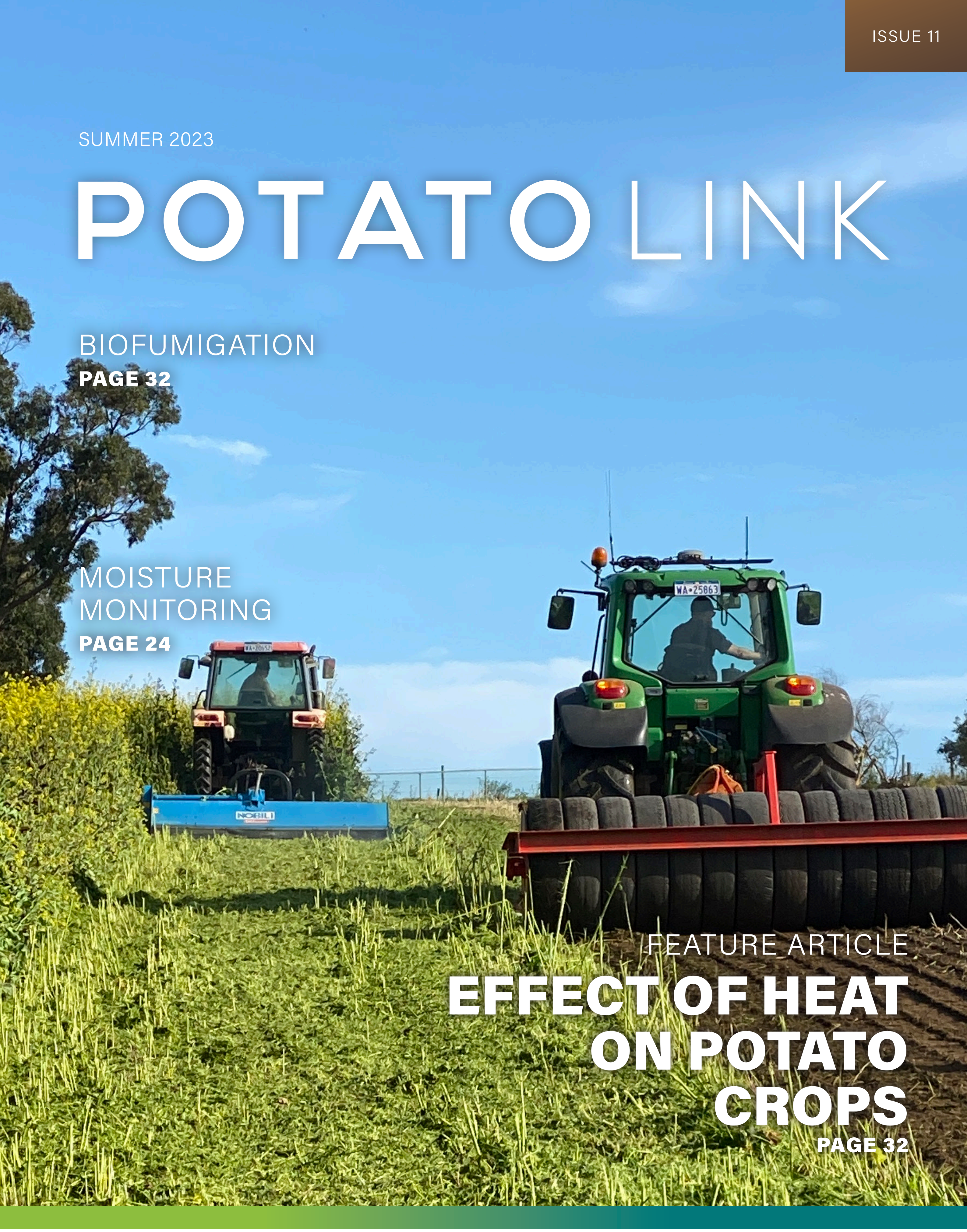
ISSUE 11

SUMMER 2023

# POTATO LINK



## BIOFUMIGATION

**PAGE 32**

## MOISTURE MONITORING

**PAGE 24**

FEATURE ARTICLE

# EFFECT OF HEAT ON POTATO CROPS

**PAGE 32**

ahr applied horticultural research

Hort Innovation POTATO – FRESH FUND

Hort Innovation POTATO – PROCESSING FUND

POTATO LINK AUSTRALIAN POTATO INDUSTRY EXTENSION PROJECT


Wondering when the next in-person event will be held in your area? Looking for a fact sheet or an update on a demonstration site? Or want to join the next webinar?

For all this and more, subscribe to our monthly newsletter.

The PotatoLink Bulletin is a free e-newsletter emailed to subscribers each month and is brimming with information. The bulletin provides a platform for growers to stay up to date on upcoming events and resources delivered by PotatoLink or other industry groups and projects.

## EACH ISSUE INCLUDES

- Upcoming events – webinars, regional in-person events, online training and conferences
- New resources – PotatoLink magazine, factsheets and case studies
- Updates from our demonstration sites
- Event reviews for all those who missed out
- General info, project updates and more

## SCAN THE QR CODE TO SUBSCRIBE

**Back issues can be downloaded from our website (potatolink.com.au/bulletins).**

**Already enjoying our bulletin but have some feedback? We're always happy to hear your thoughts.**

**Email info@potatolink.com.au**



Communications Manager

**Hort Innovation**

Level 7, 141 Walker Street
North Sydney NSW 2060
Australia

Email: communications@horticulture.com.au

Phone: 02 8295 2300



POTATO LINK
AUSTRALIAN POTATO INDUSTRY EXTENSION PROJECT

TECHNICAL CONTENT
**Dr Jenny Ekman**
jenny.ekman@ahr.com.au

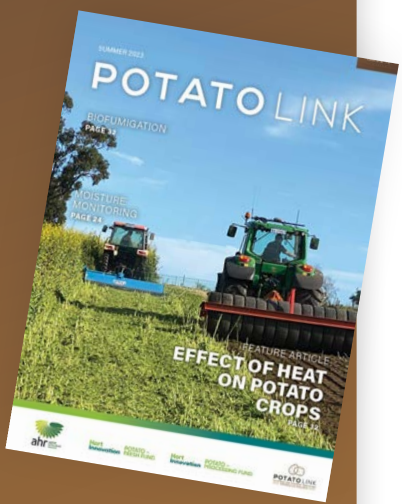
EDITOR
**Paulette Baumgartl**
paulette.baumgartl@ahr.com.au

ASSISTANT EDITOR
**Ryan Hall**
ryan.hall@ahr.com.au

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

DESIGN
**Jihee Park**
hello@jiheeparkcreative.com

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




**Cover**: *Damper Gully Farms, Manjimup WA, PotatoLink archive*

## FROM PETER O'BRIEN...

Hello and welcome to the new year and another edition of PotatoLink Magazine. We're thrilled to present our third standalone issue and sincerely appreciate your ongoing support.

For those reading online, remember that getting a hard copy is easy. Just click the **link to subscribe** and have it delivered to your doorstep.

As the PotatoLink project enters its fourth year, the objective of this magazine remains the same: providing articles that are timely, practical, and shed light on topics crucial to the Australian potato industry.

To help us deliver content that meets these needs, your feedback matters – let us know what you want to read about. Contact us anytime; we're eager to hear from you.

In this edition, we take a look at the challenge of growing potatoes in the heat, and explore efforts to develop resilient potato varieties that can withstand the changing and warming climate.

AuSPICA shares their involvement in helping Vanuatu build a robust potato industry – a fascinating journey worth exploring.

When it comes to biosecurity, AUSVEG provides its latest updates on leafminers, and Dr Roberto Barrero reports on his levy-funded project on innovations in quarantine testing.

We also look at the ins and outs of using moisture probes and summarise our recent biofumigants webinar led by John Duff, which was a very informative session including results from a recent case study.

Your engagement drives us to keep delivering valuable information about the thriving Australian potato industry. Thank you for being part of PotatoLink Magazine. Here's to a year filled with learning, growth, and insightful discoveries.

*Peter O'Brien, PotatoLink Project Coordinator*

**Send your feedback to info@potatolink.com.au**

# Contents

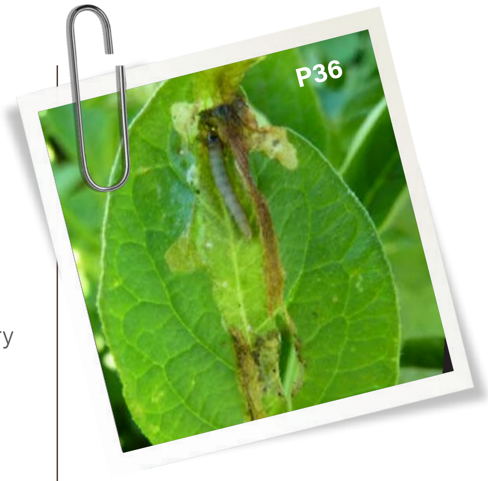




POTATO LINK
AUSTRALIAN POTATO INDUSTRY
EXTENSION PROJECT
















# EFFECT OF HEAT ON POTATO CROPS

What happens when climate change impacts one of the world's most important foods? With a burgeoning global population, food security is one of the most complex problems of our time, and our rapidly warming planet complicates the problem further.

Worldwide, potatoes are the third largest global food crop, cultivated in 158 countries and consumed daily by over a billion people[1]. According to Our World in Data, potatoes produce more food per unit of production area, yet have lower greenhouse gas emissions and use less water per kg, than virtually any other crop.

Potatoes are also low in fat but rich in starch, protein and Vitamin C. As a non-grain food staple, they have an essential role ensuring global food security.

However, potatoes have a key weakness – sensitivity to heat. High temperatures seriously reduce growth and development and can completely stop tuber formation. Heat affects the ability of seed to sprout and the quality and nutritional profile of the tubers formed.

For this reason, Australian exceptionalism aside, most potatoes are cultivated in cooler climes, like Scotland, Ireland, northern America and northern Europe.

However, summer temperature records across the globe are being smashed on a regular basis. As heat is one of the most significant uncontrollable factors affecting potatoes, it is worth examining the impact of climate change and warming on the production, yield and nutritional quality of potatoes.

## A COOL CLIMATE PLANT

Potatoes originated in the highlands of the equatorial Andes. Domesticated over 7,000 years ago, they flourished in the cool mountain climate with its constant daylength, strong light intensity and high humidity. Plants reproduced by tubers produced year-round.

One of the keys to cultivating potatoes more widely was adaptation to more variable daylengths. When Andean potatoes were first grown in Europe, they only formed tubers during the last short days of autumn. These were soon followed by freezing temperatures that killed the plants, cutting maturation short and reducing accumulation of nutrients.

Selection of plants that developed tubers under different daylengths has therefore been key to the global success of potatoes. However, as climates warm, potatoes face a new adaptive crisis – becoming more heat tolerant.

Modern European potatoes have a

narrow genetic base. Optimal yield for most commercial potato varieties occurs when average day time temperatures are between 14 to 22˚C. Any hotter and yield falls sharply.

This is largely because the signal to form tubers is highly temperature dependent. Tubers are initiated in response to a protein called SP6A. High temperatures stop production of this protein, so tubers simply don't form, even if the plant is growing well. Current varieties considered 'heat tolerant' likely have either a stronger production of SP6A or are sensitive to low concentrations of this protein.

For example, at 28˚C, yield of Desiree plummets to almost zero and Spunta to ~15%.

This issue is most acute in tropical and sub-tropical zones. In these areas potato production is already constrained by sensitivity to heat. Moreover, cooling through irrigation is not possible in the humid tropics. As a result, climate change is predicted to reduce potato yields by 18 to 32% globally[2].

Heat is not only a problem for local industries growing potatoes for consumption, but for seed growers and exporters. For example, seed maturing at high temperatures is likely to have a reduced period of dormancy. In some varieties heat stress results in strong apical dominance, with only 10-20% of non-apical buds sprouting[3]. For exporters, markets in warmer climates are likely to be impacted as potatoes become more difficult to grow.

Heat stress therefore induces an array of physical, physiological, and biochemical changes that inhibit plant growth and development, ultimately leading to a significant reduction in both yield and quality[4] (Table 1).

Table 1. Summary of heat stress effects on potatoes at different developmental stages. From Singh et al., 2020

| Growth stage | Ideal temperature (°C) | Effect of high temperature |
|---|---|---|
| Sprouting | 16 | Increased |
| Establishment | 20 to 25 | Early plant growth increased |
| Shoot growth | Up to 32 | Increased vegetative growth |
| Stolon formation | Up to 25 | Reduced at above 25°C |
| Tuber initiation | 15 to 22 | Reduced tuber initiation, reduced tuber size |
| Tuber bulking | 14 to 22 | Reduced transfer of carbohydrates to tubers, increase secondary tuber formation, increased disorders e.g. russeting, cracking |
| Harvest | 20 to 24 | Reduced total yield, size and quality |

## GROWTH AND DEVELOPMENT

The effects of high temperatures on potato crops depends on variety, development stage, how high and long the heatwave lasts, and whether high temperatures are experienced during the day, night or both.

For example, researchers in South Korea[5] examined the effects of high temperatures at night or during the day, during tuber initiation or tuber bulking (each growth period lasting approximately 3 weeks). Ambient day/night temperatures of approximately 28°C/20°C were increased by approximately 4°C during the day, the night, or around the clock.

Plants appeared unaffected for the first few days, but respiration, photosynthesis and other processes showed significant changes when high temperatures continued for a week or more.

Importantly, the results showed that high temperatures during tuber initiation were the most critical, greatly reducing yield. In contrast, the same conditions

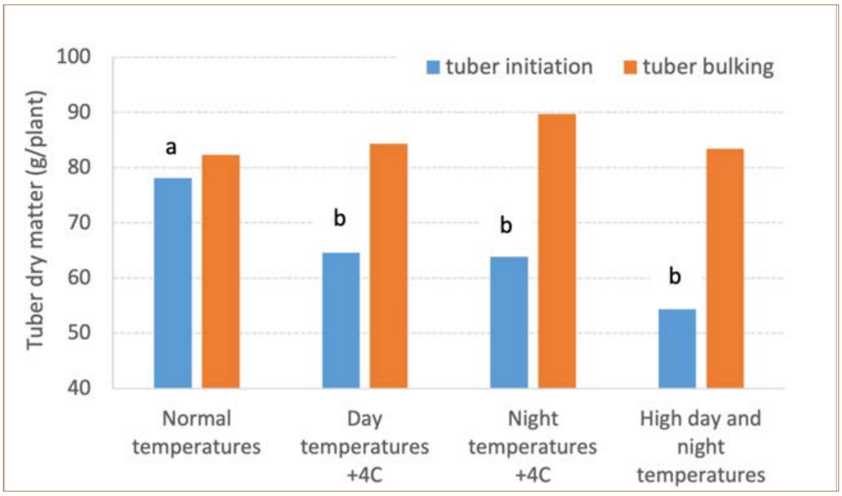



Figure 1. Effect of elevated day temperatures, night temperatures, or both day and night temperatures, occurring during either tuber initiation or tuber bulking, on total yield of potatoes. Derived from Kim and Lee, 2019.

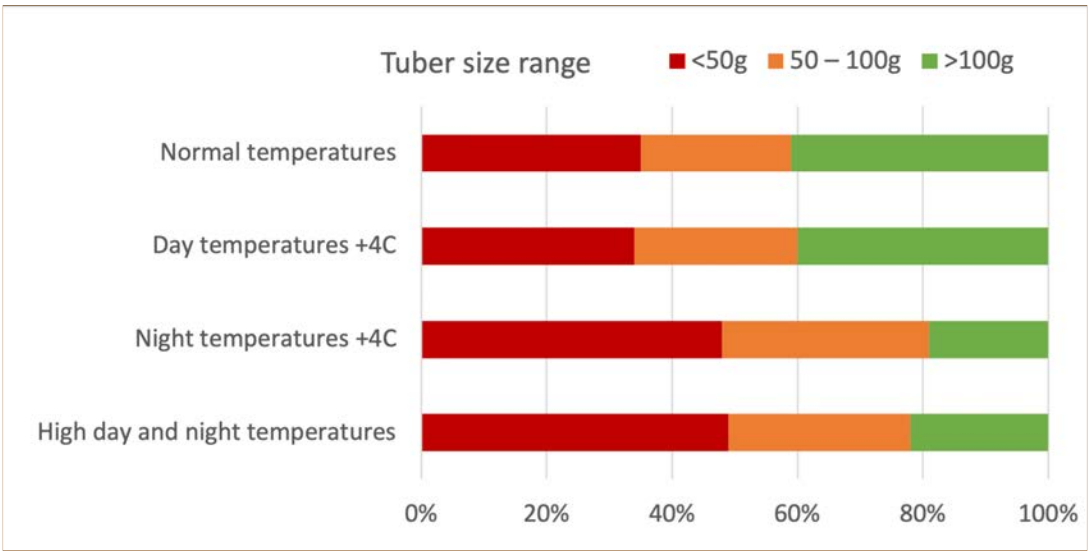



Figure 2. Effect of elevated day temperatures, night temperatures, or both day and night temperatures during tuber initiation on the number of small, medium or large potatoes. Derived from Kim and Lee, 2019.

during tuber bulking had no effect on total yield. (Figure 1).

## PHOTOSYNTHESIS

As long as there is adequate soil moisture, day temperatures up to around 30°C actually increase photosynthesis, generating larger leaf canopies.

Unfortunately though, this extra captured carbon does not flow through to the tubers but stays in the foliage[2].

If temperatures go above 30°C photosynthesis also starts to be inhibited. At the same time respiration by the plant increases, effectively sending growth backward[6] .

In the research by Kim and Lee, high night temperatures (up to 24°C) during tuber initiation increased foliage above ground but reduced the number of large size tubers beneath. In this trial, when nights were warm, nearly half of the tubers that developed weighed less than 50g.

As with the effects on yield, high night temperatures had less effect when they occurred during tuber bulking, presumably because the process of filling was already underway.

Considered from the plants point of view, this makes sense. For the potato plant, tubers are a survival mechanism of last resort. Their only purpose is to help the plant survive winter. If the weather is warm and the plant stays healthy, (true) seed is a far more efficient way to guarantee the next generation.

## HEAT IN THE ROOT ZONE

While potato plants may be able to cope with a few days of heat stress, longer periods will clearly have greater impact. In part, this is likely to be because of warming of the soil.

Recent (2023) work showed that although exposing the upper parts of the plant to high temperatures reduces tuber size and yield, it is soil temperature which is the most critical[7].

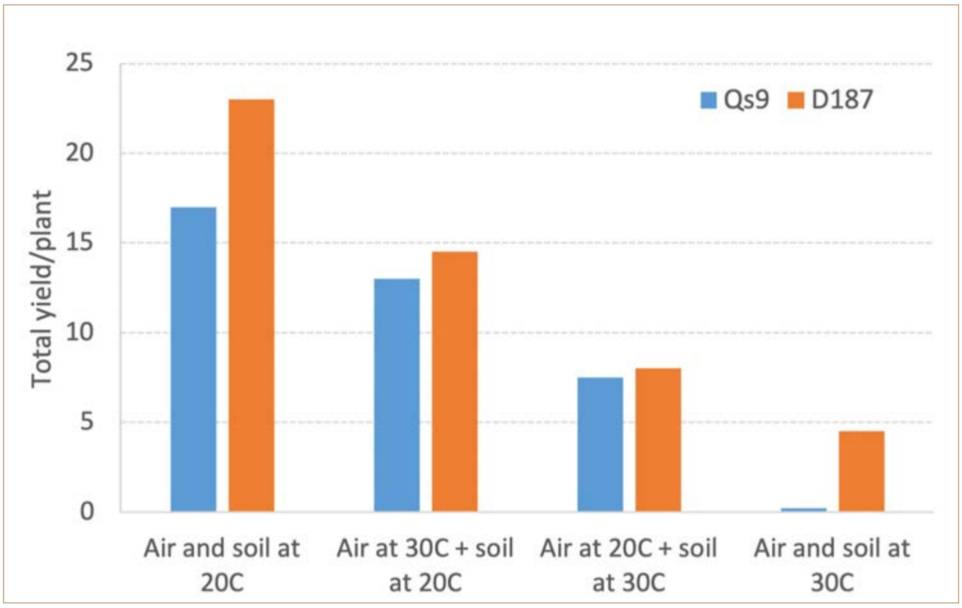



Figure 3. The effects of air and soil temperatures on yield of two different potato varieties (Qs9 and D187). Derived from Kim and Lee, 2019.

Zhou et al investigated plants with air/soil temperature controlled at 20/30°C. Plants still produced reasonable yield if their roots remained at 20°C with air at 30°C. However, when the treatments were reversed, increasing soil temperature to 30°C, the few tubers formed were small and misshapen. If both air and soil were 30°C, yield was minimal or, in the case of one variety, virtually zero (Figure 3).

## DISEASES AND DISORDERS

Heat stress induces various physiological disorders in potato tubers, affecting their shape, development, and marketability.

High temperatures close to harvest can induce pre-harvest sprouting, prematurely developing the tuber buds. Skin netting and russeting result from high soil temperatures and affect the appearance and marketability of tubers.

Potatoes exposed to high soil temperatures during development can develop a wide range of physiological disorders, including tuber deformations, translucent end, growth cracks, heat necrosis, internal brown spot, second growth, blackheart, and physiologically old seed tubers[8] .

- Tuber deformations: High temperatures stimulate cell division and reduce the availability of carbohydrates by increasing respiration. Water stress does not in itself cause deformations, but drought exacerbates the deformations caused by high temperatures. The higher the temperatures and the longer the heat wave, the greater the effect.
- Translucent end and jelly end rot: Early-stage high temperatures and water stress may interfere with starch deposition, leading to translucent end / jelly end rot. Pointy bud-end tubers are particularly prone to developing jelly end rot.
- Growth cracks: Rapid shifts from poor to good growing conditions, such as hot, dry weather followed by excessive irrigation or heavy rainfall, can cause growth cracks.
- Heat necrosis: Occurs when slow tuber growth is followed by active growth at high temperatures, resulting in light to dark brown necrotic spots in the vascular tissue. Some varieties are more susceptible than others.
- Internal brown spot: Light brown necrotic spots develop in the tuber flesh during the latter stages of tuber growth due to intense heat or excessive drought. Internal brown spot is associated with an enzymatic disorder and, at times, calcium deficiency.

- Second growth: Temperatures above 30°C prompt increased vegetative growth rather than tuber formation, leading to heat sprouts, chain tubers, or heat runners in susceptible varieties.
- Blackheart: Blackheart occurs when oxygen cannot reach the tuber centre, especially during pre-harvest, transit, or storage. Extended exposure to temperatures above 32°C before harvest is a contributing factor.
- Physiologically old tubers: Heat stress drastically increases physiological age, leading to early sprouting, more stems, and defects in potato formation

## NUTRITIONAL QUALITY

Potatoes are a vital source of carbohydrates, vitamins, and minerals. Heat stress can alter the composition of these nutritional elements, affecting the overall nutritive quality of potatoes.

Most studies about heat effects have examined the impact on carbohydrates, which make up about 75% of the potato's dry weight.

Potatoes contain two forms of starch: amylose and amylopectin. Heat stress can not only reduce carbohydrate accumulation by 30% or more, but also affects the balance of different starches. For example, exposure to 35°C reduced the content of amylose in tubers by 36%, but had less impact on amylopectin[1]. Amylose is more resistant to digestion than amylopectin, so heat stressed potatoes could be expected to have higher GI (glycaemic index) values than those grown at normal temperatures.

As carbohydrate metabolism shifts away from starch synthesis, it is replaced by accumulation of sugars, especially at the tuber ends. The result can be undesirable sweetening and, importantly, darkening when fried, a major issue for processed product.

Other effects of heat on nutritional quality are mixed. Potatoes have been bred to have low levels of glykoalkaloids (GA), not exceeding 20mg/100g fresh weight. These are protective compounds produced by the plant, so increase in response to stresses such as drought, insect attack and light exposure.

Research from the 1980s reported elevated GAs in response to high temperatures. However, more recently it was found that soil temperatures of up to 35°C for a week before harvest did not increase GA. This may reflect the extreme low GA values in modern varieties such as Desiree .

In contrast, the anthocyanins that give some varieties their red skin and/or yellow flesh are often reduced by heat stress. Even if warm growing conditions are not severe enough to affect anthocyanin production, red varieties such as Desiree may appear paler than normal. This is due to development of a thicker, rougher skin, which does not allow the anthocyanins to shine through[7] (Figure 4).

Figure 4. Desiree potatoes grown under ambient conditions (left) or with exposure to 33°C soil temperature for one week before harvest (right). From Fogelman et al, 2019.

Growth cracks in tubers (left N. Diplock, right K. Bouchek)

Left to right: Black heart (A. Robinson, NDSU), hollow heart (AHDB), brown centre

Left to right: Secondary growth (AHR), deformed bottle neck (A. Robinson, NDSU), deformed potatoes (A. Robinson, NDSU)

## MANAGING HEAT STRESS

Irrigation works as a high temperature mitigation strategy partly because of the power of evaporative cooling, but also because it is the temperature of the roots, not the leaves, which is most important.

As water turns from liquid into gas, it absorbs energy from the environment around it. The more water evaporates, the more heat is pulled from the surface of the leaf or soil.

Of course, if humidity is already high, evaporative cooling can do little to reduce temperature. However, the dry conditions in South Australia make this method highly effective. For example, on a day when it is 35ºC and 40% RH, it is theoretically possible to cool plants and soil to 20ºC simply through evaporation. Even at 40ºC and 45%RH, temperatures can still be kept below the critical limit of 27ºC by adding water.

## WHERE TO NEXT?

As global climate change intensifies, the issue of heat susceptibility in potato cultivation becomes even more critical. Currently, only a limited number of heat-tolerant potato cultivars are recognised, primarily bred for very specific conditions. This limitation has intensified conventional breeding efforts to find new, tolerant genotypes.

In response to the scarcity of heat-tolerant traits within the cultivated potato gene pool, researchers are exploring the genetics of wild potatoes native to the Americas. These plants are potential sources of valuable resistance genes.

A number of Solanum varieties are known to be heat tolerant, including *S. kurtzianum, S. chacoense, S. stoloniferum and S. demissum* (Figure 5). Genes from *S. demissum* have already been incorporated into modern varieties, providing blight resistance.

Ongoing research in genomics, proteomics, and metabolomics on potato heat response holds promise for enhancing conventional breeding strategies. These molecular approaches provide insights into the genetic and biochemical mechanisms underlying heat tolerance, helping to identify and select desirable traits. *See PotatoLink Issue 10 for more on potato breeding using novel varieties.*

Bioengineering efforts also represent an alternative avenue for developing heat stress-tolerant potatoes. Genetic modification and genome editing technologies (such as CRISPR) may offer targeted solutions by introducing or modifying specific genes associated with heat tolerance.

The combined efforts of conventional breeding, exploration of wild genomes, and advancements in molecular research offer hope for developing heat-tolerant potato varieties.

Potatoes adapted to a changing environment before.

Now, they need to do it again.

Figure 5. Genes from heat tolerant Solanum varieties such as *S. demissum* (top left, image by M. Coleman), and *S. chacoense* (below) and tubers of improved variety (bottom left, images by Cultivariable.com) could help develop new commercial varieties tolerant of heat stress

## REFERENCES

1. Momcilovic I. 2019. Effect of heat stress on potato productivity and nutritive quality. Hrana I ishrana 60:43-48.
2. Hancock RD et al., 2014. Physiological, biochemical and molecular responses of the potato (Solanum tuberosum L.) plant to moderately elevated temperature. Plant, Cell, Environ. 37:439-450.
3. Susnoschi M. 1981. Seed potato quality as influenced by high temperatures during the growth period
4. Singh B, Kukreja S, Goutam U. 2020. Impact of heat stress on potato (Solanum tuberosum): present scenario and future opportunities. J. Hort Sci. Biotech 95: 407-424.
5. Kim Y-U, Lee B-W. 2019. Differential mechanisms of potato yield loss induced by high day and night temperatures during tuber initiation and bulking: Photosynthesis and tuber growth. Front. Plant Sci. 10: https://doi.org/10.3389/fpls.2019.00300
6. Kumar Lal M et al. 2022. Mechanistic concept of physiological, biochemical and molecular responses of the potato crop to heat and drought stress. Plants. 11:2857.
7. Zhou J et al., 2023. Responses of aerial and belowground parts of different potato (Solanum tuberosum) cultivars to heat stress. Plants. 12:818.
8. Banks, E. 2021. Revisiting the impact of heat stress on potatoes. SpudSmart.com (accessed November 2023)
9. Fogelman E et al. 2019. Nutritional value of potato (Solanum tuberosum) in hot climates: anthocyanins, carotenoids and steroidal glykoalkaloids. Planta. 249:1143-1155.

## EXPLORE THE TOPIC FURTHER

Webinar: Setting up for summer - preparation for potato growers

Internal discolouration and secondary growth (E. Banks)

# GROWING POTATOES IN HIGH TEMPERATURES (>32$^{o}$C) IN THE SA MALLEE

Conditions in the Soth Australian Mallee can get hot. Around Loxton (a town on the Murray River) temperatures can reach 50°C during summer, with dry soil surface temperatures getting as high as 70°C. It is not unusual to have a five day stretch of 45°C days with warm nights. These warm temperatures can cook roots in the soil, causing significant wilt, and reflectance from the sands can burn the undersides of leaves. Yet, despite these harsh conditions, the Mallee region is a major producer of potatoes.

The key to this is irrigation infrastructure. Applying water to crops and soils helps to cool soils down, create humidity, and reduce reflectance (wet soil, especially sand, reflects less than dry sand).

Applying the right amount of water at the right time can cool soils, raise humidity, and provide the environmental conditions that promote healthy transpiration in plants. The movement of water through the vascular tissue (xylem) removes heat from the plant in a process called evaporative cooling.

However, it is not as simple as flooding a paddock during high heat events and waiting until it blows over. Overwatering can be just as bad as underwatering. Too much water can cause plant stress. If water stays in the soil profile long enough, it can warm up and cause damage to roots. Warm, watery soil is also the perfect environment for fungal and bacterial infections.

Overwatering can also impact the nutrition balance of a plant. Key nutrients such as calcium and magnesium need to balance during these heat events. Just as a person might suffer from cramps due to a lack of magnesium, or nausea from diluting salts in the body when drinking too much water, over watering can dilute nutrients in plants, weakening its defence mechanisms. The use of soil moisture probes is critical to understand the water levels in soil profiles and when irrigation is needed and, importantly, when it is not.

Another major factor to manage during high heat events is plant stress. Heat, wilt, waterlogging, and disease can all impact how a plant will respond. Management prior to and during the high heat events is critical to ensuring plants get through these times. Stressed plants are more susceptible to the negative impacts of high heat events. Forecasting tools can help growers to prepare for the high heat events.

By managing plant stress and nutrition prior to, and during, the high heat event, and applying the right amount of water to encourage transpiration and increase the relative humidity, crops can be successfully managed through these events.

# MANAGEMENT OF RECENTLY ESTABLISHED *LYRIOMYZA* LEAFMINERS

Shakira Johnson (AUSVEG)

Three new species of *Lyriomyza* leafminer flies are now present in Australia:
American Serpentine Leafminer (ASLM (*Liriomyza trifolii*))
Serpentine Leafminer (SLM (*Liriomyza huidobrensis*))
Vegetable Leafminer (VLM (*Liriomyza sativae*))

## QUICK FACTS

- They all feed on many plants and will likely affect most commercial crops (such as potato, tomato and eggplant)
- Damage on some commercial crops has been recorded from Qld, NSW, NT, WA and Vic
- Experience from other countries shows us that overuse of chemical controls will backfire
- IPM approaches are the most likely to successfully manage these insects

## CURRENT KNOWN DISTRIBUTION OF THE NEW LEAFMINERS

Vegetable Leafminer was first detected in 2015 at the tip of Cape York Peninsula in Queensland. No further detections have been made. SLM was first detected in western Sydney, New South Wales in October 2020 and a month later in Queensland's Fassifern Valley, followed by the Darling Downs and Lockyer Valley. SLM has since been detected in Victoria. ASLM was detected in July 2021 in the Torres Strait Islands and northern Western Australia. There have since been further detections in Kununurra (WA), Darwin and Katherine in the Northern Territory, and the Northern Peninsula Area of Cape York (Qld). There has been a single detection in Broome (WA).

## RISK OF SPREAD AND ESTABLISHMENT

Major risk pathways of leafminers into and across Australia is by the importation of infested ornamental host plants and cut flowers. Leafy vegetables and seedlings can move leafminers across Australia. Natural pathways or human-assisted entry can also occur at the borders (e.g., on plant material illegally imported).

Globally, *Liriomyza* leafminer dispersal

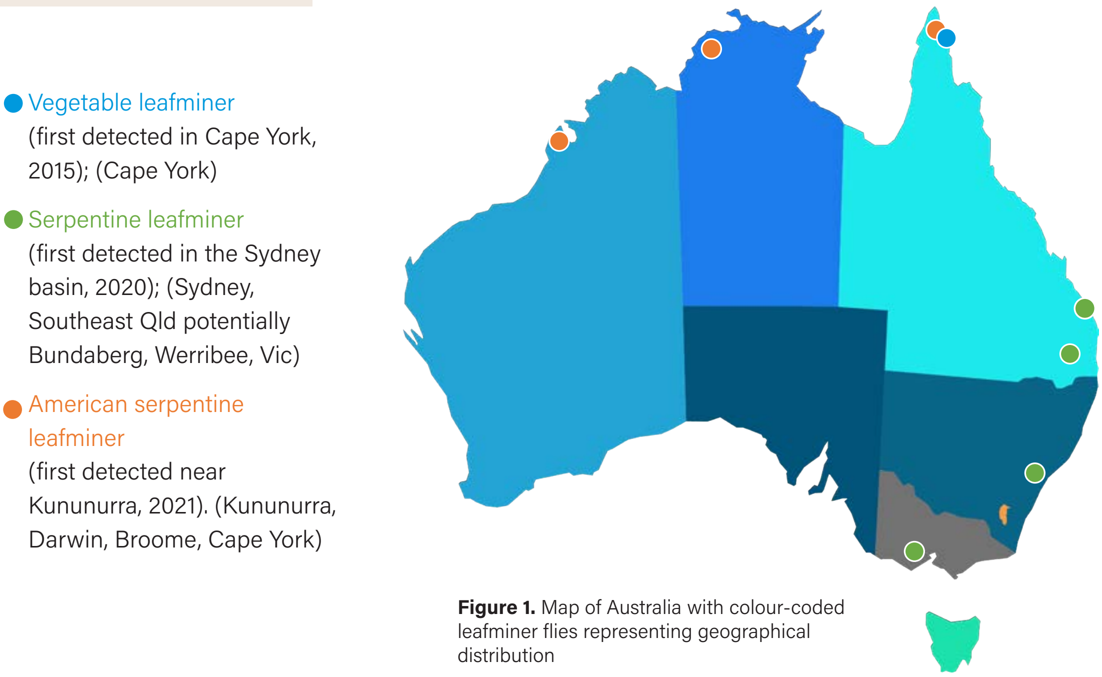



**Figure 1.** Map of Australia with colour-coded leafminer flies representing geographical distribution

and establishment has occurred rapidly, with populations found on most continents now. Many important vegetable production regions in Australia have the climatic conditions suited to *Liriomyza* spp. establishment.

In potatoes, feeding punctures are visible throughout the plant as it grows. Initial infestation begins in the lower third of the plant, which eventually leads to necrosis in the above-ground plant tissue and subsequent defoliation. Larval damage is worse in a fully-grown plant than in a developing plant. When the pest first became established in Indonesia, yield losses of up to 70 per cent were recorded as farmers struggled to control the pest with conventional insecticides. Potato growers in South America, particularly in Peru, Bolivia, Brazil, Chile and Argentina, have experienced substantial potato yield loss due to serpentine leafminer. In Peru, yield losses varied between potato varieties and greater yield losses were seen in earlier maturing potatoes (up to 60 per cent) than later maturing potatoes (up to 30 per cent). In Argentina, potatoes were severely damaged during tuber bulking but the severity of damage varied between provinces.

Climate models and existing pest knowledge have been used to determine the pest's establishment risk in regions across Australia. A predictive model based on temperature, moisture constraints and predicted dominant stressors (cold, heat, desiccation) was created by Cesar Australia as part of a levy-funded project, MT16004 which developed a contingency plan for each pest (see further reading at the end of this article).

Each of the new leafminer species has a preferred climate suitability. Modelling has been prepared to show where and when each species is likely to be at its most active (Figure 2).

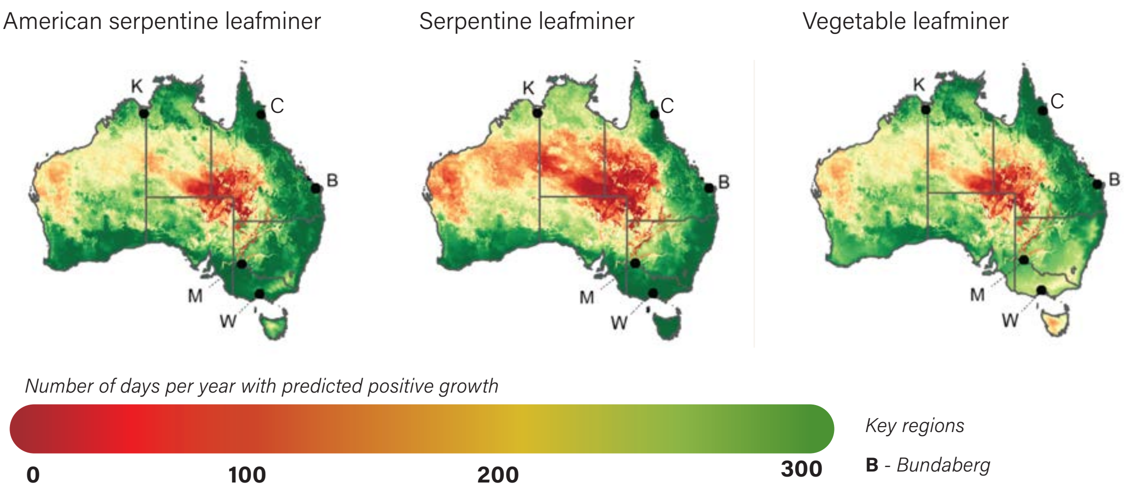



**Figure 2.** The aggregated yearly establishment potential of ASLM, SLM and VLM as the number of months across the year with increasing population sizes based on temperature and moisture constraints. Reference: Maino, J. et al. (2023) *Austral Entomol*, 62 (1), 118-130.

## INSECT LIFE CYCLE

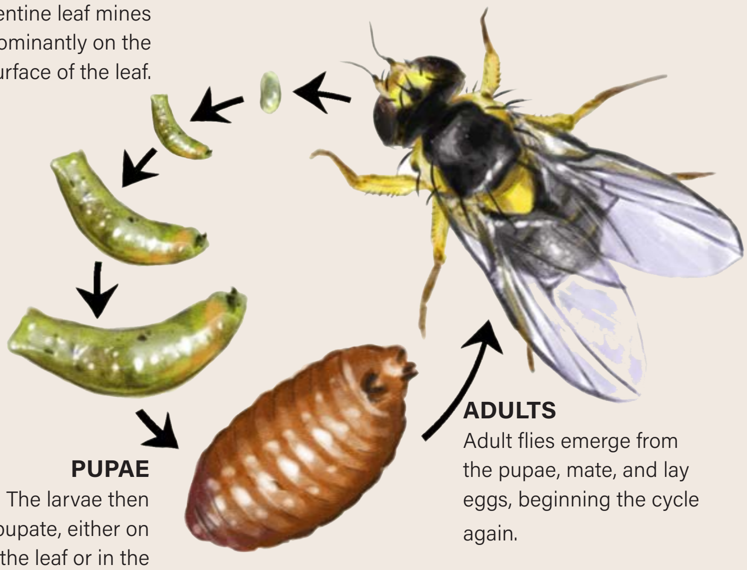
The life cycle for *Liriomyza* leafminers is generally consistent across species. Adult serpentine leafminers range from 1.3-2.3mm in length. The typical leafminer life cycle takes 13 to 43 days from eggs to adult emergence. The time taken to complete each life stage varies depending on temperature. Development rates become quicker as temperature increases, leading to overlapping generations. However, lethal temperature limits exist for each of these leafminer species:

- ASLM 10°C and 35°C
- SLM 5°C and 32-35°C
- VLM 10°C and 40°C

## LIFE CYCLE STAGES

**LARVAE**
These eggs hatch after 2-5 days and the larvae tunnel through the leaves creating serpentine leaf mines predominantly on the upper surface of the leaf.

**EGGS**
Adult females create holes (stippling) when feeding and/or laying eggs.



**PUPAE**
The larvae then pupate, either on the leaf or in the soil.

**ADULTS**
Adult flies emerge from the pupae, mate, and lay eggs, beginning the cycle again.

*Illustration by Elia Pirtle*

## IMPACT

**Damage from leaf mining and feeding can cause premature leaf drop leading to an increased risk of secondary infection from fungi and bacteria.**

'Stippling' damage (Fig. 3a), caused by adults feeding and/or laying eggs, is visible in the early stages of infestation and can lead to a high risk of plant fungal and bacterial infection. Eggs are too small to be seen by the naked eye, so a healthy-looking plant may harbour the pest without us knowing. Inside the leaf tissue, larvae begin to feed within the leaf, creating tunnels or mines that become larger as the larvae mature. These leaf mines can reduce photosynthetic activity, causing premature leaf drop. The most severe infestations usually occur late in the season and can affect large areas of the leaf (Fig. 3b). Damage from leaf mining and feeding can cause premature leaf drop leading to reduced yields, further impacted by secondary infection from fungi and bacteria (Fig. 3c). In warm areas and greenhouse production, damage may be more severe.


**Figure 3**. Damage caused by *Liriomyza* leafminers feeding on host plants: a) stippling damage caused by adult feeding and egg laying, b) mines caused by larvae feeding on potato leaf and opportunistic secondary infection, c) Severe infestation in potato crop leads to reduced photosynthetic capacity (Image credits: John Duff, Queensland DAF).

## INTEGRATED PEST MANAGEMENT

### Cultural: Monitor pest and parasitoid activity to inform management decisions.

To detect and monitor adults, look for stippling on leaves indicating adult leafminers. Yellow sticky cards can be placed at plant height and inspected at least twice weekly.

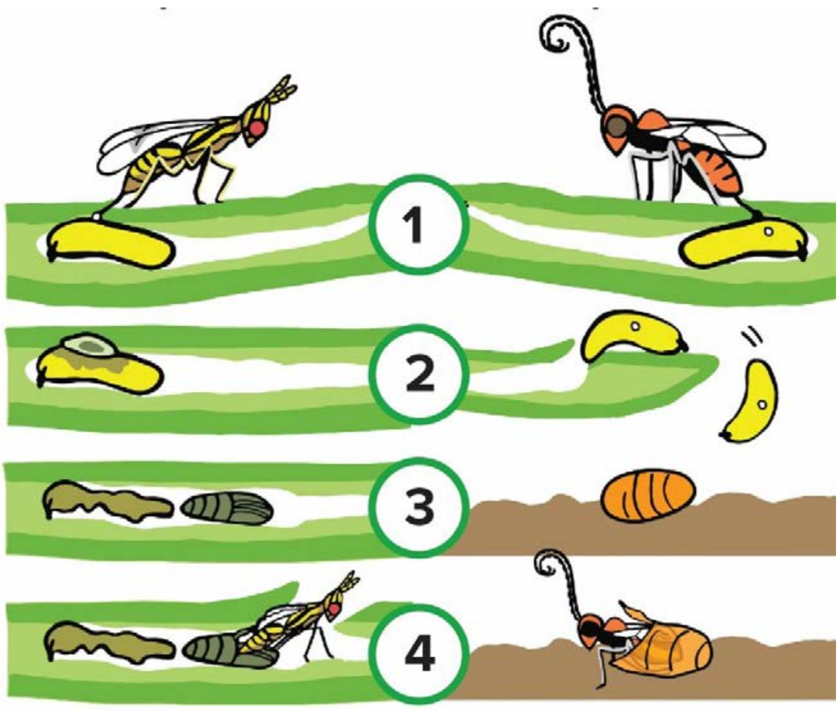
Deep soil cultivation before planting to destroy infested weeds and plant material from the previous season can reduce the severity of leafminer outbreaks. Non-host cover crops to exclude adult flies from laying eggs may also help in some cases. Alternate weedy hosts such as sowthistle, chickweed, and nightshade should be destroyed to reduce overwintering populations.

For severe, yearly infestations, consider:

- Tilling or cultivating the top 5cm of soil in early spring to disrupt the life cycle and kill overwintering pupae.
- Checking transplants for signs of leaf mines and white stippling before planting; destroy infested plants.
- Clipping and destroy infested leaves to prevent larval development.
- Using adequate irrigation to keep plants healthy and reduce stress.
- Immediately after the final harvest, removing plants and deeply ploughing crop residues to remove food sources and inhibit pupal development.

### Beneficials: Conserve beneficial natural enemies such as parasitoids; learn the signs of parasitism to determine if visible leafmining damage is associated with active parasitoid wasps controlling the leafminer population.

Parasitoid wasps are a natural way to control leafminer. International management of *Liriomyza* leafminers includes using natural enemies such as parasitoid wasps that attack larvae. Research has indicated that Agromyzid parasitoids rapidly target exotic *Liriomyza* leafminers, and many are reported to affect these pests overseas. Field mortality rates can reach up to 80%. Australia has at least 50 species of these wasps that attack native and exotic leafminers. Their life cycles vary and can be classified as 'larval' or 'larval/pupal'.




LARVAL

1. Female wasp lays an egg on or in fly larva.
2. Wasp egg hatches and feeds on fly larva.
3. The wasp pupates inside the leaf mine after consuming the fly.
4. Adult wasp emerges from the leaf mine.

LARVAL/PUPAL

1. Female wasp lays an egg on or in the larva.
2. Wasp egg stays dormant until fly larva emerges and pupates.
3. Wasp egg activates, consuming pupating fly.
4. Wasp emerges from otherwise healthy looking fly pupa.

**Figure 4.** Life cycles of parasitoid wasps: larval life cycle versus larval (left)/pupal life cycle (right) (Illustration by Elia Pirtle)

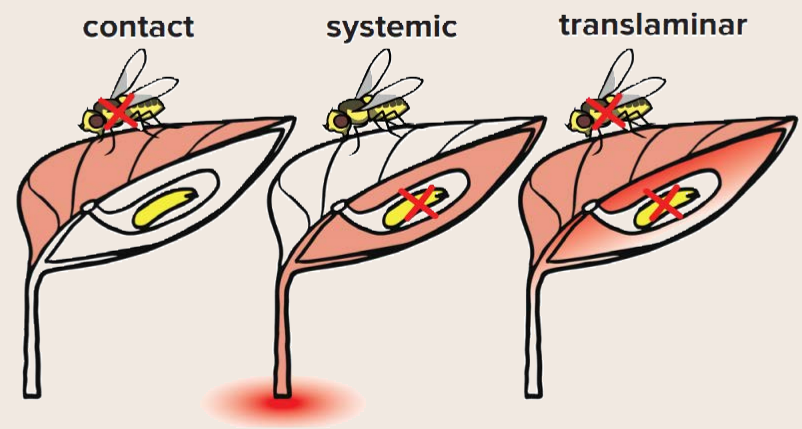
### Chemical: Avoid broad-spectrum insecticides and reduce the evolution of resistance to insecticides.

Worldwide, Serpentine leafminer and its related species have been reported to be resistant to many insecticides, including organophosphates, carbamates, synthetic pyrethroids, cyromazine, avermectin, and spinosyns. An integrated approach is needed to avoid further insecticide resistance developing. If you are using chemical treatments, rotate the mode of action groups.

Chemical management must be carefully planned, and broad-spectrum pesticides must be avoided.

Contact, systemic, and translaminar pesticides are effective at different stages (Figure 5). Because leafminers are protected within the plant, foliar insecticidal control is often difficult. Foliar protectants must be applied before egg deposition on the crop. The window of activity is a concern and may require several applications for adequate control of the emergence of leafminer.

Biological control with parasitoid wasps is more effective. Avoid harming beneficial wasp populations.




X's indicate mortality of leafminer adult or larva

■ indicates presence of chemical on/in plant tissue

- *Contact pesticides are effective against adults*
- *Systemic pesticides are effective against larvae*
- *Translaminar pesticides are effective against both adults and larvae*

**Figure 5**. Insecticide modes of action against leafmining flies (Illustration by Elia Pirtle)

*This article first appeared in 'Australian Grower' magazine, Summer 2023.*

## FURTHER READING

Resources for management of leafmining flies in Australia

Chemical management of leafminers from NSW DPI

AUSVEG biosecurity alerts

Plant Health Australia: Vegetable leafminer

Plant Health Australia: Serpentine leafminer

Plant Health Australia: American serpentine leafminer

## FIND OUT MORE

Please get in touch with the AUSVEG Extension & Engagement Team on 03 9882 0277 or email science@ausveg.com.au.

**Funding statement:** *Management strategy for serpentine leafminer, Liriomyza huidobrensis* is a strategic levy investment under the Hort Innovation Potato – Fresh, Potato – Processing, Melon, Onion and Vegetable research and development levies and contributions from the Australian Government.

Project Number: MT20005

# OPTIMISING BIOSECURITY TESTING USING NEXT GENERATION SEQUENCING

In contemporary agriculture, rapid and secure access to new plant genetic stocks is critical for the success and sustainability of primary industries. The ability to quickly adapt to new global market opportunities and access innovative plant varieties is key to remaining competitive.

## KEY POINTS

- Rapid access to new and safe plant genetics is vital to keep Australia's local industry competitive.
- Next Generation Sequencing (NGS) adoption promises faster access to new genetic material, cost savings, increased imports, and agile responses to market opportunities in agriculture.
- Current plant import processes are costly and inflexible due to extended quarantine periods.
- NGS offers a faster, versatile, and reliable method for pathogen detection.
- Collaborative research supports NGS as a practical solution for improving quarantine testing.
- Traditional diagnostics have limitations.

Currently, when imported plant material arrives in Australia, it spends up to three years in Post Entry Quarantine (PEQ) facilities, primarily for pathogen testing. This delay not only hampers the industry's flexibility but also adds significant costs.

Traditional pathogen testing methods are often time-consuming, resource-intensive, and can yield ambiguous results. This is where Next Generation Sequencing (NGS) steps in as a game-changer. NGS provides a scalable, robust, accurate, and rapid diagnostic platform, promising to expedite 'plant health' screening and reduce quarantine time.

A collaborative Horticulture Innovation Australia project spanning multiple crops has shown that NGS is a feasible alternative that will reduce time and improve accuracy of quarantine testing.

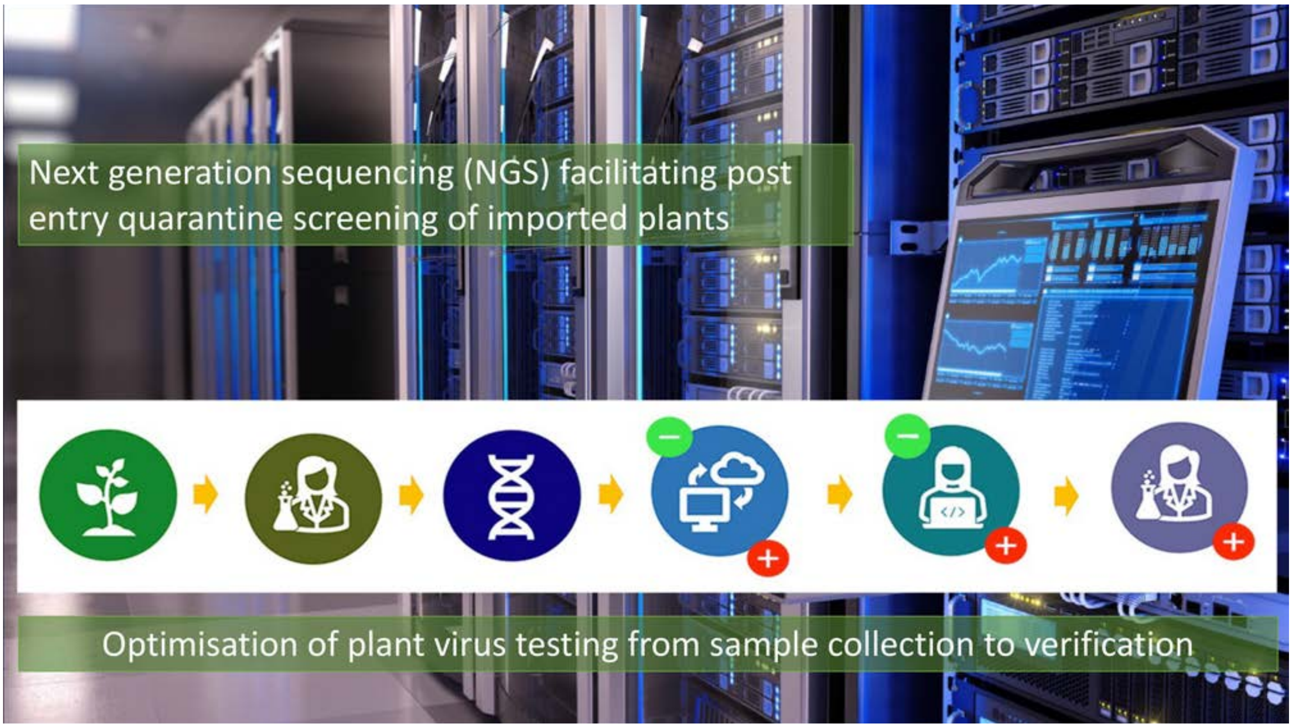
The project *Improving Plant industry access to new genetics through faster and more accurate diagnostics using next-generation sequencing* (MT18005) investigated the application of advance gene technology – known as Next Generation Sequencing (or NGS) to screen imported horticultural plant materials in PEQ.

## BIOSECURITY RELEVANCE

Biosecurity measures are primarily designed to prevent the introduction of exotic plant pests. Traditional diagnostic methods, such as tissue (serological) or molecular analyses, rely on prior knowledge of the pathogen's genetic blueprint. However, these methods are often specific to certain pathogens, limiting their versatility.

In contrast, non-specific assays like electron microscopy, woody indexing, or visual inspection do not require prior knowledge but can lead to ambiguous detections. Typically, they provide limited diagnostic certainty, mainly categorising organisms at the broad level, which is not reliable when looking for diseases.

Additionally, most traditional tests cannot detect multiple pests in a single test, causing delays in the quarantine process and hindering the industry's ability to respond promptly to emerging market opportunities.




## NGS AND PROJECT OUTCOMES

Plant viruses and viroids are tiny organisms that harm plants and detecting them when a plant is showing no symptoms can be challenging. NGS technology has changed the way we find and identify these hidden pest and diseases. When NGS is combined with computer analysis (bioinformatics), detection of known viruses is quick and accurate. Better still, new threats can be detected.

Large scale side-by-side trials of PEQ and NGS protocols demonstrated the benefits of NGS to detect virus-free plants and plants infected with pesst of biosecurity concern. NGS is informing and guiding the effective use of resources at PEQ to facilitate and optimise quarantine testing and decision making.

Technical advances in NGS diagnostics for plant viruses have led to the adoption of the technology for routine testing in prunus, rubus, strawberries, and ornamental grasses. The team continues to use the technology for a broad range of plant species including potatoes providing industries the option to opt-in to use NGS along with other existing PEQ testing protocols.

The project team has also made significant progress using NGS to detect and precisely identify bacteria in several crop species, trialling two different approaches to using the technology.

The first approach involved collecting all the genetic information from a sample of the pest – essentially gathering a complete picture of its genetic makeup. The second approach focused on specific regions of genes that are associated with known harmful bacteria.

Their research yielded promising results. When they used the first method (whole genome sequencing), they were able to produce high-quality genetic information. Importantly, this method revealed results that were clouded by interference from genetic material of other organisms.

The targeted capture approach was successful in detecting bacteria that are challenging to cultivate in a laboratory.

Based on these findings, they have developed a draft policy paper to promote the use of NGS technology to test bacterial pests in PEQ facilities. However, it will likely take a few years for NGS to become routine in testing for bacteria. Currently, NGS is only used for detecting plant viruses and viroids.

The project, carried out in close partnership with the Department of Agriculture, Fisheries, and Forestry, has successfully facilitated the policy acceptance and operationalisation of NGS for routine quarantine testing of plant viruses at PEQ facilities. This achievement is expected to enhance Australia's biosecurity system, safeguarding domestic plant industries from exotic pests.

Moreover, it will enable plant industries to gain accelerated access to new plant genetics, ultimately providing them with improved opportunities in high-value markets. This transformative capability promises to revolutionise biosecurity, ensuring the protection of domestic plant industries while opening access to global opportunities.

## GOOD NEWS FOR GROWERS

NGS has already been successfully employed for the detection and identification of numerous plant viral and bacterial diseases. This technology even leverages the innate plant immune response to detect and reliably assemble viral genomes, further enhancing its efficacy in PEQ facilities.

The implementation of NGS in plant quarantine and biosecurity procedures brings a host of benefits to growers and the agriculture industry including:

1. **Faster access to new genetics:** with NGS, the industry gains rapid access to new plant genetic stocks, allowing for quicker incorporation of innovative plant varieties.
2. **Lower costs for quarantine testing:** NGS streamlines the testing process, reducing resource and time requirements, thus lowering overall quarantine costs.
3. **Option to import a larger volume of plants:** the efficiency of NGS enables the importation of a larger volume of plants, expanding the possibilities for growers and agribusinesses.
4. **Ability to respond to emerging market opportunities:** NGS empowers the industry to quickly adapt to emerging market opportunities, ensuring a competitive edge in the global market.

NGS technology relies on the use of super computers to process the large amount of genetic data collected from imported plant species.

All plant industries importing new genetic material through PEQ can opt-in to use the NGS technology along with other existing quarantine testing procedures.

A further advantage of the NGS is its ability to detect pests that may be endemic, enabling industries to make an informed decision on building a business portfolio around new genetic imported material.

## WHAT'S NEXT

As the project progresses, further R&D is underway to improve the use of the NGS technology for the diagnosis of plant pests, particularly for challenging commodities such as imported seeds.

The team is now developing molecular techniques to facilitate the generation of virus-free plants when high value plants are imported to Australia, but these may be infected with one or more viruses of biosecurity concern.

## FURTHER READING

The final report is available to download from the Hort Innovation website.


Hort Innovation POTATO – FRESH FUND

This project has been funded by Hort Innovation using the potato – fresh research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au

Hort Innovation POTATO – PROCESSING FUND

This project has been funded by Hort Innovation using the potato – processing research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au

**Funding statement:** *Improving plant industry access to new genetics through faster and more accurate diagnostics using next generation sequencing (MT18005)* is a strategic levy investment under the Hort Innovation Citrus, Nursery, Potato - Fresh, Potato - Processing, Raspberry and Blackberry and Table Grape research and development levies and contributions from the Australian Government.

Project Number: MT18005

# MOISTURE MONITORING

## A demonstration by PotatoLink

**Beyond providing soil moisture data at a given time and soil depth, can soil moisture probes help in making future irrigation decisions? The potential of moisture probes to serve a dual role was the subject of a PotatoLink demonstration trial.**

Moisture probes act as a kind of yardstick, helping farmers align their field observations with real moisture data. They can also help optimise irrigation practices.

Using moisture data, farmers can time irrigation to match the actual water needs of their crops. This precise approach has the potential to boost crop yields significantly – essentially aligning human judgment with data-driven precision to get the best results from the field.

### ARE MOISTURE PROBES IMPORTANT?

The use of moisture probes plays a crucial role in smart agriculture for several important reasons. While not used in every paddock due to their cost, even a couple of probes in key locations can serve as valuable tools for improving irrigation practices.

One primary function of these probes is to help farmers align their visual observations in the field with what's happening beneath the ground. This calibration ensures more accurate decision-making regarding irrigation – nobody wants to under or over water.

Overwatering can lead to issues such as nitrogen leaching, while underwatering during critical crop phases, like tuber bulking, can deplete subsoil water reserves, making proper irrigation management essential.

Probes are also useful after rainfall events, providing growers with information on the impact of rainfall on soil moisture, potential nutrition movement and when to resume irrigation.

### THE DEMONSTRATION

At the demonstration site, two Wildeye moisture units were installed, each unit with two probes at different depths: at 20cm, where most of the plant roots are located, and another at 40cm to monitor water movement through the soil profile.

The locations represented two different soil types, with lighter sandier soils in northeast (NE) and heavier soils in the southwest (SW).

The data output from these probes shows fluctuations in soil moisture levels, as shown in Figure 1.

The green line, representing the 40cm depth, provides insights into subsoil conditions, while the blue line at 20cm oscillates based on irrigation, rainfall event and crop water usage (clearly showing more usage during the day and low usage at night).

The examples in this trial show the distinct differences in moisture retention in different soil types and therefore varying success of irrigation. As shown in Figure 1, the lighter soils in the NE of the paddock suffered from underwatering compared to the heavier soils in the SW, particularly during the tuber bulking stage.

### KEY TERMS

Understanding parameters like the 'full point' (maximum soil water capacity) and 're-fill point' (the level at which irrigation is triggered) is critical and can be adjusted during different crop growth stages.

**Full point:** Generally, if you've had heavy rainfall, the full point is once the field has been able to drain for a day. It is the most water the soil can hold.

**Re-fill point: There** is a bit of an art and science to set this at the right level. This is the soil moisture level that you are prepared to let the crop dry down to before irrigating. It is a dynamic number will change as the roots grow into new soil. For example, it is common to change the refill point during sensitive parts of the crop growth curve, especially tuber bulking

In the NE, the moisture levels at 40cm depth fluctuate a lot as the water moves through the profile. When the soil is waterlogged (i.e. persistently in the blue shaded zone), it is difficult for the roots to grow. Additionally, overwatering leads to nitrogen leaching. Following the blue line (20cm depth), the NE section was overwatered during the early vegetative and maturation stages and underwatered during the tuber bulking stage.

## PAIRING AND INTERPRETING THE DATA

Pairing data from moisture probes with information from tools like IrriSAT is a smart strategy. It involves combining soil moisture data with real-time insights into what the crop is doing. IrriSAT, for instance, generates a growth curve for the crop, indicating its various stages of development. This curve is valuable because it helps growers understand when the crop's water demand is likely to increase.

For example, when a crop transitions from having limited leaf area to achieving full row closure, its water requirements rise significantly. IrriSAT can track this leaf area growth and provide a growth curve to guide irrigation decisions.

Data collected from the probes can be used to examine how moisture levels change over time, then correlate these changes with rainfall and irrigation.

If the crop is overwatered, topsoil moisturewill increase rapidly immediately following an irrigation event. The key question is whether this excess moisture swiftly reaches the probe below. Sometimes, water can move rapidly through the topsoil and drain below 40cm, effectively stripping away the excess moisture from the upper layers.

It is therefore important to focus on how the subsoil behaves over time to make informed irrigation decisions.

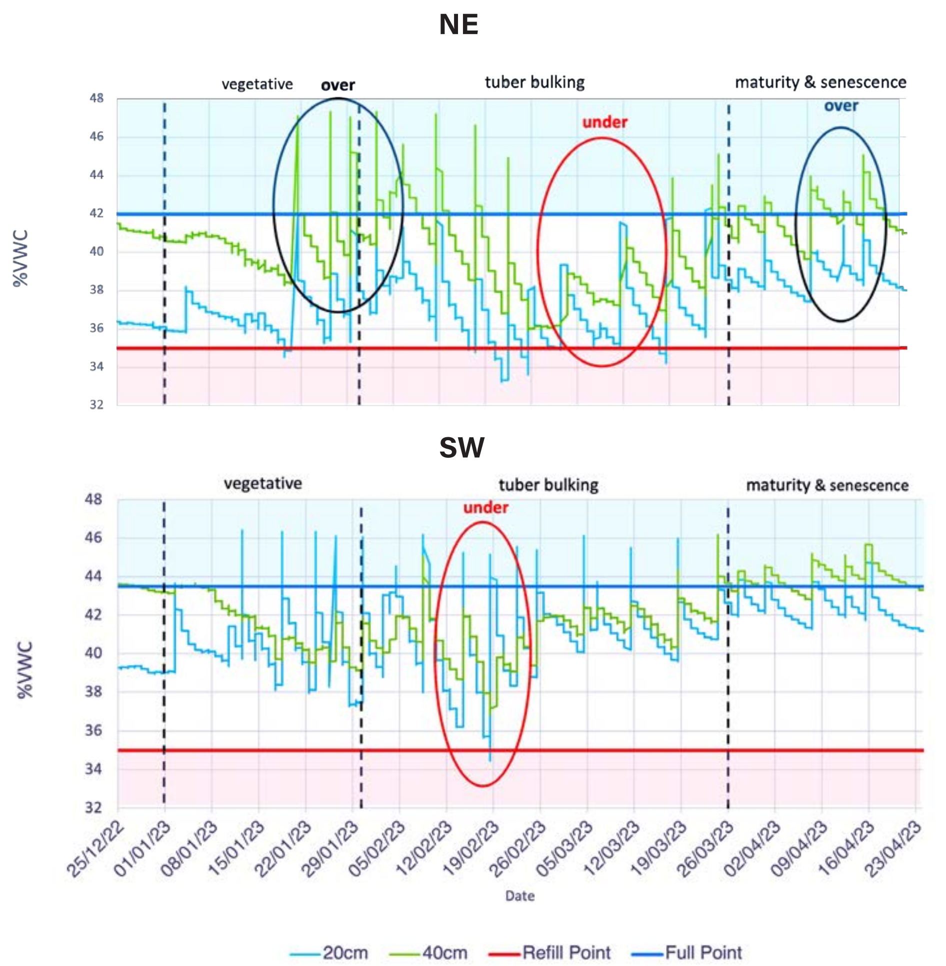



**Figure 1.** Results showing the fluctuations in moisture levels across the four main stages of development. Shaded red = refill point; shaded blue = full point; green line = moisture levels at 40cm; blue line = moisture levels at 20cm

At the demonstration site, the two distinct areas, SW and NE, show how using the same irrigation management technique for the whole paddock doesn't align with requirements of the crop grown under different soil textures.

The NE section with the lighter soil texture and lower water-holding capacity, was initially over-irrigated. Then later, during tuber bulking, it experienced a period of under-irrigation.

In contrast, the SW area was irrigated well. This difference highlights the challenge of managing irrigation across various soil textures and the importance of using moisture probes to save time and optimise decisions.

When comparing the SW and NE areas, it becomes clear that irrigation was better aligned with the SW area soil type. In contrast, the NE was challenged by both over and under-irrigation.

This underscores the difficulty of managing irrigation when dealing with diverse soil conditions.

## EVAPOTRANSPIRATION

Evapotranspiration, or the loss of water through plant transpiration and soil evaporation, is a key factor to consider.

During the early stages of crop growth, when there is limited leaf area, most water loss is due to soil surface evaporation. As the crop develops and leaf area increases, the plant begins to draw more water from the soil, leading to higher water demands.

Evapotranspiration rates can jump significantly, from 2mm per day in the early growth stages to 8-10mm per day when the crop reaches peak leaf area and row closure. Matching this demand with irrigation can be challenging, and if the irrigation system cannot keep up, reliance on soil moisture reserves becomes essential, potentially leading to under-irrigation.

For growers, moisture probes can be valuable learning tools. While traditional methods like spade and visual inspection are useful, moisture probes can help validate what growers observe visually and calibrate their decision-making processes. They also offer growers with a prompt to check irrigation when they are time poor and struggling to get to the field to check soil moisture.

Effective calibration and integration of moisture probe data can lead to more precise and efficient irrigation practices, ultimately enhancing crop yields and water use.

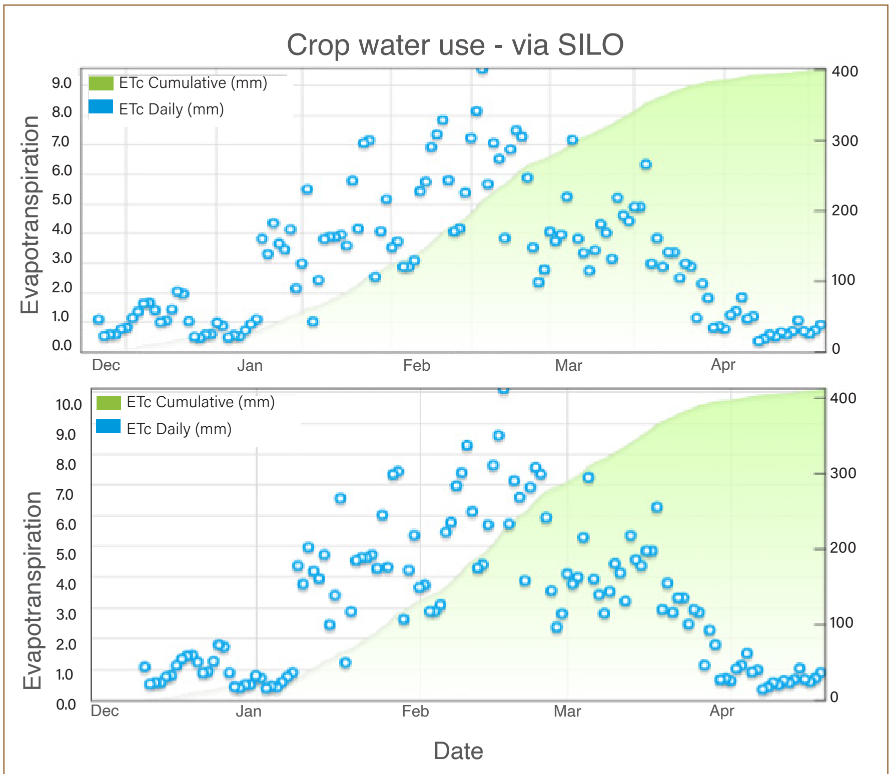



**Figure 2.** Evapotranspiration rates for the NE (top) and SW (bottom) sites

## WILDEYE PROBES

The Wildeye probes used in this demonstration are equipped with a communications box, which is a key feature. Standard moisture sensors are found in various equipment, but the addition of the communications box allows data to be transmitted to phones or computers.

Wildeye probes measure soil moisture at 30-minute intervals, uploading the data to the web daily to reduce battery consumption. The ability to initiate an upload in the paddock is also quite useful, as are the daily notifications provided by the system.

More information about different probe types can be found in the factsheet here (https://bitly.ws/38nBb)

## FURTHER RESOURCES:

PotatoLink webinar *Getting your irrigation ready for the summer*

PotatoLink factsheet *Matching irrigation to crop growth*

Soil Wealth ICP webinar *Tools to manage irrigation in potatoes*

Soil Wealth ICP case studies in potatoes
*Part 1: Practical use of Irrisat and soil moisture sensors*

Soil Wealth ICP case studies in potatoes
*Part 2: Practical use of satellite information*

Hort Innovation POTATO – PROCESSING FUND
This project has been funded by Hort Innovation using the potato – processing research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au

Hort Innovation POTATO – FRESH FUND
This project has been funded by Hort Innovation using the potato – fresh research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au


# Spirit 7200 2-Row Offset Bunker Harvester

## Call us for a demonstration

• Unique additional Haulm Separation
• Quick change Digging Units (e.g. Potato/Onion)
• New 7 Ton Bunker • Road Legal
• Independent Hydraulic System (2 x LS Pumps)




VR
VIN ROWE
FARM MACHINERY

3 ENDEAVOUR ST, WARRAGUL. VIC 3820
PH (03) 5622 9100 www.vinrowe.com.au

FOR FURTHER INFORMATION CONTACT
WAYNE MILLS 0417 945584

*Where Service is Part of the Sale!*

# SEEDING SUCCESS IN VANUATU

## DEVELOPING SEED PRODUCTION IN VANUATU TO ADDRESS FOOD SECURITY

Mia Novakovic and Dr Nigel Crump
Corresponding author Mia.novakovic@toolangielite.org.au

AuSPICA

**AuSPICA is collaborating with an Australian charity to bring sustainable potato seed production to Vanuatu and address some of the key UN sustainability goals in the region.**

Vanuatu Prevention of Blindness Project Inc (VPBPI) is a compassionate Australian charity, led by Don and Meg MacRaild who are based near Sale, Victoria. The project was initially dedicated to providing access to prescription glasses for the people of Vanuatu. Evolving from its origins, VPBPI has expanded its mission to encompass annual pop-up medical clinics (with doctors flying in from Australia), the shipping of donated goods, and advocacy efforts for the Ni-Vanuatuans residing in Australia.

The journey of VPBPI into extensive medical and optometry initiatives revealed a pressing need for enhanced nutrition and food security among the population. Recognising the potential of potatoes as an ideal staple crop, VPBPI aimed to diminish dependence on imported white rice, simultaneously fostering improved overall health, and contributing to economic growth in the region.

In recent years, the Australian Seed Potato Industry Certification Authority (AuSPICA) has joined forces with VPBPI to collaboratively develop a sustainable and viable potato production system in Vanuatu. In October 2023, both teams visited Vanuatu to conduct workshops and training programs to advance potato production, marking another milestone in this collaborative effort.

This joint initiative aligns with the United Nations' 17 Sustainability Goals, symbolising a shared commitment to making meaningful strides towards a more sustainable and secure future for all. AuSPICA is dedicated to playing a crucial role in leveraging Australia's expertise to support the development of nations in our region, with a particular focus on addressing food security and alleviating poverty through impactful collaborations.

The significance of forging partnerships and collaborations to combat poverty and food insecurity, gained formal recognition in the Declaration of Dublin: Fostering Potato Partnerships for Food Security, published by the World Potato Congress Inc. Proudly, AuSPICA actively engages in fostering collaborations and partnerships within the region, contributing expertise and know-how to support developing nations like Vanuatu.

### POTATO COLLABORATION: ADVANCING SUSTAINABILITY AND THE UN'S 17 GOALS

The strategic partnership between VPBPI and AuSPICA on potato initiatives signifies a concerted effort to contribute to the United Nations' 17 Sustainable Development Goals (SDGs). This collaborative endeavour serves as a multifaceted approach, addressing several key aspects of sustainable development, including:

- No poverty
- Zero hunger
- Good health and well-being
- Gender equality
- Decent work and economic growth
- Responsible production and consumption

Photo credit (including top banner): Vanuatu Prevention of Blindness Project

## POTATOES PROVIDE NUTRITION AND A RELIABLE FOOD SOURCE

The VPBPI medical teams have identified iron deficiency, birth defects and a high rate of diabetes as concerning health issues.

Although fresh produce is accessible during periods of favourable weather, many key nutrients are lacking from the Vanuatuan diet. This is worsened during periods of cyclone damage and recovery. Potatoes in the diet could be a key factor in reducing some illnesses, as they are an easily accessible and low GI source of key vitamins and minerals.

Many of the nutrients in potatoes are readily absorbed by the body – most notably iron and zinc. Potatoes have a high bioavailability of iron and zinc when compared to other plant-based foods. This is due to high rates of vitamin C (which aids iron absorption) and low rates of phytates (which inhibit absorption of iron and zinc).

The International Potato Centre (CIP) based in Peru is leading a program which aims to selectively breed new potato varieties with a higher content of iron and zinc. AuSPICA is developing a partnership with CIP to access these biofortified potato varieties for future trial and evaluation in Vanuatu and other countries with the Oceania region. The use of such potatoes varieties will advance the dietary nutrition and, in doing so, will address concerns of birth defects and anaemia resulting from poor nutrition.

Mia Novakovic is leading this collaboration with CIP and has identified that there is a major benefit to establishing a genetic resource bank in Australia that could provide high plant health material to the Oceania region. There is potential to achieve major social and economic benefits in the region through the availability of high yielding and suitable potato varieties including those that have been biofortified. AuSPICA is currently exploring linkages with other countries within the Oceania region that may be interested in enhancing local potato production with the production of good quality seed potatoes.

## POTATOES PROVIDE FOOD SECURITY

Currently in Vanuatu, there is interest in growing potatoes as a potential staple crop. However, up until now the local farmers have been unable to do so due to the lack of a reliable source of high-quality, affordable seed of suitable varieties for the local conditions.

Potatoes are mainly grown in Vanuatu for the fresh market, with many farmers buying new seed each year. There have been previous attempts to save part of each crop as seed, however, immediate food shortages during cyclone recovery have forced this method to be abandoned. Certified seed potatoes have been imported into Vanuatu on several occasions, but this is expensive and there have been problems associated with shipping conditions. In one case a consignment of 10 tonnes of seed was inadvertently frozen and made non-viable.

It was proposed that the importation of G0 seed was more affordable and carried less of a biosecurity risk. By importing seed at G0, and then multiplying in-field, the initial import cost is lower than certified seed and the potato supply chain within Vanuatu is extended, creating more employment and prosperity. For the past few years, AuSPICA, through the business Toolangi Elite, has provided minitubers of various varieties to trial in Vanuatu. This has been successful and shown that varieties such as Sebago, White Star, and Toolangi Delight can be grown in Vanuatu.

Generally, one minituber planted can produce four tonnes of potatoes after only five crops. In Vanuatu, it is possible to have at least two potato crops per year, so within a couple of years there is the ability to produce a significant food supply using potatoes. The recently formed Tanna Potato Growers Association is well on the way to realising the potential for potato production in Vanuatu. They have planted G1 seed grown from last year's minitubers (to be harvested G2) and planted G0 minitubers, to be harvested G1.

The farmers on Tanna are leading the development of a local seed

Photo credit: Vanuatu Prevention of Blindness Project production supply for Vanuatu. During the recent trip, AuSPICA worked with the Tanna Potato Growers Association to develop a short guide to promote the production of high-quality seed potatoes. The guide was translated into Bislama - a widely used official language of Vanuatu. The guide provides documentation for the development of an informal seed scheme, the primary goal being to ensure a consistent supply of seed potatoes to meet the demands of the market and, in addition, ensure that pest and disease issues are addressed and effectively managed.

## POTATOES PROVIDE ECONOMIC GROWTH

A seed potato industry in Vanuatu has the potential to provide a significant economic opportunity for local farmers and communities.

Potatoes can be grown on many of the 83 Vanuatuan islands. While not all are suitable for potato production, many regions do have the right conditions. Potatoes can be grown to supply food to local communities, to markets including local wholesale markets, or to support commercial tourism operations including hotels, etc. In discussion with grower groups, the AuSPICA team were consistently reminded that potato production could be a reliable cash crop for local farmers.

The island of Tanna was identified as a potential seed potato growing region. Rich, volcanic soil and year-round warm weather give the island an advantage in terms of productivity, allowing for two growing seasons per year. Potatoes are considered by locals to be less labour intensive than other root crops, such as manioc, which can be heavy and difficult to harvest.

## DELIVERING EDUCATION AND TRAINING TO ENHANCE LOCAL POTATO PRODUCTION

During the visit to Vanuatu, AuSPICA's Mia Novakovic and Dr Nigel Crump provided educational forums on seed potatoes, explaining the following concepts:

- Nutritional value of potatoes as a food source
- Background information on tissue culture and the production of G0 minitubers
- The production of seed generations to maintain high seed quality
- The importance of record keeping in producing seed potatoes
- Costs and profits of seed potatoes
- Ways to minimise the risk of potato diseases
- Seed potato storage conditions

The forums were complemented with practical advice and information from Mr Allan Condron, an experienced potato and vegetable producer from Stratford Victoria. Allan Condron provided technical advice on land management, machinery, and general farming practices.

Attending each of the forums were members of the recently formed Tanna seed growers' association and fresh market growers, as well as members of the wider community who were interested in learning about seed potatoes.

In addition to the educational forums, a practical training day was held, featuring a demonstration of minituber planting – focusing on correct depth in relation to tuber size. Community members, including children, were invited to join in and have a go at planting three varieties of potato minitubers, supplied by Toolangi Elite, Sebago, White star, and Toolangi Delight.

## KEEPING THE MOMENTUM

Long term success is dependent on continued dialogue and support to build capacity and capability.

### Overcoming connectivity challenges:

Maintaining contact is difficult as internet access is limited on Tanna, which proves to be a challenge in maintaining contact through more formal means such as email. However as many people still use Facebook when they can connect, AuSPICA has managed to offer specialised guidance efficiently and successfully to the growers in Tanna.

### High-level collaborations:

During the recent visit to Vanuatu, a fortuitous meeting with the Finance Minister unfolded, providing an opportunity to delve into discussions about the future of potato production and the critical importance of food security. Key topics included the potential development of tissue culture in Vanuatu and the imperative for heightened collaboration, particularly with government institutions. The high-level engagement reinforces the commitment to weaving potato production into the fabric of Vanuatu's broader agricultural strategy.

> *"It was exciting to see firsthand the passion and interest of farmers to grow potatoes in Vanuatu. There is a significant need for Vanuatu to enhance food security and address human health issues caused through diet. It is wonderful to witness the success the Tanna growers are having in producing quality potato seed that will be the foundation for widespread potato production in Vanuatu."*
>
> *- Mia Novakovic*

# CONTROLLING SOILBORNE DISEASES AND PESTS WITH BIOFUMIGANTS

The soil ecosystem directly impacts crop yield and quality. In recent years, there has been growing interest in sustainable farming practices that improve soil's biological, chemical and physical characteristics. Biofumigation is one of these sustainable practices.

## UNDERSTANDING BIOFUMIGANTS

The emerging tool of biofumigation can help reduce reliance on chemical fumigants. Biofumigation involves the cultivation of specialised cover crops. Brassica biofumigant crops release naturally occurring sulphur compounds, especially as they break down. These are harmful to various soilborne pathogens.

Some of these pathogens can persist in soil for extended periods, even when a suitable host is absent. Biofumigation therefore offers a natural method for managing soilborne pathogens as well as some pests and weeds

### The problem with soilborne diseases

Dormant stages of some soilborne pathogens can remain inactive in the soil for many years. It is only when conditions become favourable that they multiply and cause symptoms in plants. For example, the onion disease white rot (*Sclerotium cepivorum* pathogen), can endure in the soil for over 20 years, while the potato disease Verticillium wilt (*Verticillium dahliae*) can survive in the soil for up to seven years.

The primary challenge in disease management is to reduce pathogen loads in the soil while preserving or enhancing soil health. Good soil health is the first step in bolstering crop resilience. An integrated approach that incorporates biofumigant cover crops can provide an effective way to manage soilborne diseases.

### Which species are useful as biofumigants?

Brassica species, such as mustard, radish, and rocket, have demonstrated their capability to suppress soilborne diseases like basal rot (*Sclerotium rolfsii*), onion white rot (*Sclerotium cepivorum*), charcoal rot (*Macrophomina phaseolina*), and white mould (*Sclerotinia sclerotiorum*).

Common varieties of biofumigants available in Australia include:

- *Brassica juncea* (Indian mustards)
- *Brassica carintata* (Ethiopian mustards)
- *Brassica napus*
- White (*Sinapis alba*) and black mustards (*Brassica nigra*)
- Radish (*Raphanus sativus*), which has the added bonus of producing large roots, up to 80cm-100cm, improving the physical characteristics and providing water channels
- Rocket *(Eruca Sativa*)

*Brassica juncea* (Source: Hakgala, Sri Lanka. ID:1295029 Not Kew Copyright. Only licensed for display purposes in POWO)

*Brassica napus* (Source: Wikipedia)

*Sinapsis alba* (Source: Wikipedia)

## SELECTING AND GROWING BIOFUMIGANT CROPS

### Choose targeted and locally suited biofumigants[1]

The choice of biofumigant crops plays a pivotal role in the success of integrating them into potato crop rotations. Mustards, radishes, and other brassica species are common selections, each with its unique advantages.

Identifying which soilborne diseases are present at concerning levels is the first critical step. Once they have been identified, biofumigant cover crops can be selected that target that disease, and are suitable for local conditions.

### Grow and treat as a cash crop

Proper planting and cultivation practices are essential to maximise biofumigant potential, including timely seeding, appropriate spacing, and careful management. Biofumigant cover crops should be managed like a cash crop, as that is really what they are.

The growth stage at which biofumigant crops are incorporated into the soil influences their effectiveness, emphasising the critical importance of timing for achieving desired results.

When brassica biofumigant crops are pulverised they release two essential chemical groups; glucosinolates and myrosinases. These compounds react to form isothiocyanates (ITCs). The result is production of a gas that effectively suppresses soilborne diseases.

As ITCs are highly volatile, swift and thorough incorporation of the biofumigant material into the soil is crucial. Otherwise, their effectiveness rapidly declines. Faster incorporation therefore yields better outcomes in disease control and soil health improvement.

## IMPORTANT STEPS

1. Grow to 25% flowering
2. Mulch into small fragments
3. Incorporate
4. Irrigate or roll to seal biofumigant gases

## BENEFITS FOR POTATO GROWERS

Potato growers can reap numerous benefits from incorporating biofumigants. As well as helping manage soilborne diseases, the addition of significant volumes of organic matter can improve soil health. This enhances  microbial activity and nutrient cycling. Increased crop yields and improved quality are often reported.

Additionally, biofumigants are effective in reducing nematode populations,

This article is based on content from PotatoLink webinar: Biofumigants and cover crops for disease and nematode management, by John Duff (DAF).

Watch the full webinar here, including a presentation from Dr Mieke Daneel (ARC, South Africa) on nematodes.

### Other resources

Guide to: Brassica Biofumigant Cover Crops: Managing soilborne diseases in vegetable production systems.

*This resource was developed with funding from the vegetable levy, through project VG16068 - Optimising cover cropping for the Australian Vegetable Industry*

1. Biofumigants may not always be successful at controlling soilborne diseases; growers should research the species they plan to grow to see if it hosts other problem diseases as well. Consider the whole system and rotations with other crops. Brassica biofumigants may not be a suitable fit if growing other brassica crops.

# CASE STUDY

## MANAGING VERTICILLIUM DAHLIAE IN POTATO FARMING

In a recent webinar, John Duff from the Department of Agriculture and Fisheries, Queensland (DAF), presented a case study from a potato grower in the Lockyer Valley who was facing a serious challenge with *Verticillium dahliae* (commonly known as Verticillium wilt) in their fields.

This soilborne pathogen was causing a significant reduction in tuber size with subsequent yield loss, as well as premature plant death. The grower had attempted crop rotations with cereals, such as sorghum and corn, but these strategies were not effective in reducing disease incidence. Moreover, as the pathogen can survive in the soil for up to seven years, extended crop rotations were impractical.

## APPROACH

1. **Soil testing:** John and colleagues collected numerous soil samples for comprehensive soil analysis, including a Predicta Pt test. The testing focused on a wide range of soil-borne diseases, with a particular emphasis on the detection of active DNA levels of *Verticillium dahliae*.
2. **Test interpretation:** The soil tests revealed DNA levels well above the problematic threshold, often reaching hundreds or even thousands of picograms per gram of soil DNA. It was evident that the high pathogen load in the soil was a significant contributor to crop losses. In addition to *Verticillium dahliae*, other pathogens were identified, including black dot and nematodes.
3. **Biofumigant selection:** Based on the soil analysis, two biofumigant crops - BQ mulch® (*Brassica carinata* 75% and *B. nigra* 25%) and Caliente™ (*B. juncea*), both known for their high glucosinolate content, were recommended.
4. **Planting and incorporation:** To maximise the biofumigation effect, the grower decided to plant the biofumigant crops in both the spring and late summer/ autumn. A minimum of 2 week gap was recommended between plantings and also the subsequent potato crop. John emphasises that it is vital to incorporate the biofumigant cover crop as quickly as possible on the same day.

*Verticillium dahliae* (Source: Ontario Crop IPM)

## RESULTS

Pre cover crop results showed very high levels of *Verticillium dahliae* causing lots of problems for the grower (Table 1).

The biofumigants were very

Table 1. Soil sampling results for *Verticillium dahliae* (verticillium wilt) pgDNA/g sample (Source: J. Duff, DAF)

| Date/ sample | 2 Sept 2019 (pre cover crop) | 21 Dec 2019 | 26 Feb 2020 | 20 May 2020 | 15 April 2021 |
|---|---|---|---|---|---|
| 1 | 351 | Incorporate BQ mulch | 8 | Incorporate caliente | 1 |
| 2 | 152 | | 14 | | 0 |
| 3 | 82 | | 9 | | 7 |
| 4 | 107 | | 9 | | 13 |
| 5 | 122 | | 15 | | 6 |
| 6 | 274 | | 20 | | no data |
| 7 | 364 | | 23 | | 13 |

NB. Predicta Pt recommendations for levels of DNA: *Verticillium dahliae* pdDNA/g sample; <4 considered low, 4-20 moderate, >20 high

Table 2a. Soil sampling results for *Colletotrichum coccodes* pgDNA/g sample - Area 1 (Source: J. Duff, DAF)

| Date/ sample | 2 Sept 2019 (pre cover crop) | 21 Dec 2019 | 26 Feb 2020 | 20 May 2020 | 15 April 2021 |
|---|---|---|---|---|---|
| 1 | 661 | Incorporate BQ mulch | 123 | Incorporate caliente | 96 |
| 2 | 512 | | 272 | | 91 |
| 3 | 1128 | | 202 | | 136 |
| 4 | 441 | | 193 | | 96 |
| 5 | 513 | | 194 | | 165 |
| 6 | 368 | | 220 | | no data |
| 7 | 282 | | 213 | | 122 |

successful, disease load plummeting after the first incorporation. One year later *Verticillium dahliae* levels were still low, and only now, three years later, are they slowly increasing (results not shown). Going forward, the grower plans to include a biofumigant in his crop rotation to manage the issue.

Although the grower was not concerned about black dot, results showed elevated levels of inoculum in the soil. While the selected biofumigant crops were not so impactful against black dot as *Verticillium dahliae*, DNA load decreased dramatically (Table 2).

Because this grower's paddocks are sandier than elsewhere in the Lockyer Valley, he did have a nematode problem (note: the Predicta Pt test cannot distinguish between species of nematodes).

After one application of biofumigants, numbers almost disappeared. Even one year later after growing potatoes in the same soil, nematodes are still almost non-existent (Table 3a and 3b).

## BIOFUMIGANT CROP MANAGEMENT

The biggest challenges faced by the grower were foliar diseases on the biofumigant crops, such as downy mildew, and the presence of aphids. These challenges required continual management, including regular monitoring for pests and diseases.

*Case study funded by Queensland Department of Environment and Science and the Department of Agriculture and Fisheries as part of the project Horticultural farming systems approaches for improved waterway quality 2019-2022*

## CONTACT

**John Duff**

Principal Plant Protectionist

Horticulture and Forestry Science

Queensland Department of Agriculture and Fisheries

John.Duff@daf.qld.gov.au

www.daf.qld.gov.au

Table 2b Soil sampling results for *Colletotrichum coccodes* pgDNA/g sample – Area 2 (Source: J. Duff, DAF)

| Date/ sample | 2 Sept 2019 (pre cover crop) | 21 Dec 2019 | 23 March 2020 | 27 May 2020 | 10 Sept 2020 |
|---|---|---|---|---|---|
| 1 | 492 | Incorporate caliente | 70 | Incorporate caliente | 69 |
| 2 | 563 | | 93 | | 129 |
| 3 | 517 | | 123 | | 70 |
| 4 | 518 | | 87 | | 144 |
| 5 | 586 | | 205 | | 186 |
| 6 | 487 | | 200 | | 173 |
| 7 | 421 | | 166 | | 264 |
| 8 | 493 | | 194 | | 214 |
| 9 | 387 | | 177 | | 173 |
| 10 | 558 | | 200 | | 286 |

NB. Predicta Pt recommendations for levels of DNA: *Colletotrichum coccodes* (black dot) pdDNA/g sample - <4 considered low, 4-40 moderate, >40 high

Table 3a. Soil sampling results for *M. javanica/incognita/arenaria* pgDNA/g sample – Area 1 (Source: J. Duff, DAF)

| Date/ sample | 2 Sept 2019 (pre cover crop) | 21 Dec 2019 | 26 Feb 2020 | 20 May 2020 | 15 April 2021 |
|---|---|---|---|---|---|
| 1 | 261 | Incorporate BQ mulch | 1 | Incorporate caliente | 0 |
| 2 | 173 | | 3 | | 0 |
| 3 | 103 | | 0 | | 0 |
| 4 | 133 | | 1 | | 2 |
| 5 | 25 | | 6 | | 0 |
| 6 | 23 | | 0 | | no data |
| 7 | 11 | | 0 | | 0 |

Table 3b. Soil sampling results for *M. javanica/incognita/arenaria* pgDNA/g sample – area 2 (Source: J. Duff, DAF)

| Date/ sample | 2 Sept 2019 (pre cover crop) | 21 Dec 2019 | 23 March 2020 | 27 May 2020 | 10 Sept 2020 |
|---|---|---|---|---|---|
| 1 | 184 | Incorporate caliente | 0 | Incorporate caliente | 2 |
| 2 | 36 | | 0 | | 0 |
| 3 | 232 | | 0 | | 0 |
| 4 | 76 | | 0 | | 0 |
| 5 | 50 | | 2 | | 0 |
| 6 | 73 | | 0 | | 0 |
| 7 | 194 | | 0 | | 0 |
| 8 | 199 | | 0 | | 0 |
| 9 | 68 | | 2 | | 0 |
| 10 | 15 | | 0 | | 0 |

NB. Predicta Pt recommendations for levels of DNA: *rootknot nemoatodes* pdDNA/g sample - <5 considered low, 5-50 moderate, >50 high

# MINI GUIDE - SELECTED WARM WEATHER PESTS AND DISEASES

During the Australian summer, potatoes are susceptible to various pests and diseases that can thrive in the warm and humid conditions. Common pests include the potato tuber moth and the African black beetle, as well as the disease vectors - aphids and thrips. Diseases to watch include early blight and the Potato spindle tuber viroid (PSTvd) which can both thrive during the summer months.

## PESTS

### AFRICAN BLACK BEETLE

*Heteronychus arator*

#### Description

**Egg:** Small, round, white, laid into the soil.

**Larva:** Whitish C-shaped grub up to 30mm long with light brown head and six legs. The rear end sometimes has a dark grey tinge.

**Pupa:** Golden to reddish brown, strongly indented and shaped, found in the soil.

**Adult:** Shiny, reddish to black, stout-bodied beetle around 10-15mm long. Legs are adapted for digging. A strong flyer – adults undertake mass dispersal flights, sometimes in spring but more commonly late March-April.

#### Damage

Most damage is caused by adults feeding on the underground stems of young plants, often killing growing points so that the central shoots wither and the plants become dead-hearted.

Older plants usually survive but remain weak. Beetles are often found near the base of damaged plants. Damaged young plants usually produce suckers. Soil sampling will indicate the presence of beetles.

#### Transmission/spread

Beetles crawl on the soil or pasture surface at night. Large scale flights are sporadic and may be localised within a district, making them difficult to predict. Although the triggers for flight are not known, weather conditions associated with summer thunderstorms seem to promote swarming flights of beetles and most flight activity occurs in late summer-autumn, which coincides with the emergence of the new generation of adults.

#### Distribution

Queensland, New South Wales, Victoria, ACT, South Australia, Western Australia.

African black beetle, larvae (top, J. Ekman) and adult (left, PADIL)

## APHIDS (GREEN PEACH)

*Myzus persicae*

### Description

**Nymph:** Semitranslucent, varying from yellowish to green with dark red eyes.

**Adult:** Wingless adults resemble nymphs and are approximately 2mm long. Winged females have black heads with dark red eyes and patterned bodes. Can disperse long distances, especially if wind assisted. Infestations can therefore spread rapidly.

### Damage

Cause leaf distortion through feeding and contaminates the product. Large infestations can kill young plants. They are a vector of virus included PVY.

### Transmission/spread

Winged aphids migrating from weeds start colonies in autumn. Populations peak in late winter and early spring; development rates are particularly favoured when daily maximum temperatures reach 20–25°C.

### Distribution

Australia wide except Northern Territory.

Green peach aphids, nymphs and adults (J. Ekman)

Cluster caterpillar, adult (top, J. Ekman) and pupa (bottom, T. Klompmaker)

## CLUSTER CATERPILLAR

*Spodoptera litura*

### Description

**Egg:** Laid in a large mass, usually covered with fluffy light brown material.

**Pupa:** Reddish brown, found in the soil.

**Caterpillar:** initially grey-green and feed in a group, but separate as they grow. Smoothed bodied caterpillars are distinctively patterned with thin yellow stripes and conspicuous dark spots and triangles, reaching up to 50mm long when mature. Tends to curl into a ball if disturbed

**Adult**: Moth with brown, cream and grey patterned forewings held in a tent over the body. Cream hind wings.

### Damage

Caterpillars skeletonise the leaves.

### Transmission/spread

The moths are strong fliers and can invade crops any time from emergence through to harvest.

### Distribution

Found in the Australian Capital Territory and limited distribution in New South Wales, Queensland and Western Australia.

## POTATO TUBER MOTH

*Phthorimaea operculella*

### Description

A small moth, measuring about 10mm in length when at rest, coloured pale brown with darker marbling. Wingspan 15–17mm. The head and chest are pale brown. The front wings are pale brown with small blotches of mid-brown, and hind wings are pale grey.

### Damage

**Leaves:** Leaf mines show the presence of larvae, and the stem is weakened or broken.

**Tubers:** Detection is more difficult without them being cut open when larvae will be apparent within the potatoes.

### Transmission/spread

Adults disperse via short flights near the ground. Moths can move up to 250m to infest plants or tubers, although observations indicate that they do not move from potato fields unless the field is harvested. The moths can be dispersed over long distances via potato tubers, which has facilitated the spread of the moth around the globe.

### Distribution

Australia wide except Northern Territory.

Potato tuber moth, adult (top, P. Horne), leaf mine (bottom left, P. Horne), larvae on potato tuber (bottom right, SI Rondon).


## THRIPS (WESTERN FLOWER)

*Frankliniella occidentalis*

### Description

**Nymph:** Cream to yellowish, wingless, generally less than 1mm long.

**Adult:** Light to dark brown with thin bodies abut 1 to 2mm long. Narrow transparent wings are held along their backs

Eggs are laid in slits in leaves and growing points. Nymphs and adults feed in flowers and growing tips.

### Damage

Caterpillars skeletonise the leaves.

### Transmission/spread

Infested crops can be damaged directly through feeding, which leads to leaf discolouration, deformed new growth and buds, and spotted foliage. However, the transmission of Tomato Spotted Wilt Virus causes the greatest impact on vegetable crops .

### Distribution

All states.

WF Thrips, on flower (top, J. Rorabaugh), single adult (bottom, C. Maureira)

# DISEASES

## TOMATO SPOTTED WILT VIRUS

Tomato spotted wilt virus (TSWV) is widespread throughout Australia, affecting around 500 species including potatoes.

TSWV impacts the marketable and total yield of crops and causes a general reduction in tuber size. In some cases, necrotic spots occur internally on tubers. These can extend to the skin as concentric rings.

### Symptoms of TSWV on potato plants include

- Necrotic leaf spots. These can have concentric rings, sometimes leading to a misdiagnosis as target spot, a fungal disease caused by Alternaria species.
- Severely affected stems and even whole plants can die.
- Plants grown from infected tubers are often most severely affected, with stunted growth in the form of a rosette.

### Symptoms of TSWV on potato tubers include

- Potato tubers can grow normally after infection, but may be small and distorted sunken, black necrotic spots.
- These spots may appear as concentric rings and be visible through the skin
- Some infected tubers show no external symptoms.

### Transmission

- Infected tubers
- Thrips which thrive in warmer conditions

Symptoms on leaves (Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org 4)

Clockwise from top left:

Diseased plant (Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org 3); damage on leaves (Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org 5); infected tubers, (Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org 6); infected tubers cut (Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org 2)

## EARLY BLIGHT (TARGET SPOT)

Early blight is caused by the fungus *Alternaria solani* and is one of the most common diseases attacking leaves and stems of potatoes.

It can cause losses if outbreaks occur early in the season, or in late maturing crops. The disease attacks plants that lack vigour and often spreads towards the end of the season when the plants have stopped growing.

### Symptoms on plants

- Small circular to oval dark brown to black spots (6-12mm) on leaves and stems that become oval to angular and are normally confined within the main veins of the leaflets.
- Leaves can look leathery.
- In sever cases, spots can unite and cause an upward rolling of the leaf tips and death of leaves.

### Symptoms on tubers

- Small dark, slightly sunken, circular to irregular-shaped lesions (10mm to 20mm in diameter), with slightly raised margins.
- A brownish, corky dry rot up to 6mm deep develops in the tissue beneath the lesion.
- Affected tubers are prone to attack from other soil fungi, which can cause complete rotting of the tuber

### Transmission

In spring, spores can spread by wind, rain, and insects. Spores fall on potato leaves, remaining there until conditions are favourable. They then germinate and penetrate the plant, causing an outbreak of disease.

Symptoms of early blight on potato leaves (top, J. Ekman; bottom, R. Hall)

## POTATO SPINDLE TUBER VIROID (PSTVD)

Potato spindle tuber viroid (Pospiviroid; PSTVd) is a pathogen that poses a threat to potato, tomato, and eggplant crops in Australia. Symptom development is dependent on the strain of the viroid in conjunction with the host species and stage of development. Symptoms can be mild at first but will become more severe with each successive generation.

PSTVd symptoms can sometimes be confused with nutrient deficiency or toxicity, spray damage, insect damage or plant viruses.

### Symptoms on plants

- A reduction in leaf size
- Altered development of stem to a more upright manner
- An increase in the length of the internodes (stem regions between the leaves)

### Symptoms on tubers

- Infected tubers have pointy ends and are often smaller than healthy ones

### Transmission

PSTVd is a highly contagious disease, transmitted between plants by touch. The use of cutting or pruning tools, contaminated machinery or any form of physical contact between plants can result in disease transmission. PSTVd can also be transmitted by green peach aphid from plants that are co-infected with potato leafroll virus. In potatoes, infected seed potatoes cause the most spread.

### Distribution in Australia

Reported in Queensland and Western Australia.

Symptoms of PSTVD on potato plants (top, R.P. Singh, Bugwood.org) and inffected tubers (bottom, William M. Brown Jr., Bugwood.org 1st)

## PVY

Potato virus Y (PVY) is an aphid-borne virus that also infects other solanaceous crops including tomato and capsicum. The infection occurs in most potato growing areas in Australia and overseas.

### Symptoms on plants

- Symptoms of infection vary with cultivar, plant age, environmental conditions, and PVY strain.
- Leaf symptoms can range from mild to severe mosaic or mottling.
- In severe cases, leaf drop can occur. Infected plants are often stunted.

### Symptoms on tubers

- Tubers from infected plants are often small and can have necrotic or dead rings on the skin.

### Transmission

PVY is primarily spread by aphids, including green peach (*Myzus persicae*) and potato (*Macrosiphum euphorbiae*) aphids.

An aphid can pick up and transmit the virus within 1-2 seconds of feeding. After the aphid has probed one or two healthy plants, the virus is lost until it probes another infected plant. Due to the rapid transmission, a small number of aphids can spread the virus to a large number of plants quickly.

PVY is also readily spread via machinery.


### SOURCES

- Potato Growers' Biosecurity Manual, Version 1.0 May 2018 (PHA and AUSVEG)
- Potato Spindle Tuber Viroid Factsheet, August 2015 (Plant Health Australia)
- Tomato spotted wilt virus in potatoes, Agriculture Victoria (https://agriculture.vic.gov.au/biosecurity/plant-diseases/vegetable-diseases/tomato-spotted-wilt-virus-in-potatoes). Accessed December 2023


### EXPLORE THE TOPIC FURTHER

Factsheet: Potato tuber moth

Webinar: Early blight and brown spot

Webinar: NSW advisor workshop: Early blight

Webinar: Controlling pests in potatoes

Article: Potato Virus Y

Symptoms of PVY (left variety Marfona 2, right variety Charlotte 1, from the Scottish seed demonstration site; J. Ekman)

# EYES ON THE WORLD

## RECENT ADVANCES IN POTATO RESEARCH AND INNOVATION

### Pangenome analyses reveal impact of transposable elements and ploidy on the evolution of potato species

*Ilayda Bozan, Sai Reddy Achakkagari, Noelle L. Anglin, David Ellis, Helen H. Tai, and Martina V. Strömvik was published in the Proceedings of the National Academy of Sciences (PNAS).*

Amidst the ongoing challenges posed by climate change to global food security, researchers from McGill University (Canada) combed through the genome sequences of nearly 300 potato varieties, including cultivated and wild, in an effort to bolster the resilience and nutritional value of potatoes.

#### WHAT IS IT ABOUT?

The research created a comprehensive potato 'super pangenome' aimed at pinpointing genetic attributes crucial for developing the next generation of robust potatoes.

In scientific terms, a genome signifies the entirety of an organism's genetic instructions stored in its DNA sequence. A pangenome seeks to encapsulate the entirety of genetic diversity within a species, while a super pangenome goes further by encompassing multiple species within its scope.

This study, which included collaborators from the USA and Peru, represents an in-depth exploration into the genetic blueprint of potatoes, specifically focusing on a diverse group of potato species classified as Solanum section Petota. This group encompasses a wide array of potato types—both wild and cultivated—with varying genetic complexities.

Wild potato species can reveal which genetic traits are critical in adapting to climate change and extreme weather, enhancing nutritional quality, and improving food security.

The primary objective in this study was to construct a comprehensive pangenome by analysing and comparing the genetic material from 296 samples representing 60 distinct potato species and thereby unravel the evolutionary pathways, diversification patterns, and adaptive mechanisms that these potato varieties underwent.

The research placed particular emphasis on two critical genetic aspects: presence/absence variations (PAV) and transposable elements (TEs). PAV refers to the presence or absence of specific genes or DNA

*Solanum Jalcae*, one of the 'wild relatives' decoded in this study (image credit: Crop Trust, Flickr) segments among different potato species. TEs, on the other hand, are mobile DNA sequences capable of inducing alterations in the genome. The study meticulously examined how these genetic variances influenced the evolutionary trajectories, adaptive responses, and domestication processes observed in potato species.

To build the potato pangenome, the researchers used supercomputers to crunch data from public databanks, including gene banks in Canada, the United States, and Peru.

## WHAT WAS CONCLUDED?

The pangenome can be used to answer many questions about the evolution of this important crop that was domesticated by Indigenous peoples in the mountains of southern Peru nearly 10,000 years ago.

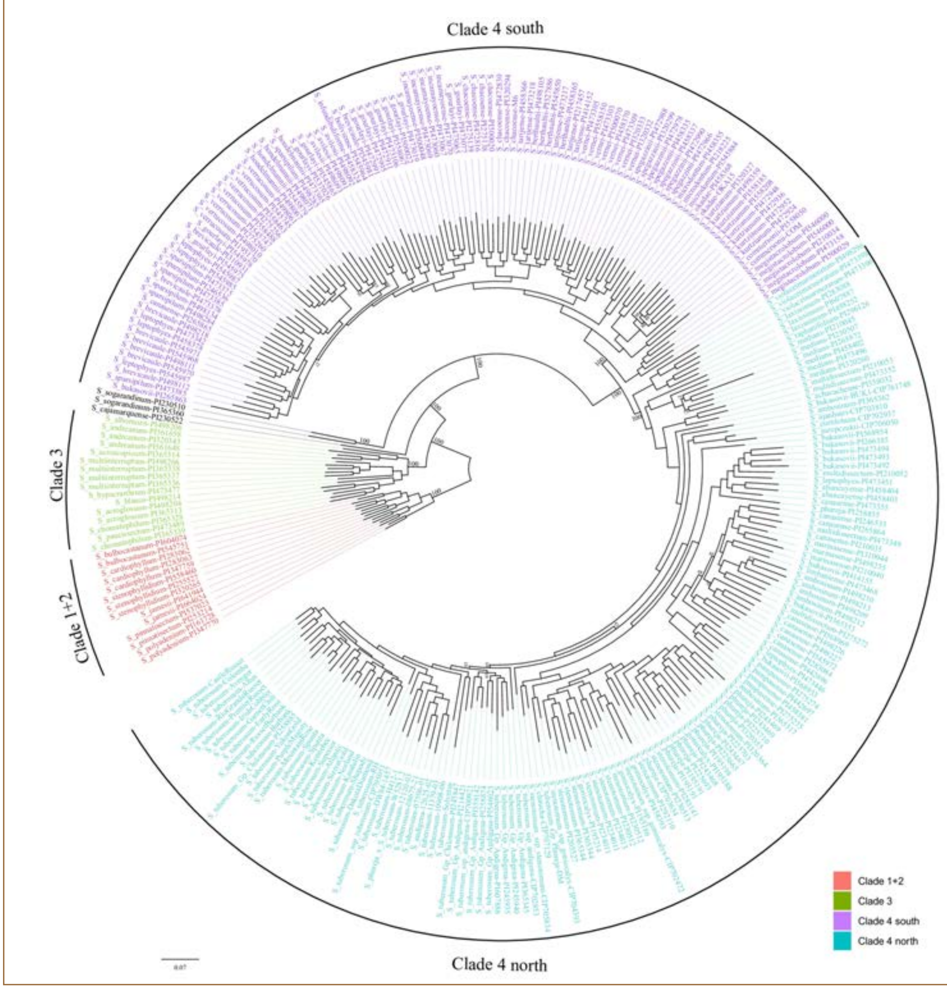
The findings of this study provided compelling insights as to which variations are important and significantly contributed to shaping the genetic distinctions among the diverse potato species belonging to the Solanum section Petota.

Notably, the study shed light on the fact that potato species cultivated under laboratory conditions exhibited heightened genetic alterations related to TEs, akin to the adaptations seen in natural environments where potatoes respond to various environmental stresses.

Understanding these nuanced genetic variations and comprehending their impact on the evolutionary pathways of potatoes is significant.

Safeguarding the genetic diversity present within these potato species can help ensure the resilience and sustainability of potato crops in the face of impending environmental changes.

Pinpointing specific 'useful' genes could facilitate the development of an enhanced potato variety—a 'super spud'—via traditional breeding methods or innovative gene editing technologies.




## THE POTATO FAMILY TREE

This phylogenetic tree represents all species and varieties (in colour) analysed in the study and how they relate to common ancestors.

It showcases the divergence of lineages from common ancestors and represents the evolutionary history.

**Clades**: Clades are groups of organisms within a phylogenetic tree that include an ancestral species and all its descendants. They are depicted as branches or groups stemming from a common node.

**Nodes:** Nodes are points on the tree where branches diverge, indicating a common ancestor. Each node represents the hypothetical point in evolutionary history where a lineage splits into two or more separate lineages.

**Branches:** Branches on the tree represent the evolutionary pathways of different species or groups. The length of a branch may represent the amount of evolutionary change or time elapsed since divergence from a common ancestor.

**Root:** The root of the tree represents the most recent common ancestor of all the organisms included in the analysis. It's the starting point of the evolutionary history depicted in the tree.

Figure credit: Bozan et al, 2023

Dear Spud GP

I've noticed a few leaves getting chewed on plants around the edge of the paddock, but I can't see any insects on there – what's causing this?

Spike

# ASK THE SPUD GP

Dear Spike

This looks like 28-spot ladybeetle (*Epilachna* spp.) damage. Not all ladybeetles are beneficial predators; 28-spots, sometimes called potato ladybird beetles, are very definitely plant eaters.

The adults are easy to see, being large orange ladybeetles with a variable number of black spots (not always 28, but quite a few) and a fine covering of soft hairs.

While the adults can certainly damage plants, the larvae are not only a lot better camouflaged, but voracious eaters.

The larvae are initially tiny, hatching out of clusters of 20 to 30 eggs laid on the undersides of leaves. They are nothing like the adult beetles, the larvae looking like small yellow grubs topped with a cluster of bristling spines. The spines are initially pale but darken and thicken as the larvae mature.

Larvae mostly feed on the leaf undersides, where they chew ribbed "windows" into the leaves between the larger veins.

Although 28-spot ladybeetles are not usually a major commercial pest, they can cause significant damage if large populations develop. Avoidance is the best control, so removing alternate hosts – including cucurbits and solanaceous weeds – is the first step in good management.

# DISPATCH FROM … QUEENSLAND

This issue, our dispatch comes from PotatoLink regional rep Dr Naomi Diplock in Queensland.

## EVENTS

Regional rep Dr Naomi Diplock has visited the three main growing areas in Queensland, including Atherton (Far North Queensland), Bundaberg, and the Lockyer Valley.

In Atherton, PotatoLink coordinator Peter O'Brien and consultant Dr Kelvin Montagu joined Naomi for a face-to-face catch up with the growers. At the event Kelvin highlighted the benefits of cover crops in creating a conducive soil environment for potatoes, aiming to enhance gross margins by reducing input costs and improving yield and quality. This was followed by a casual Q&A session during drinks.

At a joint VegNET, Soil Wealth and PotatoLink event in the Lockyer Valley, Kelvin discussed soil regeneration, cover cropping, and flood mitigation, followed by an informal discussion and dinner with growers.

Naomi had the opportunity to engage one-on-one with local growers, focusing on understanding their challenges, identifying research gaps, and determining priority areas for improvement.

## CHALLENGES/CONCERNS

In Atherton, concerns primarily revolve around the cost of production, freight expenses, and potential challenges due to late harvest leading to increased disease risks. Specific issues in this area include bacterial problems due to the warm tropical climate, nematodes, and challenges related to seed storage and handling, particularly concerning seed age, and acquiring necessary inputs while managing costs effectively.

In the Lockyer region, some growers are concerned with problems associated with tomato potato psyllid, nematodes, and various leaf diseases as well as the potential impacts of the incursion of serpentine leafminer. Implementing cover crops, exploring new chemicals for disease control, and utilising biofumigation techniques were all raised as areas of interest, as well as seed storage and handling.

Bundaberg is also focused on potential impacts of the serpentine leafminer and fall armyworm (particularly in cover crops). The region is also looking for ways to control potato tuber moth and interested in chemicals offering more extended control. Combating fungal diseases, addressing the constant issue of target spot, and managing costs related to fertilisers, diesel, and energy, were also cited as areas of concern.

## NEXT EVENTS

PotatoLink is planning a joint event in Bundaberg together with Soil Wealth ICP and VegNET in March 2024

## CONTACT

For more information about PotatoLink activities in Queensland, contact Naomi

naomi.diplock@ahr.com.au

# HORT INNOVATION PROJECTS

| Project name | Code | Lead organisation | Description | Fund | Start and end date |
|---|---|---|---|---|---|
| Potato industry minor use program | PT16005 | Hort Innovation | Used to submit renewals and applications for new minor use permits for the potato industry | Fresh & Processing | Ongoing |
| Australian potato industry communication and extension project (PotatoLink) | PT20000 | Applied Horticultural Research | Supports growers in adopting improved practices on-farm and communicating new information, research and technology | Fresh & Processing | 08/12/2020 – 30/11/2025 |
| Management strategy for serpentine leafminer, *Liriomyza huidobrensis* | MT20005 | Queensland Department of Agriculture and Fisheries | Delivering targeted R&D specifically for serpentine leafminer in response to the incursions detected in late 2020 | Multi fund including Fresh & Processing | 19/03/2021 – 30/11/2023 |
| Regulatory Support & Response Co-ordination | MT20007 | AKC Consulting Pty Ltd | Provides key information regarding domestic and international pesticide regulation | Multi fund including Fresh & Processing | 30/06/2021 – 01/07/2024 |
| Consumer behavioural data program | MT21004 | Nielsen | Provides regular consumer behaviour data and insight reports, through the Harvest to Home platform (www.harvesttohome.net.au) | Multi fund including Fresh | 20/01/2022 – 20/11/2026 |
| Feasibility/scoping study: Surveillance and diagnostic framework for detecting soilborne pathogens in vegetable industries | MT21016 | NSW Department of Primary Industries | Examining the potential to develop a national surveillance and diagnostic framework for soilborne pathogens of vegetable crops including potatoes | Multi fund including Fresh & Processing | 11/10/2022 – 31/08/2023 |
| Generation of data for pesticide permit applications in horticulture 2022 | ST22001, ST22003 and ST22004 | Agreco, Eurofins Agroscience Services and Kalyx | The generation of pesticide residue, efficacy and crop safety data to support label registration and minor use permit applications and renewals made to the APVMA | Multi fund including Fresh | 16/05/2022 – 15/12/2025 |
| People development strategy for the vegetable, potato, onion, and banana industries | MT22002 | RMCG | Building a People Development Strategy to guide future investment in building capacity and capability within a range of industries including potatoes | Multi fund including Fresh & Processing | 12/12/2022 – 01/07/2023 |
| Horticulture trade data | MT22005 | IHS Global | Provides Hort Innovation with a subscription to the Global Trade Atlas Database. | Multi fund including Fresh & Processing | 14/12/2022 – 01/12/2025 |
| Horticulture Impact Assessment Program 2020/21 to 2022/23 | MT21015 | Ag Econ | Evaluating impact of our R&D investments, providing insights into the type and magnitude of impacts that are being generated across the company's strategic levy programs. | Multi fund including Fresh & Processing | 2021-2023 |

ahr applied horticultural research

Hort Innovation POTATO – FRESH FUND

Hort Innovation POTATO – PROCESSING FUND

POTATO LINK AUSTRALIAN POTATO INDUSTRY EXTENSION PROJECT