern farming practices greatly reduce the risk of spreading the Australian A1 strain in seed. However, spread is still possible, as latent infection of tubers is not detectable through visual inspection.

Typical infection cycles are only 5-7 days. Where free moisture is present, the pathogen can spread rapidly, with devastating effects.

Between potato crops, the pathogen can survive in seed and waste tubers, volunteer potato plants and alternative Solanaceous hosts.

WEATHER DRIVES DISEASE

Late blight generally occurs sporadically, being very much driven by weather conditions. "Typical late blight weather is warm and sultry," states Dr de Boer. "Lengthy periods of warm, still and humid overcast days with cool nights and warm days present the greatest risk of disease."

Dew is the number one issue. "Rain in itself does not pose the risk. Rather, it's the prevailing weather conditions that accompany the rainy periods which are the problem."

In most potato growing regions of Australia, conditions are too dry during spring through to autumn to cause high levels of disease, especially if humidity is low. However, predictions of a wetter than average November suggest that risk may be higher this year.

There is a strong correlation between wet seasons and outbreaks of late blight. "La Niña is the link here," suggests Dr de Boer. "La Niña years are when I get the most phone calls about late blight." Outbreaks occurred between 1998-2000, 2010-2012 and now 2021-2022, all of which were La Niña cycles. While La Niña predominantly affects the north east, it can also bring late blight conducive conditions further south.

WHERE DOES IT COME FROM?

Changing weather conditions means there are big gaps between outbreaks of late blight. But we know that the A1 strain can only survive on live materials – where does it go?

According to Dr de Boer "It most likely survives in pockets of very protected areas which have favourable microclimates. These allow the fungus to regularly complete its lifecycle during drier seasons. It may be present on old tubers, self-sown potatoes or other hosts such as kangaroo apples. But that's a big question mark".

Prof. Steven Johnson agrees. In his experience, epidemics don't start from volunteer potatoes, but these plants will let an epidemic continue. "Late blight likes a young lunch, it prefers very actively growing tissue. Self-sown potatoes tend to be a little slower, so they get infected later in the season." While some mystery remains about where infection comes from, certainly the importance of using clean seed can't be overstated.

Because of the sporadic nature of conducive weather conditions, the pathogen experiences "boom" and "bust" cycles in the Australian environment. In a conducive season it will take some time for the population to build up from a very low base and the disease may not be so obvious. However, if followed by a second favourable year, the disease is likely to be much more serious. This resulted, for example, in a higher disease incidence the 2021/22 La Niña cycle compared with the 2019/20 cycle.

LATE BLIGHT SYMPTOMS

In the early stages of infection, leaves develop pale, grey green lesions. These expand rapidly, turning brown to black with pale margins. Under very wet conditions the lesions become black and slimy. Necrotic lesions can also be found on the stems (Figure 2).

Under humid conditions white fuzz develops on the infected stems and undersides of the leaves (Figure 3). These contain the wind and rain borne sporangia, which spread to neighbouring plants. Once this occurs plants generally collapse, with the infected zone clearly visible as a patch of dead and dying plants.

The spores produced on the upper parts of the plant eventually wash down into the soil and infect the tubers. Initially, the tubers develop a tan-brown reddish or purplish rot just under the skin. Irregularly shaped, sunken areas develop, turning into wet and slimy lesions. Bacterial infections often then attack the tubers, causing complete collapse.

Figure 2. As the disease develops, pale grey lesions on the leaves expand and turn brown (a). Under very humid conditions (such as in the highlands of Java) these lesions can become black and slimy (b). Necrotic areas spread through the stems (c). Eventually the plant dies, as shown on this 4 week old, untreated 'Sequioa' plant (d). - Images: R. de Boer.

Figure 3. Under humid conditions, whitish sporangia containing zoospores emerge on leaf undersides, mainly around the active margins of the leaf lesions
- Images: R. de Boer

LATE BLIGHT IN AUSTRALIA

The epidemics of the early 1900s saw outbreaks occur across all Australian potato growing districts, from the Atherton tablelands, across to Perth and down to Tasmania. Fortunately for WA it has not been recorded since. In fact, since the 1980s control has improved around Australia, with outbreaks now concentrated in pockets of NSW, Victoria, South Australia and Tasmania.

After the 1909 outbreak plant pathologists looked at where else it could be found. They found the disease widely on potatoes, tomatoes and the weed kangaroo apple (*Solanum aviculare*) – which was frequently growing around and within potato production areas. Curiously, black nightshade plants (*Solanum nigrum*) growing in late blight affected crops were immune.

"It is important to note that the 1909-11 epidemic occurred with a La Niña weather event, just like the La Niña we are having at the moment," states Dr de Boer.

KEEPING A2, AND NEW STRAINS OF A1, OUT

Not having the A2 strain in Australia is definitely a major advantage.

The A2 strain initially came out of Mexico, spreading first to the United States and Europe, but eventually – thanks to the trade in seed potatoes – to many other potato producing countries around the world. This means there is much wider genetic variability in pathogen populations in most countries outside Australia.

Dr DeBoer has worked extensively on identification of *P. infestans* strains. "These new strains are far more aggressive than the old clonal strains we had before." He explains "they have a shorter lifecycle; instead of having a turnaround of 4 to 7 days, this is reduced to 3 to 5 days or even quicker. Many are metalaxyl resistant, and some A2 strains are also 'resistance busting'; there's a strain kicking around the UK which has overcome resistance bred into new varieties. Wider genetics mean that these new strains are also more adaptable to wider temperature regimes, lower moisture and so on."

It is clearly critically important to keep A2, and new strains of A1, out of Australia. It is also important to regularly identify strains present in Australia to identify if incursion has occurred.

From 1998 – 2001 Dr de Boer led a HIA funded project examining the strains then present in Australia. "We got a lot of help from industry – chemical companies, agronomists and growers all collected samples. The pathogen was tested for mating type, metalaxyl resistance and DNA fingerprint analysis."

"All our samples were a single clone of A1 mating type (designated AU-1) and very sensitive to metalaxyl. It's the same genotype as the strain that caused the Irish famine (FAM-1). This was displaced by new strains elsewhere around the world by the 1950s, so is essentially a relic found only in Australia and New Zealand."

What this means is that there have been no new introductions of *P. infestans* to Australia in more than 100 years. This is undoubtedly due to the quarantine systems that were established in Australia in the early 1900s, including mandatory testing of seed since 1913. There have been no imports of unprocessed potatoes for several decades.

However, risk remains. The A2 strain is present in Indonesia, and various A1 strains are present in Thailand, PNG and East Timor. There is always the possibility of someone bringing back some oospores on their boots or a souvenir tuber in their bag.

CONTROLLING LATE BLIGHT

Prevention is clearly the best method of control. This means using only certified seed, ensuring there are no volunteers left over from previous crops, and removing Solanaceous weeds, especially kangaroo apple.

Minimising any initial source of infection will delay spread during cropping. However, even a tiny amount of inoculum can spread exponentially under wet conditions, infecting the entire crop. When risk is high, they key questions are therefore:

- When to spray
- What to spray
- When to salvage

When to spray is often based on prediction modelling. According to Prof. Steven Johnson from the University of Maine, "We don't control late blight, we manage it. Going for zero tolerance is expensive and can be an unreasonable approach."

According to Prof. Johnson, the most important period is during early crop development. "If late blight gets a foothold during early growth, then you just can't keep up with it, as it develops exponentially early in the crop cycle." Once a large amount of inoculum is present in the field, no amount of fungicide will be able to hold it back.

This means that the intervals for subsequent applications should be weather driven. "So not every Friday night," says Prof. Johnson; "Calendar based spray schedules are not environmentally or economically sound."

Figure 4. Timing sprays appropriately is essential. The healthy crop in the foreground has had just one more fungicide application than the late blight affected crop to the left (Image: S.B. Johnson).

Figure 6. It is essential to cover the entire crop when applying fungicides. In this field the grower has left the edge of the crop unsprayed; this has allowed development of late blight, which can then spread to the remainder of the crop (Image: S.B. Johnson).

What to spray includes choices of;

- Contact (protectant) fungicides, which don't move into the plant tissue e.g. chlorothalonil, mancozeb, fluazinam
- Translaminar fungicides, which move into the plant tissue but don't move within the plant vessels e.g. dimethomorph (Acrobat® SC)
  - Move slowly through the plant leaf from top to bottom
  - These have longer lasting effects than contact fungicides
- Systemic fungicides, which move into the plant tissue and around the entire plant
  - Most are upwardly mobile, so can protect new foliage as it emerges (e.g. Infinito®)
  - Some are also downwardly mobile (e.g. Ridomil Gold®)

Prof. Johnson suggests using either full or partial rates at different points in the season and emphasises the importance of putting the fungicide where and when it is needed. "You've got to replace eroded material," he says. "That could mean that just one extra application has a big impact on rates of disease." (Figure 4).

This is especially important when the plant is rapidly increasing its leaf area (Figure 5). "Early in the season the plant can double in size every three or four days. If you're putting on a protectant, the plant is going to outgrow it very quickly. This is when it's best to use a systemic, or at least one of the translaminar products, that can move with the new growth."

Getting good coverage is essential, so applicators need to understand their equipment. This means considering boom height, nozzle type and pattern, forward speed and using adequate water volume to fully cover the crop.

"I've seen crops where the grower didn't want to run the extra half pass with the boom spray to get right to the edge of the field, so those plants got late blight. This then became a spreader row for the rest of the field," comments Prof. Johnson (Figure 6).

Salvaging involves regular checks for areas of late blight within the crop. For example, if seed introduces disease to one area of the field, it may be better to kill those plants to prevent spread, protecting the rest of the crop (Figure 7). Prof. Johnson suggests an area around 10x the size of the initial outbreak, to be sure to get good control.

"Late season finds are important as well. We don't get a lot of tuber infection when conditions are warm, so in this case you might want to go for an early kill rather than leaving the crop to full term," suggests Prof. Johnson.

CONCLUSIONS

Late blight is something growers are likely going to have to deal with this season. As Prof. Johnson says "I'm pretty darn sure that you're going to have late blight this year, and it's going to come early. Certainly, in the Ballarat area, and east and west of Melbourne, you're starting out with a higher initial level of inoculum, and that's what is likely to drive any epidemic hard".

In central northern Tasmania late blight was a major issue last season, with infection occurring relatively early in the season. There are reports of yield losses up to 30%. There is a high risk that the pathogen has overwintered in / on other host plants or volunteer potatoes (Figure 8).

Dr Nigel Crump from AuSPICA also sees an increased risk of late blight this year. "Generally in Victoria we see late blight fairly late in the season, as inoculum builds up. It's a community disease, rather than individual paddocks, and a community approach is important for control."

Early detection is essential, so checking the crop regularly when weather conditions are right for infection is critical. If late blight starts to get away, it's virtually unstoppable.

Testing services are available, so sending in samples to confirm presence of late blight is highly recommended. These will also help to confirm that we still only have the A1, metalaxyl-sensitive strain present.

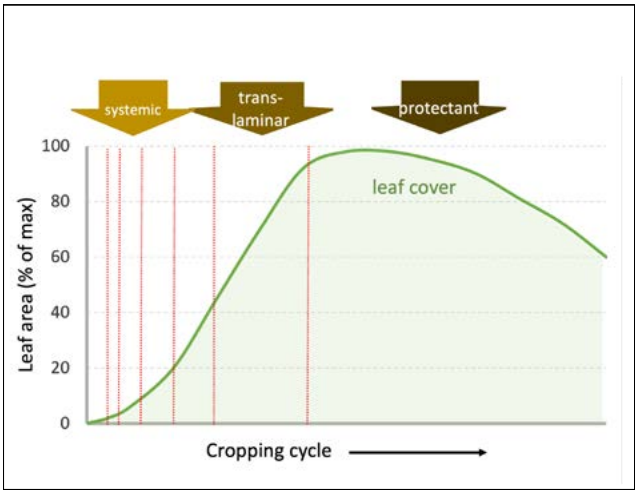


Figure 5. The red lines indicate doubling of the plant canopy area. If forecasting indicates risk of disease is high, systemic or translaminar fungicides should be applied when leaf area is increasing rapidly, and protectants once new growth has slowed or ceased. Derived from data presented by Prof. Stephen Johnson.

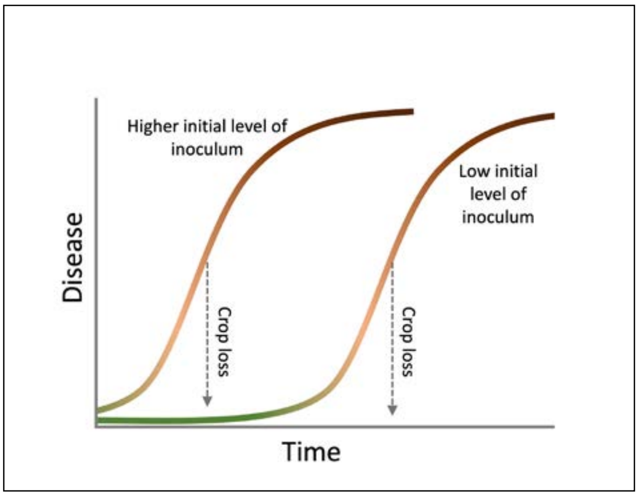


Figure 8. Even a small increase in the initial level of inoculum can see late blight become a major issue much earlier in the season.

Figure 7. If an outbreak of late blight occurs within a field, the best option may be to kill those plants, rather than risk the disease spreading into the remainder of the crop. (Images: S.B. Johnson).

Dear Spud GP

I've heard reports of fall armyworm in potato crops, how concerned should I be and what can I do? –Warren

ASK THE SPUD GP

Figure 1. Fall armyworm caterpillar, showing the distinctive inverted 'Y' on the head and dark spots on the second last segment which distinguish it from Helicoverpa and other armyworm species. - Image: M. Bertone

Hi Warren

Fall armyworm (FAW) is definitely a significant threat to horticulture globally. Originally from the Americas, it was first detected in Australia in January 2020. It spread rapidly, travelling all the way from North Queensland to Tasmania in just 14 months.

While FAW favours maize, sweetcorn, sorghum and pastures, potatoes can still be affected. When populations of FAW are high, they may move into neighbouring potato crops and cause damage.

It is important to know your risk. Areas with continual / high populations of FAW are more susceptible to damage. A map prepared by the CSIRO and Plant Health Australia indicates areas where it is most likely to be present and risk is highest (Figure 2).

The good news is that potatoes are not a preferred host for FAW, and that the insect does poorly when living in potato crops. Compared to maize, FAW has lower survival, is slower to mature, and produces fewer offspring when in potato crops.

For example, only half the baby caterpillars make it to second instar in a potato crop, whereas nearly all of them survive to pupation when they are feeding on maize. Of those females do make it to adulthood, they lay an average of 444 eggs when raised on maize but only 136 after a diet of potato (Guo et. al, 2021).

In other words, the overall fecundity (maximum potential reproductive output) of FAW is dramatically reduced in potatoes (Figure 3).

So does this mean that there will be no damage to potatoes? Not really. There can still be feeding damage to

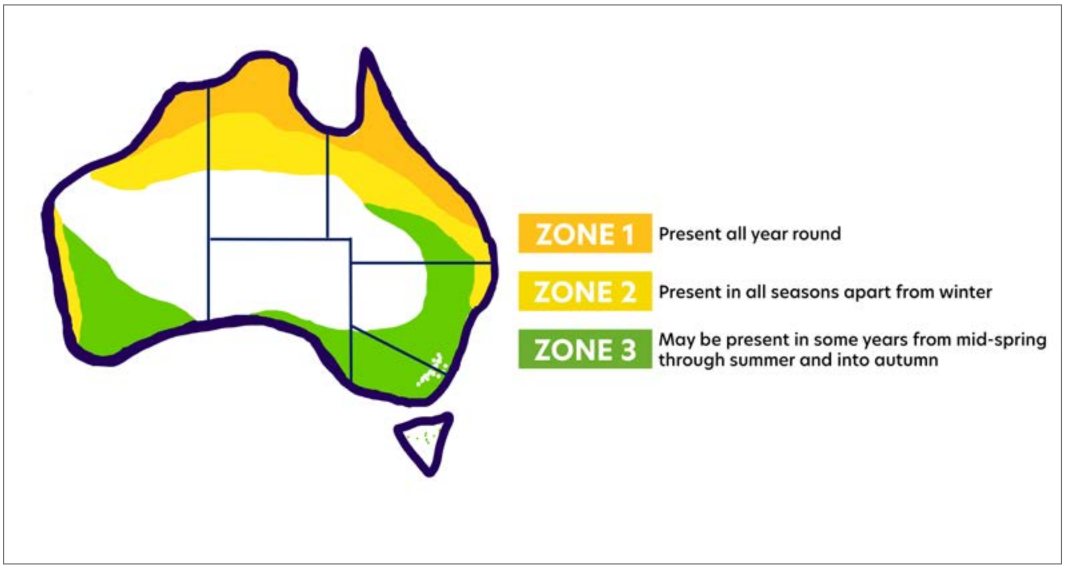


Figure 2. Potential areas at risk from FAW; adapted from original published by CSIRO and Plant Health Australia

the plant, and in a natural setting there may be other host plants around the potatoes which improve survival of the FAW larvae, increasing the adult population.

Chemical control is available for FAW. Check the Australian Pesticides and Veterinary Medicines Authority permits portal here (https://portal.apvma.gov.au/permits) and search Fall Armyworm to give a list of the available products. FAW has been noted for its ability to gain resistance to chemicals relatively quickly. Combat this by using IPM and following the AUSVEG Management of fall armyworm in vegetable crops in Australia guide.

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

Figure 4. AUSVEG FAW management guide QR code

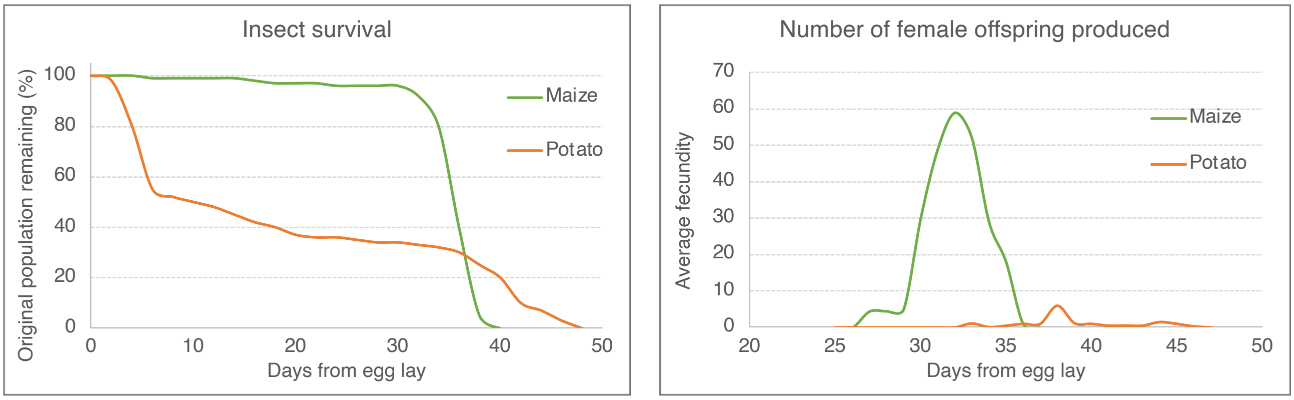


Figure 3. When taken from egg to adult, less than 50% of the original population of FAW survives past the first instar larval stage on potatoes, whereas more than 95% of the insects survive to pupation on maize (left). Fecundity is also greatly reduced on potatoes, with the number of second-generation offspring approximately 10% of what it would be on a maize crop. Data derived from Guo et al., 2021.

REFERENCES AND FURTHER READING

Guo JF et al, 2021. Comparison of larval performance and oviposition preference of Spodoptera frugiperda among three host plants: Potential risks to potato and tobacco crops. Insect Sci. *28*: 602-610.

Plant Health Australia, 2020. Fall Armyworm Continuity Plan for the Australian Grains Industry, Version 1 (November 2020) https://www.planthealthaustralia.com.au/wp-content/uploads/2020/11/Fall-Armworm-Continuity-Plan-2.pdf

AUSVEG, 2021. Management of fall armyworm in vegetable crops in Australia (November 2021) https://ausveg.com.au/app/uploads/2021/12/Final-pdf-standard-faw-guide_compressed.pdf

Aaron Haby and Peter Philp, *photo by Dr Jenny Ekman*

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