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Pathogens – it's all in their DNA

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Held in Dublin in May this year, the world potato congress attracted nearly 1,000 delegates from 60 countries.

Jenny Ekman takes a look at some of the conference highlights, with new results in sustainability, nutrition, breeding and precision ag. There was also a Field Day, and side visits to Sam Dennigan and Co. and TOMRA technologies.

With the next conference to be held in Adelaide, it's a great time to take a look at this major event.

THE CHANGING NUTRITION NEEDS OF A GROWING CROP

Surging fertiliser prices have put the spotlight on fertiliser budgets. Approaching nutrition through the 4R framework can keep up with crop nutritional needs while taking the sting out of high fertiliser prices.

by Alisa Bryce

The 4R's of fertiliser management means putting the **RIGHT** nutrients on at the **RIGHT** rate, at the **RIGHT** time, in the **RIGHT** place.

Pre-planting soil testing is the best way to gauge the right nutrients and rates to start the season.

In-season tissue testing (Figure 1) can identify which nutrients need a boost, or where the fertiliser program can be scaled back. Using in-season tissue testing can catch deficiencies early, before visual symptoms appear and yield is penalised.

For potatoes, the right time and place are particularly important. For the first few weeks, potato plants get most (but not all) of their nutrition from the seed piece. From stage 2 (stolon initiation) the plant transitions from using energy reserves in the seed piece to accessing soil nutrients through the developing roots.

Nutrient demand is highest from tuber initiation through to maturity, (Figure 2) so nutrients need to be both available and accessible. Potatoes have shallow, sparse root systems that are poor nutrient scavengers. Ensuring nutrients are within easy reach, especially immobile nutrients like phosphorus, is critical.

Potato nutrition requirements change throughout the season (Figure 5). Matching fertiliser inputs to these requirements helps avoid deficiencies (Figure 3) and maximise yield while avoiding waste of expensive inputs.

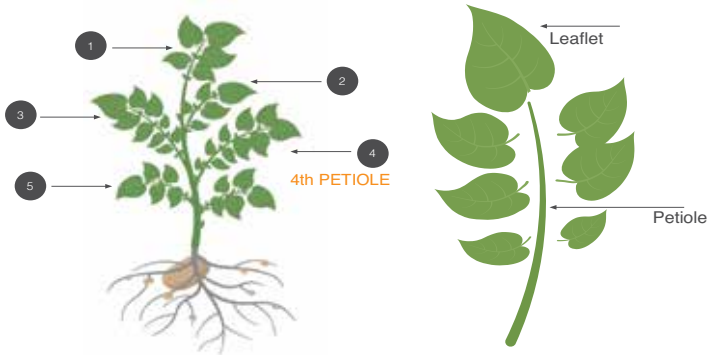

Figure 1. Nitrogen status may be assessed by sampling the fourth petiole (from the newest leaf down) from at least 30 plants around the field. Petiole nitrate-N levels during tuber bulking are; <10,000ppm = low; 10-15,000ppm = medium and >15,000ppm = sufficient

ROLES OF NUTRIENTS IN POTATOES

Nitrogen needs the most management. It is critical for developing tubers and overall crop growth. Nitrogen must be managed carefully throughout the season, as either inadequate or excessive supply can reduce crop quality and yields. In-crop mineralisation can supply some nitrogen but repeat applications are likely necessary.

Only a small amount of nitrogen is needed during establishment and stolon initiation. Crops need enough to encourage leaf growth and help deal with early blight infestations. Conversely, too much nitrogen during these growth stages can delay tuber initiation and maturity, promote excess vine growth, increase risks from disease and potentially result in internal defects in tubers.

Potatoes take up 60 – 70% of their total nitrogen requirements during tuber bulking (Ojala et al. 1990). In contrast, very little nitrogen is taken up during maturation.

Phosphorus helps the root system develop, regulates tuber set and promotes tuber maturity. Inadequate

phosphorus leads to lower tuber numbers. Because phosphorus is quite immobile in the soil, it should be applied pre-planting, near the seed, where the developing root systems can access it.

Potassium optimises tuber yield, size and quality and regulates water balance. It is also essential for root elongation, leaf expansion and photosynthesis. Potassium deficient plants have lower specific gravity and are more susceptible to disease. Being heavy potassium users, in-crop applications of potassium are common. As with nitrogen, potassium requirement peaks during tuber bulking. However, too much potassium late in the season can reduce specific gravity.

Calcium creates stronger cell walls which improves skin quality, maximises tuber storage life, and reduces susceptibility to disease. Regular calcium supply is needed throughout the season, but supply is particularly important during tuber initiation and for protection against quality disorders such as internal brown spot.

Sulfur is useful for increasing tuber numbers and can help mitigate the risk of Common and Powdery Scab. Like calcium, regular sulfur supply is important.

Magnesium is essential for photosynthesis. It is particularly important during tuber bulking for maintaining tuber size and yield.

Although only required in small amounts, trace element deficiencies can restrict root growth, yield, and disease resistance.

Boron is the trace element needed most by potatoes. It affects cell wall strength and therefore tuber storage quality, as well as supporting root growth. Boron also helps potatoes absorb and use calcium.

Manganese and **Zinc** deficiencies affect yield and skin quality. Low zinc can affect nitrogen metabolism and starch content. Too much manganese can severely reduce yield.

Copper and **Iron** deficiencies are rare. **Molybdenum** deficiency is also uncommon, being more likely if the seed piece was grown in low molybdenum soil. Without enough molybdenum, plants can't use nitrogen to make protein; symptoms look like nitrogen deficiency.

NUTRIENT INTERACTIONS

Nutrient interactions in plants are complex, but important to consider as imbalances can penalise yield and quality. In potatoes, the more commonly recognised interactions are:

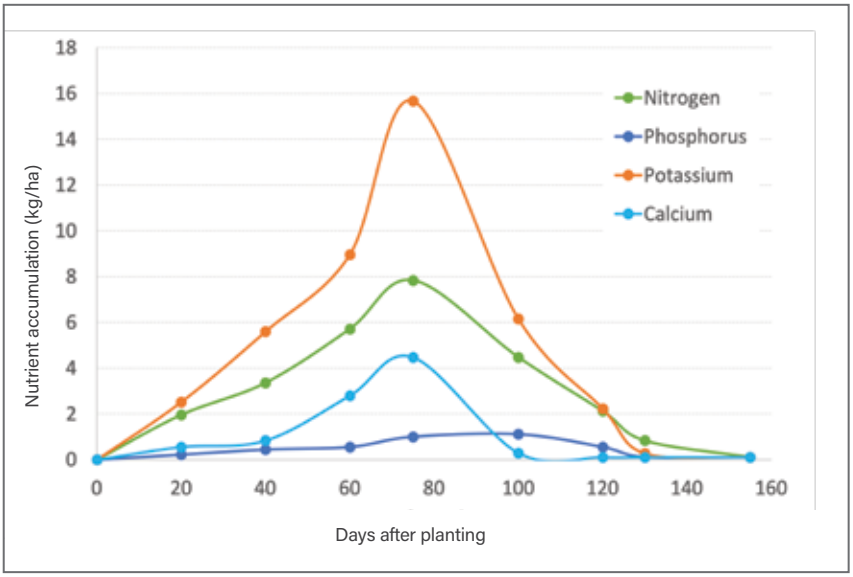

Figure 2. Daily nutrient accumulation by Russet Burbank potatoes. Derived from Horneck and Rosen, 2008.

- High rates of potassium fertiliser can induce magnesium deficiency, as potassium and magnesium compete for uptake.
- Boron improves calcium absorption.
- Increased available phosphorus can affect manganese uptake.
- Zinc deficiency can result from excess phosphorus uptake, or phosphorus-induced zinc deficiency.
- Trace element interactions can partition between the shoots and dry matter. For example, increased available soil manganese depresses iron in shoots (Reichman 2002).
- A study by Barben et al. (2011) suggested that balancing zinc and manganese availability – especially avoiding low zinc and high manganese – is vital as these nutrients can have negative impacts on phosphorus, copper and iron.

READING THE PLANT

The symptoms of nutrient deficiencies or excess vary in where they first appear in the plant. Mobile elements can be relocated from older leaves to growing shoots (e.g. potassium and magnesium), whereas deficiency symptoms of immobile elements will be most obvious in the growing tips (e.g. calcium and sulfur; see Figure 4 for illustration of zinc and sulfur deficiency).

Other ways to fine-tune fertiliser management:

- Remember Leibig's law of the minimum—yield is only as good as the most limiting nutrient i.e. more nitrogen won't help if lack of boron is suppressing growth. Addressing the full suite of nutritional needs gets the most out of the fertiliser budget.
- Match zones in paddocks to fertiliser needs based on soil type and cultivar.

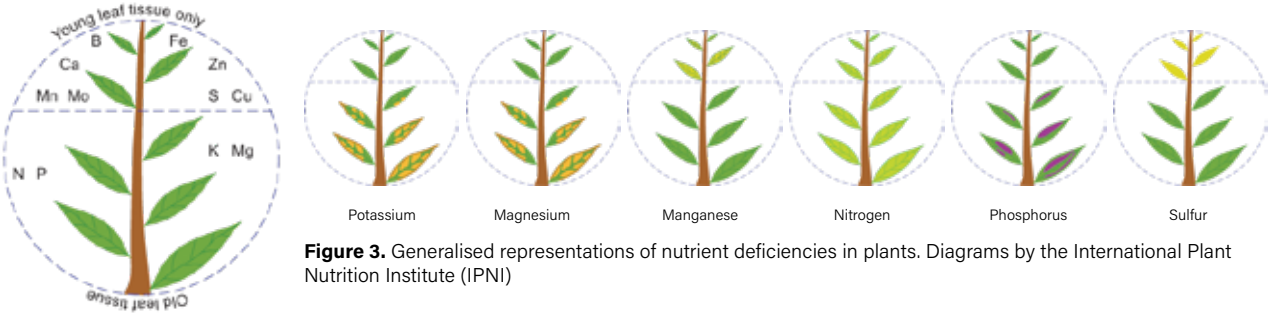

Figure 3. Generalised representations of nutrient deficiencies in plants. Diagrams by the International Plant Nutrition Institute (IPNI)

Figure 4. Both zinc (left) and sulfur (right) are immobile in the plant, so deficiencies show first in the youngest leaves. Photos by IPNI.

					
	Stage 1 – Establishment	**Stage 2 – Stolon initiation**	**Stage 3 – Tuber initiation**	**Stage 4 – Tuber bulking**	**Stage 5 – Maturation**
Nitrogen	Too much N risks delaying tuber initiation and internal defects	Too much N risks delaying tuber initiation and internal defects	N needs increasing but don't overdo it	Peak N demand	N uptake drops significantly
Phosphorus	Early shoot development and root elongation	Maximises tuber number set	Maximises tuber number set	Supports tuber bulking	
Potassium	Protection against disease and frost tolerance	Root development and photosynthesis	Root development	Peak K demand	
Magnesium				Mg most important. Maintains tuber quality	
Calcium			Ca most important. Protection against quality disorders	Improves skin finish	
Sulphur		Tuber numbers and disease protection			

Figure 5. Key potato nutritional needs across the five growth stages.

FERTILISER APPLICATION METHODS

Choosing an appropriate fertiliser application method is important for nutrient timing and placement. Broadcasting or banding granular fertiliser pre-season sets the crop up for a good start. Fertigation and foliar applications are more common in season as the fertiliser budget gets adjusted in response to tissue testing. Each method has pros and cons.

Method	Pros	Cons
Broadcasting (not incorporated)	▪ Fast, easy to apply. ▪ Can be done with cheaper equipment than other methods.	▪ Uses more fertiliser than banding. ▪ More fertiliser available for weeds. ▪ Greater chance of nitrogen loss through volatilisation and denitrification. ▪ Requires rain or irrigation to move more mobile nutrients like nitrogen into the rootzone. ▪ Less mobile nutrients like phosphorus and traces remain on the surface, away from the roots.
Banding / side dressing	▪ Puts nutrients closer to the roots for better access. Particularly important for phosphorus. ▪ Better root growth through more access to nutrients. ▪ Less nutrients for weeds. ▪ Uses less fertiliser than broadcasting. ▪ Less risk of nutrient loss with erosion. ▪ Less risk of nitrogen loss from volatilisation and denitrification.	▪ Equipment costs more than broadcasting equipment. ▪ Slower than broadcasting. ▪ Risks salt damage if fertiliser is placed too close to the seed piece.
Fertigation	▪ Can be precise with fertiliser amounts and timing. ▪ Faster nutrient uptake because nutrients are already in water. ▪ Flexibility to adjust rates throughout the season.	▪ Troublesome if it's a wet year and the soil is already saturated. ▪ Higher risk of leaching nutrients, especially nitrogen if applied early in the season. ▪ Uneven applications and wasted fertiliser if windy. ▪ Higher risk of N loss from volatilisation on hot, windy days. ▪ High calcium and/or magnesium in water can make phosphorus unavailable.
Foliar applications	▪ Fast way to correct trace element deficiencies. ▪ Useful is the soil is alkaline and some nutrients are less available for uptake. ▪ Useful for in-crop phosphorus applications if irrigation water has high calcium and magnesium. ▪ Faster nutrient uptake than fertigation and other soil application methods.	▪ Less useful for macronutrient deficiencies. ▪ Risks scorching or leaf burn if rates are too high. ▪ Shouldn't apply on moisture stressed plants.

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MAKING SENSE OF SOIL TEST REPORTS

Whether it's improving yields, using fertilisers efficiently or monitoring sustainability, regular soil testing can give you the information you need. ***By Paulette Baumgartl***

Crop health, yield and quality depend not only on the levels of plant nutrients but also how they interact in the soil. Soil testing is a great tool to help you decide how to manage your fertiliser program for crop and soil health. There are several reasons to conduct regular soil testing, including to:

- **Check soil properties** that influence nutrient availability and uptake, such as organic matter, pH, electrical conductivity, and cation exchange capacity (CEC).
- **Determine levels and ratios of nutrients** in the root zone and required interventions.
- **Prepare a nutrient budget** and management plan based on the yield target and the predicted nutrients removed with the crop.
- **Monitor** changes and trends over time.

BEFORE YOU TEST

Having an overview of the soil conditions before planning a soil testing program will help you understand what your test results mean. Specific information you should consider include:

- Site history including cropping and fertiliser and past soil test results.
- Soil type and texture, uniformity, and condition of soil surface.
- How deep is your topsoil and are there any compaction layers?

SOIL TESTING: WHERE, WHAT, WHY, AND WHEN TO TEST

Potatoes are fast growing and high yielding crops, and their demand for nutrients is high. They can remove large quantities of nutrient from the soil, and it is vital to ensure fertiliser applications are adequate to supply the crop requirement.

Soil testing often focuses on the topsoil, i.e., the top 15-30 cm, and doesn't always capture information about the subsoil or deeper crop root zone. It is important to also measure soil properties and nutrient availability at depth, as these factors can influence plant nutrient uptake and crop health. Subsoil sampling is particularly important for minimum or no till systems, where nutrients and pH can be stratified across the soil profile.

Refer to the Soil Wealth website www.soilwealth.com.au for a guide to collecting soil samples for testing.

HOW DO PLANTS TAKE UP NUTRIENTS FROM THE SOIL?

There are three ways that plants can take up nutrients from the soil:

Root interception where growing root system comes into direct contact with nutrients in the soil. This is important for immobile nutrients such as phosphorus.

Mass flow where nutrients move in the soil water to the roots. Good examples are highly soluble nutrients like nitrate and boron.

Diffusion This is where positively

While some soil characteristics can be assessed by sight and feel, soil tests can provide far more detailed information.
- Photo by L. Ketchum

Soil type can vary considerably through the profile

charged nutrients such as potassium (K+), calcium (Ca++), and magnesium (Mg++) diffuse to the soil roots from soil particles.

Laboratory soil tests extract plant available nutrients from the soil. However, understanding the levels of available nutrients is not the complete picture. How well potato plants can use these soil nutrients depends on many factors, including:

- **Soil moisture**: Plants cannot take up nutrients from dry soil, so it is important to keep the soil moist in the entire root zone.
- **Soil properties** such as texture, CEC, and organic matter will impact nutrient uptake.
- **Salinity**: Nutrient uptake and use efficiency is low in salt affected soils, due to negative interactions with nutrients or sodium at high concentrations.
- **Soil-borne disease** can reduce root efficiency and nutrient uptake.

CHEMICAL AND NUTRITION PARAMETERS – WHAT THE NUMBERS MEAN

Soil pH

What: Soil pH is a measure of the acidity or alkalinity of the soil. Soil pH mainly affects the availability of major and trace elements to plants. Highly acidic or alkaline soils can lead to either nutrient deficiencies or toxicities.

How is it measured: Soil pH can be measured in water or in a calcium chloride ($CaCl_2$) solution. When soil pH is measured in water, a level of less than 7 is acidic and greater than 7 is alkaline.

Soil pH in $CaCl_2$ is usually preferred as it is less affected by soil electrolyte concentration, providing a more consistent result. Soil pH in $CaCl_2$ is typically 0.5 to 1 unit lower than pH measured in water. To optimise nutrient availability, soil pH in $CaCl_2$ should be maintained at between 5.8 to 7.5 in the topsoil (top 15cm), and above 4.8 in the subsurface (below 15cm). Potatoes generally prefer slightly acidic soils.

Interventions: Highly acid soils can lead to toxic levels of aluminium, limit nutrient availability and soil biological activity. Acidity is best corrected using lime, which should be applied between potato crops. Note that fresh lime applied before planting may increase the likelihood of common scab.

Moderately alkaline soils (about pH 7.5) can reduce availability of phosphorus and trace elements. These soils can be corrected by applying elemental sulphur or acidifying fertilisers including urea or ammonium. Highly alkaline soils with a pH >8.5 or more are sodic. This can occur naturally or due to high levels of sodium in the irrigation water. These soils are difficult to manage, and tend to form crusts on the soil surface, restricting water infiltration.

Soil texture and Cation Exchange Capacity (CEC)

What: Soil texture refers to the proportion of sand, silt and clay in a soil.

Cation exchange capacity (CEC) is a measure of the capacity of a soil to hold nutrients such as calcium, magnesium and potassium. Clay soils normally have a high CEC, e.g. 25 meq/100g or more and sandy soils have low CECs, often 5 meq/100g or less.

Low CEC soils do not hold nutrients well. Nutrients can easily leach out with rainfall or irrigation. Low CEC soils therefore need smaller quantities of nutrients applied more frequently than heavier loam or clay soils.

How is it measured: CEC is usually expressed as meq/100g or cmol+/kg.

Interventions: Adding organic matter is a good way of increasing or maintaining CEC. Some growers have added clay to sandy soils to increase nutrient (and water) holding capacity.

Organic matter (OM)

What: Soil organic matter (OM) is an essential part of a healthy soil. It is a food source for soil micro-organisms and helps the soil hold water and nutrients.

How is it measured: Although there is no ideal number, soils with less than 2% OM are often regarded as functionally impaired. The organic matter content of soils used for potato production in Australia ranges from very low (less than 2%) in Mallee sands to high (more than 8%) in peaty soils.

Intervention: Planting cover crops, minimising tillage and erosion, spreading organic materials such as composts, manures and crop residues all help to elevate OM levels in soil.

QUICK GUIDE TO ASSESSING A SOIL TEST REPORT

The following checklist a good way to assess your soil test report and identify areas that need attention. A good soil test report should show the following results:

- Soil pH: 5.5-7.5
- Organic matter 3.5-4%
- Nitrate-N: 40-50 mg/kg
- Phosphorus (Colwell): 75-100 ppm
- Potassium: 5% cations or > 0.5 meq/100g
- Sulphur: 10-20 mg/kg
- Calcium: magnesium ratio = 4
- Micronutrients: within recommended ranges
- Salinity: EC < 1/5 dS/m and chloride <200 mg/kg
- Problem cations: Sodium < 6% cations (in a clay soil) and Aluminium less than 1 mg/kg.

PRIMARY CROP NUTRIENTS

Nitrogen (N)

What: Nitrogen (N) is a critical nutrient for crop growth and development of tubers. Too much or too little nitrogen can have a negative impact on yield and quality. Many factors, including the type of N used, when, how much and how often it is applied all need to be considered when determining nitrogen application rates.

How is it measured: Nitrogen levels can be reported as total nitrogen or plant available nitrogen. Total nitrogen is a measure of the total amount of nitrogen in the soil and usually expressed as a % value. Plant available nitrogen is normally expressed as nitrate nitrogen and reported as NO_3-N in mg/kg. Soil nitrate levels alone are guide only and not a reliable indicator of crop nitrogen requirements.

Intervention: Application of fertiliser. The amount and frequency should be based on the soil tests results and knowing the target tuber yield and crop removal rate.

Phosphorus (P)

What: Soil phosphorus (P) is a key essential element for plants, being important in root growth, cell division and tuber initiation.

How is it measured: Tests measure extractable phosphorus in mg/kg, which roughly indicates how much P is available to plants. Real available P will depend on root distribution as well as soil type as P is not mobile in the soil.

Test results may also show the PBI value (potassium buffering index). PBI is the soil's ability to 'lock up' P so the crop cannot use it. High PBI soils will require higher rates of P fertiliser.

There are several tests offered in Australian laboratories for soil phosphorus:

Colwell P (mg/kg) is the most commonly used test. Results will vary with soil type however levels less than 30 mg/kg are low; levels 70 - 100 mg/kg are generally adequate to high. Colwell P levels should be higher in heavier soils and high yielding crops where a lot of P will be removed.

Olsen P (mg/kg) is the preferred method for soils with a pH above pH 6, and a must for a pH above 7. For potatoes, less than 30 mg/kg is generally considered low, more than 50 mg/kg is high. However, critical values vary considerably with soil texture.

Mehlich 3 (M3) P (mg/kg) is the preferred method for soils below pH 7.5. Less than 30 mg/kg is low, more than 70 mg/kg is high.

Intervention: Fertilisers and/or manures can be used to increase soil P levels. It is important to note that frequent or heavy use of manures can lead to elevated soil P levels and eventually leaching and/or run-off. High P applications reduce zinc uptake and can induce zinc deficiency. However, as zinc helps plants uptake P, a careful balance is required.

AT A GLANCE – COMMON UNITS USED IN SOIL TESTS

Cmol/kg	Concentrations of cations are expressed in centimoles of positive charge per kilogram of soil (cmol(+)/kg). This measurement is equivalent to the previously used unit meg/100 g. Adding the concentrations of each cation gives you an estimate of the CEC figure.
% CEC	The proportion of a particular cation to the total cations present in a set volume of soil
meq/100g	Milliequivalents per 100 grams of soil. 1 meq/100g = 1 cmol(+)/kg, where cmol(+)/kg is the abbreviation for centimoles per kilogram.
mg/kg	Milligrams per kilogram - describes concentration of an element in a set volume

Potassium (K)

What: After nitrogen, potassium (K) is the most abundant nutrient in potatoes. As high levels are found in the tubers, it is possible for up to 350kg/ha of K to be removed at harvest. K deficiency can greatly reduce yield and result in plants more susceptible to disease.

How is it measured: Available K (in mg/kg) can be measured using several methods including Colwell, Skene, and Mehlich 3. Heavier soils usually require more K, but as a general guide, K should be present in the range of about 0.5 meq/100g or 5% of cations.

Intervention: If K is too low, it can be applied pre-planting in heavier soils. Foliar applications are more effective in lighter, sandier soils.

Calcium (Ca)

What: Calcium (Ca) strengthens plant cell walls and helps maintain soil structure. In potatoes it helps initiate tuber growth, protects against disorders such as internal brown spot, and improves storage and shelf life of tubers.

How is it measured: Calcium is usually listed as exchangeable calcium which is potentially available to the plant roots. It may also be recorded as a % of the whole CEC. A good value is between 65-80% of total CEC.

Intervention: Calcium is taken up by plants in the xylem (water carrying vessels), so can only move upwards through the plant from the soil. Dry or humid conditions, where transpiration is reduced, limit transport of calcium. Fertilisers with a high soluble calcium content can be used to increase plant access to calcium.

SECONDARY NUTRIENTS

Although plants do not need so much of the secondary nutrients as the primary, these nutrients are just as important for optimal growth and development. Measuring and monitoring their levels in soils is vital.

Sulfur (S)

What: Sulfur (S) aids in the building of proteins in plants, as well as formation of chlorophyll. For potatoes specifically, sulfur helps increase tuber numbers and reduces the risk of Common and Powdery Scab.

How is it measured: Soil test results reveal plant available sulfur in mg/kg. A value of 10-20 mg/kg is adequate; less than 5 mg/kg is low and more than 40 mg/kg is high.

Intervention: If additional sulfur is required, add a sulfate fertiliser to soils.

Magnesium (Mg)

What: Magnesium (Mg) generally assists photosynthesis, and the regulation of other elements.

How is it measured: Soil tests measure the amount of magnesium that is potentially available to the plant. This can be listed as mg/kg of exchangeable magnesium or %CEC. Magnesium present in the range 10-20 % of total CEC is adequate.

Intervention: Low magnesium can be corrected via a range of fertilisers applied to soils or as foliar products.

MICRONUTRIENTS/TRACE ELEMENTS

Boron (B), Manganese and Zinc (Mn, Zn), Copper, Iron and Molybdenum (Cu, Fe, Mo)

Adequate trace element nutrition is just as important for vigorous and profitable crops and pastures as the primary and secondary nutrients.

Critical levels for trace elements vary with soil texture and crop. Levels are lower in sandy soils than in loams or clays. Soil testing for trace elements can only be a guide; further investigation through plant testing is recommended.

GETTING THE TESTING RIGHT

A few simple measures will ensure the test is accurate, reliable and the best reflection of your soil conditions.

- Ensure the lab is using a testing strategy good for potatoes, and make sure you nominate potatoes as the crop type on submitted samples.
- Don't mix samples from different soil types.
- Use the same soil testing laboratory each year to reduce confusion and conflicting recommendations.
- Consider using precision soil sampling approaches to derive zone-based recommendations, enabling variable rate fertiliser spreading technology to be used.
- Use in-crop soil and petiole testing to confirm that your nutrient management strategies are adequately meeting your crop needs.

Table 1: Plant nutrients and soil properties: desirable ranges

MEASUREMENT	UNITS	VERY LOW	LOW	TARGET RANGE	HIGH
Soil properties					
pH (in water)		5	5.5	6.5 – 7.0	8
pH (in $CaCl_2$)		4.5	5	6	7.5
Cation Exchange (CEC)*	meq/100g	<5	<10	10 – 20	>20
Organic matter	%	<1.0	2	3.5 - 4	>5
Nutrients					
Nitrate – Nitrogen (topsoil)**	mg/kg	<10	20	40 - 50	>60
Phosphorus (Colwell)	mg/kg	<20	30-60	70 - 100	>100
Phosphorus (Ohlsen)	mg/kg	<20	<30	30 - 50	> 50
Phosphorus (Mehlich)	mg/kg	<20	<30	30 - 70	> 70
Potassium (meq/100g)	meq/100g	0.2	0.3	0.5 - 0.7	1
Potassium (%)	% of CEC	<1	3	5	>8
Calcium	% of CEC	50	65	75	>80
Magnesium	% of CEC	<5	<10	10-20	>20
Aluminum***	% of CEC	<0.1	<0.5	<1	>1
Ca/Mg Ratio		<2	3	4	>5
Sulfur	mg/kg	2	5	10 - 20	40
Copper	mg/kg	<0.3	<2	2 - 20	>50
Zinc	mg/kg		<1	1 - 20	>20
Manganese	mg/kg		<5	10 - 20	>50 (toxic)
Iron	mg/kg		<10	10 - 200	>200
Boron	mg/kg	0.1	0.4	0.5 - 4	>5
Molybdenum	mg/kg	0.5	1	2	>2
Salinity					
Conductivity	dS/m	EC 1:5 dS/m			
Sodium***	% of CEC	<1	<3	<4	>6
Chloride	mg/kg	50	100	<200	>200

Note: The units meq/100g, meq% and cmol+/kg are all the same

* CEC is a property of the soil type (clay and organic matter)

** Nitrogen application rates should be based on crop nitrogen levels (e.g. sap), potato variety, fertiliser history and crop performance from the farm or block. Soil nitrate levels alone are **not a reliable indicator of crop nitrogen requirement**.

*** For sodium and aluminium, the lower the better

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Hort Innovation Guide 2022: Innovations in Potato Management: The Australian Potato Industry Manual (In Press)

Scott, B (E E Muirs and sons) for providing technical information

ASK THE SPUD GP

Dear Doug

It looks like the symptoms include a sunken region around the apex as well as angled corky lesions. These could potentially be caused by several possible plant pathogens, or even a physiological issue.

For example, a strain of the fungus *Rhizoctonia solani* (AG3-PT) has been shown overseas to cause polygonal lesions (also known as elephant hide) on potato tubers. *Rhizoctonia* infections can cause dimpling of the tuber apex as well as typical 'black scurf' markings on tubers and dark lesions on stolons and roots.

While *Rhizoctonia* sounds a likely culprit, it is a mistake to assume a single cause just from looking at a photo. Netted scab (*Streptomyces* spp.) can cause similar symptoms. Sending a few samples to a plant pathology laboratory is really the only reliable way to identify the culprit.

Some studies have even suggested that elephant hide symptoms can simply be a physiological response to plant stress. Environmental conditions such as excess humidity, or high organic matter around the tubers during development, can trigger the disorder.

But of course, these conditions also favour the growth and infection of fungal pathogens such as ***Rhizoctonia*** and netted scab!

Preventative strategies for the future include:

- Growing a potato variety that is *Streptomyces* resistant (if that is the cause).
- Making sure tubers or planting holes are treated with an appropriate fungicide.
- Organic matter from previous crops or weeds is well degraded before planting.
- Minimise plant stress caused by too much or too little water.
- Given there are other pathogens that may cause similar symptoms, do a soil test before planting then monitor crops for disease symptoms.
  - For example, key symptoms that can help to identify Rhizoctonia include the formation of aerial tubers on stems and a dry, white fungal collar at the stem base.

Good luck Doug, and let's hope your next harvest is a lot more attractive!

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

POTASSIUM, SPECIFIC GRAVITY AND GETTING THE BALANCE RIGHT

Potassium is essential for many processes in both plants and the human body. If people want potassium, they most likely reach for a banana. However, the best source of potassium is actually the potato, with approximately 600mg per medium sized tuber.

By Marc Hinderager and Paulette Baumgartl

Potassium (K) in the tubers needs to come from somewhere, so potato plants need a lot of K to thrive[1]. Getting the right amount of potassium into the soil when and where the plant needs it is essential for maximum yield.

Potato plants take up large quantities of potassium with peak daily uptake reaching over 4 kg/ha/day. Supplying potassium is most important during stolon and tuber initiation, although maximum uptake occurs during tuber bulking.

Petiole potassium levels can decrease over time, particularly following the tuber initiation stage, with the rate of decrease dependent on soil K availability and overall potato growth rate.

Potassium plays an important role in converting carbohydrates from the leaves into starch. Increased levels of K can increase tuber size as well as total yield. Even in soils where exchangeable potassium is considered adequate, some authors have reported increases in yield from additional fertilisation.

Excessive potassium can reduce uptake of other nutrients, especially calcium and magnesium, so a balance is needed. There are also some reports of high potassium reducing specific gravity, but other studies have found no effect[2].

SUPPLYING POTASSIUM TO CROPS

There are three main sources of K:

- **potassium chloride** (KCl or muriate of potash)
- **potassium sulfate** (K_2SO_4 or sulfate of potash)
- **potassium nitrate** (KNO_3)

Among these three, potassium sulfate and potassium chloride tend to be more effective than potassium nitrate in increasing yield.

Potassium sulfate is the more readily plant available form of K, so can speed up the translocation of carbohydrates from the leaves to the tubers. This may potentially increase tuber specific gravity, especially if exchangeable K levels in soil are high[2].

MORE POTASSIUM HELPS CANOWINDRA POTATOES

A recent PotatoLink demonstration in Canowindra (NSW) looked at high rates of potassium that could increase tuber specific gravity, without inhibiting the uptake of magnesium and other essential nutrients. The demonstration was conducted on a paddock low in soil potassium.

Chipping variety Crop 77 was planted in January 2022 following a winter wheat crop (stubble retained). A pre-plant soil test (0 – 15 cm) showed a potassium content of 0.2 meq/100g and magnesium 2.8 meq/100g, which represents a low ratio of K:Mg of 0.07.

In the main crop, potassium was applied prior to planting, using a mix of 1/3 potassium chloride and 2/3 potassium sulfate to deliver 115 kg/ha of K and 42 kg/ha of sulfur (S).

Within the demonstration area, an additional 250 kg/ha of potassium sulfate (100 kg/ha of K + 45 kg/ha of S) was banded on top of the hills in one section immediately after planting, giving a total of 215 kg/ha of K and 87 kg/ha of S on the demonstration crop.

RESULTS

The additional potassium increased tuber size, and despite a 3% decrease in tuber number, **the extra potassium increased net yield by 2.1t/ha**. There

was no significant effect on specific gravity, which was high in both the control and treated areas.

The additional potassium cost $400/ha, but the extra yield was worth $850/ha, **a net return on the investment of $450/ha**.

MAGNESIUM TRIALS

In the last issue of the PotatoLink magazine, there was a report on high rates of magnesium sulfate applied to processing potatoes which found less disease and higher specific gravity benefits. For a report on the magnesium trials, refer to the autumn issue of Potato Link magazine article on magnesium (page 30): potatolink.com.au/potatolink-magazine

Interestingly, although high levels of K can reduce uptake of magnesium, high levels of soil magnesium do not reduce K uptake (a phenomenon known as unilateral antagonism)[4].

Potassium fertiliser recommendations should also consider soil magnesium content. Soil K:Mg ratios between 0.3 - 0.5 are considered ideal, where the absorption of both nutrients can be guaranteed. Both calcium and potassium have an antagonistic or inhibiting effect on the absorption of magnesium (Mg).

Site in February (left) and May following harvesting of the demonstration area (right) 2022

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USING BIOLOGICALS TO SUSTAINABLY MAXIMISE YIELD AND INCREASE RETURNS FOR GROWERS

The rising costs of labour, fuel, power and fertiliser, coupled with a desire to embrace more sustainable practices, are driving the uptake of new biological and biostimulant products among potato farmers.

An agricultural biological is a broad term used to describe naturally occurring materials derived from microorganisms, plant extracts and other organic matter. They have the potential to reduce fertiliser and pesticide requirements, reducing the environmental impact of conventional agriculture.

Functioning both as natural pesticides and biostimulants, biological products can help control disease, enhance growth, improve soil health, improve plant nutrient uptake, and enhance the tolerance of crops to environmental stresses including temperature extremes and drought.

Understanding which biologicals will work in different situations, and the optimum rates needed, is critical to optimising both economic and environmental outcomes.

Julie Finnigan, Technical Agronomist at Serve-Ag / EE Muir and Sons, has been investigating use of biologicals in a range of horticultural crops, including potatoes, on trial sites in Tasmania.

Over the past two seasons, Julie has worked with some unique enzyme products that work to condition the soil around the root systems of plants. This increases the availability and uptake of nutrients that are otherwise unavailable or difficult for plants to access.

One of her trials investigated the effectiveness of *Nucleon* on potato yields. *Nucleon* is a liquid enzyme additive from Agreva Sustainable Agriculture that contains lipase and mannanase to enhance nutrient uptake in horticultural crops.

Lipase works in the soil, assisting the conversion of lipids contained in soil organic matter into nutrients readily taken up by the roots. Mannanase works in the root zone, helping to break down root exudates around the outer layer (rhizosphere) of root tips. Collectively, these two enzymes help to improve soil conditions, improving plant root growth and nutrient uptake.

Based on the success of international trials, and the expected benefits in Australian conditions, Julie conducted several trials with both fresh market and processing potato varieties. These examined whether improved plant health, tuber growth and premium yields could be gained in Australian conditions.

Over two seasons, *Nucleon* was trialled at different rates using different methods, but primarily applied in-furrow at the time of planting. This mode of application ensured there are no extra passes or application costs for growers. The addition of only 24 to 75mL/ha of *Nucleon* in a tank-mix with soil-directed fungicides is very straight-forward.

According to Julie "The addition of such a small quantity of liquid to improve plant performance and yield was something of a "must see to believe" type of exercise!"

While early results were variable, more recent results at new rates were more consistent and demonstrate the promising potential of *Nucleon* for

Figure 1. Early root development in c.v Nicola treated with 24mL/ha *Nucleon* at planting (left) or left untreated (right).

- Photo by J. Finnigan.

Figure 2. Yield and tuber size of mature c.v. Russett Burbank treated with 50ml/ha Nucleon split between two applications (left) compared to untreated controls (right). *- Photo by J. Finnigan.*

the potato industry. "In the 2020/2021 potato season, *Nucleon* was trialled at the very low rate of 24mL/ha in processing potatoes along the Northwest Coast of Tasmania, along with fresh market potatoes in the southeast of the state" explained Julie. "For all trial sites, early root development and tuber set was excellent, with healthy fibrous root systems, and noticeably more around the stolons (Figure 1). This is a really advantageous start for good tuber development."

Yield estimates conducted prior to commercial harvest for the trial sites were variable, ranging from -3 T/ha through to +20t/ha compared to the untreated controls. Site variability and on-site management conditions had a significant impact on these results, including high weed pressure, irrigation breakdowns, early and late harvests, and soil type and potato variety.

Removing the extreme values revealed an average increase in yield in the treated areas (Figure 2). According to Julie "While the gains were variable, Nucleon still provided a return on investment for growers. Additionally, there were underlying benefits. Tuber sizes were consistently larger in the treated areas than the control plots, typically putting them into the premium size range."

More recent trials conducted in the 21/22 season trialled *Nucleon* at a rate of 75mL/ha, or 100mL/ha applied over two applications. These trials, conducted in processing potato varieties also along the northeast coast of Tasmania, provided yield increases ranging from 1.6T/ha to 4.1T/ha of premium sized potatoes.

These results are consistent with international potato trials using *Nucleon*, which have also yielded positive responses. "The product therefore seems to show great promise for the industry, environment and – most importantly - growers back pockets" concludes Julie.

For the coming season, *Magno*, a dry enzyme product containing the enzymes mannanase and phosphatase, will also be trialled in potatoes. *Magno* is designed to both improve uptake of phosphate applied in fertiliser, as well as releasing phosphate typically bound in soils.

The results from *Magno* trials in other crops ranging from lettuces to tree crops have been outstanding. Combined with the same ease of use and application as experienced with *Nucleon*, this could be expected to provide sustainable positive outcomes for the potato industry.

FOR MORE INFORMATION, CONTACT JULIE FINNIGAN AT SERVE-AG.

PATHOGENS – It's all in their DNA

As the sun sets later each day and the soil starts to warm, now is the time to be planning for the coming season, and a key part of that is testing soil and seed for the presence of pathogens.

By Ryan Hall and Jenny Ekman

Healthy soil bristles with activity. Like an endless external gut, it hums with scavenging, predation, parasitism and digestion by its inhabitants, all searching for moisture, nutrients and safe sanctuary from the thrum of life.

Bacteria and fungi dominate life in the soil. Many benefit from the growth of potato plants, or are at least neutral. However, a few are clearly harmful. Such soil-borne pathogens wage war against their host. They impact rotations, reduce yield and quality and, if left unchecked, can destroy the very plants they depend upon.

Figure 1. The risk of powdery scab increases if there is a high level of inoculum in the soil at planting, especially if environmental conditions are otherwise not favourable to the disease.

KNOWING THE ENEMY

Enter PREDICTA Pt. Developed by SARDI (South Australian Research and Development Institute) this commercial DNA testing service can identify which pathogens are in the soil, or in the skin of seed tubers. In effect, this puts power back into the farmer's hands when managing soil-borne diseases.

PREDICTA Pt testing detects specific areas of pathogen DNA. It provides not just a "detected or not", but also a quantitative result. That is, how much of that DNA is present in the original sample.

For some diseases, the amount of pathogen DNA present can be linked directly to the degree of risk from that specific disease (Figure 1). In other words, a large amount of inoculum in the soil = high risk of disease.

In this way, PREDICTA Pt can provide a risk assessment for powdery scab (*Spongospora subterranea*), black dot (*Colletotrichum coccodes*), root-knot nematodes (*Meloidogyne* spp.) and verticillium wilt (*Verticillium dahliae*) in soils.

The test can also be used to test the skins of seed potatoes and, in certain circumstances, potato plants themselves. The degree of risk of common scab (*Streptomyces scabies*), silver scurf (*Helminthosporium solani*), and rhizoctonia (*Rhizoctonia solani*) on seed potatoes can all be linked to detection and quantification of pathogen DNA in potato peel.

Expression of disease is not just due to presence of the pathogen, but also environmental and plant factors; the familiar "disease triangle" (Figure 2). It's a bit like catching a cold; whether there have been twenty people sneezing around you or just one won't necessarily change how sick you feel!

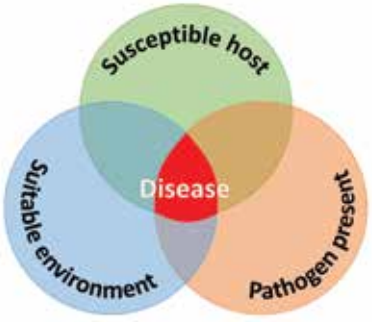


Figure 2. The disease triangle

Although the PREDICTA Pt test reports the relative amount of DNA present in soil of pathogens that cause soil-borne diseases such as rhizoctonia, pink rot and sclerotinia, in this case there isn't a clear relationship between population density and occurrence of disease. Other environmental factors, as well as the susceptibility of the plants themselves, is likely to play a major role in whether disease will be expressed or not.

It is also important to understand that getting a negative test doesn't mean the pathogen is not there. Pathogens are not evenly distributed around a paddock, or even within soil. This means that sampling is critical. Testing is a numbers game; the more samples you take, the better the chance of detection.

If only low populations are present, it can be a bit like finding a needle in a haystack. For some pathogens, levels of inoculum (spores or hyphae) that are below the level of detection can still result in high levels of disease if conditions are right.

There are also some serious pathogens – such as Fusarium dry rot (*Fusarium oxysporum*) for which no test has been developed.

WHEN SHOULD PREDICTA PT TESTING BE DONE?

According to SARDI Research Scientist Michael Rettke "PREDICTA Pt testing needs to be done well before planting. Samples should be sent to the lab one to three months prior to planting. Although turnaround of samples at SARDI lab is four to 14 days, you also need time to interpret the results, and decide what actions to take next."

Testing seed tubers before planting can be particularly valuable. Using only high quality, tested seed is the best way to maximise the chance of growing a healthy, high yielding crop.

HOW SHOULD IT BE DONE?

Sampling is conducted using a network of accredited providers. These providers have been trained in soil (and peel) sampling techniques, understand key details regarding the different pathogens tested, and can help growers interpret the test results.

A list of accredited providers is available on the SARDI website, simply search for PREDICTA Pt.

The recommended number of PREDICTA Pt soil tests varies according to paddock size. Where one or two tests may be sufficient for paddocks up to five hectares, four or more tests may be advised for paddocks over 10 hectares. The number of tests conducted might also vary depending on variations in previous incidences of disease, soil type and drainage.

Each tested sample consists of 30 combined soil cores collected in a "W" pattern over a one hectare area.

In the case of peel, samples of up to 250g fresh weight can be submitted. A single piece of peel is taken from each of 100 tubers and tested in a single sample. Using correct sampling strategies to obtain representative samples is critical when testing to assess the risk of disease.

USING THE RESULTS

There are many ways that the results can be used to take informed management decisions. "For example, you might identify that a particular paddock, or part of a paddock, is at increased risk from disease, then take actions to reduce risk" explains Michael.

This could mean improving drainage, targeted fumigation, selecting a resistant variety or choosing to plant a different crop in paddocks where risk is unmanageable. For example, if there is a high risk of black dot, then selecting a less susceptible variety, optimising nutrition, irrigation, haulm and harvest management and pro-actively managing disease risk with fungicides can help reduce risk.

As another example, use of expensive nematicides may be justified if high levels of root knot nematodes are present. Similarly, using a soil treatment where high levels of verticillium wilt are present has been demonstrated to improve crop health.

In the case of seed potato production, growers are using the tests to avoid planting in paddocks where a high risk of disease, particularly of powdery scab, is identified.

"In the longer term, using the PREDICTA Pt test to monitor paddocks provides valuable information to improve soil management and crop rotation, reducing risk for future potato crops".

"Knowledge gained from these tests can be instrumental in developing new approaches to manage potato diseases" commented Michael.

CASE STUDY – USING PREDICTA PT TO MONITOR THE EFFECT OF CROP ROTATIONS ON SOIL-BORNE DISEASE

This Tasmanian case study describes the use of PREDICTA Pt to monitor powdery scab and rhizoctonia on a commercial farm over a five-year period.

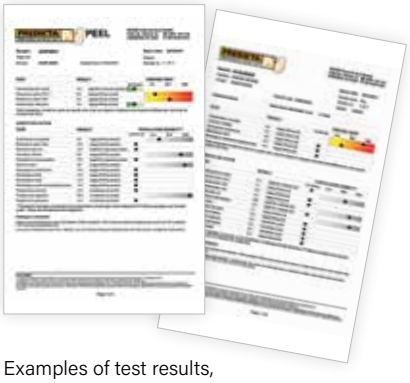
Over the winter of 2015, the paddock was divided into quarters and sown with:

1. Left fallow (commercial practice)
2. Saia oats
3. Caliente + Nemat (brassica biofumigant mix)
4. Caliente (nematode suppression)

In preparation for planting in October 2015, the cover crops were terminated, and samples analysed with PREDICTA Pt. These points were mapped using GPS, allowing sampling from the same points over time.

Each location was resampled:

- January 2016, mid potato crop
- April 2016, after the potatoes had been harvested
- March 2017, following a crop of poppies
- May 2018, after a year under clover-dominated pasture
- April 2019, after two years under pasture
- May 2020, after three years under pasture



Examples of test results, from the SARDI PREDICTA Pt website

Corer used to extract soil samples for testing. Image from SARDI

POWDERY SCAB *(Spongospora subterranea)*

Interestingly, poppies increased soil populations of powdery scab (Figure 3). Following the poppy crop, powdery scab was higher in the areas previously planted with a cover crop or biofumigant, compared to the area left fallow.

Although levels of pathogen DNA declined under pasture, they once again increased following a wetter than usual autumn in 2020.

It has not been confirmed whether or not infected poppy supports the production of *Spongospora subterranea* long-term resting spores.

RHIZOCTONIA *(Rhizoctonia solani AG2.1)*

Detections of Rhizoctonia DNA increased in areas planted to caliente or caliente + nemat (Figure 4). Levels declined during cropping with poppies and fell below detectable levels after a year or more under pasture.

Black dot was also tested. However, levels of DNA remained relatively low and constant over the entire testing period, regardless of cover crop used.

CONCLUSIONS

The results demonstrate how populations of soil-borne diseases fluctuate over time. In this case, planting a cover crop tended to increase levels of certain diseases compared to simply leaving the area fallow.

Of course, there are many benefits of cover crops in terms of improving soil health and structure, increasing soil organic matter, and preventing erosion.

However, the results suggest that brassica biofumigants should not be used if Rhizoctonia is known to be an issue. They also indicate that poppies are an alternate host to powdery scab, so are likely to increase levels of this pathogen within the soil.

Disclaimer: These results are observational only and have not been evaluated in a replicated scientific study.

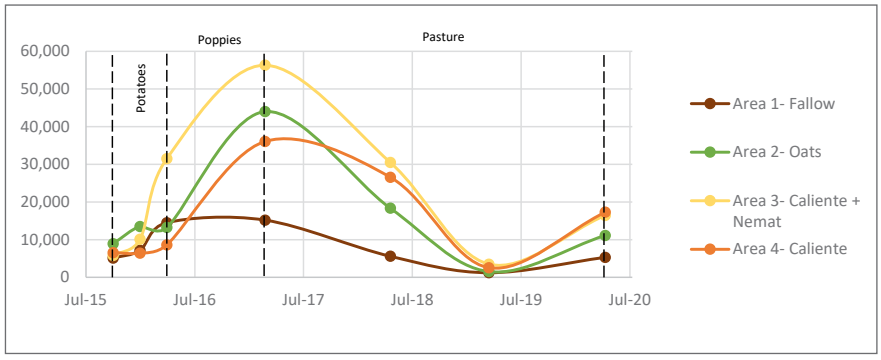


Figure 3. Relative amounts of powdery scab DNA in areas of a paddock initially planted with a cover crop or left fallow, then used to grow potatoes, poppies and finally pasture.

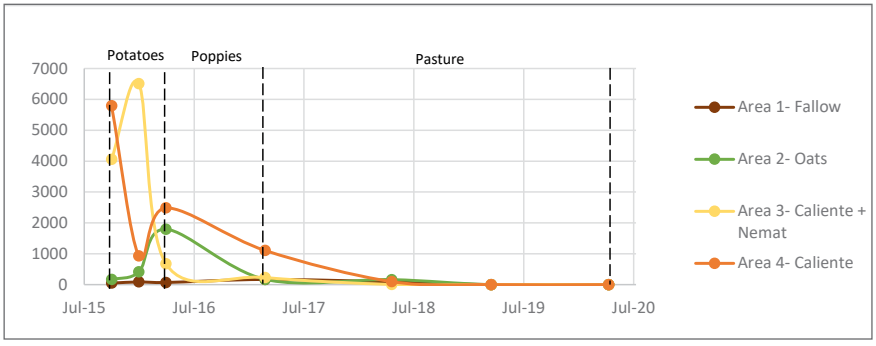
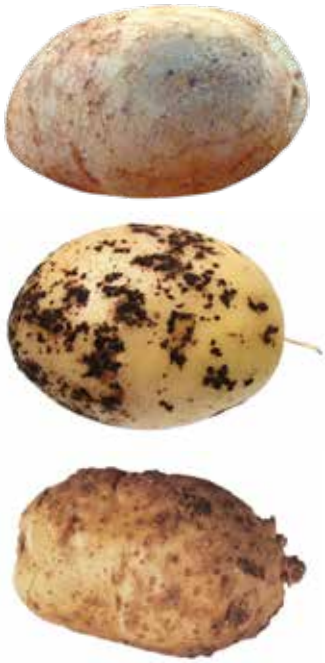


Figure 4. Relative amounts of rhizoctonia DNA in areas of a paddock initially planted with a cover crop or left fallow, then used to grow potatoes, poppies and finally pasture.



From top: PREDICTA Pt can provide an estimate of risk from black dot (*C. Hutchinson*), Rhizoctonia (*A. Hussein)* and root knot nematodes (*G. Holmes, Bugwood.org*)

WORLD POTATO CONGRESS 2022

Ireland, considered by many to be the potato's natural home, was host to the 11th World Potato Congress, held earlier this year. Over 1,000 delegates from 60 countries came to Dublin to enjoy an extensive trade show and talks ranging across every aspect of production, processing and consumption.

By Jenny Ekman, with help from Georgia Thomas

Left to right: Michael Hoey (President IPF, Ireland), Georgia Thomas (Potatoes WA), Dr Tom Arnold (Chair, Irish 2030 Agri-Food Strategy Committee), Lauren M Scott, (Chef Strategy Officer, International Fresh Produce Association), Romain Cools (President / CEO WPC Inc.) Tara McCarthy (Chief Executive, Bord Bia), Cedric Porter (Managing Editor, World Potato Markets)

With Adelaide set to host the next Congress (23-26 June 2024), it was an excellent prequel for the 16 or more Australian growers, researchers, agronomists and suppliers who were able to make the trek to the Emerald Isle, with its rolling hills, rich soil, high quality potatoes and tasty pints of Guinness.

The Congress was formally opened by Charlie McConalogue, Ireland's minister for Agriculture, Food and the Marine. The plenary session that followed featured many distinguished speakers, including Dr Qu Dongyu, Director General of the FAO (Food and Agriculture Organisation) and Mr Janusz Wojciechowski, Commissioner for Agriculture in the EU.

POTATOES TO FEED THE WORLD

According to Mr Wojciechowski, "As a staple food, the potato carries deep social and historical significance in Ireland, as it does in my home country of Poland, and continues to nourish populations around the world today."

Indeed, food security was a consistent thread throughout the congress, with many speakers noting the potato's importance as a productive, nutritious and sustainable food. There was much talk of expanding populations, shrinking resources, and the ways that potatoes could help to avert calamity.

World consumption of potatoes already provides some jaw dropping

figures. In 2020, 360 million tonnes of potatoes were produced worldwide. Divided by a world population of 7.7 billion, this suggests that each person on the planet eats around 130g, or one small-medium potato, daily. Belarusians are the champions, consuming around 175kg annually per person; Australians need to lift their game – a mere 18kg!

While China is far and away the world's largest potato producer (782 billion tonnes), followed by India (513 billion tonnes), the next two largest producers are Ukraine and Russia. While both produce large volumes, these are mostly from small, relatively low technology family farms.

According to Professor Damien McLoughlin (UCD Smurfit Business School), it can cost five times more to grow a hectare of potatoes than a hectare of wheat. Despite this, potatoes are more carbon, water and land efficient than almost any other food.

Potato production in western Europe, like Australia, generally averages around 40t/ha. The USA and New Zealand are even more productive, averaging around 50t/ha. However, average yields globally are closer to 20t, with many countries only achieving around 17t/ha (including Russia, Ukraine and China).

Moreover, gains in productivity have not kept up with other crops. "Since 1960, wheat yields have increased 220%, corn by 195%, rice by 150% but potatoes have only increased by 80%," commented Professor McLoughlin.

Left: Lauren Scott (Chief Strategy Officer, International Fresh Produce Association); Tara McCarthy (Chief Executive, Bord Bia) and Georgia Thomas (WA Potatoes) at the conference opening

Bottom: DUG potato milk promotion *(we preferred the creamy potatoiness of the 'Barista' blend)*

Professor McLoughlin also discussed sustainability, and what that means. "Consumers demand all sorts of things, but are often unwilling to pay for it. They have been conditioned to expect that food is cheap," he said. "While there is widespread eco-anxiety, most are looking to industry to take a lead. This means we need to find ways to resonate with consumers so that they will pay for sustainability goals."

POTATOES TO NOURISH THE WORLD

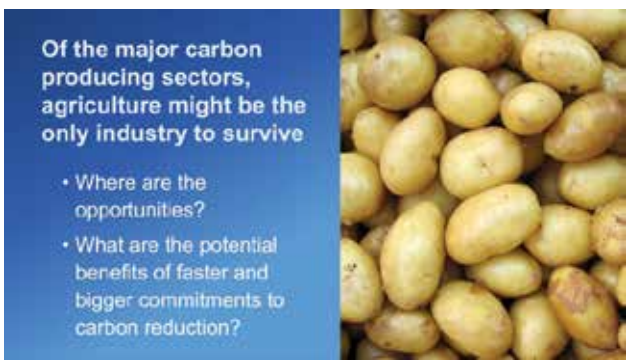
Potatoes do not provide calories alone, but also nutrients vital to health.

In a fascinating presentation, Dr Gabriela Burgos from the International Potato Centre (IPC) in Peru explained how they have been developing a high iron potato. Iron deficiency is extremely common in women around the world, and a particularly serious problem in less developed countries.

Iron is more bioavailable in yellow fleshed potatoes than many other foods, meaning it is readily absorbed by the body.

The IPC breeding programme has developed biofortified potatoes with 40 -70% more iron than common varieties. Lines have been selected that are also productive, disease resistant and tolerant of heat and dry conditions.

These fortified potatoes have been promoted in Rwanda, Ethiopia and Peru. "Mothers of young children visiting health clinics were given vouchers they could exchange for the



Slides by Professor D. McLoughlin

Biofortified seed potatoes. Photo by World Potato Centre, Peru

high-iron variety potato seeds. We also made cartoon videos promoting high-iron potatoes to children," explained Dr Burgos.

"So far, there has been good acceptance of the varieties. The next step is to conduct a follow-up study to demonstrate improvement in health status for these women," Dr Burgos added.

There seems little doubt that high-iron potatoes would have great appeal for many women, not just those in less developed countries. Increasing iron content seems particularly timely as many people seek to reduce their red meat intake, adopting a more 'flexitarian' diet.

This presentation was followed by what was surely one of the conference highlights – our own Georgia Thomas from WA Potatoes outlined some of the findings from the Hort Innovation funded project, PU19002 *Educating health professionals about Australian potatoes*.

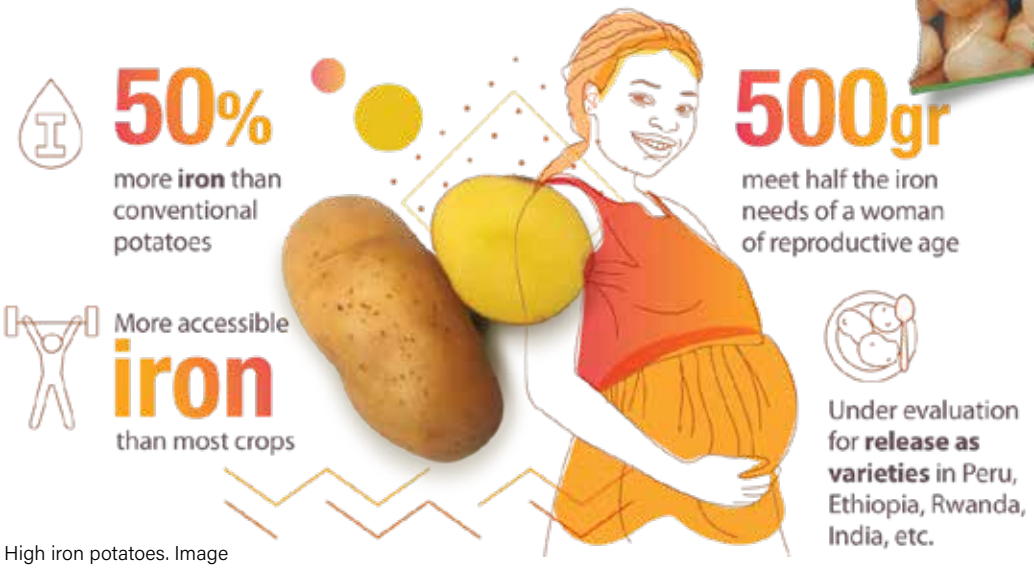
The project was developed to address the perception that, unlike other vegetables, potatoes are fattening due to their carbohydrate content. Diabetics, in particular, may avoid potatoes due to concerns about blood glucose spikes.

However, tests of six different varieties have shown that they are an excellent source of fibre, as well as potassium and other nutrients. Analysis also demonstrated that cooling cooked potatoes promotes conversion into resistant starch. Resistant starch has been shown to have significant benefits for gut health and glycaemic control as well as helping people 'feel full.' If cooled potatoes are then reheated, resistant starch levels rise even higher, further reducing their GI (glycaemic index) value.

Georgia also mentioned the low GI certified Carisma potatoes, a variety which appeared new to many in the audience.

The PU19002 study showed that nutritional value was maximised by:

1. Keeping the skin on
2. Choosing coloured varieties
3. Steaming or microwaving
4. Eating cooked potatoes after cooling.



High iron potatoes. Image by the International Potato Centre, Peru

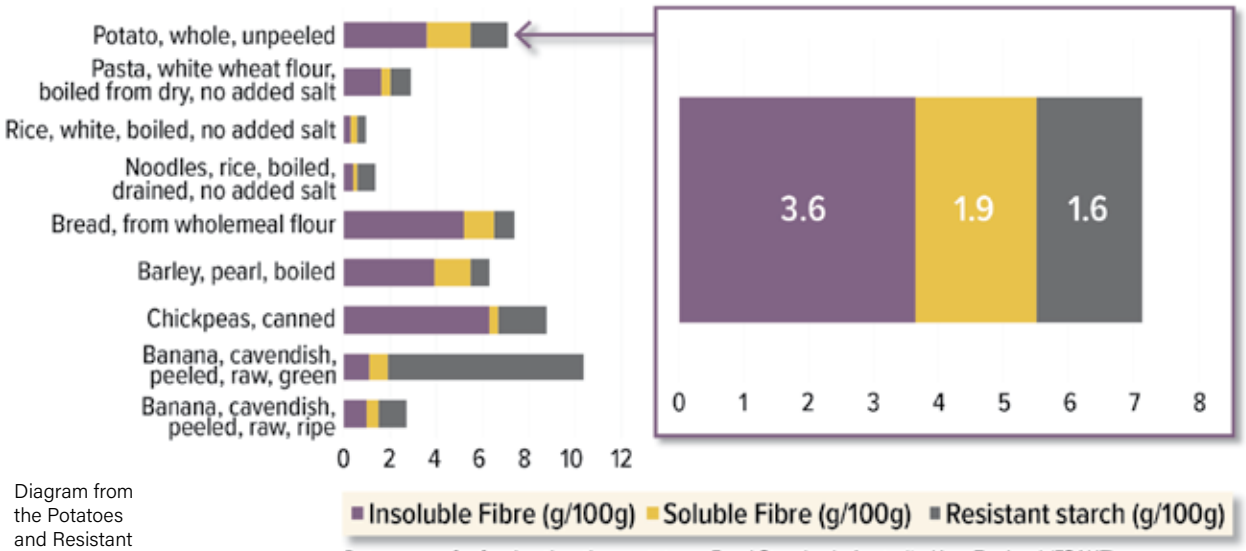


Diagram from the Potatoes and Resistant Starch fact sheet (PU19002)

Data source for foods other than potatoes: Food Standards Australia New Zealand (FSANZ)
The project data was tested using cooked, then cooled whole, unpeeled potatoes.

"We have been using these results to promote potatoes through a website, social media and in schools," explained Georgia. "Providing potato seeds and growing guides for school gardens has proven incredibly popular. It has really improved understanding of, and liking for, potatoes, thanks to WA grower investment."

The sea of hands for questions following Georgia's presentation attested to the interest in her findings, particularly, achieving so many outcomes for a local industry with such a limited marketing budget.

BREEDING A BETTER POTATO

Breeding new potato varieties is a key component in responding to consumer preferences, climate change and pest and disease pressures. Unfortunately, producing new varieties has been slow and imprecise, often taking 10 years or more to reach commercial reality.

However, according to Dan Milbourne (Teagasc), "Potato breeding is in the midst of a sea change that will transform the speed and precision with which new varieties will be developed. Genomic techniques similar to those that have transformed cattle breeding are now widely used by potato breeders."

Central to this is the development of diploid potato varieties. Current potato varieties are tetraploids – that is, they have four copies of every gene. Diploids have only two copies. Using diploids makes breeding a lot easier, as the outcome from crossing two varieties is far more predictable.

Diploids are produced by using the pollen from a true-to-type, desired variety to fertilise a flower of the same variety. This means that the true potato seeds produced are essentially 'fatherless.'

The true potato seeds produced are an 'F1' hybrid, which often increases vigour as well as meaning all seeds are essentially the same. However, they still often need to be inbred to ensure they are genetically uniform. One major advantage of using true potato seed is that most potato pathogens are not internalised, so the chance of disease transmission is reduced by around 95%.

The other breeding method much discussed related to CRISPR (clustered regularly interspaced short palindromic repeats). CRISPRs are stretches of DNA which act like molecular scissors. They can selectively remove, or duplicate, parts of the plant genome.

Diploid potato varieties are created by crosspollinating flowers of the same variety.

Potatoes on Prince Edward Island

Because CRISPR techniques do not introduce foreign DNA, the resulting plants are not considered 'genetically modified' in most countries of the world, including Australia.

Essentially, CRISPR just means that breeding can be faster and more targeted than breeding using traditional techniques – "like GPS for DNA," explained Dr Haven Baker.

Dr Baker, co-founder of the biotech company Pairwise, gave a fascinating presentation on the applications of CRISPR technology. Examples included corn with 22 kernels around the diameter instead of the normal 16, increasing yield by nearly 38%. They have also developed thornless, seedless blackberries and salad leaves with the texture and flavour of lettuce but the nutritional qualities of kale.

"Three years ago, it took us a whole year to make three gene-edited berry plants, none of which was commercially viable. Now we can create 100s of new varieties in only six months, including several with commercial promise," explained Dr Baker.

But it's not that easy for potatoes. "Potatoes are more challenging than other crops. It is difficult to assess traits below ground. Moreover, trials must be done in the field rather than in greenhouses. And starting with tetraploid varieties makes the process more technical and more time consuming as testing requires a minimum four years rather than 6-12 months for other crops. All this makes potatoes a difficult commercial prospect."

However, factors in potatoes' favour include the good genomic data already available. This helps them to be transformed relatively efficiently with excellent potential to breed for higher yields and disease resistance. Combining CRISPR with diploid varieties could also speed the process.

With billions being poured into CRISPR research, high acceptance of the technology (especially by young people), and major potential advances in variety improvement, expect a CRISPR potato near you soon!

GROWING POTATOES SMARTER

It has already been noted that potatoes are an expensive crop to grow. With input costs rising sharply around the world, it's no surprise that there were numerous presentations on precision agriculture. These focussed on variable rate planting, precision spray equipment for weeds and disease, as well as improved efficiency of fertiliser application.

One standout presentation by agronomist Evan MacDonald described trials on Prince Edward Island in Canada. Intensive mapping of soil, water, topography and EC at three very different sites was combined with different planting rates. Areas were classed as low, medium or high productivity, then planted at normal density +/- 15%.

Crop value/acre including seed costs and size profile

Trial site	Productivity index	Seed spacing		
		tight	normal	wide
Site 1	low	$3,610	$4,726	$4,473
	medium	$4,035	$4,341	$4,232
	high	$4,878	$4,412	$4,726
Site 2	low	$5,933	$6,618	$6,885
	medium	$6,788	$6,414	$6,445
	high	$6,695	$6,713	$7,917
Site 3	low	$5,417	$5,307	$6,026
	medium	$5,023	$4,231	$4,840
	high	$5,019	$4,842	$4,744

Data presented by agronomist Evan MacDonald on the effects of seed spacing in different productivity zones of the paddock on total profitability at three different sites on Prince Edward Island, Canada

What set this work apart was the focus on net returns, rather than simply yield and quality.

While results were highly variable and, it was noted, relate to only one season, the value of changing planting density according to productivity index was quite site specific.

Site 1. Planting seed more densely in the most productive areas of the paddock increased returns, whereas increasing density in the low productivity areas of the paddock significantly reduced returns.

Site 2. The normal planting density may be too tight; returns tended to increase by spacing seed more widely, regardless of productivity index.

Site 3. Profitability could be maximised by reducing planting density in the low productivity areas and increasing density in the medium and high productivity areas.

The take home message from this was that there is no one-size-fits-all approach to increasing or reducing seed planting density, and that only by monitoring yield by productivity index can growers make informed decisions about optimising plant spacing.

To give a commercial perpective, Mark James from John Deere presented an overview of some of the new spray technology that the company is developing.

While it is common for spray systems to have GPS based sector control, the new units also feature individual nozzle control. These recognise when the boom is turning and compensate by changing flow rate, thereby reducing underspray/overspray on headland areas. These systems also reduce overlaps on the boom width and allow spot spraying of individual areas.

"Images made using a drone or robotic scout can be put into the controls on the tractor. This can be used to target weeds selectively, or address areas of high pest pressure," Mark said. "We also attach an additional nozzle at

See and Spray unit from John Deere

the end of each boom, which ensures there are no gaps in crop coverage."

While the gains from reduced overspray are relatively slight (around 1%), increasing costs increase their significance. Other trends noted were:

- Reduced nozzle spacing from 50cm to 25-35cm, allowing lower height settings while reducing drift.
- 'ExactApply' nozzles with remote control of droplet size and pressure.
- 'See and Spray' with high-definition cameras installed on the spray boom:
  - Identifying plants vs soil as well as plants vs weeds and adjust spray accordingly, all while travelling at 19kph.
  - Estimates of up to 77% reduction in herbicide use across an average crop with medium weed density.
  - Available now for corn, soybeans and cotton, still under development for potatoes.
  - Cost is approximately double a normal spray unit.

THE FIELD DAY

With our brains full after more than two days of talks, field trips were the focus of day three. The key attraction was the 'Potato Field Event' at Maple Lodge farm just outside Dublin. Maple Lodge Farm not only grows potatoes, but is home to one of the best collections of vintage farm machinery in Europe, all lovingly restored to showroom condition.

Field displays included plot trials of growth stimulators, showcasing of potato varieties and an impressive display of gleaming new farm machinery. A neighbouring field was used to demonstrate the machinery in action, to the delight of onlookers, equipment reps and large numbers of gulls.

It was interesting to see that many of the planters, harvesters, balers and other machines were self-propelled. This is because field conditions in Ireland are often wet, limiting use of tractors, particularly at harvest.

In fact, most Irish potato farms do not use irrigation at all, water being supplied regularly from the sky. Despite this, local yields average 40-45t/ha and sell for approximately €265 to €300/tonne (AUD 390-450).

Ruby Daly and Lelani van der Merwe examine potato varieties, and other images from the potato field day

WORLD POTATO CONGRESS 2024

The next World Potato Congress is to be hosted by Potatoes Australia in Adelaide from 23-24 June 2024.

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

Get involved

Potatoes Australia are calling for Expressions of Interest from those who would like to be involved. Please contact:

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POTATOES AUSTRALIA
The Voice Of The Potato Industry Value Chain
WPC 2024

SAM DENNIGAN AND CO.

With the support of partial funding from PotatoLink (PF20000), a small but select group of growers and agronomists, together with the author and AuSPICA board member Jonathan Eccles, conducted some pre-conference investigations.

Left to right: Jenny Ekman, Lachlan Heyson, Anna Young, Ruby Daly, Lelanie van der Merwe, Joe Dennigan, Tom McDonnell, Jonathan Eccles.

At Sam Dennigan and Co. we were hosted by co-owner Joe Dennigan, together with manager Tom McDonnell.

Dennigans handle 50,000t of potatoes annually, mainly sourced from local growers. The ware potatoes they were packing on the day of our visit (30 May) had been stored since last September. Stored at 3°C, the potatoes are then warmed to 10-12°C before packing. They had been treated with the new anti-sprouting treatment 1,4Sight (dimethylnaphthalene) due to the withdrawal of CIPC (chlorpropham) by the EU.

The Irish industry is dealing with the same personnel issues as we are in Australia and is similarly seeking to automate wherever possible. To my eye, the packing lines were so clean they looked almost brand new! They also featured the latest high tech vision systems for automatic grading and bagging. Impressive.

Dennigans does not just pack potatoes; they also act as a distribution centre for all fresh and frozen produce for a large Irish supermarket chain. Their 35,000m^2 storage and cold rooms hold everything from bananas to cheese and meat to icecream. A fully computerised pick and pack system feeds a fleet of refrigerated trucks which service the whole of Ireland.

One of the key challenges facing the business is finding ways to reduce its carbon footprint. This is not just an altruistic move to help meet the EU meet its goal of a 50% reduction in emissions by 2030; a carbon tax is in place and increases every year.

Dennigans have a large solar array in place, which provides 20% of the distribution centre energy needs – clearly the Irish sun has more power than we thought! There are also plans for a wind farm. However, there is still no viable alternative to diesel, so trucks represent a real challenge.

The company has made progress on reducing waste. Cardboard and soft plastics are all accumulated and recycled. While there are labour costs involved, sale of materials has made this cost neutral or even slightly profitable.

Another aspect the company is very proud of is its wastewater treatment system, which was designed by VESI Environmental. After initial treatment, wash water and sewage is fed through a series of three ponds. These artificial wetlands have been planted with reeds, sedges and other species selected for their capacity to remove nutrients from the water.

The water is tested for nitrates, phosphorous, etc., before flowing into the local creek, and demonstrated clean. While this system was the first of its kind in Ireland, its success has seen it adopted more widely.

With abundant birdlife, it even makes a pleasant picnic spot for employees to have lunch!

Anti-clockwise from top: Lelanie Van der Merwe, Ruby Daly, Anna Young and Tom McDonnell examine packed spuds; the company's wastewater treatment ponds; Joe Dennigan explains their recycling program

TOMRA

At TOMRA the group was generously hosted by Marco Giovanni Colombo (Global Category Director Potatoes), together with John McGloughlin (Head of Innovation), and Eamonn Cullen (Market unit manager).

TOMRA was founded in Norway on April 1, 1972 by brothers Petter and Tore Planke. After seeing a local grocer struggle with the manual collection of empty bottles in their store, the brothers developed the first fully-automated reverse vending machine (RVM) in their family's garage. This means TOMRA is now celebrating its 50th Anniversary!

The sorting technology they developed for collection and processing of recyclables, as well as for the mining industry, has proven readily transferable to food. Although involved for only 10 years, TOMRA already represent around 25% of food processing technology.

Potatoes are a key area with the company making sorting, grading and processing equipment.

For example, 85% of peeling worldwide is now done using TOMRA equipment. Their new steam peeling technology was previously featured in PotatoLink (Spring 2021).

However, on this visit we were most interested in their new optical sorters.

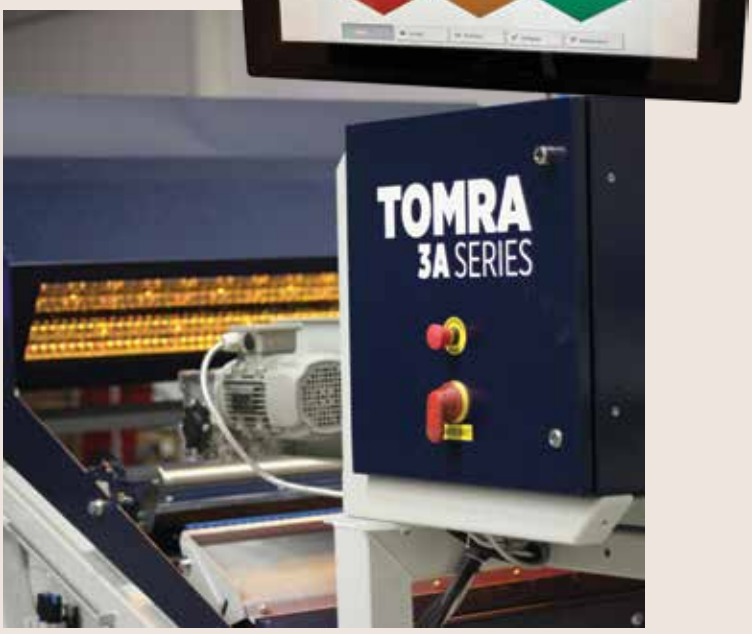
TOMRA is currently developing a portable optical sorter which could be fitted to a harvester. A row of LEDs analyses the potatoes as they fall from a top belt onto a 'trampoline' belt below. Clods and rocks are flicked out the back using a bank of 'fingers.'

Although the unit is limited by 'seeing' only one side of the potato, it still has potential to be used to reject green or rotten tubers. It could also be used to estimate yield in real time, while removing the need for human sorters on the back of the harvester.

A similar device developed for packing lines has two banks of LEDs, thus 'seeing' all sides of each tuber. Again, analysis occurs – impressively – as the tubers fly through the air. In this case they can be sorted three ways: Good; Repurpose e.g. green, marked, small rot; or Full rejection e.g. clods, foreign objects (see image below).

The units are 90-95% efficient and can process up to 100t/hour, reducing labour requirements by as much as 70%. Adding NIR (near infrared) detectors could potentially allow the machine to detect internal defects, such as blackspot or hollow heart.

Videos showing the operation of the TOMRA 3A for both washed and unwashed potatoes, and other sorting technologies, can be viewed at https://video.tomra.com/tomra-3a-potato-sorting



Marco Combo explains air sorting technology to Anna Young and Lelanie van der Merwe, and the new TOMRA 3A air sorter at their Dublin development facility.

Packing potatoes at Sam Dennigans and Co. Dublin. - *Photo by J. Ekman*

Hort Innovation Strategic levy investment | POTATO – FRESH FUND

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POTATO LINK AUSTRALIAN POTATO INDUSTRY EXTENSION PROJECT