Hort Innovation

Final Report

VegNET - NSW

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Delivery partner:

Local Land Services

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VegNET – NSW (VG19011)

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Content

Summary

The project Regional Capacity Building to Grow Vegetable Businesses (VegNET NSW) Project VG19011 (CON001894) was delivered by Greater Sydney Local Land Services (GS LLS) between April 2020 and September 2021.

The project focused on the extension of existing research and development (R&D) levy funded projects. It further developed and delivered activities focused on targeted and measurable practice change to support sustainable and profitable growth of vegetable businesses in NSW. The project worked mainly on the needs of Greater Sydney and North Coast vegetable growing businesses as funding constraints limited the same delivery service to other NSW regions.

An experienced Local Land Services (LLS) team delivered the project, led by staff from Greater Sydney LLS and assisted by regional extension staff from North Coast, Central Tablelands and Riverina LLSs. They include: Paul Bennett, Sylvia Jelinek, Jonathan Eccles, Matthew Plunkett, Peter Conasch, Nikki McGrath, Maddy Humphreys, Richard Stephens, from GS LLS.

In addition, LLS staff in the following regions as follows:

- Julie Dart (North Coast LLS)
- Karen O'Malley (Central Tablelands LLS)
- Justin Vardanega (Riverina LLS)

Translators and local community leaders and influencers were also engaged to work with the various cultural and linguistically diverse background (CALD) grower groups in NSW, particularly in Greater Sydney.

Priorities for extension of levy funded R&D topics were established as requested by Hort Innovation, this project developed and implemented a regional extension strategy with the assistance from the VegNET NSW Regional Extension Advisory Group (REAG) consisting of key industry influencers and high-profile growers across the State.

The project's duration coincided with the outbreak of COVID-19 in Australia. The subsequent lockdown and movement restrictions severely affected the project team's ability to deliver many of the planned activities. Feedback from growers showed that alternative extension methods such as virtual meetings and webinars would be ineffective with many vegetable growers particularly those in northern NSW and Greater Sydney. These growers overwhelmingly prefer 'face to face' extension.

Six months into the project, an emergency plant pest response was initiated after the detection of Serpentine leafminer in South West Sydney. The NSW VegNET team was heavily involved in the response which proved valuable due to relationships with growers that had been developed with this and earlier projects. We used it as an example about the importance of biosecurity and how growers can manage biosecurity on farm.

Major flooding in Coastal vegetable growing areas of North Coast and Western Sydney occurred in March 2021. Again, the NSW VegNET team was involved in the emergency response. It was through the relationship that the VegNET team had built with growers, that various agencies involved in the recovery requested the assistance of the team. The combination of these events made it challenging to conduct R&D extension activities as growers were more focused on clean up and recovery.

Keywords

Extension, VegNET, Hort Innovation, Allied Industry, Local Land Services, Greater Sydney Local Land Services, Greater Sydney Demonstration Farm, Cultural and Linguistically Diverse Background Growers, Practice Change, Research and Development, Innovation, Community of Practice, Engagement, Industry Development Officers, Key Influencers.

Introduction

The NSW vegetable industry has undergone significant change over the last 10 years, particularly in the peri-urban areas of Greater Sydney. Rising land prices, increasing input costs, lack of succession planning, depressed market prices for some vegetable commodities and environmental pressures have all been drivers encouraging growers to look for efficiencies across the whole supply chain. Some growers have left the industry or have moved to growing other crops.

There has also been a reduction in smaller to medium vegetable enterprises and the move to larger corporate farms particularly in the Riverina and the Central Tablelands regions. Mixed farms have emerged to diversify income streams and spread risk given the volatility in vegetable prices. For instance, vegetable crops such as pumpkins may only be grown opportunistically in the Riverina if prices are reasonable in any given year.

Despite some growers leaving the industry, there are many new growers that have entered the industry in the last five years. These growers are keen to network and learn from 'key influencers' in the industry. They are often the early adopters of research and development (R&D) levy funded innovations. There is also a new cohort of younger generation growers who see opportunity long term in the vegetable industry.

NSW also has an emerging and growing protected cropping industry, particularly on the mid north coast of NSW. Many private companies are putting increasing resources and effort to service this growing region. There is a considerable shift away from traditional farming practices to more sustainable and innovative farming practices across the State.

This project has enabled strong partnerships to be forged and grower recognition of their levy investment and Innovation's brand. The NSW VegNET brand is well established in industry with both growers and allied industry. Continuity of funding and the employment of experienced industry development officers are critical to the ongoing success of the project to build on the outcomes achieved so far.

GS LLS has delivered project VG15042, *Regional Capacity Building to Grow Vegetable Businesses NSW,* since July 2016 followed by VG18003 (CON-001719) VegNET NSW since July 2019 (both commonly referred to as VegNET1). Over this time, GS LLS has engaged with over 2,500 growers and industry personnel in NSW. Projects VG15042 and VG18003 (CON-001719) have also formed effective relationships with over 80 per cent of the allied industry and resellers within the NSW vegetable industry. This has been a continued importance while developing a regional extension strategy through this effective and trusted network.

GS LLS have worked successfully with culturally and linguistically diverse (CLDB) growers in the Greater Sydney region. Extension resources developed and translated as part of project VG15042 were extended to Arabic, Cambodian, Chinese, Vietnamese CLDB grower groups. These resources have been distributed through the national VegNET project networks based on the needs of this group, and other national levy funded communication platforms.

Each grower group and segment have different engagement methods and strategies. Industry feedback identified significant growth areas that required increased resourcing as part of this project. The NSW North Coast is expanding rapidly and with significant environmental challenges a major area of focus delivering R&D programs such as EnviroVeg.

Sydney Markets will continue to be an efficient and effective location to disseminate information to growers in a targeted and cost-effective manner, particularly with the Chinese growing community, the largest CLDB group in NSW.

GS LLS extension staff are trusted advisers in the vegetable industry particularly in areas of soil health, irrigation, biosecurity, integrated crop production, protected cropping and integrated pest management. The core team has over 90 years of experience in agricultural extension and understand the drivers of change for growers.

GS LLS Sydney Demonstration Farm at Richmond has been a great success in demonstrating vegetable innovation and new technologies to growers at one independent location. Practical R&D trials such as the University of New England's Integrated Weed Management project, funded by Hort Innovation, prove the value of the Farm in showcasing practical results to growers and industry.

The new Western Sydney Airport offers significant opportunities for growing vegetable export markets. GS LLS is uniquely positioned to work with Cooperative Research Centres, Hort Innovation and Universities to link growers with appropriate services and other government agency programs. Of interest is linking growers to training opportunities with the National Vegetable Protected Cropping Centre (Hort Innovation project VG17003) at the Western Sydney University in Richmond.

GS LLS is a flexible delivery model that can adapt to changing priorities. Our networks with growers and industry are demonstrated through the number of programs that can be delivered state wide and we are highly capable to deliver practice change outcomes for our investors.

Method

The vegetable industry in NSW is fragmented with significant regional variation in scale, connectivity and demography. The project's methodology is split into categories as described below:

Project team

An experienced LLS team was involved in the delivery of this large state-wide project.

- Matthew Plunkett has worked full time as the NSW Vegetable Industry Development Officer, and led the project from 2016 to 2019 and was involved in the planning and delivery of the project since 2019
- Sylvia Jelinek has assisted with the delivery of the project in 2018-19 and has work 0.8FTE since 2019 as the NSW VegNET Regional Development Officer (RDO)
- Paul Bennett and Jonathan Eccles have assisted with project and financial management and reporting
- Nikki McGrath has led the media and communications work with the assistance of Maddy Humphrys
- Peter Conasch has coordinated the Greater Sydney Demonstration Farm engagement
- Several regional LLS extension staff were also involved in delivery including Julie Dart (North Coast LLS), Karen O'Malley (Central Tablelands LLS) and Justin Vardanega (Riverina LLS).

Consultation, planning and professional development

The NSW RDO participated in professional development online training and mentoring provided to the national VegNet team by Sean Kenny from Rural Consulting group and organised by Hort Innovation. The training/mentoring provided direction in all the following project establishment documents.

The NSW VegNET team conducted a lengthy and in-depth analysis of the vegetable industry in NSW and the findings and recommendations were documented in the *VegNET NSW Regional Discussion Paper* (see appendix 1). This document was used for further planning and conversation with '*key influencers'* that would later become the recognised group known as the NSW Regional Extension Advisory Group (REAG). Five major focus categories were identified for current and ongoing extension. Project briefs (see appendix 2) were established for each focus category, they are:

- Improving water and nutrient management for NSW protected cropping vegetables
- Developing export preparedness for NSW vegetable growers
- Pest and disease management including biosecurity and farm hygiene
- Developing a soil health community of practice for the Australian Cambodian Growers Association of NSW and Australian Chinese Growers Association of NSW
- Farm innovation and technology – Precision irrigation and nutrition management in sweet corn.

A Regional Extension Advisory Group (REAG) for NSW was established. This group was formed under the terms of reference put together with the assistance of Sean Kenny and other national VegNET Regional Development Officers (RDO) and supported by Hort Innovation (see appendix 3). The REAG consists of representative growers, a NSW vegetable industry consultant and Hort Innovation Regional Extension Manager. The REAG membership was confirmed and agreed by Hort Innovation Regional Extension Manager.

A Five-Year Regional Vegetable Industry Extension Strategy was developed (see appendix 4). This plan was prepared in collaboration with input from the REAG and as many regional stakeholders as possible to ensure it is fit for purpose and the REAG agreed to Plan. It drew on the past four years' extension work carried out by GS LLS and already identified the target market segmentation and activities that have achieved successful practice change. It also involved regional growers and culturally and linguistically diverse (CLDB) growers.

Implementation, monitoring and evaluation of events

A Program Logic and Monitoring & Evaluation (M&E) Plan (see appendix 5) was developed and included three aspects of intended project delivery; facilitating stakeholder collaboration and design processes (and review), brokering delivery of projects/activities by other providers and directly participating in key projects designed to bring about improved practice change and associated benefits

A Stakeholder Engagement Plan (see appendix 6) was created and completed with input from the training provider and included links to the Hort Innovation project VG18000 National Vegetable Communications Program.

The 2020/21 Annual Regional Extension Work Plan (see appendix 7) was established and implemented in line with

the Five-Year Regional Vegetable Industry Extension Strategy. This was limited by funding over the period of this project so the NSW REAG set priorities for activities that could be carried out in NSW production areas. The production areas focused on was Greater Sydney and the NSW North Coast. The REAG agreed to the work plan. Progress on the 2020/21 Annual Regional Work Plan and the M&E Plan was reported back to the REAG in early 2021 and agreed by the REAG.

Communications, social media and development of extension resources

The VegNET RDO is the central point of contact in NSW for information on R&D projects and to assist researchers developing extension strategies for current and potential vegetable levy funded projects. The role is led by an experienced Regional Development Officer, Sylvia Jelinek, and was responsible for delivering the outcomes of this project.

Due to budget constraints during VegNET2 events planned were limited. Events were further limited due to flooding declared as a natural disaster by the federal government on the NSW North Coast and the Hawkesbury regions, these regions are major vegetable growing areas. The focus turned to recovery rather than capacity building, the VegNET team were led by the needs of the vegetable levy payers. Beyond the natural disaster the COVID-19 pandemic resurged and placed NSW and more so Greater Sydney into a three-month long lockdown which reduced any lingering appetite for vegetable R&D extension. Vegetable growers needed support in understanding restrictions imposed by the federal and state governments and busy keeping their businesses afloat.

Throughout this period the VegNET team assisted in extending R&D outcomes from Hort Innovation projects, by developing appropriate regional communication strategies and organising extension activities where possible. VegNET NSW contributed an article for each quarterly edition of *Vegetables Australia* magazine on relevant R&D outcomes applicable to NSW growers (see appendix 8). The NSW VegNET team attended Hort Connections in Brisbane in June 2021 as the identified conference for networking, education and further industry development, as well as the RDO participating in the Hort Innovation extension workshop.

A database was developed in VegNET1 for those interested in receiving newsletters, information on upcoming events and more information on specific R&D projects. Text messaging growers was a highly effective way of promoting events and extending R&D information. At the Sydney Produce Markets, over 150 Chinese growers have received extension material through a targeted campaign during the project.

E-newsletters, text messaging, emails and social media posts (Facebook & Twitter) were sent to VegNET members to update them on a variety of events, R&D projects and resources available for downloading. Events were also actively promoted through resellers and the allied industry through targeted social media blasts.

Weekly internal team meetings were held to keep the project on track and enable the project to adapt to grower and industry feedback as required.

Monthly to bi-monthly vegetable RDO meetings were held via video link with Hort Innovation and the other national VegNET RDOs and the appropriate team members. Meetings were also held by AUSVEG's national manager for extension and engagement with all the RDOs to connect with each other and learn from one another's experiences and gain industry updates and insights.

When extension events were not possible to be held during the COVID-19 lockdown period, focus turned to resource development. Agrology was contracted to develop in conjunction with the NSW VegNET team technical fact sheets on *'Substrate Use in Hydroponics – Basic Principles and Planning'* (see appendix 10) and *'Hydroponic Irrigation – Drip Irrigation Substrate'* (see appendix 11). Applied Horticultural Research (AHR) was contracted with the collaboration of the Soil Wealth and Integrated Crop Protection Project and NSW VegNET to develop fact sheets on *'Biofumigation'* (see appendix 12) and *'Cover Crops'* (see appendix 13) and translated into Simplified Chinese and Khmer.

Outputs

The deliverables and outputs established and implemented as part of this project are:

- VegNET NSW Regional Discussion Paper
- Regional NSW VegNET Project Briefs
- Regional Extension Advisory Group (REAG) and terms of reference
- Five Year Regional Vegetable Extension Strategy
- Project program logic and M&E plan
- Stakeholder engagement plan
- 2020/21 Annual regional extension work plan.

VegNET NSW Regional Discussion Paper

The NSW VegNET team conducted an in-depth analysis of the vegetable industry in NSW and the findings and recommendations were documented in the *VegNET NSW Regional Discussion Paper* (see appendix 1). This document was used for further planning and conversation with '*key influencers*' that would later become the recognised group known as the NSW Regional Extension Advisory Group (REAG).

Regional NSW VegNET Project Briefs

As an outcome from the VegNET NSW Regional Discussion Paper, five major focus categories were identified for current and ongoing extension. Project briefs (see appendix 2) were established for each focus category:

- Improving water and nutrient management for NSW protected cropping vegetables
- Developing export preparedness for NSW vegetable growers
- Pest and disease management including biosecurity and farm hygiene
- Developing a soil health community of practice for the Australian Cambodian Growers Association of NSW and Australian Chinese Growers Association of NSW
- Farm innovation and technology – Precision irrigation and nutrition management in sweet corn.

Regional Extension Advisory Group (REAG) and terms of reference

A Regional Extension Advisory Group (REAG) for NSW was established as a foundation of this project. This group was formed under the terms of reference put together with the assistance of Sean Kenny from the training provided by Hort Innovation and other national VegNET Regional Development Officers (RDO) and supported by Hort Innovation (see appendix 3). The REAG consists of representative growers, NSW vegetable industry consultants and the Hort Innovation NSW Regional Extension Manager. The REAG membership was confirmed and agreed by Hort Innovation's NSW Regional Extension Manager.

The following is a list of 'key influencers' who have guided and advised the project team and form the REAG:

- Mario Muscat - Field vegetables, Demonstration Farm, Greater Sydney
- Val and Sam Micallef - Field vegetables, Greater Sydney/Central Tablelands
- Jason Chung - Field vegetables (Chinese Growers Association of NSW), Greater Sydney
- Nicky Mann - Protected cropping vegetables, Greater Sydney
- Kim Ngov - Field and protected cropping vegetables (Cambodian Growers Association of NSW), Greater Sydney
- Paul and Kaka Singh - Protected cropping vegetables, North Coast
- Bari Mann - Pacific Blue Cooperative (Flavorite), North Coast
- Rhod Cook - Protected cropping vegetables, North Coast.

The following industry representatives have assisted greatly with the project and form the industry consultant membership of the REAG include:

- Darryl Cislowski - Agronomist / Reseller, Greater Sydney
- Bahram Fayez - Seed company, Greater Sydney & North Coast
- Johnny Capuyan - Agronomist / Reseller, Greater Sydney
- Len Tesoriero - Researcher / Private consultant, All regions
- Chris Fyfe – Researcher, All regions.

Five Year Regional Vegetable Extension Strategy

A Five-Year Regional Vegetable Industry Extension Strategy was developed (see appendix 4). This plan was prepared in collaboration with input from the REAG and as many regional stakeholders as possible to ensure it is fit for purpose and the REAG agreed to Plan. It drew on the past four years' extension work carried out by GS LLS and already identified the target market segmentation and activities that have achieved successful practice change. It also involved regional growers and culturally and linguistically diverse (CLDB) growers.

Project program logic and M&E plan

A Program Logic and Monitoring & Evaluation (M&E) Plan (see appendix 5) was developed through training, mentoring and support provided by Sean Kenny in the VegNET team meetings. They include three aspects of intended project delivery; facilitating stakeholder collaboration and design processes (and review), brokering delivery of projects/activities by other providers, and directly participating in key projects designed to bring about improved practice change and associated benefits.

Stakeholder engagement plan

A Stakeholder Engagement Plan (see appendix 6) was created and completed with input from the training provider and included links to the Hort Innovation project VG18000 National Vegetable Communications Program.

2020/21 Annual regional extension work plan

The 2020/21 Annual Regional Extension Work Plan (see appendix 7) was established and implemented in line with the Five-Year Regional Vegetable Industry Extension Plan. This was limited by funding over the period of this project so the NSW REAG set priorities for activities that could be carried out in NSW production areas. The production areas focused on were Greater Sydney and the NSW North Coast. The REAG agreed to the work plan. Progress on the 2020/21 Annual Regional Work Plan and the M&E Plan was reported back to the REAG in Early 2021 and agreed by the REAG.

There are also a range of outputs completed and drafted that have been developed and/or performed as part of this project and split into the following categories.

- Extension events
- Resource development
- Media and communications.

A short summary of each section is described below:

Delivered Extension events

- Serpentine Leafminer webinar Serpentine leafminer (nsw.gov.au) https://youtu.be/m5_rC2BeANk
- Peri-urban biosecurity workshop – Demonstration Farm, Hawkesbury, March 2021
- Vegetable growers flood information session – Demonstration farm, Hawkesbury, April 2021.

Resource development

- *'Substrate Use in Hydroponics – Basic Principles and Planning'* Draft
- *'Hydroponic Irrigation – Drip Irrigation Substrate'* Draft
- *'Biofumigation'* fact sheet - and translated into Simplified Chinese and Khmer
- *'Cover Crops'* fact sheet - and translated into Simplified Chinese and Khmer
- Cucumber Diseases and Insect Chemical tables
- Brassica Diseases and Insect Chemical Tables
- Lettuce Diseases Chemical Tables - Draft
- Serpentine Leafminer Primefact – New Pest Alert
- Serpentine Leafminer Primefact - Management
- Pre-purchase of SESL soil testing x 24
- SLM webinar Serpentine leafminer (nsw.gov.au) https://youtu.be/m5_rC2BeANk

Media and communications

- Vegetables Australia Magazine Autumn Edition 2020 – *New zucchini varieties on show at field day*
- Vegetables Australia Magazine Winter Edition 2020 – *VegNET enters Phase Two*
- Vegetables Australia Magazine Spring Edition 2020 – *Providing grower support across New South Wales*

- Vegetables Australia Magazine Summer Edition 2020/21 – *Adoption of soil moisture monitoring in sweet corn*
- Vegetables Australia Magazine Autumn Edition 2021 – *Engaging with growers from culturally diverse backgrounds*
- Vegetables Australia Magazine Winter Edition 2021 – *Flood recovery journey continues for New South Wales' veg growers*
- Vegetables Australia Magazine Spring Edition 2021 – *Vegetable grower Kim Ngov in-focus*
- Soilless Australia Magazine Volume 5 Summer 2020
- NSW VegNET Newsletter #6 July 2020.

Outcomes

The NSW VegNET team undertook extensive planning and industry consultation at the start of the project to ensure the project exceeded its contractual milestones and delivered a suite of integrated outcomes primarily focused on improving the reach, and ultimately the adoption of levy funded R&D projects. Due to the financial constraints on this project, there were only a few extension activities contracted. There were several barriers to achieving even the smallest extension events during this project as early to mid-2020 saw the COVID-19 pandemic emerge and cause disruption to business as usual as we all learned to work from home and alter our perspective on extension activities. This was not a huge disruptor at the time to the project as the national VegNET team were participating in an in-depth professional development program to learn and develop the 5-year extension plan and project establishment documents that are vital in keeping VegNET focused and relevant.

The project initiated an adaptive management model and the continual monitoring of the projects progress against contracted deliverables and what was allowable by the NSW Health and our own agency's restrictions. This has been at a reduced level as planned in the projects Monitoring and Evaluation Plan together with the Grower Engagement Plan. Engagement methods were adapted to suit the variety of grower segments and accommodate different regional needs. Regular interaction with 'key influencers' ensured the project was keeping momentum at minimum a holding pattern. Aspirations were continued as interest in projects planned were communicated back and forth from grower/industry to the VegNET team.

These tables represent Intermediate outcomes after extension event/activities. With the lack of opportunities to host extension events many scheduled events were postponed or put on hold. This time was used to engage in other ways by assessing the M&E plan and developing further resources that would complement the postponed activities and be extended by mail and email on completion. Most of the outcomes for the 4 main projects are assumed and aspirational which will lead to attitude changes once engaged with face to face which growers and allied industry will build on their knowledge and use this to increase their skills with targets being met through practice change on their farms or through second hand consultations by allied industry.

Project 1 Improving Water and Nutrient Management in the NSW Greenhouse Protected Cropping Industry

What Changes are Sought from the M&E plans	Who	VegNET 2 outcomes
80% of surveyed growers participating in the project indicate they now have a greater understanding of managing water and nutrient management "on-farm" as a result of attending workshops or receiving extension resources or being part of extension activities.	New greenhouse vegetable growers with low tech systems in the cooperatives and agronomists	Workshop postponed until 2022.
80% of surveyed allied trade participants in the project are providing new targeted and relevant advice to growers based on learnings or resources from the project.	Allied Trade and Industry	Workshop postponed until 2022.
6 target growers are converting from 'open run to waste' to 'fully closed reticulation systems' with program support.	New growers and a sample of med/high tech growers	Attitudes and aspirations to adopt change was gauged via earlier farm visits, no M&E collected as travel restriction impeded on project momentum.

Project 2 Developing export preparedness for NSW vegetable growers

What Changes are Sought from the M&E plans	Who	VegNET 2 outcomes
A proportional number of NSW growers enrolled in WSU masterclass in protected cropping.	Growers, food companies such as Perfection Fresh	Not contracted to be engaged yet.
Engaging with over 20% of industry participants. This seems low as only a small proportion will be geared up to export.	All growers and the supply chain	Not contracted to be engaged yet.

Project 3 Pest and disease management including biosecurity and farm hygiene

What Changes are Sought from the M&E plans	Who	VegNET 2 outcomes
90% of attendees in the program will improve in spray application efficiency programs (North Coast) & Greater Sydney.	North Coast focus group and Chinese and Vietnamese growers in Greater Sydney	Not contracted in this phase of the project.
60-70% of attendees will embrace using selective pesticides and/or introduction of biocontrol agents on their farms.	Growers, Allied industry, Government	Assumed changes attitudes and practices once growers and allied industry receive updated chemical tables, feedback will be collected once distributed.
Building awareness of potential improvements.	Growers, Allied industry, Government	Knowledge and skills improved from biosecurity workshop attendance of 44 with 75% of workshop survey respondents have a sound understanding of biosecurity importance. SLM webinar registration of 62 with 298 online views. 5-10% increase in VegNET subscription due to capturing new vegetable growers during the SLM incursion exercises.

Project 4 Developing a soil health community of practice for the Australian Cambodian Growers Association of NSW and Australian Chinese Growers Association of NSW

What Changes are Sought from the M&E plans	Who	VegNET 2 outcomes
13 Australian Cambodian Growers participating in the program understand their Farm soil test results, have learnt something new about their soil and intend to implement recommendations for continued improvement in soil health.	13 previous Australian-Cambodian participants who received compost application in 2018.	Events unable to be undertaken. Further resources developed and translated for extension when a more suitable time is identified.
80% of Farm Walk participants have improved their knowledge and awareness of soil health as a result of attending events.	All Australian-Cambodian Growers Association of NSW members. All Australian-Chinese Growers Association of NSW members.	Events unable to be undertaken. Further resources developed and translated for extension when a more suitable time is identified.
2 x Soil Health Communities of Practice established for both the Australian Cambodian and Australian Chinese Growers.	All Australian-Cambodian Growers Association of NSW members. All Australian-Chinese Growers Association of NSW members.	2 x Soil Health Communities of Practice established within the grower's own membership. Australian-Chinese growers have a WeChat group and the Australian-Cambodian growers have a Facebook group. Timing for soil health extension has been pushed into 2022 as many growers are reluctant to do anything face to face.

Project 5 Farm innovation and technology – Precision irrigation and nutrition management in sweet corn

What Changes are Sought from the M&E plans	Who	VegNET 2 outcomes
50% increase in the knowledge, skills and attitudes of Sweet Corn growers on the Central Tablelands in relation to the application of precision technologies (including variable rate water and nutrition technologies being adopted at Simplot Bathurst).	20 Growers in the Bathurst, Dubbo & Cowra regions	Aspirational and attitudinal via telephone calls to key growers. Contact with Simplot unsuccessful for current collaboration. Will need to adjust future extension activities and do direct grower delivery.
80% of growers demonstrate an improvement in knowledge, skills and attitudes in relation to precision irrigation and nutrition management in Sweet Corn. 10% adoption of precision irrigation and nutrition technologies in the Central Tablelands.	Allied industry and 25 growers to 80% of the Sweet Corn growers on the Central Tablelands	Aspirational and attitudinal via telephone calls to key growers. Contact with Simplot unsuccessful for current collaboration. Will need to adjust future extension activities and do direct grower delivery.
Increase grower and the project teams understanding of current yield benchmarks and impediments to the adoption of precision technologies.	2 growers across the Bathurst, Dubbo or Cowra regions	Events unable to be undertaken.

As spring 2020 came around getting out and about became easier, we discovered an exotic plant pest in South West Sydney. The Serpentine Leafminer (SLM) *Liriomyza huidobrensis* was discovered by the NSW VegNET RDO from a report to the Exotic Plant Pest Hotline. This triggered an emergency management response declared by NSW DPI and Plant Health Australia. The VegNET RDO and VegNET team were involved in the planning and operations of the response. While there was a fine balance between being seen as a regulator on the one hand and extension officer on the other to affected vegetable growers and vegetable seedling producers, it proved to be a positive for the emergency response. VegNET and the vegetable growers respect the VegNET team as they are trusted, well known and could guide and assist the affected growers with SLM management information which was developed quickly. This also was a time when old grower connections were reformed, and new growers discovered. The NSW VegNET team organised and hosted an on-line webinar on SLM and its management.

Biosecurity workshop participants at the Greater Sydney LLS Demonstration Farm – learning in the field, March 2021

During the 2020/21 Summer, a Serpentine Leafminer (SLM) webinar was held in conjunction with NSW DPI on December 3, 2020. 62 people were registered for the event and has since received 298 views online. This webinar focused on informing stakeholders of the incursion, pest and beneficial lifecycles and available management strategies, with a heavy emphasis on IPM. The VegNET team used the SLM incursion as well as the discovery of Fall Army Worm (FAW) in the Greater Sydney Region to host a pest and disease workshop to highlight the importance of biosecurity on-farm. This biosecurity workshop was held on 19 March 2021. 44 people attended with 20 evaluation sheets completed at the close of the workshop. Respondents of the evaluation survey were asked *How would you define the term "biosecurity"?* with an ability to select multiple answers, 25% replied *How you manage chemical residues* and *Quarantine at the Australian border.* 30% said *Protecting Australia from biological warfare* and 75% also selected *the protection of the environment, economy and community from new pests and diseases.* The large response for this statement indicates growers and allied industry have a firm understanding of biosecurity and its capacity to disrupt their business if there are breaches. *If you noticed a new pest/disease in your crop what would you do?* was asked and 75% selected *Consult my local agronomist/consultant* which is an indication that growers turn to their consultants for help, therefore the consultants need to know the correct avenues of reporting and sampling to get the best outcome for their customer and for the greater good of growers in Australia (especially if dealing with an exotic). 50% chose *Read up and learn what to do next,* 32% said they would *Send in a sample for diagnostic testing,* only 25% would *Call the Exotic Plant Pest Hotline for guidance* and 20% selected *Use my experience to decide what to do next.*

In March 2021 NSW North Coast and Greater Sydney were seriously affected by flooding and torrential rain caused by a large East Coast low pressure system and was declared a natural disaster. This rain event dampened the

spirits of many growers in Hawkesbury and Western South Sydney areas, many of whom were under water for several days or suffered several days of crop destroying rain. Many growers lost their entire season of crops. Once again VegNET changed its course and the team used their closely developed relationships to reach out to those affected growers, measure the extent of damage and assist in emergency response needs and long-term recovery. Greater Sydney Local Land Services provided resources to assist those greatly affected, attended flood recovery centres and organised a flood and recovery information workshop specifically for vegetable growers. This workshop was well received by growers and there were follow-ups with individual growers. New relationships were formed, and old ones strengthened during the recovery process. The vegetable industry in Greater Sydney, North Coast and some areas in the Central Tablelands were on their knees for recovery support and in no frame of mind to engage in R&D extension activities. The best and appropriate role that NSW VegNET team could provide at the time was recovery support and assistance to growers. There was no M&E captured for this event due to the sensitive nature of the flood recovery event and the fragility of the mental health of those effected.

Entering winter 2021 the COVID-19 pandemic resurged with the Delta variant and the Greater Sydney region and most of NSW at times placed into lockdown. Not being new to this we knew what to do and how to assist the VegNET members and vegetable levy payers affected. This lockdown brought new challenges as it restricted growers that lived in 'areas of concern' from their farms in other Local Government Areas. Many enquiries were made to deem clarification of 'authorised workers' as well as maintaining COVID-safe practices on farms and in the markets. Some momentum was lost in pursuing extension and the focus needed to be re-evaluated. This was done by using the time to create much needed extension resources that would complement planned extension activities that were postponed, rescheduled and postponed again.

Increased knowledge of the vegetable R&D program

The project was contracted to engage with a reduced number of growers in the NSW regions due to financial constraints of the project and COVID-19 restrictions in NSW over the Winters of 2020 and 2021. The regional areas engaged with were the North Coast greenhouse vegetable growers and Greater Sydney field and greenhouse growers, the Australian Chinese growers and Australian Cambodian growers.

The project now has three hundred and seventy growers and industry members on the NSW VegNET mailing list with a larger database of one thousand NSW vegetable growers and industry members updated regularly. This database is continually kept up to date as growers exit the industry and new growers emerge or discovered across the four key vegetable growing regions in NSW. The database increased by 5-10% during VegNET2 by capturing new growers and industry members met through the Serpentine leafminer incursion and flood recovery exercises.

Knowledge was increased in these grower groups through extension activities such as one on one grower interaction on farm, in the Sydney Markets or over the phone with replied extension material in the form of emails and posted extension resources.

Improved adoption of outcomes from levy funded R&D projects

The key areas of priority extension of VegNET2 NSW were:

- Improving water and nutrient management for NSW protected cropping vegetables
- Developing export preparedness for NSW vegetable growers
- Pest and disease management including biosecurity and farm hygiene
- Developing a soil health community of practice for the Australian Cambodian Growers Association of NSW and Australian Chinese Growers Association of NSW
- Farm innovation and technology – Precision irrigation and nutrition management in sweet corn.

The adoption was concentrated in Pest and Disease Management including biosecurity and farm hygiene across all grower segments in NSW with an exotic pest incursion of Serpentine Leaf Miner (SLM) bringing it to the forefront. Majority of winter/spring grower enquiries and active extension was focused in educating growers in recognising and managing (SLM).

Significant preparation went into planning workshops and soil testing amongst the Community of Practice (CoP) Australian Chinese growers and Australian Cambodian growers. COVID-19 resurgence of 2021 made growers hesitant to participate or have anyone on their farms prior to NSW Health restrictions being tightened. With many postponements of extension activities, the focus shifted to resource development and translation. Newly developed materials are yet to be finalised and mailed out in extension post packs. These extension activities will be carried out prior to December 2021 when final drafts are completed and reported against in VegNET3. There will be follow up contact to capture feedback for M&E.

Maintain effective partnerships within key NSW vegetable growing regions

One of the success stories of the project has been the engagement of the private sector in communicating levy funded R&D to a much larger audience than originally intended. Previously over 80 per cent of the allied industry, agronomists, seed companies, resellers and consultants together with R&D service providers have been engaged

either at workshops, 'one on one' farm visits or through trials at the Greater Sydney Demonstration Farm. In-light of COVID-19 and other challenges these relationships were maintained throughout this project and grower needs relayed back to the VegNET team to make decisions considerately on R&D appetite and extension timings amongst the identified grower segments.

Several farm visits with agronomists were undertaken on the North Coast and Greater Sydney to meet a larger cross section of growers. This engagement strategy was particularly effective on the North Coast of NSW where partnerships were developed with packing houses such as Oz Group and Pacific Blue. Extending levy funded R&D and resources at these locations is highly time effective, with over 50 growers dropping off cucumbers at packing houses in any given day at packing houses, particularly in the warmer months. M&E wasn't captured for these farm visits but will be moving forward.

The NSW VegNET team have also worked closely with AUSVEG assisting with a variety of events targeting different crop and grower segments including the Project VG16063 National Innovation Coach/Hort 360 and The EnviroVeg Program 2017-2022. The Greater Sydney Demonstration Farm is currently participating in the EnviroVeg project to demonstrate leadership in environmental stewardship and encourage other growers to adopt this program.

During 2019 and 2020, University of New England researchers have been undertaking trials at the Demonstration Farm as part of their Hort Innovation funded project on cover crops and weed management in vegetables. In Summer 2021/21 researchers from Applied Horticultural Research have been using the Farm for capsicum trials investigating varietal differences and management options for internal fruit rot.

In addition to the above-mentioned R&D projects, a number of Hort Innovation's R&D service providers have approached the NSW VegNET team seeking assistance to engage growers in their R&D projects.

Identify R&D needs and industry training priorities

The first half of this project focused on identifying the R&D needs and gaps in industry training. This was achieved by the development of the VegNET NSW Regional Discussion Paper, a comprehensive document pieced together in collaboration with key growers and allied industry analysis of the vegetable sector. The related documents are intended to be dynamic as priorities change through market preferences, environmental concerns, pest and disease incursions and public health orders. The VegNET NSW Regional Extension Strategy identify the specific needs and are further outlined in the Project Briefs. Those training priorities and opportunities exist as Improving water and nutrient management for NSW protected cropping vegetables; Developing export preparedness for NSW vegetable growers; Pest and disease management including biosecurity and farm hygiene; Developing a soil health community of practice for the Australian Cambodian Growers Association of NSW and Australian Chinese Growers Association of NSW and Farm innovation and technology – Precision irrigation and nutrition management in sweet corn.

Facilitating linkages with existing industry communication programs

Relationships continued with the project "National Industry Communications Program" (VG18000) and seven articles contributed to Vegetables Australia Magazine in the duration of this project. Majority of these articles demonstrate and capture outcomes such as "*Vegetable grower Kim Ngov in-focus"* story from the spring edition 2021 shows how he has changed focus on his farm and practices from VegNET extension events and Soil Wealth project activities. The story on *Adoption of soil moisture monitoring in sweet corn* in the Summer 2020 edition of Vegetables Australia Magazine reveals outcomes from an extension event a few years ago, growers rolling up their sleeves and trying new things that have been demonstrated and with all participants increasing profit margins per megalitre of irrigation water. The story published in the Autumn 21 edition *Engaging with growers from culturally diverse backgrounds* show that from a previous training program coordinated by VegNET NSW resulted in growers improving their farming practices and their awareness in best practice.

Demonstrating the effectiveness of practice change to growers and industry

The VegNET team has consistently referred growers and industry to the practice change stories as a source of affirmative reinforcement in adoption of practice change and R&D uptake. For example, grower Kim Ngov acted after reading the case study "*Adoption of strip tillage practices"* and has implemented the use of cover crops on his farm, becoming a champion grower and early adopter amongst his peers in the Australian-Cambodian growers Association. Formal feedback in the form of M&E were not officially collected for this. In the previous project, many practice-change case studies were developed and are offered on the Greater Sydney Local Land Services VegNET web page. These can be found HERE or at https://www.lls.nsw.gov.au/regions/greater-sydney/key-projects/national-vegetable-extension-network-nsw/resources.

Brokering opportunities for exporting vegetables linked to infrastructure developments in NSW

With the opening of the Western Sydney Aerotropolis scheduled for 2026, there are significant opportunities to improve the export capability of NSW horticultural businesses. Over the last two years, the VegNET NSW team has been working with NSW Department of Primary Industries, Western City Aerotropolis Authority and Hort

Innovation to identify existing and potential export businesses and what challenges and opportunities are in this market sector. This was recognised as the least significant of the 5 priorities for VegNET2, activities were not sort after and no outcomes were captured.

Currently, there is a range of export programs that is offered by AUSVEG, Regional Development Australia and the Western City Aerotropolis Authority. NSW VegNET project can play a key role in not only facilitating grower adoption of technologies, processes and innovation that are required to be 'export ready' but also identify and link businesses with the Future Food Systems Cooperative Research Centre and other programs involved in export development. These will make a great platform for future work in the VegNET project.

Participation in the development of the national vegetable industry extension strategy

After the development of the NSW regional extension strategy, the NSW RDO alongside the other regional RDO's were involved in assisting Sean Kenny from Rural Consulting Group in developing the national vegetable extension strategy (Hort Innovation project VG18003).

The Vegetable Industry Extension Strategy guides the collaborative development and delivery of user defined activities focused on targeted and measurable practice change to support the profitable and sustainable growth of Australian Vegetable Businesses. This assisted in producing clearly defined and focused extension activities and build on current available extension material and Hort Innovation funded project outcomes and is intended to guide future extension activities for the vegetable industry.

Monitoring and evaluation

GS LLS undertakes monitoring and evaluation of all projects delivered both externally and internally. GS LLS uses integrated recording systems and databases to ensure outputs are captured and recorded that meet the objectives documented within the Monitoring and Evaluation plan. This was done so for VegNET2 in a lesser constructed matter due to the lack of opportunities to collect MERI data as the capacity of running extension activities was reduced and then further reduced due to the pandemic. M&E data was captured for organised events through post event evaluation surveys and overall project evaluation was conducted through conversations with allied industry and selected growers in an informal way and building on assumptions.

The objective of the MERI Project was to test the hypothesis that vegetable growers working with trained consultants and industry development officers involved in the VegNET project will adopt practice change.

The planning, implementation and evaluation of the program and its effectiveness was by a Monitoring, Evaluation, Reporting and Improvement (MERI) Plan developed at the start of the project through profession development and training provided by Sean Kenny in group an individual online mentoring session's. The MERI Plan includes a Program Logic to show how the project activities delivered the intended outcomes. The Plan developed a set of key evaluation questions that addressed project effectiveness, relevance, process appropriateness and efficiency as per the Hort Innovation Evaluation Framework. This allowed us to determine the project's effectiveness in achieving the desired outcomes when the questions are tested.

Keeping in mind the challenges met during this project were under unprecedented times of a global pandemic.

The project team engaged with industry levy payers through their preferred learning style where possible. This was done so through the face to face workshop at the GS LLS Demonstration farm for a well-received pest and disease biosecurity workshop in March 2021.

The project increased the adoption of the industry Best Practice Guidelines through extension events where/when possible to be achieved, through a pest and disease forum held at the Greater Sydney Demonstration farm with an emphasis on biosecurity and the serpentine leafminer incursion and discovery of the fall army worm in NSW. The educational workshop was received very well with 44 participants and 100% of the respondents from the post workshop evaluation said that they learnt something vital in pest control on their vegetable farm businesses such as growing native plants that attract beneficial parasitoids, with 3 growers planting out refuges. Others reported as understanding that spraying harsh chemicals can increase incidents and pest pressure on farm as it eliminates natural predators. Respondents of the evaluation survey were asked *How would you define the term "biosecurity"?* with an ability to select multiple answers, 25% replied *How you manage chemical residues* and *Quarantine at the Australian border.* 30% said *Protecting Australia from biological warfare* and 75% also selected *the protection of the environment, economy and community from new pests and diseases.*

A vegetable growers' flood information session was held in April 2021 at the Demonstration Farm. Many of the attendees were familiar faces and those that were new to the Demonstration Farm became VegNET members on the day. Nearly 60 people attended the event which was organized with short notice. R&D extension material was made available on the day in the form of fact sheets, pest guides and posters for those that were seeking further assistance in their vegetable businesses. M&E was not collected at this event as it was a sensitive topic for the attendees, and we didn't want to offend anyone by asking evaluation questions of them at that time.

Due to the inability to hold many of the planned events many resources were extended via mail and email and newly developed resources produced ready to be distributed in post packs and email blasts. The SLM webinar was widely distributed to all contacts on the greater grower and industry list to get information out as far and wide as possible to raise awareness and educate those of potential impact of SLM and has since had 298 views.

The project met the needs of industry levy payers through extending customised extension material and responses on an as needs basis. This was achieved through phone calls and emails, meeting growers at Sydney Markets and using the allied industry network.

The target engagement levels of industry levy payers were not achieved in most of the project period due to the public health order restrictions and employer limitations placed on the VegNET teams' movements and working from home directives. This was overcome by regular contact with 'key influencers' in all growers' segments for further dissemination by the proxy extension officers. These were vital interactions to reaching project outcomes through this difficult period and at times giving growers what they needed in the regards to support in disseminating COVID-19 restrictions with some communications being urgent of nature and being conducted outside of regular business hours to assist those groups promptly. Knowing our grower base well, meant that webinars would not be well received and were abandoned to achieve a better communication outcome with a more personalised approach.

Most extension events were accessible to industry levy payers although certain communications were aimed at specific segmented grower groups. This was due to having culturally and linguistically diverse groups and different production systems such as greenhouse growers on the North Coast. Segmented grower groups were identified earlier in the previous VegNET project so as to better meet the needs of specific regions or groups.

Recommendations

The VegNET NSW brand has been very successful in communicating the outcomes of Hort Innovation projects to growers and industry. The development of a national framework for monitoring extension and adoption outcomes is important to ensure consistency in reporting across Australia.

VegNET NSW has continued to use a variety of extension methods and has implemented an innovation systems approach since VegNET NSW commenced in July 2016. Our team has developed, implemented and evaluated a Monitoring, Evaluation, Reporting and Improvement (MERI) model including publishing a paper on our approach to work undertaken in this space (APEN Conference September 2019).

The VegNET NSW team do not subscribe to the concept of the 'pipeline approach' or 'linear transfer of technology approach'. The system-based approach ('co-innovation') has been our primary focus since the project began as articulated in the Regional Stakeholder Engagement Forum summaries.

The focus has been on adoption of Hort Innovation R&D outcomes to manage complex farming system problems to ensure practice change. For example, the VegNET NSW team has worked with several R&D providers at the Greater Sydney LLS Demonstration Farm to undertake trials, involve growers in the design of trials and incorporate feedback as the project progresses. This ultimately leads to better research and development outcomes and adoption of the research findings. Similarly, the VegNET NSW team have worked closely with other horticultural industries to share common information and broker knowledge particularly in the areas of biosecurity and food safety through groups such as Agriculture Victoria's Horticulture Industry Network, NSW Department of Primary Industries and AUSVEG.

The following recommendations from the project are:

Recommendation 1

Before any Hort Innovation vegetable levy funded project is contracted, the R&D provider should develop a communication and extension strategy in conjunction with the VegNET extension officer(s) to ensure appropriate strategies are developed and resourced. Also, the R&D service providers should provide a two-page fact sheet on the key messages, economic benefits and 'Where to from here?' recommendations at the completion of the project.

Recommendation 2

Hort Innovation should create national vegetable commodity-based interest groups to drive R&D priorities. For example, there could be an interest group for Brassica crops that have representatives from the major growing regions (growers and consultants), a VegNET representative and key R&D service providers. R&D priorities could be incorporated into Hort Innovation's vegetable levy fund annual investment plans with a subsequent call for proposals.

Recommendation 3

That Hort Innovation host an event with the new Extension and Adoption Team together with R&D providers to plan how each party will work together and exchange knowledge and ideas. This could include a formal mentoring pathway and opportunities to meet and exchange ideas and knowledge.

Recommendation 4

Standardisation of funding for VegNET service providers is currently inequitable given some regions have many production areas, more experienced extension staff and varying operating costs. Each project should be assessed based on a track record of delivering value for money, adoption of relevant R&D and practice change outcomes.

Recommendation 5

That Hort Innovation ensures that cultural and linguistically diverse background growers are included in any vegetable industry communication strategy and adequately resourced.

References

Vegetable Industry Extension Strategy. Sean Kenny (Rural Consulting Group), Jeff Coutts (Coutts J&R) & Neels Botha (Neels Botha Ltd) Hort Innovation final report, VG18003, October 2019,

National action plan for extension delivery in the Vegetables industry, Draft Version 3 Feb 2021, Sean Kenny (Rural Consulting Group).

Intellectual property, commercialisation and confidentiality

The project did not produce commercial intellectual property. All project deliverables have been made publicly available. All project outputs include branding and acknowledgement as per the Horticulture Innovation Publications Guide.

Acknowledgements

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In addition, LLS staff in the following regions as follows:

- Julie Dart (North Coast LLS)
- Karen O'Malley (Central Tablelands LLS)
- Justin Vardanega (Riverina LLS)

The following growers have been 'key influencers' in the project and include:

- Mario Muscat - Field vegetables, Demonstration Farm, Greater Sydney
- Val and Sam Micallef - Field vegetables, Greater Sydney/Central Tablelands
- Jason Chung - Field vegetables (Chinese Growers Association of NSW), Greater Sydney
- Nicky Mann - Protected cropping vegetables, Greater Sydney
- Kim Ngov - Field and protected cropping vegetables (Cambodian Growers Association of NSW), Greater Sydney
- Paul and Kaka Singh - Protected cropping vegetables, North Coast
- Bari Mann - Pacific Blue Cooperative (Flavorite), North Coast
- Rhod Cook - Protected cropping vegetables, North Coast

The following industry representatives have assisted greatly with the project include:

- Shannon Mulholland – Plant pathologist/Epidemiologist, NSW DPI
- Maddy Quirk – Biosecurity and project officer, AUSVEG
- Andy Ryland – Private consultant/Entomologist, Greater Sydney
- Darryl Cislowski - Agronomist / Reseller, Greater Sydney
- Bahram Fayez - Seed company, Greater Sydney & North Coast
- Johnny Capuyan - Agronomist / Reseller, Greater Sydney
- Len Tesoriero - Researcher / Private consultant, All regions
- Chris Fyfe – Researcher, All regions.

Appendices

1. VegNET NSW Regional Discussion Paper
2. Regional NSW VegNET Project Briefs
3. Regional Extension Advisory Group (REAG) terms of reference
4. Five Year Regional Vegetable Extension Strategy
5. Project program logic and M&E plan
6. Stakeholder engagement plan
7. 2020/21 Annual regional extension work plan
8. Vegetables Australia Magazine articles
    - Vegetables Australia Magazine Autumn Edition 2020 – *New zucchini varieties on show at field day*
    - Vegetables Australia Magazine Winter Edition 2020 – *VegNET enters Phase Two*
    - Vegetables Australia Magazine Spring Edition 2020 – *Providing grower support across New South Wales*
    - Vegetables Australia Magazine Summer Edition 2020/21 – *Adoption of soil moisture monitoring in sweet corn*
    - Vegetables Australia Magazine Autumn Edition 2021 – *Engaging with growers from culturally diverse backgrounds*
    - Vegetables Australia Magazine Winter Edition 2021 – *Flood recovery journey continues for New South Wales' veg growers*
    - Vegetables Australia Magazine Spring Edition 2021 – *Vegetable grower Kim Ngov in-focus*
9. Soilless Australia Magazine Volume 5, Summer 2020 – *VegNET Program targets Vietnamese growers*
10. 'Substrate Use in Hydroponics – Basic Principles and Planning' Draft
11. '*Hydroponic Irrigation – Drip Irrigation Substrate'* Draft
12. *'Biofumigation'* Fact sheet
    - *'Biofumigation'* - translated into Simplified Chinese
    - *'Biofumigation'* - translated into Simplified Khmer
13. *'Cover Crops'* Fact sheet
    - *'Cover Crops'* - translated into Simplified Chinese
    - *'Cover Crops'* - translated into Khmer
14. Cucumber Diseases Chemical Table
15. Cucumber Insect Chemical Table
16. Brassica Diseases Chemical Tables
17. Brassica Insect Chemical Tables
18. Lettuce Diseases Chemical Tables Draft
19. Serpentine leafminer Primefact – New Pest Alert
20. Serpentine leafminer Primefact – Management
21. Industry field day: Pest and disease management flyer

APPENDIX 1

VegNET NSW Regional Discussion Paper

Introduction

Vegetable production in NSW is spread across many different growing environments involving many different production systems with a culturally and linguistically diverse grower base (see Figure 1).

NSW has the second highest number (24 percent) of vegetable businesses in Australia (Ref: ABARES 2018). Many farms are less than 20 hectares but grow high value and potentially high return crops under advanced production systems.

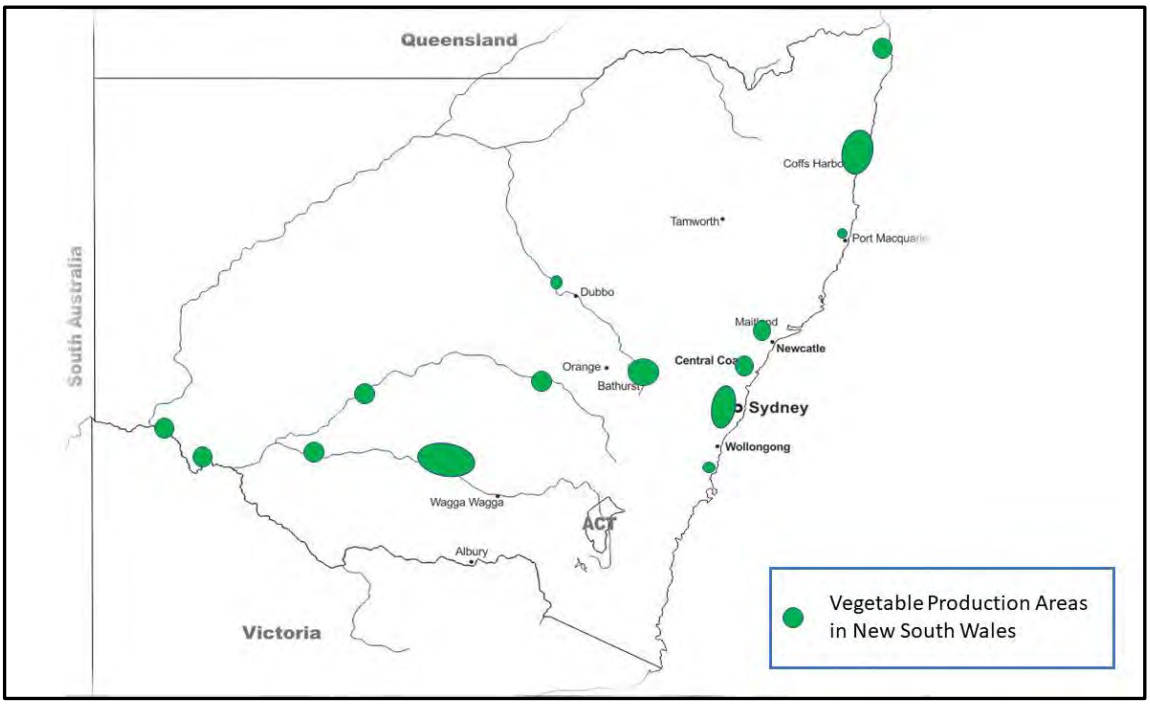


Figure 1

Challenges

- The NSW vegetable industry has undergone significant change over the last 10 years particularly in the peri-urban areas of Greater Sydney and New South Wales North Coast.
- There are many challenges facing vegetable producers including:
  - rising land prices
  - ageing demographic and lack of succession planning
  - new entrants into the industry many of whom are from culturally and linguistically diverse backgrounds
  - increasing input costs
  - depressed market prices for some vegetable commodities
  - climate change and drought

- environmental pressures that have all been drivers encouraging growers to look for efficiencies across the whole supply chain.

- Over 55 percent of vegetable producers are based in the Greater Sydney region with a growing number of growers diversifying into high value crops under protected cropping structures especially on the Mid North Coast (Coffs Harbour area).
- Increasing urbanisation of traditional vegetable growing areas is driving production into new regions which often have different environmental, water and labour resources.
- There has been a reduction in smaller to medium vegetable businesses and a move to larger corporate mixed enterprise farms in the Riverina and the Central Tablelands regions. These farms typically grow lower value commodity crops and often only grow vegetables when prices are likely to give reasonable return.
- The vegetable industry is highly fragmented and culturally diverse in NSW. Over 80 percent of the Greater Sydney region growers are from a cultural and linguistically diverse background such as Lebanese, Cambodian, Chinese and Vietnamese. These groups are resource hungry and need significant additional extension support.

Opportunities

- Despite some growers leaving the industry in the Greater Sydney region there are many new growers that have entered the industry in the last five years. These growers are keen to network and learn from 'key influencers' in the industry. They are often the early adopters of new technology including research and development outcomes. There is also a new cohort of younger generation growers who see opportunity long term in the vegetable industry.
- Many stakeholders in the Greater Sydney region wanted an independent site where they can view applied R&D innovations and trials. The Greater Sydney Local Land Services Demonstration Farm provides this function, with the Cambodian Growers also setting up a demonstration site in south western Sydney.
- LLS is identified as the key broker of information and the coordinating body who could bring growers together for the mutual benefit of all in the industry. Connections were reformed with culturally and linguistically diverse (CALD) grower groups in the Greater Sydney region with strong interest from growers to engage at the Sydney Markets.
- NSW also has an emerging and growing protected cropping industry particularly on the Mid North Coast of NSW. Many commercial companies are putting increasing resources and effort to service this growing region. There is also a considerable shift away from traditional farming practices to more sustainable and innovative farming practices across the State.
- Given the geographic spread and the large proportion of CALD growers, NSW is limited in our scope to achieve practice change outcomes with current funding levels. There is a risk that a lot of the momentum and trust may be lost due to inadequate levels of funding and the need to cover a large geographical area.
- The establishment of the Western Sydney International Airport will bring significant opportunity for the horticultural sector in NSW. Private investment in protected cropping, training and retention of skilled labour, particularly in medium to high tech protected cropping is a major issue being addressed through the National Vegetable Protected Cropping Centre at Western Sydney University.

Detailed Monitoring, Evaluation, Reporting & improvement analysis undertaken by the NSW VegNET team identified opportunities in the following key areas.

- Water management and irrigation efficiency (focus on water recycling, irrigation management and water budgeting, drought resilience, water security)
  - opportunity to educate growers about water and nutrient management in greenhouse production (Greater Sydney & North Coast)
  - facilitate irrigation training, particularly with CLDB groups who use potable or town water (Greater Sydney)
  - broker information with water users and link them with consultants and allied trade
- Export preparedness (focus on Western Sydney Airport)
  - opportunity to leverage existing export programs to communicate the benefits of export
  - identify market segments and private companies that need 'brokering services' if applicable
  - provide innovative extension opportunities for uptake of the latest R&D from research and training providers
  - link companies and growers to training such as the Technical Masterclass in Protected Cropping managed by the University of Western Sydney
  - managing market access issues and improved postharvest management
- Pest and disease management (including farm hygiene through to biosecurity)
  - access to pesticide chemistry and biocontrol agents
  - demonstrate Integrated Pest Management benefits to allied industry and growers (Greater Sydney Demo Farm)
  - 'train the trainer' program with agronomists and allied trade in IPM and Keep It Clean program (Biosecurity) including peri-urban biosecurity training
  - replicate targeted spray application efficiency programs (North Coast) & Greater Sydney
- Sustainable crop management (including agronomy, soil health, crop nutrition)
  - costs of production for different crops in hydroponics
  - integrated weed management and economics of controlling priority weeds better understood
  - assess and monitor the long-term benefits of compost (Cambodian Extension project)
  - use of key informants to communicate the benefits of soil health, cover crops and managing soil borne diseases
  - NSW Vegetable Industry Field Days and Expo (at the Greater Sydney Demonstration Farm) to build grower and supply chain capability
- Advanced production technologies (including protected cropping, drones, automation, remote sensing)
  - commercialisation of robots (Greater Sydney smaller hybrid robots)
  - costs of converting from low to medium/high technology
  - use of remote sensing and Irrisat to schedule irrigations with limited water supply (Central Tablelands)

Key Focus Area 1: Water Management & Irrigation Efficiency
Appendix 1a: Regional service scan

What is currently being done in this area?	Who, where, and for how many is this work targeted?	What changes are sought from this work?	How will these changes benefit the target audience?
Webinars on irrigation topics	Central Tablelands & larger vegetable growers	Increased adoption of Irrisat and other irrigation scheduling technologies	Improve water use efficiency and increase production per tonne
Best practice irrigation demonstrations	Greater Sydney Demonstration Farm & North Coast	Improved knowledge of growers in best practice irrigation management technology	Greater understanding of advanced sprinkler technologies, automation and savings in water and fertilizer use
Non-urban Water Metering Framework	All non-urban surface water users in NSW	Transition meters to private ownership and ensure compliance with Australian Standards	Use meters to better enable better water budgeting and (planning)
Extension in efficient water use in hydroponics	North Coast and Greater Sydney protected cropping industry	Increased understanding and adoption of closed water recycling systems & improved water use efficiency	Savings in water and fertiliser usage. Reductions in runoff and community concerns (in the Marine Estate Management Authority area of the north coast)
Precision irrigation of sweet corn	Up to 25 sweet corn growers in the Central Tablelands/Central West of NSW	Improved yield per ML of water input	Increased productivity and crop yields

Key Focus Area 1: Water Management & Irrigation Efficiency
Appendix 1b: Regional service gap analysis

What is missing in this area?	What would change if we addressed this gap?	Who, where, and how many would benefit?	How will these changes benefit the target audience?
Extension in water and nutrient management in hydroponics (focus on water recycling and closed systems)	Growers having a broader understanding of water and nutrient management and the economics and risks of converting to closed systems in hydroponics	North Coast (120 growers) and Sydney Basin (300 plus)	Savings in water and fertilizer use. Healthier crops and less runoff (and potential land use conflict)
Irrigation management training for CLDB groups using potable water in the Greater Sydney region	Greater understanding of soils, irrigation system management and irrigation scheduling	Greater Sydney (300 plus growers) - incl. Chinese, Vietnamese, Cambodian and Arabic communities	Reduction in potable water use, less pest & disease pressures and savings per ML of water applied

Key Focus Area 2: Export preparedness
Appendix 2a: Regional service scan

What is currently being done in this area?	Who, where, and for how many is this work targeted?	What changes are sought from this work?	How will these changes benefit the target audience?
AUSVEG Vegetable Industry Export program	All NSW vegetable growers in the first instance (through the VegNET network)	Leverage levy funded investments, contacts and knowledge to support engagement strategy	Greater understanding of the opportunities available to industry and growers. Link non export industries with networks who are successfully exporting
Tracking interest with stakeholders	Growers, Co-op's	Preparation for future export training	Get growers to look beyond Sydney, Melbourne and Brisbane markets for their produce
Export workshops linked with Western City Agri-precinct	Consultants, agents, government, peak industry bodies, supply chain	Preparation for future opportunities and demands	Export ready, ramping up production, greater job opportunities throughout entire supply chain

Key Focus Area 2: Export preparedness
Appendix 2b: Regional service gap analysis

What is missing in this area?	What would change if we addressed this gap?	Who, where, and how many would benefit?	How will these changes benefit the target audience?
Export preparedness program for NSW Vegetable growers	Understanding of export requirements	Larger companies and growers with economies of scale	Being export ready and improve long term profitability and access to new markets
Adoption of food safety and environmental management programs	Meeting export customers' expectations for Global Food Safety Initiative (GFSI) standard	All growers and the supply chain	Increased confidence and continued market access for' in demand' products
Western Sydney Aerotropolis	Protected cropping industries in Greater Sydney as well as regional production areas in Central West NSW	Growers close to urban areas such as Greater Sydney	Opportunities to grow markets and export high value products
Good understanding of postharvest and packaging requirements	Improved postharvest vegetable management and improved product quality. Less product wastage due to poor postharvest management	Growers, wholesalers, retails, consumers	Improved out turn of product
Linking interested parties to the Western Sydney University Technical Masterclass in Protected Cropping	Greater uptake of the horticulture workforce in managing medium to high technology	Growers, Food companies such as Perfection Fresh	Skilled and adaptable workforce pool to address supply shortages in the labour market for the protected cropping sector

Key Focus Area 3: Sustainable Crop Management (Agronomy, New Varieties, Soil Health)
Appendix 3a: Regional service scan

What is currently being done in this area?	Who, where, and for how many is this work targeted?	What changes are sought from this work?	How will these changes benefit the target audience?
Strip till webinar from EGVID	All vegetable growers growing in soil	Improved soil health and reduced input costs	Increase in yield, and improved gross margins per hectare
EPA Compost Project GS LLS Demo Farm	Soil based vegetable growers	Reduce input costs (water & nutrients), improve the physical, chemical & biological properties of soils	Maintain and increase yields. Improved long term soil health and reliance on synthetic fertilisers
Crop variety trials at GS LLS Demo Farm	All grower segments in the Sydney basin who grow zucchinis, sweet corn and brassica crops in soil	Growers understanding the performance of different veg varieties compared against each other and their pest and disease resistance Greater number of vegetable growers involved in VegNET and attending the events Increased number of seed companies trialling new products	Greater number of seed companies engaged in the project and extending levy funded R&D Growers adopting more efficient and higher yielding vegetable varieties
Soil Wealth ICP Demo Farms	Bathurst (Central Tablelands) & Greater Sydney growers	Greater number of growers in the Central Tablelands & Greater Sydney region adopting Strip Till practices and improved soil management practices	Improved soil health and increase in crop production
Integrated Weed Management & Optimising Cover Cropping (UNE, AHR, TIA, QDAF)	Greater Sydney growers (in soil)	Improved understanding and management of priority weeds and control options (incl. economics) Use of the Integrated Weed Management Manual	Reduction in input costs and cleaner more higher yielding crops Reduction in use of sprays that certain weeds have developed resistance to

Key Focus Area 3: Sustainable Crop Management (Agronomy, New Varieties, Soil Health)
Appendix 3b: Regional service gap analysis

What is missing in this area?	What would change if we addressed this gap?	Who, where, and how many would benefit?	How will these changes benefit the target audience?
NSW Vegetable Industry Expo and Field Days (held at the Greater Sydney LLS Demonstration Farm)	Greater understanding and awareness of the VegNET R&D program Growers introduced to new products and services by the allied trade and seed companies	Over 600 vegetable growers in the Riverina, Central Tablelands and Greater Sydney region Over 10 seed companies and major resellers 80% of the vegetable industry	More engagement with the Hort Innovation R&D & Consumer Alignment program & the VegNET program Increased understanding of crop varieties, innovations and services across the industry Reduction in input costs and an interest in EnviroVEG (environmental stewardship projects) Adoption of levy funded R&D
Work with 'key growers' to share the benefits of long-term compost use & sustainable soil management practices (develop case studies)	Improve demand for the product and uptake from growers	Sydney basin field growers Note: Cambodian growers (15 growers had compost applied at different rates in 2018)	Improved understanding of the benefits of compost for improved crop and soil health Greater uptake of compost within the crop segmented groups
Use existing networks and newsletters to promote soil health and management of soil borne disease (incl case studies)	Greater number of growers aware of the benefits of compost, cover crops and soil borne disease management practices	Growers in the Greater Sydney, Riverina, Far North Coast and	Improved understanding of the benefits of compost for improved crop and soil health Greater uptake of compost within the crop segmented groups
Costs of production for different hydroponic crops	Over 100 growers in protected cropping on the North Coast	North Coast growers (over 100)	Diversify crops and improve income streams Spread risk to ensure profitability
Cucumber greenhouse nutrition training program	More targeted crop nutrition and less runoff of N&P into waterways Savings in water and fertiliser	Over 200 growers in the Greater Sydney and Mid North Coast regions	Savings in input costs. Reduction in land use conflicts and compliance costs

Key Focus Area 4: Pest and disease management (including biosecurity and farm hygiene)
Appendix 4a: Regional service scan

What is currently being done in this area?	Who, where, and for how many is this work targeted?	What changes are sought from this work?	How will these changes benefit the target audience?
Fall armyworm Webinar	Government employees, consultants, biosecurity officers and then through to growers by second hand communication	Learning specific pest identification, trapping methods and surveillance	Educate first contact specialists with growers and land holders for fast diagnostics and surveillance
Spotted winged drosophila, BMSB, Veg Leaf Miner	Government employees, biosecurity officers, researchers, consultants and then through to growers by second hand communication	Learning specific pest identification, trapping methods and surveillance as well as exotic pest management strategies and protocols, incursion preparedness	Being able to communicate future possible threats to growers' businesses
Demo farm biosecurity procedures	GS LLS Demo farm biosecurity procedures in action, targeted at growers, consultants and government workers.	Increased awareness on what on farm good practice looks like	Being able to see that simple changes in on farm hygiene and biosecurity is achievable an inexpensive through minor practice changes
Area wide management project	Growers and consultants all over NSW	Surveying, identifying and diagnosing vegetable viruses and bacteria currently found in NSW (and other states) crops	Newer diagnostic tests, foreseeing future crop issues, prioritising future Hort Innovation funded projects to assist in the gaps found in surveillance
CGMMV incursion	Cucurbit Growers and consultants all over NSW	Awareness and preparedness	Increase knowledge of CGMMV incursions and steps to take in eradication and tightening on-farm biosecurity measures as a safeguard
Biosecurity workshop with CALD growers	All CALD growers in the Sydney Basin and North Coast. Chinese, Vietnamese, Cambodian, Lebanese, Sikh	Improved farm best practice, hygiene and biosecurity awareness	Improved systems, cleaner farms, less waste and greater knowledge on biosecurity

Key Focus Area 4: Pest and disease management (including biosecurity and farm hygiene)
Appendix 4b: Regional service gap analysis

What is missing in this area?	What would change if we addressed this gap?	Who, where, and how many would benefit?	How will these changes benefit the target audience?
IPM and IPM support	Reinvigorate IPM principles in the growing community	Would benefit growers to consumer, field and greenhouse growers, small and large	Less unnecessary chemical use, safer for producer and customer
Farmgate Biosecurity & Keep It Clean Training for protected cropping growers	Growers would be more aware of on-farm biosecurity processes, from limiting traffic on their farms to order of entry.	Growers	Cleaner farms, lowers biosecurity risks, reduces costs in the long term
Basics on farm hygiene	Create a waste reduction program	Growers	Reduction in agricultural waste
Best practice spray application workshops and follow up farm visits	Better use of pesticides	Growers	Reduced use of pesticides, reduced production cost and better pest control
Better pest, disease and beneficial identification	Improved strategic pest control using integrated pest management	Growers	Better use of pesticides and reduced input costs
Chemical tables in other popular vegetable varieties	Growers would have better guides and understanding on available chemicals per crop	Growers, Consultants and Resellers	Correct chemical selections, cost savings
Highlighting the importance of legislated Chemical training & resource development for new Cultural & Linguistically Diverse Background growers	Improved awareness of chemical regulations, safety and handling	Chinese growers (up to 50 in Greater Sydney)	Compliance and correct application of chemicals. Improvement in WHS

Key Focus Area 5: Advanced production systems
Appendix 5a: Regional service scan

What is currently being done in this area?	Who, where, and for how many is this work targeted?	What changes are sought from this work?	How will these changes benefit the target audience?
Robotics Sydney Uni	All soil-based vegetable growers in the Greater Sydney, Central tablelands and Riverina regions (up to 800 growers)	Better uptake and adoption of the technology due to its commercialisation	Reduction in labour costs and input costs such as spraying and weed management
Precision Ag QLD DAF	Greater Sydney growers (leading growers) and the Central Tablelands (100 in total)	Better understanding of soils, irrigation systems and technology that monitors and maps crop production and what impacts yields	Greater adoption of the technology to save water and fertilizer and benchmark paddocks
Innovative weed & soil disease management (microwave technology)	Greater Sydney field-based growers (100)	Demonstration of the technology to see if it is suitable as a weed management control option	Awareness of another innovative weed management technique to reduce input costs
Stingless bees as Effective Managed Pollinators (WSU) and alternatives to honeybees	Greater Sydney & North Coast protected cropping growers (over 200 not incl. cucumber growers)	Alternative pollination option in addition to honeybees	Greater options for pollination
Innovative Smart Glass Research project (WSU)	Greater Sydney (medium to high tech growers). Less than 50 growers, but several hundred around Australia	Better understanding of the role smart glass can play in increasing crop yields and reducing input costs	Adoption of smart glass technologies once research is completed
Technical Masterclass in Protected Cropping	All protected cropping businesses in vegetables (number unknown)	Drive training opportunities for the protected cropping sector (incl. postgraduate)	Retention of staff in the protected cropping sector and a higher skilled workforce

Key Focus Area 5: Advanced production systems
Appendix 5b: Regional service gap analysis

What is missing in this area?	What would change if we addressed this gap?	Who, where, and how many would benefit?	How will these changes benefit the target audience?
Benchmarks for irrigation and nutrition management and extend current best practice information.	Increase grower and the project teams understanding of current yield benchmarks and impediments to the adoption of precision technologies.	20 Growers in the Bathurst, Dubbo & Cowra regions, farm visits to determine current benchmarks.	Better use of available water and greater crop per ML water.
Extension in the latest R&D outcomes from the Precision Technologies levy funded project. Extending results of summer crop yield & Benchmarking /monitoring program to all growers.	50% increase in the knowledge, skills and attitudes of Sweet Corn growers on the Central Tablelands in relation to the application of precision technologies (including variable rate water and nutrition technologies being adopted at Simplot Bathurst).	Allied industry and 25 growers to 80% of the Sweet Corn growers on the Central Tablelands. Farm Walks/Field Days showcasing Precision Irrigation and Nutrition Management Technologies.	Improved awareness and knowledge of R&D outcomes and improved irrigation efficiencies.

APPENDIX 2

Regional NSW VegNET Project Briefs

Improving water and nutrient management for NSW protected cropping vegetables

1. The Problem or Opportunity

The rapid expansion of the protected cropping industry on the Mid North Coast has highlighted a range of issues including nutrient rich runoff leaving farms and entering waterways and eventually into environmentally sensitive marine parks. Community pressure to reduce runoff from farms is increasing particularly from intensive greenhouse vegetable production enterprises that carry high nitrogen and phosphorous loads in runoff water.

After extensive grower consultation, basic nutrition and the fundamentals of best practice water management in greenhouse production have been identified as key extension needs especially with new growers. As a response, an extension program consisting of online, 'one on one' and group workshops will target new growers initially. This will occur through benchmarking current practice, developing new training resources, extending existing R&D resources and upskilling leading growers and allied trade to enable practice change. The effectiveness of the extension program will be evaluated by firstly benchmarking current grower knowledge and practice, followed by evaluations throughout the program delivery. This will allow the program to by modified, if required, to meet grower needs.

2. The Practice Gap

Water and nutrition management in greenhouse vegetable production is critical to maximise productivity and minimise input costs. The open hydroponic system is the most common production methods used by growers in this region. Results from NSW DPI's Clean Coastal Catchments research project has shown that growers tend to over irrigate crops. Open systems result in wastewater draining away from the greenhouse, ending up in waterways.

Growers will be shown the benefits of converting from open 'run to waste' systems to closed recirculated systems. Initial research shows this can save up to 40% in water and 60 % in fertiliser costs. Only 2% of growers are using closed systems. These growers are considered the 'top tier' early adopters who have moved from 'low tech' open systems into medium and higher tech growing systems. The challenge is to increase this number of growers using closed systems.

3. Benefits of bridging the gap

The benefits of bridging the gap will improve understanding of managing water and nutrients in intensive greenhouse vegetable production. Implementation of improved systems will increase crop yields, reduce input costs such as water and fertiliser, reduce disease pressure due to healthier crops and enhance environmental credentials including the 'right to farm' and reduce agricultural land use conflict with regulators.

4. Project Objectives and Indicators

Objectives

- 80% of attendees in the program have a greater understanding of managing water and nutrient management 'on farm'.
- 10% of attendees making at least one practice change in the areas of water and nutrient management.
- 80% of allied trade participants providing targeted and relevant advice based on sound scientific principles.
- 5% of growers converting to closed recycling and medium high-tech facilities a g/systems.

Indicators

- At least a 10% saving in water and nutrient inputs for growers undertaking training with 'open run to waste systems'
- A 40% saving in water and 60% saving in nutrient inputs for those adopting 'closed recirculation' systems.

5. Project Strategy and Deliverables

WHAT, WHEN & WHERE?	BY WHO?	TO WHO?	FOR WHAT CHANGE?
1.Two workshops per year in best practice water and nutrition in greenhouse vegetable production developed and delivered (both online and face to face).	Workshops delivered by greenhouse and water nutrient management leader/s.	New greenhouse vegetable growers with low tech systems in the cooperatives and agronomists.	80% of attendees have a greater understanding of managing water and nutrient and can demonstrate a 10% savings in water and nutrient management as a result of attending the training.
2. Using case study demonstration sites to show successful conversion from open run to waste to closed and or higher tech systems. (2/year)	Matthew Plunkett	Growers who have attended the workshops and likely to consider changing to closed and/or higher tech systems.	5% of growers adopting closed and or med to high tech growing systems that improve water and nutrient management.
3. Annual benchmarking surveys in current water and nutrition practices in greenhouse vegetable production.	Developed by Matthew Plunkett	New growers and a sample of med/high tech growers.	Identification of gaps and areas to change project scope (adaptive management) and have tangible data for future comparison.
4. Six individual trips to the North Coast for targeted extension and support in converting from 'open run to waste' to 'fully closed systems'.	Matthew Plunkett	Top Tier Growers using advanced technologies.	40% saving in water and up to 60% savings in nutrient inputs.

There are over 120 Greenhouse Protected Cropping Growers on the NSW Mid North Coast. Of this group, there are estimated to be 40 new growers who have limited understanding of how to manage an efficient and effective greenhouse protected cropping vegetable system. More technical and in-depth extension in "closed recirculation systems" will be provided to growers who have received grant funding through the

Clean Coastal Catchments project and on recommendations provided by Agronomists and Allied Industry personnel.

6. Capability and Collaboration

- North Coast and Greater Sydney Local Land Services (LLS),
- Genesis Horticultural Solutions,
- NSW DPI, NSW Government's investment in research trial sites and modelling nutrient runoff as part of the Clean Coastal Catchments project,
- Protected Cropping Australia, the national peak industry body,
- Allied trade, seed companies and packing houses.

7. Budget

1. Two workshops / year 'Consulting facilitator' $10,000 + venue/catering costs $3,800^ = $13,800
2. Two demonstration sites / year $4,000
3. Annual benchmarking. Development of survey $2,000, Rolling out benchmarking survey / year $3,000, benchmarking analysis / year $2,000 = $7,000
4. North Coast Greenhouse growers / year for one-on-one farm visits $6,000

Total: $30,800 + 0.25 FTE and associated costs (administration, travel, etc)

8. Benefit cost

Growers will have an improved understanding of managing water and nutrient management in intensive greenhouse vegetable production, those who convert from 'open run to waste' systems to 'fully closed' systems will save in input costs such as water and fertiliser, increasing crop yields with healthier plants lead to less disease pressure.

Enhanced environmental credentials including the 'right to farm' or social license, preventing environmental damage to waterways and marine park areas and reducing land use conflict. Avoiding environmental regulation imposed by EPA which will force growers to cease operating.

9. Risks

Risk	Likelihood	Severity	Risk Mitigation Steps
Growers' unwillingness to participate in field days or provide data on farm visits	Low	High	Clear communication on the cost benefits to the grower and the ability to continue with intensive farming.
Growers' concerns about sharing information restricts engagement	Possible	Low	Develop rules around shared vision, Revisit the vision at the start of every workshop/extension engagement.
COVID-19	Medium	High	Enact COVID safe plan, Monitor health advice before events, Practise good hygiene and social distancing measures.
Lack of budget to deliver program	Medium	Medium	Delay project to 2021-22 season when VegNET budget position is known.

Developing export preparedness for NSW vegetable growers

1. The Problem or Opportunity

With the opening of the Western Sydney Aerotropolis scheduled for 2026, there are significant opportunities to improve the export capability of NSW horticultural businesses. Over the last two years, the VegNET NSW team has been working with NSW Department of Primary Industries, Western City Aerotropolis Authority and Hort Innovation to identify existing and potential export businesses and what challenges and opportunities are in this market sector. Currently, there is a range of export programs that is offered by AUSVEG, Regional Development Australia and the Western City Aerotropolis Authority. NSW VegNET project can play a key role in not only facilitating grower adoption of technologies, processes and innovation that are required to be 'export ready' but also identify and link businesses with the Future Food Systems Cooperative Research Centre and other programs involved in export development.

2. The Practice Gap

NSW Vegetable growers lack export preparedness, armed with some knowledge on accessing export opportunities through adoption of food safety and environmental management programs; Western City Aerotropolis Authority education programs; Good understanding of postharvest, packaging and air freight/shipping requirements, and linking interested parties to the Western Sydney University Technical Masterclass in Protected Cropping growers will have many market access doors opened.

3. Benefits of Bridging the Gap

The benefits of bridging the gap will prepare NSW vegetable growers in upscaling business to export level and being able to access premium paying markets outside of an already flooded Australian market so to gain a higher price and increase profits.

- Being export ready and improve long term profitability and access to new markets,
- Increased confidence and continued market access for' in demand' products,
- Diversification of markets for NSW growers,
- Opportunities to grow markets and export high value products,
- Improved out turn of product,
- Skilled and adaptable workforce pool to address supply shortages in the labour market for the protected cropping sector.

4. Project Objectives and Indicators

Objectives

- Growers increase knowledge of market access and export protocols.
- Extending information from Western City Aerotropolis Authority, Regional Development Australia, Hort Innovation and others.

Indicators

- A proportional number of NSW growers enrolled in WSU masterclass in protected cropping.
- Engaging with over 20% of industry participants. This seems low as only a small proportion will be geared up to export.

5. Project Strategy and Deliverables

WHAT, WHEN & WHERE?	BY WHO?	TO WHO?	FOR WHAT CHANGE?
1. Four Export preparedness workshops for NSW Vegetable growers	VegNET RDO and experts in export	Larger companies and growers with economies of scale in Sydney, Riverina, North Coast, Central Tablelands	Understanding of export requirements, Development of profitable co-ops for smaller growers.
2. Online food safety and environmental management programs	Freshcare	All growers and the supply chain	Meeting export customers' expectations for Global Food Safety Initiative (GFSI) standard. Increased adoption of Freshcare food safety and environmental programs, or equivalent.
3. Two Western City Aerotropolis Authority education seminars	Western City Aerotropolis	Growers close to urban areas such as Greater Sydney	Protected cropping vegetable industries in Greater Sydney as well as regional production areas in Central West NSW.
4. Two postharvest and packaging seminars, (delivered online or face-to-face)	Postharvest expert speakers	Growers, wholesalers, retails, consumers	Improved postharvest vegetable management and improved product quality. Less product wastage due to poor postharvest management.
5. Linking interested parties to Western Sydney University's Technical Masterclass in Protected Cropping	WSU	Growers, food companies such as Perfection Fresh	Greater uptake of the horticultural workforce in managing medium to high technology.

6. Capability and Collaboration

- NSW DPI, international engagement
- Western City Aerotropolis Authority
- AUSVEG
- NSW Farmers
- Freshcare
- Hort Innovation – marketing and trade

7. Budget

1. Four workshops at $3,000 each = $12,000
2. Online food safety webinar $3,000^
3. Two seminars at $4,500 incl venue and catering = $9,000*
4. Two postharvest/packing seminars $4,000 each = $8,000^
5. Linking to WSU PC masterclass, $2,000*

Total = $34,000 + 0.2 FTE and associated costs (administration, travel etc)

8. Benefit cost

Growers who take part and prepare for export will a better understanding of the quality standards and required specifications of vegetables to meet export market requirements. The follow on will be that growers will see the benefits of producing higher quality vegetables for the domestic market and hopefully receive a premium price for their produce. Lower quality produce marketed only leads to reduced prices.

9. Risks

Risk	Likelihood	Severity	Risk Mitigation Steps
Growers' unwillingness to participate in seminars	Low	High	Clear communication on the benefits to the growers and future opportunities.
Growers' concerns about creating a profitable cooperative	Possible	Medium	Investigate successful co-op's established and their steps taken to overcome issues
COVID-19	Medium	High	Implement COVID19 safe plan, Monitor health advice before events, Practise good hygiene and social distancing measures.
Lack of budget to deliver program	Medium	Medium	Delay project to 2021-22 season when VegNET budget position is known.

Pest and disease management including biosecurity and farm hygiene

1. The Problem or Opportunity

Several opportunities exist to increase and continue knowledge to the next level in pest and disease management including biosecurity and farm hygiene throughout NSW and amongst most grower groups. With recent and continued plant pest threats to Australia has highlighted further importance in increasing on-farm biosecurity. Some groups such as the Khmer growers in the Sydney Basin and the Chinese growers have very specific needs and would require very tailored extension activities for the highest gains in practice change. Biosecurity threats include Serpentine leafminer, Fall army worm, Spotted-winged drosophila, BMSB, Vegetable leafminer and Cucumber Green Mottle Mosaic Virus (CGMMV).

2. The Practice Gap

Pest and disease management with improved farm hygiene coupled with good biosecurity preparedness and practices will focus on integrated pest management, pest and disease identification (current, endemic and future threats), incorporating best practice spray application, with development and distribution of new and continued pest and disease spray tables in several major vegetable commodities. There is currently a need for targeted approaches to integrated pest management and major gaps exist in the understanding and effectiveness of chemical groupings and spray application efficiency, particularly in Cultural & Linguistically Diverse Background (CALD) communities.

3. Benefits of Bridging the Gap

The benefits of improving on-farm hygiene will result in reduction in agricultural waste, cleaner farms, lowering pest pressure, improvements in WHS and reduced risk of pesticide residues. Less and more judicious agrichemical use will lower biosecurity risks, improve integrated pest management (IPM), improve grower compliance with pesticide application and reduced input costs.

4. Project Objectives and Indicators

Objectives

Reinvigorate IPM principles in the growing community: Growers would be more aware of on-farm biosecurity processes, from order of entry to limiting traffic on their farms and learn about current plant pests and reporting biosecurity threats.

Improved strategic pest control using IPM: Growers would have better pesticide guides and understanding on available chemicals per crop, along with improved awareness of chemical regulations, safety and handling.

Using ‘Train the trainer’ program with agronomists and allied trade in IPM and ‘Keep It Clean’ program (Biosecurity) including peri-urban biosecurity training.

Indicators

Greater awareness of pest and disease pressure by 80%. Increased IPM uptake of 40% to 50%. 90% of grower attendees in the program will improve in spray application efficiency programs on the North Coast and Greater Sydney. 60 to 70% of grower attendees will embrace using selective pesticides and/or introduction of biocontrol agents on their farms.

5. Project Strategy and Deliverables

WHAT, WHEN & WHERE?	BY WHO?	TO WHO?	FOR WHAT CHANGE?
1. Ongoing farm visits, meet and greet at packing sheds/markets, demonstration farm. Webinar/brokering.	Matthew Plunkett	Allied trade	Identify gaps in chemical registrations, efficient and effect spray application, general IPM with scouting, seasonal observations, identification. 'Train the trainer' with flow on education to their grower clients of greater than 50%. Education on current biosecurity threats, surveillance, reporting, sampling and diagnostics on behalf of growers.
2. Five forums in the form of farm walks to include targeted grower visits. Learning about current biosecurity threats. Extending current levy funded resources and extension material.	AUSVEG Biosecurity team, Area Wide Management Project team, VegNET RDO	North Coast focus group and CALD growers in Greater Sydney	Increased adoption of surveillance and diagnostics validated with a series of follow up farm visits with a bi-lingual officer (if necessary). Mitigating pest incursion through education and awareness. Increased IPM adoption.
3. Creation and extension of Chemical Table's in major crops including Cucurbits, Brassicas, Lettuce, etc	VegNET RDO	Growers, Allied industry, Government	An instant tool for easier chemical selection for pest and diseases in promoting IPM.
4. Three workshops in best practice spray application and follow up farm visits.	Croplands, Matthew Plunkett	North Coast focus group and Chinese and Vietnamese growers in Greater Sydney	Greater confidence in pest and disease ID, chemical application/weed control. Increased IPM adoption.

6. Capability and Collaboration

- North Coast allied trade/resellers
- NSW DPI, Hort Innovation funded Area Wide Management team
- AUSVEG Biosecurity team
- Croplands
- North Coast LLS
- Bi-lingual officer in Greater Sydney

7. Budget

1. Ongoing farm visits $6,000 + webinar brokering $2,000^
2. Five workshops at $2,000 each + venue hire and catering $3,000 each = $25,000
3. Resource development $8,000
4. Three workshops at $3,000 each + $2,000 each catering and venue hire = $15,000

Total = $56,000 0.3 FTE& associated costs (administration, travel etc)

8. Benefit cost

Growers who adopt better farm hygiene reduce the risk of pest infestations. Awareness of early detection and reporting of exotic pests will lessen impact on productivity and market access, avoiding future restrictions.

Avoiding breaches in pesticide use (especially in peri-urban areas) gives a more positive perception from community of the vegetable industry. When there is a breach of pesticide use it casts a bad light over the whole industry. Correct use of pesticides reduces WHS risks and better targeted use of pesticides would give better pest control and reduce costs in labour and chemical products used over the longer term.

9. Risks

Risk	Likelihood	Severity	Risk Mitigation Steps
Growers' unwillingness to participate in farm walks	Low	High	Clear communication on the benefits to the grower.
Growers' concerns about sharing information restricts engagement	Possible	Low	Develop rules around shared vision, Revisit the vision at the start of every workshop/extension engagement.
COVID-19	Medium	High	Implement COVID19 safe plan. Monitor health advice before events, Practise good hygiene and social distancing measures.
Lack of budget to deliver program	Medium	Medium	Delay project to 2021-22 season when VegNET budget position is known.

Developing a soil health community of practice for the Australian Cambodian Growers Association of NSW and Australian Chinese Growers Association of NSW

1. The Problem or Opportunity

In 2016 and followed up in 2018, 16 growers participated in soil wealth extension which saw 13 Australian Cambodian farms participate in soil testing. Growers who applied compost to their soils were split into three groups based on their soil type, levels of organic matter and water permeability of their soil. This demonstration is a direct benefit of productivity and improved soil health. Given that the application of compost can take several years to see a direct benefit, particularly in terms of crop productivity, it is now prudent to follow up testing and determine the economic, physical, chemical and biological benefits resulting from this initial uptake by growers. Members of the Australian Chinese Growers in Greater Sydney will be introduced to the benefits of using cover crops and compost application to replicate what has been achieved in the past with the Australian Cambodian Growers in adopting improved soil management.

Growers will be encouraged to implement using cover crops, green manure crops and compost across established demonstration sites. Recently the Soil Wealth Team demonstrated and assisted an Australian-Cambodian Grower with cover crops and this has created a strong interest among other growers, creating a perfect moment to exploit the benefits to others. There is also an opportunity to contribute to the newly formed -Community of Practice on Facebook and work with Applied Horticultural Research through the Soil Wealth project to extend the work being undertaken and ultimately drive further practice change.

2. The Practice Gap

Poor soil management, over cultivation and lack of cover crops are common on these farms, particularly on the heavy clay loam soils in south western Sydney. These soils become difficult to manage when wet, and in the absence of interrow cover crops make some farm husbandry and harvesting practices difficult.

Essentially, the long-term benefits of adopting compost and other cover crops need to be substantiated, particularly the economic costs. This work also seeks to answer whether the rates of compost application (40m/ha, 30m/ha, 20m/ha) based on different variables such as organic matter content and permeability achieve the stated crop productivity and soil health benefits.

3. Benefits of Bridging the Gap

The benefits include increasing organic matter, better soil structure and improvement in plant health, which leads to suppression of pathogens and diseases and increase in crop productivity.

Improved soil structure will decrease damage done after rain events and allow growers to return to filed operations sooner. It will also improve aeration and water holding capacity, thus creating a water savings and increased water use efficiency. Planting out cover crops will decrease herbicide use in inter rows/ weed suppression in inter-rows and decrease fertiliser use.

4. Project Objectives and Indicators

Objectives

- 80% of attendees in the program participate in further testing and engagement within the project.
- 50% of the target audience involved in extension activities and engagement through the Soil Wealth/VegNET project and/or Facebook Community of Practice.

Indicators

- 60% to 80% of participants trialling one new cover crop rotation 'on farm',
- 60% of participating farms achieving at least one benefit in the areas of increased productivity and/or improved soil health, measured by soil testing and on farm discussions and extension and extensive project MERI surveys post demonstration,
- 10% engagement in other growers within the Community of Practice.

5. Project Strategy and Deliverables

WHAT, WHEN & WHERE?	BY WHO	TO WHO?	FOR WHAT CHANGE?
1. A farm walk extending the long-term benefits of compost and cover crop alternatives.	VegNET RDO, Bi-lingual officer and AHR Soil Wealth/UNE Integrated Weed Management	20-25 Australian-Cambodian growers including the 16 who participated in the program previously.	80% of participants engaged within the project and implement new cover crop rotations.
2. Soil testing for up to 13 previous Australian-Cambodian farms who received compost undertaken.	SESL and VegNET RDO	13 previous Australian-Cambodian participants who received compost application in 2018.	To gain information for reinforcing long term benefits of compost application.
3. Reports compiled for up to 13 farms who received compost previously.	VegNET RDO	13 previous Australian-Cambodian participants who received compost application in 2018.	Reinforce long term benefits in the areas of improved crop productivity and/or soil health.
4. A farm walk extending the long-term benefits of compost and cover crop alternatives.	VegNET IDO, Matthew Plunkett, Bi-lingual officer, AHR Soil Wealth/UNE Integrated Weed Management.	20-25 Australian-Chinese growers who are interested in Soil Wealth and other cover crops.	40 - 50% of the Australian Chinese Growers actively engaged and implement new cover crop rotations. Seek 12-14 Australian-Chinese farms who are interested in soil improvement.
5. Soil testing for up to 12-14 Australian-Chinese farms.	SESL and VegNET RDO	12-14 Australian-Chinese interested participants.	To gain information on where the growers stand in current soil health so a soil improvement amendment can be prescribed.
6. Reports complied for up to 12 Australian-Chinese farms soil tested and soil amendments prescribed and delivered.	SESL, ANL and VegNET RDO	12 Austrailian-Chinese farms	To show benefits in a practical way on demonstration farms (Chinese farms and GS LLS Demonstration Farm) to encourage growers to embrace and adopt best practices in soil health.
7. A farm walk extending the long-term benefits of compost and cover crop alternatives and prescribed results delivered.	SESL, ANL and VegNET RDO	20-25 Australian-Chinese growers who are interested in Soil Wealth and other cover crops.	Reinforce long term benefits in the areas of improved crop productivity and/or soil health.
8. Extend results on WeChat Community of Practice & VegNET direct engagement.	VegNET RDO, Bi-lingual officer and Matthew Plunkett	All (100+) Australian-Chinese Growers Association of NSW members.	Learning through sharing and engaging in other growers within the Community of Practice.
9. Extend results on Facebook Community of Practice & VegNET direct engagement.	VegNET RDO, Bi-lingual officer and Matthew Plunkett	All (30+) Australian-Cambodian Growers Association of NSW members.	Learning through sharing and engaging in other growers within the Community of Practice.

6. Capability and Collaboration

- AHR and Soil Wealth and Integrated Crop Protection
- UNE Integrated Weed Management
- Australian Native Landscapes (ANL)
- GSLLS Demonstration Farm in Richmond
- Bi-lingual officers and 'key leaders'

7. Budget

1. Farm walk Australian-Cambodian Growers $4,000
2. Soil testing $13,500
3. Reporting, translation $1,500
4. Farm walk Australian-Chinese Growers $4,000
5. Extend results to Australian-Chinese Growers $1,000
6. Extend results to Australian-Cambodian Growers $1,000

Total = $25,000 + 0.2 FTE and associated costs (administration, travel etc)

Project variation to:

1. 1 x Farm walk Australian-Cambodian Growers $4,000
2. Soil testing $17,000
3. Reporting, translation $1,500
4. 2 x Farm walks Australian-Chinese Growers $8,000
5. Extend results to Australian-Chinese Growers $ 2,500
6. Extend results to Australian-Cambodian Growers $ 2,500

Total = $35,500

8. Benefit Cost

Growers that implement compost and cover crops will increase soil organic matter, improve soil structure and improve crop health (from suppressing plant diseases) which will lead to improved crop productivity.

Better soil structure will decrease damage after rain and allow growers to return to the field sooner. Improving aeration and water holding capacity will save water and increase water use efficiency. Planting out cover crops will decrease herbicide use in inter rows with better inter-row weed suppression and decrease fertiliser use.

9. Risks

Risk	Likelihood	Severity	Risk Mitigation Steps
Growers' unwillingness to participate in field days or provide data on farm visits	Low	High	Clear communication on the benefits to the grower and the community of practice.
Growers' concerns about sharing information restricts engagement	Possible	Low	Develop rules around shared vision, Revisit the vision at the start of every workshop/extension engagement.
COVID-19	Medium	High	Implement COVIS19 safe plan, Monitor health advice before events Practise good hygiene and social distancing measures
Lack of budget to deliver program	Medium	Medium	Delay project to 2021-22 season when VegNET budget position is known.

Farm innovation and technology – Precision irrigation and nutrition management in sweet corn

1. The Problem or Opportunity

Irrigation and nutrition management in sweet corn production is the single most important determinant in achieving consistently high yields.

Work undertaken by Simplot, Queensland Department of Agriculture and Fisheries together with the NSW VegNET project in the Central Tablelands region has identified significant opportunities for growers to increase yields through better irrigation management and the use of Precision Irrigation technologies such as soil moisture monitoring.

Improving the efficiency of centre pivot and lateral move precision watering systems coupled with the use of satellite imagery, variable rate irrigation and nutrition applications and a targeted benchmarking and extension program can lift yields from an average of 18-20 tonne per hectare to over 25 tonnes per hectare.

2. The Practice Gap

Many growers are not achieving higher yields due to lack of water supply and availability, inefficient irrigation systems and/or not applying enough water at the critical growth stages of the crop.

Research has shown that irrigators are not applying enough water early in the crop cycle, particularly from crop growth stages 3-5 (days 42-66 – 12 leaves stage to tasselling/silking).

Crop water use can increase up to 400 per cent during this time and if the irrigation system cannot keep up with crop water use, significant reductions in yields will occur.

Further work is needed to demonstrate the yield benefits of using Irrisat technologies and the use of Variable Rate Irrigation and Nutrient applications and other soil moisture monitoring tools in sweet corn production.

3. Benefits of Bridging the Gap

- Higher crop yields
- Reduction in water use
- Lower energy costs
- Better financial returns per hectare
- Increase in water use efficiency

4. Project objectives and Indicators

Objectives:

- Growers develop the knowledge and skills to identify limitations and opportunities for improvement with their irrigation and nutrition management programs
- Practice change and adoption of precision technologies that lead to improved productivity with less resources.

Indicators:

- Growers reporting a change in knowledge, skills and attitudes through a targeted extension program
- Growers and industry reporting an increase in yields and adoption of precision irrigation and nutrition technologies.

5. Project Strategy and Deliverables

WHAT, WHEN &WHERE?	BY WHO?	TO WHO?	FOR WHAT CHANGE?
1. Farm visits over Summer /Autumn of 2020/21 with Simplot to determine current benchmarks for irrigation and nutrition management and extend current best practice information	Evan Brown and Matt Plunkett	20 Growers in the Bathurst, Dubbo & Cowra regions	Increase grower and the project teams understanding of current yield benchmarks and impediments to the adoption of precision technologies
2. Two Farm Walks/Field Days (March 2021 & September 2021) showcasing Precision Irrigation and Nutrition Management Technologies. Extend the latest R&D outcomes from the Precision Technologies levy funded project. Extending results of summer crop yield & Benchmarking /monitoring program to all growers.	Facilitated by Simplot Bathurst with support from the NSW VegNET team	Allied industry and 25 growers to 80% of the Sweet Corn growers on the Central Tablelands	50% increase in the knowledge, skills and attitudes of Sweet Corn growers on the Central Tablelands in relation to the application of precision technologies (including variable rate water and nutrition technologies being adopted at Simplot Bathurst)
3. Benchmarking irrigation through irrigation assessments (March – April 2021)	Simplot Bathurst & LLS Greater Sydney	2 growers across the Bathurst, Dubbo or Cowra regions	Improved irrigation efficiency from average of 65% to over 85%-90% across these properties
4. Survey growers on change in knowledge, skills and attitudes in relation to precision irrigation and nutrition management in Sweet Corn (August 2020)	NSW VegNET team with assistance from Simplot	25 growers in the Central Tablelands region	80% of growers demonstrate an improvement in knowledge, skills and attitudes in relation to precision irrigation and nutrition management in Sweet Corn. 10% adoption of precision irrigation and nutrition technologies in the Central Tablelands
5. Develop and extend two case studies to all growers (September/October 2021) to various forums including national VegNET network and Vegetables Australia magazine	NSW VegNET Team	Over 50 sweet corn growers in NSW	Case studies used to encourage other growers to adopt precision irrigation and nutrition technologies over the season of 2021/22.

6. Capability and Collaboration

- Central Tablelands Local Land Services Team
- Head Agronomist for Simplot, Evan Brown
- Irrigation/Allied Trade companies

- Applied Horticultural Research

7. Budget

Estimated annual project costs are as follows:

- 2 x Farm visits = $2,000
- 2 x Farm walks/field days = $4,000
- 2 Case Studies $1,000 each = $2,000
- 2 Irrigation assessments = $10,000

Total- $18,500 + 0.15 FTE and associated costs (administration, travel etc)

8. Benefit Cost

- Improving irrigation efficiency through 'on farm' testing can improve irrigation efficiency by 10-15% with centre pivot and lateral move systems.
- Yield increases per tonne will be compared with benchmarked irrigation data to report on returns per hectare and the savings in input costs.

9. Risks

Risk	Likelihood	Severity	Risk Mitigation Steps
Grower unwillingness to participate in field days or provide data on farm visits	Low	High	Clear communication on the benefits to the grower and Simplot
Wet Summer and Autumn delaying benchmarking of irrigation work	Medium	High	Undertake the irrigation assessments as soon as possible in March 2021, Use other historical data to develop case studies.
COVID-19	Medium	High	Implement COVID19 safe plan. Monitor health advice before events, Practise good hygiene and social distancing measures.
Lack of budget to deliver program	Medium	Medium	Delay project to 2021-22 season when VegNET budget position is known.

APPENDIX 3

Regional Extension Advisory Group for VegNET New South Wales, VG19011 – (CON-001894)

Terms of Reference (Issued: 24 September 2020)

PURPOSE OF THE REGIONAL EXTENSION ADVISORY GROUP (REAG)

To provide advice and guidance to Greater Sydney Local Land Services (GSLLS) to

- develop and implement the activities for the Hort Innovation funded project, *VegNET New South Wales* (VG19011), and
- develop and implement the NSW Regional Vegetable Extension Plan and its associated project plans,

to ensure it meets the needs of the NSW vegetable industry including growers, advisers, extension providers and other key stakeholders

MEMBERSHIP

Membership for the NSW REAG will comprise:

- Growers from the various production regions of NSW. As a minimum, this will include NSW North Coast, Central Tablelands and Greater Sydney growing areas;
- Allied industry representatives (rural traders, seed and agricultural chemical resellers), consultants and researchers from across NSW;
- Hort Innovation representative;
- NSW Regional Development Officer;
- Independent chair provided by Greater Sydney Local Land Services.

Membership in is by nomination and approval by the Greater Sydney Local Land Services' Agricultural Business Team with agreement by Hort Innovation.

Vacancy: If a REAG member must leave the group for any reason, a new REAG member will be appointed through the same process:

TIMEFRAME

The REAG will be formed in September 2020 and will be required to perform the duties as identified in the *Purpose* for the period of the life of this project (which ends in September 2021). Membership representatives during this period may change but the representation from different growing regions and independent advisers will remain (as per the *Membership*).

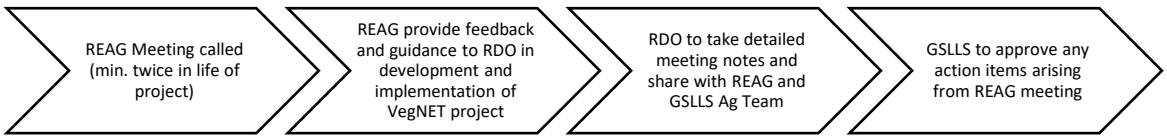
The REAG will meet twice a year before milestone reports are completed and approve the development of annual work plans and other activities as appropriate.

DUTIES OF THE REAG

The REAG is expected to:

- provide feedback and guidance to the NSW RDO in development and implementation of VegNET NSW project (VG19011) to ensure it meets the needs of the vegetable industry regionally including growers, advisors, extension providers and other key stakeholders.
- provide strategic direction with respect of regional input,
- review the regional extension plan and its associated project plans,
- provide guidance on any new priorities or areas for focus that may arise during the life of project,
- ensure the project stays focussed on delivering the project outcomes including review of progress and effectiveness,
- be a conduit between growers, research, extension and the commercial sector both within and across NSW regions,
- approve workplans.

The RDO will record meeting outcomes, feedback and correspondence (written or verbal) and share these notes with the REAG within two weeks of the meetings being held. GSLLS, as the contracted project delivery partner with Hort Innovation, require input and final approval on any action items arising from REAG meetings.



The Regional Extension Advisory Group members are (current 24 September 2020):

Growers	**Commodities**	**Group**	**Region**
Mario Muscat	Field vegetables, Demo Farm	Field vegetables	Greater Sydney
Val/Sam Micallef	Field vegetables (lettuce, sweet corn, brassicas, potatoes)	Field vegetables	Greater Sydney/Central Tablelands
Jason Chung	Field and hydroponics (Asian vegetables, parsley & herbs)	Field vegetables (Chinese Growers Association of NSW)	Greater Sydney
Nicky Mann	Snacking cucumbers	Protected cropping vegetables	Greater Sydney
Kim Ngov	Cucumbers, cherry tomatoes & herbs	Field and protected cropping vegetables (Cambodian Growers Association of NSW)	Greater Sydney
Paul/Kaka Singh	Cucumbers, beans, berries	Protected cropping vegetables	North Coast
Bari Mann	Cucumbers, solanaceous crops, berries	Pacific Blue Cooperative (Flavorite)	North Coast
Rhod Cook	Lettuce and herbs	Protected cropping vegetables	North Coast
Role	**Organisation**	**Group**	**Region**
Technical Advisors			
Darryl Cislowski	Ace Ohlsson	Agronomist / Reseller	Greater Sydney
Bahram Fayez	Clause Seeds	Seed company	Greater Sydney & North Coast
Johnny Capuyan	T&W Greenhouse	Agronomist / Reseller	Greater Sydney
Researchers			
Len Tesoriero	NSW DPI / Crop Doc Consulting	Researcher / Private consultant	All regions
Chris Fyfe	University of New England	Researcher	All regions
Regional Development Officers			
Sylvia Jelinek (Secretary & Admin Support)	Local Land Services Greater Sydney	Extension	All regions
Matt Plunkett	Local Land Services Greater Sydney	Extension	North Coast (support to Sylvia)
Hort Innovation			
Adrian Englefield	Hort Innovation	Regional Extension Manager	South East Australia
REAG Chair			
Jonathan Eccles	Local Land Services	REAG Chair	Greater Sydney / NSW

APPENDIX 4

VegNET NSW Regional Extension Strategy

Overview of region and summary of challenges and opportunities

The NSW VegNET project covers 4 geographical regions with a large diversity of crops and commodities grown. These regions include; Central Tablelands, Greater Sydney, North Coast & the Riverina.

NSW has the second highest number (24 percent) of vegetable businesses in Australia (Ref: ABARES 2018). Many farms in the state are less than 20 hectares in size but growing high value and potentially high return crops under advanced production systems such as protected cropping.

The NSW vegetable industry has undergone significant change over the last 10 years particularly in the peri-urban areas of Greater Sydney and the mid North Coast.

There are many challenges facing NSW vegetable producers including, but not limited to:

- rising land prices and urbanization
- ageing demographic & lack of succession planning
- new entrants into the industry, many of whom are from culturally and linguistically diverse backgrounds
- increasing input costs
- depressed market prices for some vegetable commodities
- climate change and drought
- environmental pressures that have all been drivers encouraging growers to look for efficiencies across the whole supply chain.

The vegetable industry is highly fragmented and culturally diverse in NSW. Over 80% of the Greater Sydney region growers are from a Cultural & Linguistically Diverse Background (CLDB) including, but not limited to: Arabic, Cambodian, Chinese and Vietnamese. These groups are resource hungry but need significant additional extension support.

Despite some growers leaving the industry in the Greater Sydney region, there are many new growers that have entered the industry in the last five years. These growers are keen to network and learn from 'key influencers' in the industry. They are often the early adopters of research and development (R&D) levy funded innovations. There is also a 'new cohort' of younger generation growers who see opportunity long term in the vegetable industry.

Many stakeholders in the Greater Sydney region wanted an independent site where they can view applied R&D innovations and trials. The Greater Sydney Local Land Services Demonstration Farm provides this function, with the Cambodian Growers also setting up a demonstration site in south western Sydney.

The establishment of the Western Sydney International Airport will bring significant opportunity for the horticultural sector in NSW. Private investment in protected cropping, training and retention of skilled labour, particularly in medium to high tech protected cropping is a major issue being addressed through the National Vegetable Protected Cropping Centre at Western Sydney University.

Detailed Monitoring, Evaluation, Reporting & improvement analysis undertaken by the NSW VegNET team identified opportunities in the following key areas.

- Water management and irrigation efficiency (focus on water recycling, irrigation management and water budgeting, drought resilience, water security)
- Export preparedness (focus on Western Sydney Airport)
- Pest and disease management (including farm hygiene through to biosecurity)
- Sustainable crop management (including agronomy, soil health, crop nutrition)
- Advanced production technologies (including protected cropping, drones, automation, remote sensing).

Regional Scan

Water Management & Irrigation Efficiency	Export preparedness	Sustainable Crop Management (Agronomy, New Varieties, Soil Health)	Pest and disease management (including biosecurity and farm hygiene)	Advanced production systems
Webinars on irrigation topics	AUSVEG Vegetable Industry Export program	Strip till webinar from EGVID	Fall armyworm Webinar	Technical Masterclass in Protected Cropping
Best practice irrigation demonstrations	Tracking interest with stakeholders i.e RDA5	EPA Compost Project GS LLS Demo Farm	Spotted winged drosophila, BMSB, Vegetable leaf miner	Precision Ag - QLD DAF
Non-urban Water Metering Framework	Export workshops linked with Western City Agri-precinct	Crop variety trials at GS LLS Demo Farm	Demo farm biosecurity procedures	Innovative weed & soil disease management (microwave technology)
Training in efficient water use in hydroponics		Soil Wealth ICP Demo Farms	Area wide management project	Stingless bees as Effective Managed Pollinators (WSU) and alternatives to honeybees
Precision irrigation of sweet corn		Integrated Weed Management & Optimising Cover Cropping (UNE, AHR, TIA, QDAF)	Biosecurity workshop with CALD growers	Innovative Smart Glass Research project (WSU)
			CGMMV incursion	Robotics Sydney Uni

Regional Gap Analysis

Water Management & Irrigation Efficiency	Export preparedness	Sustainable Crop Management (Agronomy, New Varieties, Soil Health)	Pest and disease management (including biosecurity and farm hygiene)	Advanced production systems
Extension in water and nutrient management in hydroponics (focus on water recycling and closed systems)	Export preparedness program for NSW Vegetable growers	NSW Vegetable Industry Expo and Field Days (held at the Greater Sydney LLS Demonstration Farm)	Best practice spray application workshops and follow up farm visits	Benchmarks for irrigation and nutrition management and extend current best practice information.
Irrigation management training for CLDB groups using potable water in the Greater Sydney region	Adoption of food safety and environmental management programs	Work with 'key growers' to share the benefits of long-term compost use & sustainable soil management practices (develop case studies)	Farmgate Biosecurity & Keep It Clean Training for protected cropping growers	Extension in the latest R&D outcomes from the Precision Technologies levy funded project.
	Linking interested parties to the Western Sydney University Technical Masterclass in Protected Cropping	Use existing networks and newsletters to promote soil health and management of soil borne disease (incl case studies)	Extend importance of legislated Chemical training & resource development for new Cultural & Linguistically Diverse Background growers	Extending results of summer crop yield & Benchmarking /monitoring program to all growers.
	Good understanding of postharvest and packaging requirements	Costs of production for different hydroponic crops	Chemical tables in other popular vegetable varieties	
	Western Sydney Aerotropolis education programs	Cucumber greenhouse nutrition training program	Better pest, disease and beneficial identification	
			IPM and IPM support	
			Basics of farm hygiene	

Ranked list of Potential Actions

Water Management and Irrigation Efficiency (Cluster - Irrigation training). Irrigation management is critical to the success of sustainable and profitable vegetable production. Extension events in the irrigation and training space is largely run in an ad hoc manner in NSW and GS LLS have two Certified Irrigation Agronomists who can work with Applied Horticultural Research to deliver integrated training in both the Central Tablelands and the Greater Sydney regions. To date, irrigation extension has not been marketed and promoted as efficiently and effectively as possible. Given the drought is still ongoing, targeted training in measuring irrigation system performance, water budgeting, irrigation scheduling and the use of precision technologies will ensure crop production is maximised per megalitre of water input.

Export Preparedness (Cluster - Brokering and Facilitating Opportunities for Growers and Industry). With the opening of the Western Sydney Airport in 2026, there is significant opportunity to improve the export capability of NSW Horticultural commodities. VegNET NSW, over the last 2 years has been working with the NSW Department of Primary Industries, Western Sydney Aerotropolis Authority and Hort Innovation to identify existing players and gaps in this space. Currently, there are a range of export programs that AUSVEG, Regional Development Australia and the Western Sydney Aerotropolis offer. The NSW VegNET project can play a key role in not only facilitating grower adoption of technologies, processes and innovation required to be 'export ready' but also identify and link businesses with the Food Production CRC and other programs involved in export.

Sustainable Crop Management (Cluster - R&D&E trials and using Enablers of Change to Drive Adoption). There has been a large amount of work being undertaken by Local Land Services, the Soil Wealth and Integrated Weed Management projects looking at sustainable crop management with a focus on soil health. The Greater Sydney Demonstration Farm and the Cambodian Growers Association of NSW Demonstration Farm are critical sites to build on current knowledge and leverage further extension opportunities. The VegNET NSW team, through the use of 'key informants' undertaking an extension campaign promoting the benefits of research undertaken by the Soil Wealth and Integrated Crop Protection projects in this area will help drive practice change. This would be enhanced through working with the allied trade and the seed companies to deliver commodity specific variety trial field days that are a 'key driver' to engage these market segments.

Pest and Disease management including biosecurity and farm hygiene (Cluster - IPM Training). Pest and disease management coupled with good biosecurity preparedness and practices will focus on integrated pest management, pest and disease identification (endemic and future threats), incorporating best practice spray application, with development and distribution of new and continued pest and disease spray tables in several major commodities. There is currently a need for targeted approaches to integrated pest management and major gaps exist in the understanding and effectiveness of chemical groupings and spray application efficiency, particularly in Cultural & Linguistically Diverse Background Communities.

Precision Irrigation and Nutrition Management (Cluster - Advanced Production Systems). Irrigation and nutrition management in sweet corn production is the single most important determinant in achieving consistently high yields. Work undertaken by Simplot, Queensland Department of Agriculture and Fisheries together with the NSW VegNET project in the Central Tablelands region has identified significant opportunities for growers to increase yields through better irrigation management and the use of Precision Irrigation technologies such as soil moisture monitoring. Improving the efficiency of centre pivot and lateral move precision watering systems coupled with the use of satellite imagery, variable rate irrigation and nutrition applications and a targeted benchmarking and extension program has the opportunity to lift yields from an average of 18-20 tonne per hectare to over 25 tonnes per hectare.

Appendix 5

VegNET NSW Project M&E Plan

1 Program logic

Figure 1.1 Logic model for Improving water and nutrient management for NSW protected cropping vegetables

Long term social, economic or environmentral outcome(s)	Growers implementing new practices improving economic, social and environmental outcomes			
End of project outcomes	10% of surveyed growers who have attended workshops have implemented some form of practice change on-farm resulting in water and nutrient savings. 5% of surveyed growers who have been part of extension activities have converted to closed or med/high tech systems that improve water and nutrient management 6 target growers who have converted to 'fully closed reticulation systems' with program support area achieving 40% savings in water and 60% savings in nutrients as a result of changed practice			
Intermediate outcomes (following extension activity)	80% of surveyed growers participating in the project indicate they now have a greater understanding of managing water and nutrient management "on-farm" as a result of attending workshops or receiving extension resources or being part of extension activities. 80% of surveyed allied trade participants in the project are providing new targeted and relevant advice to growers based on learnings or resources from the project 6 target growers are converting from 'open run to watste' to 'fully closed reticulation systems' with program support.			
Outputs	2 workshops developed and delivered targeting 20+ participants. 20+ workshop participants surveyed about knowledge change following workshops	2 x sites identified (existing) or developed (new) 2 x Fact Sheets developed and distributed to 60 growers profiling the demonstration sites	30 growers surveyed 1 Benchmark established	6 on-ground site visits undertaken and recommendations provided to 6 growers convert systems
Activities	Workshops (online and face to face) in best practice water and nutrition in greenhouse vegetable production	Case study demonstration sites identified or developed to show successful conversion from open run to waste to closed and / or higher tech systems	Face to face/telephone/online survey of growers (sample of new growers and medium/high tech growers) to a) benchmark current water and nutrition practices in greenhouse vegetable production for future comparison, and b) identify knowledge gaps and areas to change project scope	On-ground site visits to growers farms from an expert to provide technical support and recommendations for converting from 'open run to waste' systems to 'fully closed systems'
Foundational outputs	Workshop content and extension material developed based on best practice and objectives of program	The objectives of the demonstration farms are established and inform selection	Benchmark survey design	6 growers selected for targeted extension based on ability and willingness to make changes
Foundational activities	Establish the objectives of workshops and the intended outcomes	Establish the objectives of the demonstration farms	Appropriate benchmark survey developed to be used to benchmark current water and nutrition practices in greenhouse vegetable production	Establish criteria for selecting sites to visits and assist. Establish objectives of site visits and desired outcomes.

Figure 2.2 Logic model for Developing export preparedness for NSW vegetable growers

Long term social, economic or environmental outcome(s)	Improved capability of levy payers to adopt improved practices and new innovation through improved communication and extension programs, grower innovation support, professional development and workforce building programs, and through improved farm management and information systems.				
End of project outcomes	Growers increase knowledge of market access and export protocols. Extending information from Western City Aerotropolis Authority, Regional Development Australia, Hort Innovation and others.				
Intermediate outcomes (following extension activity)	A proportional number of NSW growers enrolled in WSU masterclass in protected cropping. Engaging with over 20% of industry participants. This seems low as only a small proportion will be geared up to export.				
Outputs	4 x Export preparedness workshops for NSW Vegetable growers, Sydney, Riverina, North Coast, Central Tablelands. 10 x attendees at each workshop.	20 x participants Online food safety and environmental management programs.	2 x Western City Aerotropolis Authority education seminars, 20 x participants at each.	2 x postharvest and packaging seminars, (delivered online or face-to-face). 20 x participants at each.	Linking interested parties to Western Sydney University's Technical Masterclass in Protected Cropping
Activities	Workshops for growers and industry educating on the processes in place for exporting interstate/overseas.	Online food safety and environmental management programs.	Western City Aerotropolis Authority education seminars.	Postharvest and packaging seminar	Western Sydney University's Technical Masterclass in Protected Cropping.
Foundational outputs	Develop/access content and extension material based on export processes and objectives of program.	Access content and facilitate extension of food safety and environmental management program.	Develop/access content and facilitate extension based on opportunities in the export space and objectives of program.	Workshop content and extension material developed based on best practice and objectives of program.	Broker information to interested/eligible parties.
Foundational activities	Establish communication lines with Federal Government export officers, AUSVEG export project team.	Re-establish relationship with Freshcare to discuss opportunities to expand and grow export opportunities with growers.	Establish relationship with Western City Aerotroplis Authority to discuss opporunties for them and within the vegetable industry.	Establish the objectives of workshops and the intended outcomes and establish communication lines with postharvest specialists.	Establish the objectives of the technical masterclass and the intended outcomes.

Figure 3.3 Logic model for Pest and Disease Management including biosecurity and farm hygiene

Long term social, economic or environmental outcome(s)	Improved capability of levy payers to adopt improved practices and new innovation through improved communication and extension programs, grower innovation support, professional development and workforce building programs, and through improved farm management and information systems.			
End of project outcomes	Reduced use of pesticides, reduced production cost and better pest control, Better use of pesticides and reduced input costs. Cleaner farms, lowers biosecurity risks, reduces costs in the long term. 50% of project participants are members of Soil Health Communities of Practice.			
Intermediate outcomes (following extension activity)	90% of attendees in the program will improve in spray application efficiency programs (North Coast) & Greater Sydney. 60-70% of attendees will embrace using selective pesticides and/or introduction of biocontrol agents on their farms. Building awareness of potential improvements.			
Outputs	3 x workshops in best practice spray application and follow up farm visits.	5 x forums to include targeted visits, farm walk and follow up one on one visits. Grower segment ie, North Coast greenhouse, Vietnamese greenhouse growers, Khmer growers, Chinese growers and Sydney growers.	Chemical tables extended out to VegNET NSW members.	Farm visits, meet and greet at packing sheds/markets, demonstration farm. Webinar/brokering
Activities	Workshops in best practice spray application and follow up farm visits	Forums to include targeted visits (likelihood to adopt change) Farm walk and follow up one on one visits.	Creation and extension of Chemical Table's in major crops including Cucurbits, Brassicas, Lettuce, etc.	'Train the trainer' program with agronomists and allied trade in IPM and 'Keep It Clean' program (Biosecurity) including peri-urban biosecurity extension.
Foundational outputs	Workshop content and extension material developed based on best practice and objectives of program.	Determine gaps in understanding and knowledge.	Develop chemical tables.	Compile content and extension material developed based on best practice and objectives of program.
Foundational activities	Establish the objectives of work shops and the intended outcomes. Connect with grower groups. Identify workshop sites.	Re-establish contact with growers and grower groups. Determine appropriate style of learning to assist project objectives.	Develop template for chemical tables.	Establish communication with allied industry members.

Figure 4.4 Logic model for Developing a soil health community of practice for the Australian Cambodian Growers Association of NSW and the Australian Chinese Growers Association of NSW.

Long term social, economic or environmentral outcome(s)	Improved capability of levy payers to adopt improved practices and new innovation through improved communication and extension programs, grower innovation support, professional development and workforce building programs, and through improved farm management and information systems.		
End of project outcomes	80% of project participants (Australian Cambodian Growers) have implemented practice change by trialling one new cover crop rotation 'on-farm' per year. 40% of project participants (Australian Chinese Growers) have implemented practice change by trialling one new cover crop rotation 'on-farm' per year. 60% of participating farms are achieving at least one measurable benefit in the areas of increases productivity and/or improved soil health, measured by soil testing results and post project participant surveys. 50% of project participants are members of Soil Health Communities of Practice.		
Intermediate outcomes (following extension activity)	13 Australian Cambodian Growers participating in the program undertstand their Farm soil test results, have learnt something new about their soil and intend to implement recommendations for continued improvement in soil health. 80% of Farm Walk participants have improved their knowledge and awareness of soil health as a result of attending events. 2 x Soil Health Communities of Practice established for both the Australian Cambodian and Australian Chinese Growers.		
Outputs	1 x Farm Walk for Cambodian growers with 15 anticipated attendees. 2 x Farm Walk for Australian Chinese Growers with 20 anticipated attendees.	13 x Farm soil tests undertaken and results interpreted in reports for each grower group.	2 x post on Australian Chinese Growers WeChat Community of Practice 1 x post on Australian Cambodian Growers Facebook Community of Practice 1 x post on VegNET network
Activities	Farm walks for growers extending the long term benefits of compost and cover crop alternatives.	Comprehensive Farm soil tests undertaken and interpreted on farms that have previously applied compost to demonstrate benefits - comparing with pre-compost application baseline and making recommendations for further soil improvements.	Extension of project messages and results via appropriate communication channels.
Foundational outputs	Farm Walk content and extension material developed based on best practice and objectives of program.	Soil Test paramaters determined. Pre-compost application benchmarks for comparison.	Develop template for communications.
Foundational activities	Establish the objectives of Farm Walks and the intended outcomes. Connect with grower groups. Identify Farm Walk sites.	Re-establish contact with growers who had previously applied compost. Identify growers to participate in soil testing. Determine appropriate soil testing paramaters to assist project objectives.	Establish communication lines with Codes of Practice administrators.

Figure 5.5 Logic model for Farm innovation and technology – Precision irrigation and nutrition management in sweet corn

Long term social, economic or environmentral outcome(s)	Improved capability of levy payers to adopt improved practices and new innovation through improved communication and extension programs, grower innovation support, professional development and workforce building programs, and through improved farm management and information systems.					
End of project outcomes	Improved irrigation efficiency from average of 65% to over 85%-90% across these properties. Case studies used to encourage other growers to adopt precision irrigation and nutrition technologies over the season of 2021/22.					
Intermediate outcomes (following extension activity)	50% increase in the knowledge, skills and attitudes of Sweet Corn growers on the Central Tablelands in relation to the application of precision technologies (including variable rate water and nutrition technologies being adopted at Simplot Bathurst). 80% of growers demonstrate an improvement in knowledge, skills and attitudes in relation to precision irrigation and nutrition management in Sweet Corn. 10% adoption of precision irrigation and nutrition technologies in the Central Tablelands. Increase grower and the project teams understanding of current yield benchmarks and impediments to the adoption of precision technologies.					
Outputs	Farm visits over Summer /Autumn of 2020/21 with Simplot to determine current benchmarks for irrigation and nutrition management and extend current best practice information.	2 x Farm Walks/Field Days showcasing Precision Irrigation and Nutrition Management Technologies. Extend the latest R&D outcomes from the Precision Technologies levy funded project. Extending results of summer crop yield & Benchmarking /monitoring program to all growers.	2 x benchmarking irrigation through irrigation assessments.	Survey growers on change in knowledge, skills and attitudes in relation to precision irrigation and nutrition management in Sweet Corn.	Develop and extend 2 case studies to all growers in various forums including national VegNET network and *Vegetables Australia* magazine.	
Activities	Farm visits over Summer /Autumn to determine current benchmarks for irrigation and nutrition management and extend current best practice information.	Farm Walks/Field Days showcasing Precision Irrigation and Nutrition Management Technologies.	Benchmarking irrigation through irrigation assessments.	Survey growers.	Develop 2 x case studies.	
Foundational outputs	Benchmark survey design.	Farm walks content and extension material developed based on best practice and objectives of program.	Benchmark assessments.	Survey design.	Develop case studies.	
Foundational activities	Appropriate benchmark survey developed to be used to benchmark current water and nutrition practices in sweet corn.	Establish the objectives of workshops and the intended outcomes.	Appropriate benchmark survey developed to be used to benchmark current water and nutrition practices in sweet corn.	Appropriate survey developed to be used.	Approach grower/situation to be an appropriate case study/s.	

2 Project M&E scope

2.1 Audience

Table 1: M&E audience and their information needs

Audience	Information need
Primary	
Project team	Extension priorities from Hort Innovation SIP Regional Extension Advisory Group (REAG) R&D products Feedback on project progress from Hort Innovation
Hort Innovation	Progress reports on project implementation
Rate/levy payers and growers	Evidence of rates resulting in outcomes
Secondary	
Co-investors; NSW DPI projects	Evidence of rates resulting in outcomes
Project partners, WSU, AHR	Evidence of rates resulting in outcomes

2.2 Key evaluation questions

Table 2: Project key evaluation questions

Key evaluation questions	Relevant?	Project-specific questions
Effectiveness		
1. To what extent has the project achieved its expected outcomes?	Yes	To what extent has the project increased the adoption of the industry Best Practice Guidelines?
Relevance		
2. How relevant was the project to the needs of intended beneficiaries?	Yes	To what extent has the project met the needs of industry levy payers?
Process appropriateness		
3. How well have intended beneficiaries been engaged in the project?	Yes	To what extent was the target engagement levels of industry levy payers achieved? Have regular project updates been provided through linkage with the industry communication project?
4. To what extent were engagement processes appropriate to the target audience/s of the project?	Limited by 9-month timeframe	Did the project engage with industry levy payers through their preferred learning style? How accessible were extension events to industry levy payers?
Efficiency		
5. What efforts did the project make to improve efficiency?	Limited by 9-month timeframe	What efforts did the project make to improve efficiency?

2.3 M&E budget

Work planning	$1,000
Project evaluation and Final Report	$4,000

3 Performance expectations, data collection and analysis

Table 3.1: Project monitoring plan for Regional NSW Improving Water and Nutrient Management in the NSW Greenhouse Protected Cropping Industry				
What will you deliver?	**Who?**	**What change?**	**What to Measure**	**Data Collection & Reporting (Responsibility/Timing)**
1. Two workshops per year in best practice water and nutrition in greenhouse vegetable production developed and delivered (both online and face to face).	New greenhouse vegetable growers with low tech systems in the cooperatives and agronomists.	80% of attendees have a greater understanding of managing water and nutrient and can demonstrate a 10% savings in water and nutrient management as a result of attending the training.	1a. Document the timing, location, and content of the workshops, and numbers details of participants involved. 1b. Proportion of participants who change understanding of managing water and nutrient, and aspiration to change practice. 1c. Savings in water and nutrient management as a result of attending the workshops, and proportion who save 10%	• Report 1a (by RDO, after each event) –collected from attendance records into spreadsheet, reported as table in next milestone report. • Conduct, analyse and report assessment of 1b (by RDO, after each event) - collected by a paper questionnaire at the end of workshop, reported as a written report in next milestone report. • Conduct, analyse and report assessment of 1c, (by RDO, when data is available) - collected by grower measurement/ records, reported as a written report in milestone when enough time has lapsed for changes to be made and data to be collected.
2. Using case study demonstration sites to show successful conversion from open run to waste to closed and or higher tech systems. (2/year)	Growers who have attended the workshops and likely to consider changing to closed and/or higher tech systems.	5% of growers adopting closed and or med to high tech growing systems that improve water and nutrient management.	2a. Document case study demonstration farms. 2b. Proportion of growers adopting closed and or med to high tech growing systems that improve water and nutrient management and assess whether that was influenced by the training and/or case study.	• Report 2a (by RDO, when data is available) –from project records, reported as a written description in the next milestone. • Conduct, analyse and report assessment of 2b (by RDO, when data is available) - collected from grower measurement/ records and assessment of attribution by questionnaire, reported as a stand-alone case study and in milestone report.
3. Annual benchmarking surveys in current water and nutrition practices in greenhouse vegetable production.	New growers and a sample of med/high tech growers.	Identification of gaps and areas to change project scope (adaptive management).	3a. Document the timing, location, and content of benchmarking activities, and numbers details of participants involved. 3b. Proportion of participants who identified gaps, and those who made changes, and document the opportunities and changes.	• Report 3a (by RDO, by RDO) –collected from survey data into spreadsheet, reported a table in milestone report. • Conduct, analyse and report assessment of 3b (by RDO, once surveying is completed) - collected by an action plan completed by participants, reported as a written report in milestone report.
4. Six individual trips to the North Coast for targeted extension and support in converting from 'open run to waste' to 'fully closed systems'.	Top Tier Growers using advanced technologies.	40% saving in water and up to 60% savings in nutrient inputs.	4a. Document the timing, location, and content of targeted extension, and numbers details of participants involved. 4b. Extent of saving in water and nutrient inputs, and proportion who saved 40% and 60% respectively.	• Report 4a (by RDO, by when support work is completed) – collected from attendance records into spreadsheet, reported a table next milestone report. • Conduct, analyse and report assessment of 4b (by RDO, when data is collected) - collected by grower measurement/ records, reported as a written report in milestone report.

Table 3.2: Project monitoring plan for Developing export preparedness for NSW vegetable growers

What will you deliver?	Who?	What change?	What to Measure	Data Collection & Reporting (Responsibility/Timing)
1. Four Export preparedness workshops for NSW Vegetable growers	Larger companies and growers with economies of scale in Sydney, Riverina, North Coast, Central Tablelands	Understanding of export requirements. Development of profitable co-ops for smaller growers.	1a. Document the timing, location, and content of the workshops, and numbers details of participants involved. 1b. Proportion of participants who change understanding of export preparedness, and aspiration to change practice.	• Report 1a (by RDO, after the events) –collected from attendance records into spreadsheet, reported as a table in milestone report. • Conduct, analyse and report assessment of 1b (by RDO, by RDO) - collected by a paper questionnaire at the end of workshop, reported as a written report in next milestone report.
2. Online food safety and environmental management programs	All growers and the supply chain	Meeting export customers' expectations for Global Food Safety Initiative (GFSI) standard. Increased adoption of Freshcare food safety and environmental programs, or equivalent.	2a. Document the timing and numbers of participants in Online food safety and environmental management programs. 2b. Proportion of growers adopting Freshcare and Freshcare Environmental accreditation.	• Report 2a (by Freshcare, when Online programs are completed) – from project records, reported as a written description in milestone report. • Conduct, analyse and report assessment of 2b (by Freshcare/RDO, when registrations are completed) - collected from grower and assessment of attribution by questionnaire, reported as a written report in milestone report.
3. Two Western City Aerotropolis Authority education seminars	Protected cropping vegetable industries in Greater Sydney as well as regional production areas in Central West NSW.	Understanding of changing agribusiness opportunities.	3a. Document the timing, location, and content of the workshops, and numbers details of participants involved. 3b. Proportion of participants who change understanding of agribusiness opportunities, and aspiration to change practice.	• Report 3a (by RDO, after the events) –collected from attendance records into spreadsheet, reported as a table in milestone report. • Conduct, analyse and report assessment of 3b (by RDO, by RDO) - collected by a paper questionnaire at the end of workshop, reported as a written report in next milestone report.
4. Two postharvest and packaging seminars, (delivered online or face-to-face)	Growers, wholesalers, retails, consumers	Improved postharvest vegetable management and improved product quality. Less product wastage due to poor postharvest management.	4a. Document the timing, location, and content of the workshops, and numbers details of participants involved. 4b. Proportion of participants who change understanding of postharvest best practice, and aspiration to change practice. 4c. Savings in food wastage and having greater product quality as a result of attending the seminar.	• Report 4a (by RDO, after each event) –collected from attendance records into spreadsheet, reported as table in next milestone report. • Conduct, analyse and report assessment of 4b (by RDO, after each event) - collected by a paper/online questionnaire at the end of seminar, reported as a written report in next milestone report. • Conduct, analyse and report assessment of 4c, (by RDO, when data is available) - collected by grower measurement/ records, reported as a written report in milestone when enough time has lapsed for changes to be made and data to be collected.
5. Linking interested parties to Western Sydney University's Technical Masterclass in Protected Cropping	Growers, food companies such as Perfection Fresh	Greater uptake of the horticultural workforce in managing medium to high technology.	5a. Document the details and referrals of linking to Masterclass.	• Report 5a (by RDO, when necessary) –collected from conversation records into spreadsheet, reported as table in next milestone report.

Table 3.3: Project monitoring plan for Pest and disease management including biosecurity and farm hygiene				
What will you deliver?	**Who?**	**What change?**	**What to Measure**	**Data Collection & Reporting (Responsibility/Timing)**
1. Ongoing farm visits, meet and greet at packing sheds/markets, demonstration farm. Webinar/brokering.	Allied trade	Identify gaps in chemical registrations, efficient and effect spray application, general IPM with scouting, seasonal observations, identification. 'Train the trainer' with flow on education to their grower clients of greater than 50%. Education on current biosecurity threats, surveillance, reporting, sampling and diagnostics on behalf of growers.	1a. Document the timing, location, and content of the meet and greets, and numbers details of participants involved. 1b. Proportion of participants who change understanding of pest and disease management, and aspiration to share information with their clients. 1c. Savings in savings in water and nutrient management as a result of attending the training, and proportion who save 10%	• Report 1a (by RDO, on completion of event/s) –collected from attendance records into spreadsheet, reported a table in milestone report. • Conduct, analyse and report assessment of 1b (by RDO, on completion of event/s) - collected by a paper questionnaire at the end of event, reported as a written report in milestone report. • Conduct, analyse and report assessment of 1c (by RDO, after each event) - collected by an online questionnaire at the end of webinar/s, reported as a written report in next milestone report.
2. Five forums in the form of farm walks to include targeted grower visits. Learning about current biosecurity threats. Extending current levy funded resources and extension material.	North Coast focus group and CALD growers in Greater Sydney	Increased adoption of surveillance and diagnostics validated with a series of follow up farm visits with a bi-lingual officer (if necessary). Mitigating pest incursion through education and awareness. Increased IPM adoption.	2a. Document the timing, location, and content of the workshop, and numbers details of participants involved. 2b. Proportion of growers improving their understanding in IPM, exotic pest mitigation and on farm biosecurity with increased adoption in IPM.	• Report 2a (by RDO, after each event) –from project records, reported as a written description in next milestone report. • Conduct, analyse and report assessment of 2b (by RDO, after each event) - collected from grower measurement/ records and assessment of attribution by questionnaire, reported as a written report in milestone report.
3. Creation and extension of Chemical Table's in major crops including Cucurbits, Brassicas, Lettuce, etc	Growers, Allied industry, Government	An instant tool for easier chemical selection for pest and diseases in promoting IPM.	3a. Proportion of recipients who make chemical selection changes to improve performance in targeted spraying to save money and time in the long term.	• Report 3a (by RDO, on completion of delivery) –collected from recipient and recorded in a spreadsheet, reported a table in milestone report.
4. Three workshops in best practice spray application and follow up farm visits.	North Coast focus group and Chinese and Vietnamese growers in Greater Sydney	Greater confidence in pest and disease ID, chemical application/weed control. Increased IPM adoption.	4a. Document the timing, location, and content of the workshop, and numbers details of participants involved. 4b. Proportion of growers improving their understanding in IPM, pest and disease identification and chemical application.	• Report 4a (by RDO, on completion of event/s) –collected from attendance records into spreadsheet, reported a table in milestone report. • Conduct, analyse and report assessment of 4b (by RDO, on completion of event/s) - collected by a paper questionnaire at the end of event, reported as a written report in milestone report.

Table 3.4: Project monitoring plan for Developing a soil health community of practice for the Australian Cambodian Growers Association of NSW and Australian Chinese Growers Association of NSW				
What will you deliver?	**Who?**	**What change?**	**What to Measure**	**Data Collection & Reporting (Responsibility/Timing)**
1. A farm walk extending the long-term benefits of compost and cover crop alternatives.	20-25 Australian-Cambodian growers including the 16 who participated in the program previously.	80% of participants engaged within the project and implement new cover crop rotations.	1a. Document the timing, location, and content of the farm walk, and numbers details of participants involved. 1b. Proportion of participants who change understanding of compost and cover crops, and aspiration to change practice. 1c. Savings in water and herbicide use as a result of attending the farm walk, and proportion who save 10%	• Report 1a (by RDO, after the event) –collected from attendance records into spreadsheet, reported as a table in milestone report. • Conduct, analyse and report assessment of 1b (by RDO, after the event) - collected by a paper questionnaire at the end of the workshop, reported as a written report in next milestone report. • Conduct, analyse and report assessment of 1c, (by RDO, after the event) - collected by grower measurement/ records, reported as a written report in next milestone report.
2. Soil testing for up to 13 previous farms who received compost undertaken.	13 previous Australian-Cambodian participants who received compost application in 2018.	To gain information for reinforcing long term benefits of compost application.	2a. Document activity, content, numbers details and participants involved.	• Report 2a (by RDO, after activity) –from project records, reported as a written description in a table in the next milestone report.
3. Reports compiled for up to 13 farms who received compost previously.	13 previous Australian-Cambodian participants who received compost application in 2018.	Reinforce long term benefits in the areas of improved crop productivity and/or soil health.	3a. Measuring soil improvements over time.	• Conduct, analyse and report assessment of 3a, (by RDO, when testing is completed) - collected by RDO and measured and reported by SESL. Reported as a written report in next milestone report.
4. A farm walk extending the long-term benefits of compost and cover crop alternatives.	20-25 Australian-Chinese growers who are interested in Soil Wealth and other cover crops. Seek 12-14 Australian-Chinese farms interested in soil improvement.	40 - 50% of the Australian Chinese Growers actively engaged and implement new cover crop rotations.	4a. Document the timing, location, and content of the farm walk, and numbers details of participants involved. 4b. Proportion of participants who change understanding of compost and cover crops, and aspiration to change practice. 4c. Savings in water and herbicide use as a result of attending the farm walk, and proportion who save 10%	• Report 4a (by RDO, after the event) –collected from attendance records into spreadsheet, reported as a table in milestone report. • Conduct, analyse and report assessment of 4b (by RDO, after the event) - collected by a paper questionnaire at the end of the workshop, reported as a written report in next milestone report. • Conduct, analyse and report assessment of 4c, (by RDO, after the event) - collected by grower measurement/ records, reported as a written report in next milestone report.
5. Soil testing for up to 12-14 Australian-Chinese farms.	12-14 Australian-Chinese interested participants.	To gain information on where the growers stand in current soil health so a soil improvement amendment can be prescribed.	5a. Document activity, content, numbers details and participants involved.	• Report 5a (by RDO, after activity) –from project records, reported as a written description in a table in the next milestone report.

6. Reports complied for up to 12 Australian-Chinese farms soil tested and soil amendments prescribed and delivered.	12 Austrailian-Chinese farms	To show benefits in a practical way on demonstration farms (Chinese farms and GS LLS Demonstration Farm) to encourage growers to embrace and adopt best practices in soil health.	6a. Setting a benchmark for future testing to show improvements (benefit comes with time).	• Report 6a (by RDO, after activity) –from project records, reported as a written description in a table in the next milestone report.
7. A farm walk extending the long-term benefits of compost and cover crop alternatives and prescribed results delivered.	20-25 Australian-Chinese growers who are interested in Soil Wealth and other cover crops.	Reinforce long term benefits in the areas of improved crop productivity and/or soil health.	7a. Document the timing, location, and content of the farm walk, and numbers details of participants involved. 7b. Proportion of participants who change understanding of compost and cover crops, and aspiration to change practice. 7c. Savings in water and herbicide use as a result of attending the farm walk, and proportion who save 10%	• Report 7a (by RDO, after the event) –collected from attendance records into spreadsheet, reported as a table in milestone report. • Conduct, analyse and report assessment of 7b (by RDO, after the event) - collected by a paper questionnaire at the end of the workshop, reported as a written report in next milestone report. • Conduct, analyse and report assessment of 7c, (by RDO, after the event) - collected by grower measurement/ records, reported as a written report in next milestone report.
8. Extend results on WeChat Community of Practice & VegNET direct engagement.	All Australian-Chinese Growers Association of NSW members.	Learning through sharing and engaging in other growers within the Community of Practice.	8a. Document amount of views/social media interactions. 8b. Proportion of participants who change understanding of compost and cover crops, and aspiration to change practice.	• Report 8a (by Bi-lingual Officer, periodically) –collected from social media driven data, reported as a table in milestone report. • Conduct, analyse and report assessment of 8b, (by RDO, after the event) - collected by grower measurement/ records, reported as a written report in next milestone report.
9. Extend results on Facebook Community of Practice & VegNET direct engagement.	All Australian-Cambodian Growers Association of NSW members.	Learning through sharing and engaging in other growers within the Community of Practice.	9a. Document amount of views/social media interactions. 9b. Proportion of participants who change understanding of compost and cover crops, and aspiration to change practice.	• Report 9a (by Bi-lingual Officer, periodically) –collected from social media driven data, reported as a table in milestone report. • Conduct, analyse and report assessment of 9b, (by RDO, after the event) - collected by grower measurement/ records, reported as a written report in next milestone report.

Table 3.5: Project monitoring plan for Farm innovation and technology – Precision irrigation and nutrition management in sweet corn				
What will you deliver?	**Who?**	**What change?**	**What to Measure**	**Data Collection & Reporting (Responsibility/Timing)**
1. Farm visits over Summer /Autumn of 2020/21 with Simplot to determine current benchmarks for irrigation and nutrition management and extend current best practice information.	20 Growers in the Bathurst, Dubbo & Cowra regions.	Increase grower and the project teams understanding of current yield benchmarks and impediments to the adoption of precision technologies.	1a. Document the timing, location, and content of benchmarking activities, and numbers details of participants involved. 1b. Proportion of participants who identified gaps, and those who made changes, and document the opportunities and changes.	• Report 1a (by RDO, by RDO) –collected from survey data into spreadsheet, reported a table in milestone report. • Conduct, analyse and report assessment of 1b (by RDO, once surveying is completed) - collected by an action plan completed by participants, reported as a written report in milestone report.
2. Two Farm Walks/Field Days (March 2021 & September 2021) showcasing Precision Irrigation and Nutrition Management Technologies. Extend the latest R&D outcomes from the Precision Technologies levy funded project. Extending results of summer crop yield & Benchmarking /monitoring program to all growers.	Allied industry and 25 growers to 80% of the Sweet Corn growers on the Central Tablelands.	50% increase in the knowledge, skills and attitudes of Sweet Corn growers on the Central Tablelands in relation to the application of precision technologies (including variable rate water and nutrition technologies being adopted at Simplot Bathurst).	2a. Document the timing, location, and content of the farm walk, and numbers details of participants involved. 2b. Proportion of participants who change understanding of precision irrigation and nutrition management technologies and aspiration to change practice. 12c. Savings in water and nutrient use as a result of attending the farm walk, and proportion who save 10%	• Report 2a (by RDO, after the event) –from project records, reported as a written description in the next milestone report. • Conduct, analyse and report assessment of 2b (by RDO, after the event) - collected from grower measurement/ records and assessment of attribution by questionnaire, reported as a written report in the next milestone report. • Conduct, analyse and report assessment of 2c, (by RDO, when data is available) - collected by grower measurement/ records, reported as a written report in next milestone report.
3. Benchmarking irrigation through irrigation assessments (March – April 2021).	2 growers across the Bathurst, Dubbo or Cowra regions.	Improved irrigation efficiency from average of 65% to over 85%-90% across these properties.	3a. Document case study demonstration farms. 3b. Proportion of sweet corn growers adopting best practice water and nutrition management and assess whether that was influenced by the farm walk/s.	• Report 3a (by RDO, when data is available) –from project records, reported as a written description in the next milestone. • Conduct, analyse and report assessment of 3b (by RDO, when data is available) - collected from grower measurement/ records and assessment of attribution by questionnaire, reported as a stand-alone case study and in milestone report.
4. Survey growers on change in knowledge, skills and attitudes in relation to precision irrigation and nutrition management in Sweet Corn (August 2020).	25 growers in the Central Tablelands region.	80% of growers demonstrate an improvement in knowledge, skills and attitudes in relation to precision irrigation and nutrition management in Sweet Corn. 10% adoption of precision irrigation and nutrition technologies in the Central Tablelands.	4a. Document changes in knowledge, skills, attitudes and aspirations in precision irrigation and nutrition management in sweet corn. 4b. Proportion of growers adopting best practice irrigation and nutrition management in sweet corn.	• Report 4a (by RDO, on completion of survey) –from project records, reported as a written description in the next milestone. • Conduct, analyse and report assessment of 4b (by RDO, when data is available) - collected from grower measurement/ records and assessment of attribution by questionnaire, reported in milestone report.
5. Develop and extend two case studies to all growers (September/October 2021) to various forums including national VegNET network and Vegetables Australia magazine	Over 50 sweet corn growers in NSW	Case studies used to encourage other growers to adopt precision irrigation and nutrition technologies over the season of 2021/22.	5a. Document case study on two assessed farms. 5b. Proportion of participants who change understanding of precision irrigation and nutrition management technologies and aspiration to change practice.	• Report 5a (by RDO, when data is available) –from project records, reported as a written description in the next milestone. • Conduct, analyse and report assessment of 5b (by RDO, when data is available) - collected from grower measurement/ records and assessment of attribution by final assessment, reported as a stand-alone case study and in milestone report.

4 Evaluation

Table 4: Additional evaluation data requirements

KEQ	Data collection requirement	Source and method
To what extent has the project increased the adoption of the industry Best Practice Guidelines?	Post extension evaluations.	Surveys
To what extent has the project met the needs of industry levy payers?	Number of attendees at consultations and events. Satisfaction level of participants.	Records Surveys
To what extent were the target engagement levels of industry levy payers achieved?	Number of attendees at consultations and events. Growth and size of Network.	Records
Have regular project updates been provided through linkage with the industry communication project?	Attendance and updates at VegNET Team meetings. Number of Newsletters.	Records
Did the project engage with industry levy payers through their preferred learning style?	Satisfaction level of participants with communication styles.	Survey
How accessible were extension events to industry levy payers?	Number of attendees.	Records
What efforts did the project make to improve efficiency?	N/A within short time frame.	N/A

Table 5: Independent evaluation studies (as required by Hort Innovation)

Type of evaluation	When (start and finish)
Mid-term evaluation	N/A with short timeframe
Final evaluation	At end of project

5 Reporting and continuous improvement

Table 6: Project progress reporting

Report type	To whom	Timing
Milestone Reports	Hort Innovation	Quarterly
Final Reports	Hort Innovation	At end of project
Articles	Industry magazine	Quarterly
Written and verbal update	Project Reference Group	Quarterly
Financial reports	Hort Innovation	At end of project

Table 7: Project continuous improvement activities

Continuous improvement process	Details	Timing
Reflection meeting with Hort Innovation Regional Extension Manager	Meeting between Regional Extension Manager, R&D Manager/Marketing Manager and Delivery Partner to discuss progress to-date and what's working well/not, and agree any follow up actions.	Six-monthly
Team meetings	Meeting between project team members to discuss project trials and their timing/Meeting between project team members to discuss feedback from extension event participants to determine gaps in adoption and preferred learning styles for incorporation into project.	Quarterly
Project Reference Group meetings	Meetings between project team members, Hort Innovation and industry representatives to gain feedback on project activities and refine methodology.	Quarterly
VegNET RDO's	Meetings between VegNET RDO's, Hort Innovation and Peak Industry Body representatives to gain feedback on project activities and refine methodology.	Monthly to bi-monthly

APPENDIX 6. NSW VegNET Stakeholder Engagement Plan 2020- 2021

(1) Who: Organisation and key contact person	*(2) Relationship status* ES: Existing strong ED: Existing develop P: previous (inactive) N: New	*(3) Engagement opportunity (role)*	*(4) Benefits of engagement*	*(5) Partnership constraints (if any) and how these will be addressed*	*(6) Communication and engagement strategies*
Hort Innovation (Adrian Englefield)	ES	To demonstrate the return on investment and demonstrate the benefit of R&D to growers and government.	Project delivering on outcomes in an efficient and effective manner.	Short term funding, loss of key staff and a measurable extension strategy that maximises the project reach and collaboration within VegNET.	Milestone reports, project outputs in the form of media releases and teleconferences, industry journal articles, engagement with key representatives.
AUSVEG – Peak industry body (Zarmeen Hassan)	ES	To leverage R&D through AUSVEG's communication and extension platforms.	A greater number of levy payers exposed to and aware of levy funded R&D (ie Biosecurity).	PIB not recognising the value of R&D investment, ensuring effective communication and building of partnerships.	Bi- monthly VegNET RDO meetings. An article per edition in the Vegetables Australia magazine and regular contact with technical staff on relevant projects and issues.
Protected Cropping-Australia - Peak Industry Body (Nicky Mann)	ES	To extend R&D and participate in Industry development activities to grow the protected cropping in NSW.	Increase engagement across low, medium and high-tech sectors of the industry.	PIB not recognising the value of R&D investment, ensuring effective communication and building of partnerships.	Through promotion of R&D relevant to PC through Soilless magazine and participating in regional tours.
Resellers, rural traders (several across LLS regions)	ES	Assist VegNET to promote and identify R&D opportunities and benefits of practice change.	Using them as intermediaries to enable the delivery and adoption of R&D outcomes by growers, and help grow the VegNET subscription list.	Differing messages being communicated to growers leading to doubt, loss of reputation and impeding adoption of R&D outcomes, building strong relationships.	Invitation to workshops, participate in trials on demonstration farms, extending R&D at targeted locations and events.
Seed companies (ie Bahram Fayez from Clause)	ES	Assist VegNET to promote and identify R&D opportunities and benefits of practice change.	Using them as intermediaries to enable the delivery and adoption of R&D outcomes by growers, and help grow the VegNET subscription list.	Differing messages being communicated to growers leading to doubt, loss of reputation and impeding adoption of R&D outcomes, building strong relationships.	Invitation to workshops, participate in trials on demonstration farms, extending R&D at targeted individual extension visits with key influencers.
Agronomists (several. Key contact is Daryl Cislowsk, Ace Ohlsson)	ES	Assist VegNET to promote and identify R&D opportunities and benefits of practice change.	Using them as intermediaries to enable the delivery and adoption of R&D outcomes by growers, and help grow the VegNET subscription list.	Differing messages being communicated to growers leading to doubt, loss of reputation and impeding adoption of R&D outcomes, building strong relationships.	Invitation to workshops, participate in trials on demonstration farms, extending R&D at targeted individual extension events with key influencers.
Applied Horticultural Research (AHR)- Soil Wealth and Integrated Cropping Protection project outcomes (Gordon Rogers)	ES	Facilitate practical demonstrations of applied R&D.	Practical trials allow growers to see first-hand the benefits of R&D outcomes at an independent farm such as GSLLS' Demonstration Farm. Add value to VegNET events by extending their project outputs and outcomes.	Reluctance to involve IDO's in consultations and hence poor adoption of R&D project. Regular communication on R&D gaps on different commodities.	Through well marketed events and regular individual consultation at demonstrations farms.
Pack houses (Anika Miller – Oz Group, Woolgoolga)	ES	Assist VegNET to promote and identify R&D opportunities and facilitate the adoption of R&D outcomes to achieve practice change.	Using them as intermediaries to enable the delivery and adoption of R&D outcomes by growers,	Differing messages being communicated to growers leading to	Invitation to workshops, participate in trials on demonstration farms, extending

			and help grow the VegNET subscription list.	doubt, loss of reputation and impeding adoption of R&D outcomes.	R&D at targeted locations and hosting meet n greet events at packhouses.
Genesis Horticultural Solutions (Tony Bundock)	ES	Delivering greenhouse water and nutrients management best practice workshops and events.	Greater number of growers adopting better practice in water and nutrient management.	Low risk, due to clear contract deliverables, previously delivered high quality work on time and on budget.	Facilitating face to face events and follow up technical advice with a sample of levy payers. Also roll out on line delivery as appropriate.
Low-tech Greenhouse Vegetable Growers – Mid North Coast (over 40 on the VegNET list)	ED	Delivery of outcomes of relevant R&D projects, adoption of best practice to support industry efficiency and sustainability. Improved knowledge & understanding, to demonstrate an effective ROI, support industry efficiency & sustainability to demonstrate return on investment.	Increase knowledge and reach of vegetable R&D and facilitate the adoption of R&D to levy payers.	Low risk, engaging with influential growers with a good reputation within the growing community, and electing key informants within those groups.	Invitations to workshops, webinars, one-on-one visits, engagement with key representatives, product development and links to resources to further improve practice change uptake.
NSW DPI – Clean Coastal Catchments project (Melinda Simpson)	ES	Assist with the promotion, assessment and development of grower grant applications.	Having several best practice vegetable demonstrations showcasing innovations in water and nutrient management and reducing runoff and improving social license to farm.	Reluctance to involve IDOs in consultations and hence poor adoption of R&D project, regular communication to ensure the right people are being involved.	Extend R&D through fertiliser stewardship group and other existing Landcare/NRM programs, using a collection of these grant recipients to demonstrate best practice.
Western City Aerotropolis Authority (WCAA) (TBC)	N	Providing our network of growers and allied industry opportunities to participate in export preparedness.	Realising export potential of the new Western Sydney 24-hour airport, linking and upskilling existing vegetable levy payers to existing opportunities and other R&D levy investments.	Identifying LLS' role with the development of Western Sydney Airport agricultural precinct.	Approaching the WCAA to facilitate export preparedness workshops, linking growers/co-operatives to appropriate extension and food safety programs.
NSW Farmers (David Banham)	P	Keeping on the front foot on policy issues that we communicate to vegetable growers.	Growers can make better decisions based on policies that effect their businesses.	Reduction in government funding.	Becoming associate members of NSW Farmers and quarterly discussions with appropriate policy staff.
Freshcare (TBC)	P	Facilitating more opportunities for growers in Freshcare (both food safety and environmental).	Ensuring the highest standards of food safety and environmental management are adhered to.	Low risk, linking for export benefit.	Meet with them and invitations to workshops.
NSW DPI – Food Safety Research (SP Singh)	N	Assisting the VegNET team, allied industry and growers with current research and strategies on food safety.	Providing and accessing current research and strategies on food safety.	Low risk, linking for best practices and overall benefits in postharvest and export.	Invitations to workshops, webinars and a two way benefit for growers and researchers.
NSW DPI – Area Wide Management and Peri-urban biosecurity projects (Shannon Mullholland)	ES	Assisting growers with viral and bacterial diagnostics and management options.	A greater number of levy payers exposed to and aware of levy funded R&D, assisting Hort Innovation funded R&D projects reaching their milestones and creating stronger ties with growers.	Reluctance to involve IDOs in consultations and hence poor adoption of R&D project. Regular communication on R&D gaps on different commodities.	Invitations to workshops and one-on-one farm visits to facilitate introductions for R&D work to be carried out efficiently.
Other Local Land Services regions: Central Tablelands (Karen O'Malley) Riverina (Justin Vardenega) North Coast (Julie Dart)	ES	Being the conduit and contact point for VegNET inquiries outside of Greater Sydney, promotion on delivery VegNET events.	Trusted local contact person who can give timely and relevant extension advice and connect growers with the relevant services as appropriate.	Reduction in government and industry funding.	Regular teleconferences and visits to the regions in addition to promoting levy funded R&D (one-one-, internal newsletter communications).

Croplands – (Dave Farmer)	ES	Demonstrate the best pest management techniques in chemical spraying.	There is always room for improvement in pest and disease management. This provider has had very good results in practice change.	Differing messages being communicated to growers leading to doubt, loss of reputation and impeding adoption of R&D outcomes.	Aim to have face to face practical workshops with growers and follow up as appropriate.
AUSVEG – Biosecurity team (Madeline Quirk)	ES	Leverage through our existing networks the outreach capacity of biosecurity programs to a greater number of levy payers and industry personnel.	Educating a greater number of vegetable industry players in managing and/or preparing for potential biosecurity incursion.	Reluctance to involve IDOs in consultations and hence poor adoption of R&D project.	Invitations to workshops and include relevant updates at our extension events.
AgSkilled 2.0	N	Linking growers to necessary training.	Assisting growers access federal Government training, resources and initiatives.	Low risk, RDO building relationships with AgSkilled staff.	Promoting training where possible.
Greater Sydney vegetable growers (over 200 on contact list)	ED	Delivery of outcomes of relevant R&D projects, adoption of best practice to support industry efficiency and sustainability. Improved knowledge & understanding, to demonstrate an effective ROI, support industry efficiency & sustainability. To demonstrate return on investment for their levy funds.	Increase knowledge and reach of vegetable R&D and facilitate the adoption of R&D to levy payers.	Low risk, engaging with influential growers with a good reputation within the growing community, and electing key informants within those groups.	Invitations to workshops, webinars, one-on-one visits, engagement with key representatives, product development and links to resources to further improve practice change uptake.
Australian Cambodian growers Association of NSW (Kim Ngov)	ED	Delivery of outcomes of relevant R&D projects, adoption of best practice to support industry efficiency and sustainability. Improved knowledge & understanding, to demonstrate an effective ROI, support industry efficiency & sustainability. Demonstrate return on investment.	Increase knowledge and reach of vegetable R&D and facilitate the adoption of R&D to levy payers.	Low risk, although engagement barriers exists with Culturally and Linguistically Diverse background (CLDB) growers, developing relationships with CLDB grower group leaders. Engaging with influential growers with a good reputation within the growing community and electing key informants within those groups.	Invitations to workshops, webinars, one-on-one visits, engagement with key representatives, product development and links to resources to further improve practice change uptake.
Australian Chinese growers Association of NSW (Jason Chung)	ED	Delivery of outcomes of relevant R&D projects, adoption of best practice to support industry efficiency and sustainability. Improved knowledge & understanding, to demonstrate an effective ROI, support industry efficiency & sustainability. Demonstrate return on investment.	Increase knowledge and reach of vegetable R&D and facilitate the adoption of R&D to levy payers.	Low risk, although engagement barriers exists with Culturally and Linguistically Diverse background (CLDB) growers, developing relationships with CLDB grower group leaders. Engaging with influential growers with a good reputation within the growing community and electing key informants within those groups.	Invitations to workshops, webinars, one-on-one visits, engagement with key representatives, product development and links to resources to further improve practice change uptake.
NSW Vietnamese vegetable growers (Ho Dang)	ED	Delivery of outcomes of relevant R&D projects, adoption of best practice to support industry efficiency and sustainability. Improved knowledge & understanding, to demonstrate an effective ROI, support industry efficiency & sustainability. Demonstrate return on investment.	Increase knowledge and reach of vegetable R&D and facilitate the adoption of R&D to levy payers.	Low risk, although engagement barriers exists with Culturally and Linguistically Diverse background (CLDB) growers, developing relationships with CLDB grower group leaders. Engaging with influential growers with a good reputation within the growing community and electing key informants within those groups.	Invitations to workshops, webinars, one-on-one visits, engagement with key representatives, product development and links to resources to further improve practice change uptake.

Bi-lingual Officer (Key Leaders) – Stephen Ng (Chinese) Dr Ho Dang (Vietnamese) Kim Ngov (Khmer)	ES	Work with RDO to assist with communicating levy funded R&D projects.	Trusted Bi-lingual officers that enhance practice change uptake. Accurate technical R&D levy funded information communicated in both written and verbal format that is appropriate to the relevant cultural and linguistically diverse background grower groups.	Low risk, although engagement barriers exists with Culturally and Linguistically Diverse background (CLDB) growers, developing relationships with CLDB grower group leaders. Engaging with influential growers with a good reputation within the growing community and electing key informants within those groups.	Through a variety of targeted farm visits, workshops, and extension at Sydney Markets.
Universities/tertiary institutions UNE – Integrated Weed management (Chris Fyfe) WSU – Agriculture/horticulture (Lynn Andersen & Zhonghua Chen)	ES	Provide access to suitable grower/demonstration sites as part of existing and/or future levy projects.	Better practical outcomes from levy funded projects through co-innovation in relevant thematic areas.	Reluctance to involve IDOs in consultations and hence poor adoption of R&D project. Regular communication on R&D gaps on different commodities.	Link researchers to growers where there are opportunities to solve problems through R&D, suggest suitable sites to undertake R&D.
Australian Native Landscapes (ANL) (Rob Nicholls)	P	Further extend research undertaken with GS LLS to new target groups.	Well respected service provider amongst our grower groups and can potentially co-invest in other projects.	Low risk, due to clear project plans and deliverables.	Invite to events to extend relevant products and services and results of research previously undertaken.
Demonstration farms (Peter Conasch, Paul and Karmjit Singh, Kim Ngov)	ES	To practically demonstrate best practice across productivity and sustainability areas levy funded co-innovation.	Removing risk from making on farm changes that effects financial viability of a grower and seeing the success stories for themselves before embarking on practice change.	Reluctance to involve IDOs. Regular communication and clear expectations, select demonstration sites that are willing to work with VegNET.	Promoting relevant R&D projects to growers and industry through field days using influencers and champions. Promote a prospectus to new players wishing to undertake appropriate R&D at Greater Sydney LLS Demonstration Farm.
Simplot – (Evan Brown)	ED/N	Assist in extending irrigation management programs and supporting the collection of data for benchmarking purposes.	Better understanding of water management and how that effects crop production. Simplot are well respected co-operative that deliver technical expertise to their contracted growers.	Differing messages being communicated to growers leading to doubt, loss of reputation and impeding adoption of R&D outcomes.	Writing articles for *Vegetables Australia*, extending benchmarking data from the growing season and engaging irrigation specialists at extension events.
Sweet corn growers in Central Tablelands and Central West NSW (25 as per Simplot list)	ED	Delivery of outcomes of relevant R&D projects, adoption of best practice to support industry efficiency and sustainability. Improved knowledge & understanding, to demonstrate an effective ROI, support industry efficiency & sustainability. Demonstrate return on investment.	Increase knowledge and reach of vegetable R&D and facilitate the adoption of R&D to levy payers.	Low risk, engaging with influential growers with a good reputation within the growing community, and electing key informants within those groups.	Writing articles for *Vegetables Australia*, extending benchmarking data from the growing season and engaging irrigation specialists at extension events.
Other State VegNET RDOs (various)	ED	Peer support, sharing of resources relevant to our growers in respective regions.	More cohesive and trusted group willing to share resources and collaborate for mutual benefit.	No real constraints, knowing what is being delivered and working together to not recreate the wheel.	Monthly RDO meetings. Bi-monthly RDO AUSVEG meetings, and dedicated MS Teams network.

Appendix 7 Veg Net 2.0 Annual Workplan and Gantt chart

Annual Workplan 2020 - 2021

National Vegetable Extension Network

Project Plan	Team members	Outputs	Extension content	Project links or collaboration
Improving Water and Nutrient Management in the NSW Greenhouse Protected Cropping Industry	• Matthew Plunkett, Project delivery, Irrigation specialist, GS LLS • Sylvia Jelinek, Project support GS LLS • Tony Bundock, Genesis Horticultural Solutions	• 1 workshop, North Coast, with online content. • 20 attendees. • 2 demonstration site farms. • Annual benchmarking of 30+ growers. • 6 on-ground site visits, North Coast for targeted extension.	• GS LLS	• NSW VegNET 3 • NSW DPI – Clean coastal catchment project • Protected cropping Australia • Hort Innovation projects
Developing export preparedness for NSW vegetable growers	• Sylvia Jelinek, Project lead, GS LLS • Matthew Plunkett, Project support • Freshcare • Western City Aerotropolis Authority (WCAA), education • Post-harvest specialists	• Start planning, building relationships and surveying growers interest.	• GS LLS • AUSVEG	• NSW VegNET 3 • Western City Aerotropolis Authority • AHR, post-harvest • WSU • Freshcare & Freshcare environmental • AUSVEG • Hort Innovation projects.
Pest and disease management including biosecurity and farm hygiene	• Sylvia Jelinek, Project lead, GS LLS • Callum Fletcher, Maddy Quirk - AUSVEG Biosecurity, • Shannon Mulholland, Toni Chapman, NSW DPI – Area wide management project,	• Ongoing farm visits, meet and greet at packing sheds /markets, demonstration farm. • Webinar/brokering to over 300 VegNET NSW members. • 2 forums, 20 participants in Sydney. • Chemical tables on major crops.	• Chemical tables on major crops, GS LLS. • Extension material on emerging biosecurity risks, AUSVEG Biosecurity. • Sampling techniques of pest and plant material.	• NSW VegNET 3 • AUSVEG Biosecurity • NSW DPI • Croplands • Hort Innovation projects.
Developing a soil health community of practice for the Australian Cambodian Growers Association of NSW	• Sylvia Jelinek, Project lead, GS LLS • Peter Conasch, Project support, GS LLS	• Start planning, building relationships and surveying growers interest.	• Translated extension material on cover crops, soils and compost.	• NSW VegNET 3 • AHR – SW and ICP projects • UNE- IWM project • Hort innovation projects.

and Australian Chinese Growers Association of NSW	• Matthew Plunkett, Project support, GS LLS • Bi-lingual officers, Stephen Ng (Chinese) and Sunly Sao (Khmer) • Kelvin Montagu, AHR/Soil wealth (SW) and integrated crop protection (ICP) • Christine Fyfe, UNE – Integrated weed management (IWM)Rob Niccols, Australian Native Landscapes (ANL)	• 1 Workshop with Australian-Chinese growers, 20-30 participants • Soil testing, 12-14 Australian-Chinese farms.	• Soil testing reports communicated and soil improvement strategies identified.	• ANL
Farm innovation and technology – Precision irrigation and nutrition management in sweet corn	• Matthew Plunkett, Project lead, GS LLS • Sylvia Jelinek, Project support, GS LLS • Evan Brown, Simplot	• Summer farm visits, engaging with over 10 growers. • 1 farm walk/field days, with 25+ participants at each. • 2 growers irrigation benchmarking through assessments	• Extend the latest R&D outcomes from the Precision Technologies levy funded project.	• NSW VegNET 3 • Simplot, Bathurst • Hort Innovation projects.

Gantt chart 2020 - 2021

Output	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Contract											
Milestones		103					104				190
Program logic											
M&E plan											
Stakeholder engagement plan											
Annual workplan											
REAG Meeting											
RDO Team meeting											
Workplan progress											
M&E plan progress											
Workplan 2021/22											
Final report											
Operational											
Improving water and nutrient management in protected cropping					Preparation				Workshop		
Developing export preparedness											Preparation
Pest and disease management			Preparation		Workshop		Preparation	Workshop			
Developing a soil health CoP								Preparation Australian-Chinese		Preparation Australian-Cambodian	Workshop Australian-Chinese
Precision irrigation and nutrition management in sweet corn				Preparation			Workshop				

KEY

Completed	In Progress

Appendix 8

Vegetables Australia – Autumn 2020 edition

Darryl Cislowski from Ace Ohlsson discussing zucchini variety performance at the Greater Sydney Local Land Services Demonstration Farm.

New zucchini varieties on show at field day

Zucchini varieties and precision agriculture were the focus of a field day held in late 2019 at the Greater Sydney Local Land Services Demonstration Farm. Over 80 growers and industry members converged on the site on the Richmond Lowlands in the picturesque Hawkesbury region of New South Wales. The event was coordinated by NSW Industry Development Officers, and delivered as part of the National Vegetable Extension Network (VegNET).

More than 80 people turned out to the New South Wales VegNET field day, which was held late last year at the Greater Sydney Local Land Services (GS LLS) Demonstration Farm on the Richmond Lowlands. GS LLS partnered with one of the biggest rural supplier in NSW, Ace Ohlsson, and seed companies Terranova, Lefroy Valley, HM Clause and South Pacific Seeds to showcase over 20 zucchini varieties.

"These trials were designed to look at the crop performance and susceptibility to diseases such as mosaic virus. This included the size and shape of the fruit and flowers, as some growers also market zucchini flowers, which is why they were included in the assessment," VegNET Industry Development Officer Sylvia Jelinek said.

As well as the varietal trial, a pollination trial was set up by Darryl Cislowski and his staff at Ace Ohlsson with the assistance from Adrian Grew, known as 'The Bee Farmer'.

A popular commercial zucchini variety was planted down an entire bed. One-third was permanently covered with floating row covers, one-third was covered in the morning until midday and one-third was permanently left uncovered. Growers were able to walk down the rows to judge for themselves the effect of row covers on pollination by seeing the amount of fruit. Adrian talked about the benefits of having beehives in or near zucchini crops to enhance pollination, improve good quality fruit and increase yield.

A number of suppliers and industry representatives also showcased a range of precision agricultural technologies, including XAG drones, Agerris' digital farmhand robot, Ecrotek's beekeeping systems and compost displays from Australian Native Landscapes.

Focus on precision ag

Julie O'Halloran, Senior Development Horticulturist at Queensland Department of Agriculture and Fisheries, provided excellent grower tips on how to use precision information technologies to better understand and manage crop variability.

Julie is working on the project *Adoption of precision systems technology in vegetable production* (VG16009), a strategic levy investment under the Hort Innovation Vegetable Fund. She discussed grower case studies that demonstrated a range of precision information technologies, including EM38 mapping, Veris™ mapping, variable rate technologies, satellite imagery, yield monitoring and drones. All of these technologies are commercially available.

Sylvia said the field day gave vegetable growers a chance to see the first-hand results of the zucchini demonstration trials and the potential benefits of precision agricultural technology. This is what the VegNET project is all about – taking the latest innovations and outcomes from levy-funded R&D and showing growers how it can be applied in the real world.

Grower feedback from the day was positive. They reported an excellent mix of demonstrations and speakers and were impressed by the number of zucchini varieties that were showcased. They also gained a greater understanding about the role that bees play in crops.

Previous VegNET evaluations have shown that field days, such as those held at the GS LLS Demonstration Farm, greatly assist growers in making decisions in adopting innovative practices to enhance their businesses.

The GS LLS team is now busy preparing for a field day on sweet corn varieties, which is set to take place in March 2020.

Find out more

Please contact NSW Industry Development Officer Sylvia Jelinek from Greater Sydney Local Land Services on 0427 086 724 or sylvia.jelinek@lls.nsw.gov.au.

Regional capacity building to grow vegetable businesses – New South Wales is a strategic levy investment under the Hort Innovation Vegetable Fund.

This project has been funded by Hort Innovation using the vegetable research and development levy and contributions from the Australian Government.

Project Number: VG18003

Hort Innovation | VEGETABLE FUND

Vegetables Australia – Winter 2020 edition

VegNET enters Phase Two

Hort Innovation has commenced the second phase of VegNET, the vegetable industry extension program, which will fund ten regional development officers located across Australia to support vegetable growers in growing healthy crops and develop successful, profitable businesses. Shaun Lindhe reports.

What is VegNET?

In 2016 Hort Innovation invested in ten regional capacity building projects to effectively transfer R&D information to vegetable growers through regionally-based extension projects and associated coordination and training projects. These projects were contracted to delivery partners based in the ten major vegetable growing regions and were unified under a national brand – VegNET.

The first phase of VegNET finished in early 2020, with the regional development officers (RDOs) delivering R&D awareness and extension activities in their geographical regions.

The VegNET delivery partners are:

- New South Wales – Local Land Services.
- Northern Territory – NT Farmers.
- Queensland – Bowen Gumlu Growers Association (Bowen Gumlu), Bundaberg Fruit and Vegetable Growers (Bundaberg) and Lockyer Valley Growers Association (Lockyer).
- South Australia – AUSVEG SA.
- Tasmania – RM Consulting Group.
- Victoria – RM Consulting Group (south-eastern, western and northern regions) and Food and Fibre Gippsland (Gippsland).
- Western Australia – vegetablesWA.

The delivery partners for Phase One will also deliver the project in Phase Two.

What is new in Phase Two?

Following grower consultation, the national vegetable extension strategy was developed in late 2019. The next phase of the VegNET project supports the extension approach from this strategy and will result in RDOs who are more focused on the development of regional plans based on targeted stakeholder engagement with growers, researchers and industry members.

RDOs will transition from acting as conduits of technical insight to enablers of knowledge from various sources. This will ensure they are an effective resource to address industry regional challenges. In this approach, extension becomes the key link to bring broad and diverse groups together to find solutions to problems in a strategic and focused way.

The most common challenges from the consultations carried out to develop the National Vegetable Extension Strategy were in relation to:

- Water (availability, quality and cost).
- Labour (availability, awards, HR and skills).
- Input costs.
- Biosecurity.
- Pest management.
- Market development (including export).
- Post-harvest and marketing.
- Urban encroachment.
- Social license (environmental impact and chemical (mis)usage).
- Business management.

Some or all of these issues may be raised during the development of the individual regional extension plans. Regional issues will be prioritised, and growers and other stakeholders will work with RDOs to identify which ones VegNET is best suited to target.

What will VegNET RDOs do during Phase Two?

Establish a regional extension reference group

VegNET RDOs will convene a regional reference group that will be responsible for developing a regional extension plan and strategies, as well as an annual review of progress and effectiveness in implementing the plan.

Get in touch with your VegNET RDOs

New South Wales
- Local Land Services – Sylvia Jelinek, sylvia.jelinek@lls.nsw.gov.au, 0427 086 724

Northern Territory
- NT Farmers – Simone Cameron, ido@ntfarmers.org.au, 0413 308 335

Queensland
- Bowen Gumlu – Eilis Walker, idm@bowengumlugrowers.com.au, 0427 701 225
- Bundaberg – Bree Grima, bree.grima@bfvg.com.au, 0403 616 702
- Lockyer Valley – Zara Hall, ido@lockyervalleygrowers.com.au, 0456 956 340

South Australia
- AUSVEG SA – Yanyu Liang, yanyu.liang@ausveg.com.au, 0432 742 896

Tasmania
- RM Consulting Group – Theresa Chapman, theresac@rmcg.com.au, 0413 039 733

Victoria
- South-eastern, western and northern regions – Hugh Wardle, hughw@rmcg.com.au, 0427 109 057
- Gippsland – Bonnie Dawson, bonnie.dawson@foodandfibregippsland.com.au, 0407 683 938

Western Australia
- vegetablesWA – Samantha Grubiša, sam.grubisa@vegetableswa.com.au, 0427 373 037

Develop a regional extension plan

With guidance and advice from the regional extension reference group, VegNET RDOs will develop a regional extension plan for the period 1 July 2020 to 30 June 2025. This regional extension plan will be collated into a single national document that will help ensure all growers receive extensive, coordinated extension services. The vegetable industry Strategic Investment Plan will be used as a guide, in assisting in this process.

This plan will include identifying each region's key priority issues and key regional resources and links that will be critical in ensuring growers receive assistance, as well as information that will help them grow better crops and operate more efficient and profitable businesses.

Implement the regional extension plan using an innovation systems approach

Depending on each region's specific plan, VegNET RDOs will deliver tailored and targeted extension activities to meet the needs of their region's growers. Activities may include:
- Field days.
- Farm walks.
- Webinars.
- Workshops.
- Fact sheets.

These events will include face-to-face and remote learning opportunities for growers to reflect the post-COVID-19 landscape.

VegNET RDOs will work closely with Hort Innovation's Extension Team to ensure industry extension activities are delivering the expected outcomes and that the breadth of research commissioned by Hort Innovation is made available for adoption by growers.

Communicate to industry though AUSVEG and Hort Innovation

VegNET RDOs will work closely with AUSVEG and Hort Innovation to ensure their work reaches as many growers and industry stakeholders as possible. This will include content in industry publications, including *Vegetables Australia*, as well as videos, podcasts and newsletters made available to all growers.

How will VegNET help levy-paying growers?

Phase Two of VegNET will benefit vegetable levy-paying growers in the following ways:
- Identify regional challenges to the productivity, profitability, and sustainability of grower businesses.
- Growers and other stakeholders will prioritise these issues and with RDOs identify which ones VegNET is best to target.
- Increased knowledge of the vegetable R&D program administered by Hort Innovation.
- Improved adoption of outcomes from Hort Innovation-funded R&D projects.
- Connect growers with industry partners to improve productivity and profitability of vegetable growing businesses.
- Demonstrating the effectiveness of practice change to growers and industry to promote adoption of innovations.
- Effective linkage between vegetable growers and levy-funded R&D service providers.

Find out more R&D

Please contact Hort Innovation Head of Extension Lead Jane Wightman at jane.wightman@horticulture.com.au.

VegNET are strategic levy investments under the Hort Innovation Vegetable Fund.

These projects are funded by Hort Innovation using the vegetable research and development levy and contributions from the Australian Government.
Project Number: VG19008-VG19017

Hort Innovation | VEGETABLE FUND

Vegetables Australia – Spring 2020 Edition

Healthy grafted plant (top) and non-grafted plant (bottom) in Fusarium-affected growing media.


A successfully grafted cucumber. Images courtesy of Len Tesoriero.

Providing grower support across New South Wales

The VegNET New South Wales team is busily preparing for phase two of the extension project. It is looking to further identify knowledge gaps in research, and support vegetable growers in adopting on-farm practices. In this article, VegNET Regional Development Officer Sylvia Jelinek provides an example of how extension can address popular areas of interest and produce tangible results for vegetable growing operations.

The VegNET New South Wales project is expanding into a second phase after the team successfully secured funding to continue supporting NSW vegetable growers. With the current focus on developing a strategy to determine key focus areas for the industry, the team is calling on growers and other interested industry members to have their say on priority extension areas.

VegNET NSW Regional Development Officer Sylvia Jelinek said she looked forward to exploring new and exciting methods of engaging with growers.

"The success of VegNET comes down to the great input we've had from growers who are keen to hear about innovations in research, and explore how these innovations can be applied on their farm," she said.

Protected cropping in-focus

Ms Jelinek said protected cropping was a popular area of interest for phase two of the program.

"Greenhouse cucumbers was an area we looked into in partnership with plant pathologist Dr Len Tesoriero," she said.

This project explored the grafting of cucumbers to disease resistant rootstocks.

"Greenhouse cucumbers are affected by a number of diseases which can severely reduce yields. Fusarium wilt and Pythium root rot are the most important causes of losses across major production areas of Australia," Dr Tesoriero said.

"The strain of Fusarium affecting cucumbers in Australia is unlike any that occurs overseas. There are no commercial cucumber varieties resistant to this strain of Fusarium available."

Over a period of two years, Dr Tesoriero and his team evaluated cucumbers grafted onto resistant rootstocks for control of Fusarium wilt and Pythium root rot.

"Preliminary studies identified a cucumber rootstock (cv. Affyne) and a hybrid pumpkin rootstock (cv. Cobalt) as being resistant to Fusarium wilt and highly tolerant to Pythium root rot," Dr Tesoriero said.

"In two commercial-scale trials, we demonstrated that both rootstocks could support healthy plants that easily out-yielded ungrafted plants in the same house.

"In a winter crop there was a 29 per cent yield difference between a grafted treatment and ungrafted plants. This can easily translate into an economic benefit under high disease pressure after the increased cost of seedlings is taken into account."

"Of course, the benefit really depends on how much disease pressure there is and the cucumber wholesale price," Dr Tesoriero added.

Project results: Net benefits

In the winter trial, there was a 29 per cent yield increase with grafting and say, for example, the average cucumber yield is 7 kg/plant. That yield difference represents a saving of about 2kg/plant. If cucumbers are worth $2/kg, it translates to a saving of $4 per plant.

Now if the difference between grafted and ungrafted seedling costs is $2.50, there is still a saving of $1.50 per plant. Obviously, this number changes for the better if prices are higher and vice versa for lower cucumber values. Overall, it provides growers with an effective disease management option.

There were a few other issues and factors that were observed during the trials:

- Care needs to be taken when transplants are placed into media. This is to ensure the graft union is not buried too deep, so that roots do not form above the graft union and become infected by Fusarium.
- If plants are layered – or vine training is delayed – roots can form above the graft union, enter the medium and become infected.
- In a single trial over winter, the cucumber rootstock outperformed the pumpkin rootstock. Over summer, both rootstocks performed equally. This result probably should be repeated to validate this effect.
- It is possible to use two heads on grafted plants to off-set increased seedling costs. This may require other changes to crop management so should be done with caution.

For further details or to get involved in the VegNET NSW program, visit lls.nsw.gov.au/regions/greater-sydney/key-projects/national-vegetable-extension-network-nsw.

Find out more R&D

Please contact NSW Industry Development Officer Sylvia Jelinek from Greater Sydney Local Land Services on 0427 086 724 or sylvia.jelinek@lls.nsw.gov.au.

VegNET – New South Wales is a strategic levy investment under the Hort Innovation Vegetable Fund.

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Hort Innovation | VEGETABLE FUND

Vegetables Australia – Summer 2020/21 edition

R&D | VEGNET NEW SOUTH WALES

Adoption of soil moisture monitoring in sweet corn

VegNET – New South Wales, in partnership with Simplot, engaged with growers to hold a Farm Technology Field Day in Bathurst and Geurie in September 2018. The focus of the day was soil moisture monitoring in sweet corn crops and its benefits for vegetable growers. The VegNET-NSW team reports on the outcomes and previous research into this irrigation technology.

Through the adoption of soil moisture probes, growers can set clear irrigation targets based on soil moisture and monitor remotely to see if they are being met. Alerts can be set for low line irrigation system pressure. Irrigation schedules can be adjusted easily as well as checking run times – and these can be done remotely.

This technology monitors irrigation performance and prevents needless irrigation on saturated soils. It also takes into consideration any variation of soil type within the crop and ensures sufficient deep watering at critical crop intervals. Growers can see how much water makes it to the root zone and it saves pumping and fertiliser costs as well as preventing unnecessary over-irrigation.

After the recent drought across eastern Australia, water shortages and water use efficiencies are even more important. Profit margins per ML of irrigation water are a big driver for large scale sweet corn cropping.

Grower outcomes

Brendan Booth is a sweet corn grower using centre pivot irrigation from Geurie in Central West New South Wales. He was introduced to moisture monitoring through *Review of current irrigation technologies* (VG14048), a strategic levy investment under the Hort Innovation Vegetable Fund.

Brendan urges other growers to learn to 'push out water further', with a focus on increasing returns per ML of water used.

After using the Wildeye Soil Moisture Monitoring probes, Brendan says he now uses more water but grows more crop, so the margin per hectare is greater.

Scott Stevenson from Ponto, near Dubbo, is a sweet corn, adzuki bean and wheat farmer who has also trialled Wildeye Soil Moisture Monitoring probes. Even though Scott was watering more because of the moisture probes, he was watering more accurately – and the result was a better sweet corn crop.

Another sweet corn grower near Dubbo is Mark Carter, who has used soil moisture probes on all of his crops.

"Testing them out gives you confidence with water use and is a good back up tool," Mark said.

Matthew Plunkett is the Senior Land Services Officer Irrigation with Local Land Services, and he said soil moisture probes are another tool to aid decision-making.

"They allow growers to drive returns per ML of water further. This is particularly important when water availability is an issue as we have seen in recent years," Matthew said.

"Based on discussions with growers and feedback from Simplot, it was clear that many growers were not applying enough water early in the crop cycle. Failing to do so has a significant impact on yields, and this is where soil moisture monitoring tools pay dividends in addition to deciding when to restart irrigation after rainfall events."

Previous research

Many irrigation systems that have been assessed in the past, particularly centre pivot and lateral move systems, have not been applying water evenly and/or at the correct pressure. This leads to under, and over-watering in some areas.

Growers can undertake simple checks on their systems. These include ensuring the nozzle size matches the supplier specifications, pressure gauges are fitted to machines, and putting out some buckets in the path of the irrigators to measure sprinkler output.

Work undertaken by Applied Horticultural Research at Cowra has shown that using satellite imagery in conjunction with soil moisture monitoring in sweet corn can improve crop yields and quality. This study can be found on the Soil Wealth website: soilwealth.com.au/resources.

The bottom line

The critical take home messages from this study is ensuring that growers use these tools to apply enough water early in the crop cycle, particularly from crop growth stages 3-5 (days 42-66 – 12 leaves stage to tasselling/silking).

Crop water use can increase up to 400 per cent during this time and if the irrigation system cannot keep up with crop water use, significant reductions in yields will occur.

Monitoring soil moisture improves crop productivity per ML and allows for critical crop periods to be monitored. Water stressing plants at critical times, such as flowering, reduces yields and crop quality.

Find out more R&D

Please contact NSW Regional Development Officer Sylvia Jelinek from Greater Sydney Local Land Services on 0427 086 724 or sylvia.jelinek@lls.nsw.gov.au, or Matthew Plunkett on 0428 978 390 or matthew.plunkett@lls.nsw.gov.au.

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Vegetables Australia – Autumn 2021 edition

R&D | VEGNET NEW SOUTH WALES

Engaging with growers from culturally diverse backgrounds

In 2017, the VegNET team established a training program for vegetable growers from a culturally and linguistically diverse background with an aim to increase their farming knowledge and improve on-farm best practice. In this column, VegNET – New South Wales Regional Development Officer Sylvia Jelinek provides an overview of the program and the positive impact it has had on these growers from the Greater Sydney region.

Vietnamese growers in the Greater Sydney region are part of a grower group from a culturally and linguistically diverse background (CALD). Many started farming operations in the early 1980s when Asian vegetable varieties were becoming more popular in Australia. The majority of their farms are small (two to four hectares), and most do not own their land. They often lease land for a relatively short-term. Their experience in farming ranges from only a few years to more than 30. Many experienced growers are retiring from farming in the next few years and their children show little to no interest in continuing their parents' businesses. New growers also have little farming background or experience before migrating to Australia.

Prior to arriving in Australia, these growers were often employed in trade or process work in Vietnam and did not have any prior farming experience. They learned basic greenhouse vegetable and herb production from friends or from other CALD groups, such as the well-established Arabic speaking background growers and technical advisers in the region. Many of the Arabic speaking background growers now lease their farms to Vietnamese and other growers from CALD background, such as the Cambodian community.

Much of what these growers have learnt has been a case of trial and error. This group of growers tend to rent greenhouses from landholders, so there is little motivation to invest in improving infrastructure. Consequently, the VegNET project focused on increasing new growers' knowledge of basic technology that requires minor investment, as well as improving skills in 'low' to 'medium tech' greenhouse production. Fertigation, irrigation and pest management were identified as skills needed most by these growers.

Training that began in 2017 focused on the immediate needs of new growers and promotes basic best practices. The aim was to deliver benefits to the growers without needing much financial farm investment. Bringing in an agriculturally-experienced Vietnamese translator, Ho Dang, helped engage with growers and build relationships with the VegNET – New South Wales team and the community. Mentorships have also developed over this period of engagement.

Grower impact

Through a coordinated, co-innovation approach, the VegNET – New South Wales project resulted in growers improving their farming practices and, more importantly, their awareness of best practice, learnt through training, workshops and farm tours. The greatest impact was seen with new growers.

Practice changes were found in pest and disease management as well as improved crop management and awareness of environmental impacts from farming. Improvements in pest and disease management included weed removal and herbicide spraying, leaving farms cleaner both in and outside greenhouses; crop debris removal and disposal; and waterlogged areas levelled and covered with weed mat to reduce the incidence of pests and diseases.

Growers are now aware of the risks of repeated use of broad spectrum and

Enthusiastic Vietnamese growers after an irrigation workshop in Greater Sydney.

Regular farm visits and extension activities with growers was part of their training.

Vietnamese growers enjoying farms fours as part of a training scheme. In all, 20 growers took part in the farm tours.

'hard' chemicals. They have started using selective chemicals despite the higher cost, which will reduce spray applications in the long run and lessen the risk of pests developing chemical resistance. After the training, growers are more aware of the importance of natural predators; however, more training is needed to help them practise integrated pest management (IPM) effectively.

Growers are also now more aware of the connection between over watering and disease incidence. They have rescheduled water frequency and volume according to the weather on the day, rather than one-schedule-fits-all days and started practising regular maintenance on their irrigation systems. By seeing the benefit of a regular cleaning schedule on the farm tour, some cucumber growers are now cleaning their system using chlorine dioxide after each crop.

The size of pots and spacing between pots have also been addressed. Through practical training and farm tour observations, some growers realised the importance of increasing the medium volume in relation to root development and yield. They have started changing pot size from smaller to larger as well as increasing space between the pots. Also, they saw the benefit of partly removing lower leaves from cucumber and tomato plants. A number of growers have started implementing this practice and have gained better crop quality and yield.

Positive results

Although aspects of environmental management have always been included in different training sessions, we observed that growers' appreciation for long-term environmental sustainability is more profound when they gain economic benefits from applying recommended practices.

It has been great to see new Vietnamese greenhouse growers respond enthusiastically with new understanding and knowledge learned in a short time, as persuading growers to adopt practice change can be a challenging task. Training has been a crucial part in creating practice change. Prior to this training, for example, many growers believed that weeds were harmless and did not harbour insect pests and diseases. Removing or spraying weeds was seen as a waste of time and labour. Once growers gained experience and adopted better farm hygiene, they could see positive results. With the project taking a systems-based approach to problem solving, growers changed their practices and improved their production systems when it was affordable to do so.

It was evident that newer growers showed a greater desire to improve on-farm practices than experienced growers. The belief is that once growers change and improve, in time their income and cost savings will improve. The VegNET – New South Wales project has initiated a considerable impact on the life of new growers who are very appreciative of our effort in facilitating to upgrade their skills and understanding in farming.

VegNET recommendations

We recommend that further assistance be extended to these growers in the future. As growers' knowledge, skills and understanding improves, the benefits would be multi-faceted and include not only better income for growers, but also safer and better quality produce for the wider community and an environmentally sustainable industry in peri-urban areas around Greater Sydney. After seeing the benefits of adopting improved practices, these growers are keen to learn more new ideas that with help improve productivity.

It is hoped that other Vietnamese growers in Australia can be connected to local growers – through the national VegNET network – to share knowledge and information.

Find out more

Please contact VegNET – NSW Regional Development Officer Sylvia Jelinek from Greater Sydney Local Land Services on 0427 086 724 or sylvia.jelinek@lls.nsw.gov.au, or Matthew Plunkett on 0428 978 390 or matthew.plunkett@lls.nsw.gov.au.

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R&D | VEGNET NEW SOUTH WALES

Flood recovery journey continues for New South Wales' veg growers

Dead capsicum trial (crop) was underwater for a few days at 'River Farm'.

Earlier this year, parts of New South Wales and south-east Queensland experienced the worst flooding seen in decades. Vegetable growers – particularly those in Greater Sydney – were greatly affected, losing millions of dollars in crops and infrastructure. In this column, VegNET – New South Wales Regional Development Officer Sylvia Jelinek discusses the flood impact and how the VegNET project is helping growers through the recovery process.

The Hawkesbury-Nepean River is one of the biggest river catchments east of the Great Dividing Range and is renowned for its risk of flooding. The Nepean River represents the upper half of the river system with the Hawkesbury below. Deerubbin is the Aboriginal name for the Hawkesbury-Nepean River, which is believed to mean wide and deep water.

The river is a reliable source of irrigation for many Greater Sydney agricultural industries, including the vegetable market. The recent flooding emergency is the worst seen in more than 30 years. Prior to that, like many places in Australia, Greater Sydney endured a 10-year drought that culminated with the worst fire season seen in generations. The drought finally broke in February 2020 and was followed by regular rain resulting in the significantly saturated catchment.

In late March, two major weather systems collided over the east coast creating a slow-moving low-pressure trough, which started in south-east Queensland and gradually moved south. Vegetable growers on the New South Wales north coast and in Greater Sydney experienced major storm damage and flash flooding.

The Hawkesbury Valley is a major turf growing area, but there is a significant vegetable growing industry which includes brassicas, lettuce, Asian vegetables, sweet corn and pumpkin production. Growers in South Creek and Kemps Creek were also impacted, with crops destroyed from sustained heavy rain and water logging. The estimated cost to the vegetable industry in the Greater Sydney region is $19 million in crop loss and infrastructure damage.

Grower impact

Long-time resident and vegetable grower Mario Muscat has lived through several floods in the Hawkesbury Valley.

"This one rose faster than any I have seen before, catching many growers unaware. The new generation has never experienced a flood before and were under prepared," Mario said.

Growers usually have time to bring machinery to higher ground, but roads were very quickly cut off as water backed up into lagoons from the overflow of the river.

They had not long planted their winter crops of brassicas, which were destroyed in the flood waters. The window for replanting a winter crop in the Hawkesbury region has been lost due. Any summer heat absorbed by the soil – that gives winter plantings a head start – was also quickly lost due to the cold flood waters.

Clubroot is endemic in the Hawkesbury Valley and growers have learnt to manage the disease; however, spores of the pathogen are carried in flood waters and have potential spread to new growing areas.

Another hazard that vegetable growers need to be aware of is biological contaminants in the flood waters. Getting a soil test is a good way to determine the full impact of the flood waters on crops.

The VegNET – NSW team is playing a key role in the flood recovery process. It is providing information and advice for growers and can give advice on flood recovery, best practice management, soil testing for contaminants, plant pest and diseases and food safety.

Flood assistance resources for affected regions

Further information and flood assistance is available online through a range of channels.

- Special Disaster Grants – Storms & Floods: raa.nsw.gov.au/disaster-assistance/special-disaster-grants-floods
- Natural disaster recovery assistance for primary producers: dpi.nsw.gov.au/climate-and-emergencies/emergency/community/after-an-emergency/natural-disaster-recovery-assistance
- Recovery centres and hubs: service.nsw.gov.au/floods/recovery-centres-and-hubs
- NSW Storms and Floods – 10 March 2021: disasterassist.gov.au/Pages/disasters/current-disasters/New-South-Wales/storms-floods-10-March-2021-onwards.aspx
- Disasters and emergencies: salvationarmy.org.au/need-help/disasters-and-emergencies/
- Hawkesbury City Council: hawkesbury.nsw.gov.au/

Find out more R&D

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R&D | VEGNET NEW SOUTH WALES

Veg grower Kim Ngov in-focus

Kim Ngov grows vegetables in Wedderburn, located in Sydney's south-east. VegNET – New South Wales Regional Development Officer Sylvia Jelinek chats to Kim about his business and its innovations as well as R&D practices that he is focused on, which includes using cover crops to build soil health, control weeds and eliminate single-use plastic mulch. Kim has been involved with the *Soil Wealth ICP Phase 2* (VG16078) project, which is a strategic levy investment under the Hort Innovation Vegetable Fund.

Kim Ngov with his daughter, Summer.

Can you please give readers a brief overview of your business and the produce that you grow?

We grow basil in the greenhouse all year round. Outdoors, we grow snow peas and broad beans during the winter and long fruited chilli, snake beans and cherry tomatoes in the summer months.

What new innovations, research and/or practices has your business implemented recently?

In the greenhouse, we have implemented a heating system that keeps the temperature up for growing basil. It is a watering system based on time and temperature, rather than just on time scheduled. If the weather is hotter, the crop will get watered more frequently. On cooler days, the crop receives less frequent watering but has longer watering periods.

Outdoors, I've been moving towards no plastic mulch and focusing on cover crop residue as mulch. Basically, it is no till cover cropping or minimum till. We are currently trialling our first cover crop. We are experimenting with rye corn, millet, sorghum and Sudan grass. On some parts of the farm, we sowed the whole area; while we sowed inter-row those areas where crops were still growing.

Previously we used plastic mulch and raised beds and would cultivate annually. This leads to the soil developing a hard pan that reduced water infiltration, shallow roots and overuse of fertiliser. Cover crops help to break up the hard pan. We've also moved away from using raised beds and developed permanent tractor rows. Growing cover crops is like growing a cash crop that makes no money, so you want inputs – such as such as fertilisers and labour – to be minimal.

In terms of research and development, what do you think is vital to the vegetable industry right now?

We need to maximise crop yields by getting the most of what you put in, rather than growing a lot of plants that give a little return.

Agricultural waste is a huge issue. It is unsustainable to keep growing with plastic. There is so much waste every year and contributes to excess use of artificial fertilisers.

Soil improvement has become a high priority, and this includes improving soil structure and water infiltration. Continual use of plastic mulch creates a hard pan, so it must be constantly tilled between crops. Growing a crop with a large tap root like radishes helps to till the soil for you. Cover cropping will decrease the use of plastic mulch and lessen waste. It also improves weed management and soil structure.

What do you enjoy most about being involved in the vegetable industry?

I like being outdoors and setting up a farm that uses sustainable cropping techniques. I am determined to solve issues and challenges of growing something sustainably that will make money. Experimenting with different management techniques is the main aim of the farm right now. I have diversified away from cucumbers and tomatoes in the greenhouse and growing basil now. I grow basil in peat moss, which uses less fertiliser and grows faster. The restaurants love it.

What is your proudest achievement as a vegetable grower?

My greenhouse basil. By switching growing techniques, we use less effort by thinking 'outside the box' from our normal routine. We are making more money with less effort.

Do you have future plans for the farm – is there a particular direction you'd like to pursue? Where would you like to see the business develop across the next decade?

I want to see where using cover crops take us. If it improves the soil health, disease and weed management – and plants are healthier – it's more sustainable. I want to put back into the soil what I took out by replenishing the soil with compost. This is a five-to-10-year project. Most growers are here for the long run, and I want to see where I can take cover cropping to fix the soil management issues that we've had before.

Find out more R&D

For information about VegNET – New South Wales activities, please contact VegNET – NSW Regional Development Officer Sylvia Jelinek from Greater Sydney Local Land Services on 0427 086 724 or sylvia.jelinek@lls.nsw.gov.au.

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Hort Innovation | VEGETABLE FUND

VegNET program targets Vietnamese growers

Photos Sylvia Jelinek.

Vietnamese growers enjoying farms fours as part of a training scheme. In all, 20 growers took part in the farm tours.

Workshops, training and on-farm visits have changed practices and brought benefits to growers from Greater Sydney's Vietnamese community. Matthew Plunkett presents a case study on a recent VegNET program in New South Wales.

[copy]Vietnamese growers in the Greater Sydney area are part of a grower group from a culturally and linguistically diverse background (CALD). Many started farming operations in the early 1980s when Asian vegetables were becoming more popular in Australia. The majority of their farms are small (2-4ha) and most do not own their land. Most lease land, often for a relatively short term. Their experience in farming ranges from only a few years to more than 30. With many experienced growers retiring from farming in the next few years and their children showing little to no interest in continuing their parents' businesses, new entrants have little farming background or experience before immigrating to Australia.

Prior to arriving in Australia, these growers were often employed in trade or process work in Vietnam and did not have any farming experience. They learned basic greenhouse vegetable and herb production from friends or other CALD groups in the region such as the well-established growers and technical advisers with an Arabic-speaking background. Many of the Arabic-speaking background growers now lease their farms to Vietnamese and other growers from CALD background such as the Cambodian Growing Community.

Much of their learning has been a case of trial and error and, because this group of growers tends to rent greenhouses from landholders, there is little motivation to invest in improving infrastructure. Consequently, the VegNET project focussed on improving knowledge for new farmers in basic technology, which requires minor investment, and improving skills in 'low' to 'medium tech' greenhouse production. Fertigation, irrigation and pest management learning areas were identified as skills most needed by these growers.

Training began in 2017, aimed at the immediate needs of new growers and to promote basic best practices. The aim was to deliver benefits to the growers without needing much financial farm investment. Bringing in an agriculturally experienced Vietnamese translator, Ho Dang, helped engage growers and build relationships between the New South Wales VegNET team and the community. Mentorships have also developed over this period of engagement.

"ONCE GROWERS GAINED EXPERIENCE AND ADOPTED BEST PRACTICE, THEY COULD SEE POSITIVE BENEFITS..."

Positive results and recommendations

Through a coordinated, co-innovation approach, the VegNET NSW project resulted in growers improving their farming practices and, more importantly, their awareness of best practice, learned through training, workshops and farm tours. The greatest impact was seen with new farmers.

Practice changes were found in pest and disease management, crop management best practice and awareness of environmental impacts. Improvements in pest and disease management included weed removal and herbicide spraying leaving farms cleaner both in and out of greenhouses; crop debris removal and disposal; and waterlogged areas levelled and covered with weed mat so pest and disease incidence is reduced.

Growers are now aware of the risks of repeated use of broad spectrum and hard chemicals and have started using selective chemicals despite of the higher cost, but which will reduce spray applications in the long run, while also decreasing chemical resistance.

After the training, growers are more aware of the importance of natural predators however more training is needed to help them practice IPM effectively.

Enthusiastic Vietnamese growers after an irrigation workshop in Greater Sydney.

In crop management best practice growers are now more aware of the connection between over watering to disease incidence. They have rescheduled water frequency and volume according to weather on the day, rather than one schedule fits all days, and have started practising regular scheduled maintenance on their irrigation systems. By seeing the benefit of a regular cleansing schedule at the farm tour, some cucumber growers are cleaning their system using chlorine dioxide after each crop. The size of pots and spacing between pots has also been addressed.

Through practical training and farm tour observations, some growers realised the importance of increasing the medium volume in relation to root development and yield and have started changing pot size from smaller to larger as well as increasing space between the pots. Also through observations

Practice Change in Vietnamese growers in Greater Sydney through workshops, training and farm tours

Farmer and farm situation pre-training	Training – aspect learned	Changes of practices – improvements
A. PESTS AND DISEASES		
A.1. Pest and disease management **1.1.** Weed management: Farm is too weedy. **1.2.** Crop debris not removed and rotting in and out of greenhouse. **1.3.** Farm hygiene conditions poor, stagnant water in and around greenhouses.	IPM training • Learn about pest resistance mechanisms. • Chemical groups. • Learn to use recommended chemicals and rates.	• Farms are cleaner. Weeds were sprayed. • Crop debris buried/ placed in heap and covered. • Stagnant water spots levelled and in greenhouse covered with floor mat.
A.2. Pesticide spraying **2.1.** Use of harsh chemicals and broad-spectrum pesticides. **2.2.** No knowledge of chemical groups, confused between insecticide and fungicide (new farmers). **2.3.** Use of PPE: wearing shorts and paper mask during spraying.	IPM training	• Start using selective insecticide (even though it can be more expensive than broad-spectrum choices). • Wearing overalls and paper masks (only one farmer currently uses a cartridge mask). • Frequent contact with Project Officer for advice.
A.3. Understanding of natural enemies No knowledge of beneficial organisms (new farmers).	IPM • Field monitoring demonstration. • Identification of pests and natural enemies.	• Learn to check crops for insect before spraying. • No calendar spray program.
B. CROP MANAGEMENT		
B1. Irrigation – source of water **1.1.** Water distribution (drip irrigation). • Distribution Uniformity (DU) frequently too low. • Irrigation systems old and leaking. **1.2.** Overwatering, increasing root, diseases and water logging. **1.3.** Dam water with high EC and too high/low pH. **1.4.** No regular maintenance program for filter, no scheduled cleaning.	Field demonstration of how to measure DU water balance. • Aspects of Irrigation and crop nutrition workshop 1. • Basic knowledge on water quality, pH, EC, crop tolerance (Irrigation and Plant Nutrition Workshop 2). • Farm tour: Filtration and chlorine dioxide cleansing schedule.	• Two farms have changed sections of drip irrigation systems. • One farm gradually changing to self-pressure drip system to counteract effect of high slope in greenhouse. • Adjust pH and EC appropriate to crops. • One farmer cleans filter weekly. • Some farmers start using chlorine hydroxide for end of crop cycle cleansing.
B2. Growing media and planting space: Farmers complaining about low crop yield, high incidence of diseases and cucumber fruit not green and shiny.	Aspects in irrigation and plant nutrition workshop 2 • Balance root development rate, water retention in growing media. • Bag capacity vs yield. • Water and air affecting root health, diseases and yield.	• Two farms changed their plastic bag size from 7L bag to 10L bag. • One farm change planting space from 15cm between plant to 20cm.
C. AWARENESS OF ECONOMIC CONSEQUENCES – FARMING IS A BUSINESS – PROFITABILITY VS INPUT		
Prior to training, Vietnamese farmers tended to save as much money as they could. Such as using old drip system, buying used and old T-tape cheap from other farmers and undertaking little weed control.	• IPM • Farm tour • Spray workshop	• Scheduled weed control. • Purchase selective pesticides (regardless of expense). • Replace old T-tape with new drip irrigation system to improve DU.

during farm tours and getting to know the benefit of partly removing leaves from cucumber and tomato plants, some growers started implementing the practice and gained better crop quality and yield.

Although the aspects of environmental management have always been included in different training sessions, we observed that when growers gain economic benefits from applying recommended practices, their appreciation of the benefits for long-term environmental sustainability is more profound.

IT HAS BEEN GREAT TO SEE NEW VIETNAMESE GREENHOUSE GROWERS RESPONDED ENTHUSIASTICALLY WITH NEW UNDERSTANDING AND KNOWLEDGE LEARNED IN A SHORT TIME, AS PERSUADING GROWERS TO UPTAKE PRACTICE CHANGE CAN BE A TRYING TASK.

Training has been a crucial part in creating practice change. For example, prior to training many of the growers believed that weeds were harmless and did not harbour insect pests and diseases.

Removing or spraying weeds was seen as a waste of time and labour. Once growers gained experience and adopted best practice, they could see positive benefits from their changes in practice. With the project taking a systems-based approach to problem solving, growers changed their practices and improved their production systems when it was affordable to do so.

It was evident that newer growers showed a greater desire to improve on-farm practices than experienced growers. The belief is that once growers change and improve, in time their income and cost savings will improve. The VegNET NSW project has initiated a considerable impact on the life of new growers who are very appreciative of our effort in facilitating to upgrade their skills and understanding in farming.

We recommend that further assistance be extended to these growers in the future. As their knowledge, skill and understanding improves, benefits would be multi-faceted and include not only better income for growers, but also safer and better-quality farm produce for the community at large and an environmentally sustainable industry in peri-urban areas around Greater Sydney. It is hoped that other Vietnamese growers in Australia can be connected through the national VegNET network with local growers to share knowledge and information.

Acknowledgements

Matthew Plunkett is Vice-Chair of PCA and Vegetable Industry Development Officer, New South Wales with Local Land Services. He is based at Penrith. He would like to acknowledge the work that Sylvia Jelinek, Senior Land Services Officer, Greater Sydney Local Land Services, and Ho Dang, Vietnamese translator, have undertaken with the Vietnamese growers in this region in the past two years.

He would also like to acknowledge funding provided by Hort Innovation using vegetable levy funds and matched funds from the Australian Government.

For more information about this project contact Matthew Plunkett on 0428 978 390 or by email matthew.plunkett@lls.nsw.gov.au or Sylvia Jelinek on 0427 086 724 or by email sylvia.jelinek@lls.nsw.gov.au.

Regular farm visits and extension with growers was part of the training program.

Substrate Use in Hydroponics

Basic Principles and Planning

National Vegetable Extension Network

Strictly speaking, hydroponics is the science of growing plants in water culture without any soil or substrate. However, in commercial terms it is accepted that plants may be grown in a substrate that is relatively inert and devoid of nutrients, with the nutritional needs of the crop provided by elements dissolved in the irrigation water.

Whilst nutrients are supplied via the irrigation water, this does not mean the substrate is unimportant, in fact far from it! The composition of your media plays a critical role in determining the yield potential of your crop.

This paper provides general guidance on the selection of an appropriate growing media and factors that a grower should consider when establishing a system and managing it.

Introduction

Most commercial hydroponic production of fruiting crops (e.g., cucumber, capsicum, and egg plant) occurs in substrate-based production systems. Plants are grown in a slab, bag or pot that is filled with a substrate in place of soil.

Unlike soil, these substrates typically provide no direct nutrition to the growing plant, instead this is supplied via the irrigation water, and hence is still commercially referred to as hydroponic farming.

If the media is not providing nutrition, then what is its purpose?

The roll of the substrate is to form a physical matrix for the plants roots and enable a zone for supplying adequate water, air, and to act as an exchange site for the introduced nutrients to be accessed by the plants.

Unlike aqueous only hydroponics systems (e.g., Nutrient film or deep flow techniques), substrate culture allows growers infinitely more control, enabling a grower to use irrigation as a highly effective tool to alter the balance of the crop and help direct assimilates towards the production of saleable products (fruit) instead of just leaves.

Ultimately, substrate based produciton is the most controlled form of hydroponic farming and selecting the correct substrate will form the foundation for your crops success, both literally and figuratively.

Key Messages

- **There is no one substrate to rule them all! You can have success with a wide range of products; however, you may need to adapt your irrigation strategy to suit.**
- **Ensuring your substrate has the appropriate physical characteristics is essential for both water and air management in the rootzone.**
- **Matching growing containers and substrates can help get the best result out of a product, different containers may require variations in substrate.**
- **Understand that many measurable parameters are 'dynamic' and will change over time.**
- **Chemical properties of substrates vary, not all substrates are inert, and some interact with nutrient availability and pH buffering.**
- **Purchase substrate from a reputable supplier that can provide technical specifications.**
- **If in doubt, use this resource to carry out on farm testing to verify the quality of your substrate.**

Hort Innovation Strategic levy investment | VEGETABLE FUND

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

NSW GOVERNMENT Local Land Services Greater Sydney

Types of Substrates and Growing Containers

Do not be fooled by an opinion that success is realised with only one substrate! You will find amazing growers using a range of products, with success achieved via ensuring the fundamentals are correct, and adapting management strategies to get the best out of each solution.

Beyond the type of substrate used, there are several options in respect to growing containers, that is, the device which holds the substrate. Different substrates will be better suited to different containers.

The choices may feel overwhelming at first, however, after reviewing this paper you can expect to gain a much better understanding of the pros and cons to each approach and combinations that suits your needs, or even just how to better manage what you have.

Substrate Types

Substrates can typically be broken into two distinct classes, those considered organic and those considered inorganic (mineral based).

Organic	Inorganic
Coir (Coir) Saw dust Peat Composts and bark	Stonewool (Rockwool) Perlite Scoria Sands and Gravel Expanded clay pellets Foams and Sponges Pumice

Each substrate has different attributes that bring both advantages and disadvantages, and over time the substrates used in commercial production has consolidated to a preferred few.

In Australian vegetable crop production, the mid to high-tech sector typically utilise rockwool or coir slabs, whilst the lower tech sector will typically use sawdust or coir in bags or pots (though not exclusively of course!).

Beyond 'pure' substrates, growers can also utilise blends that contain 2 or more ingredients in one premixed product. This is quite common for use in soft fruit such as blueberry where media must last not only a single season, but potentially >7 years.

The pros and cons of each substrate will be considered later in this paper, after we explain the basic properties and management approaches to consider.

Containers

The growing container is what holds the substrate. This typically consists of three main options:

1) **Pots or trough**
   Rigid round, square or rectangular pots. Designed to be used for many years, they create a rigid structure with well-designed drainage solutions and air exchange considerations. The substrate within the pot is typically replaced after each cropping cycle. They are higher cost units; however, the annual cost is reduced if amortised over many years. The biggest drawback is the labour associated with emptying, cleaning, sterilising, and refilling each season. For this reason, they are not utilised by may vegetable growers, but are more common in longer term crop like blueberries (that can last for many years).

2) **Grow Bags**
   A non-structural bag that is filled with substrate, they rely on the substrate to create the shape and hold the bag open. These can further be considered in 2 types-

   a. Woven bags
      A woven fabric and typical used for perennial species like blueberries and nursery tree production. Grower often like the benefits of breathability and durability offered by the woven fabric. They are a more expensive option compared to single use plastics.

   b. [1]Single use plastic.
      Most of these are made from a recyclable thin plastic film that is either black or preferable black and white. The black plastic stops light penetrating the rootzone, whilst and outer white layer will reflect radiant heat, very useful in most Australian climates. Labour saving option supplied with an easy fill compressed coir block included are becoming quite popular.

   Bags do not offer the same level of structural integrity as pots, so ensuring correct filling and placement of drainage holes is important. Also, take care when using substrates that degrade rapidly (saw dust) as these can suffer from reduced aeration in longer cycles

3) **Slabs**
   Consist of a plastic sleeve filled with a substrate. Typically, ~1metre in length filled with about 12-24litres, though various sizes are available. The most common substrates used are rockwool or coir. Slabs are a preferred choice of high-tech growers using hanging gutter systems due to the labour-saving during installation and removal and a high degree of control when matched with precision irrigation.

[1] Crops like cucumber are typically using these bags 3-4 times

Figure 1. Various substrates and container options: 1. Cucumber in potted containers with a blended mix. 2. Capsicum in coir slabs. 3. Cucumber seedlings in coir filled plastic bags. 4. Blueberry in composted pine bark filled woven bags. 5. Stonewool block used during propagation growing into a stone wool slab.

Physical Characteristics of Substrates

Consider your Substrate like the foundations of a house; the overall integrity of the house will be limited by the strength of its foundation. The same can be said for your crop, without a strong foundation for growth being provided by a quality substrate, the overall integrity of the crop is compromised, and ultimately reduces your yield potential.

There are several factors that must be considered when selecting a substrate, the first, and most important is its physical characteristics.

What Makes up a Substrate?

In general, the physical (and hydraulic) characteristics of modern substrates are considered superior to most naturally occurring soils, allowing plants easier access to both water and air (and ultimately nutrients).

The physical characteristics of a substrate will ultimately determine the availability of two essential elements for plat growth- water and oxygen.

Unlike the upper portion of the plant that takes in CO_2, the root zone in commercial crop species requires an aerobic environment with high levels of available oxygen (and air exchange to expel CO_2 produced during respiration) that are also balanced with adequate availability of moisture (water).

These two components must be carefully balanced; too much air may result in water stress and too much water can limit the availability of oxygen causing conditions that are directly detrimental to the crop, and secondarily are conducive to the development of plant pathogens (such as pythium).

The physical characteristics of your media will ultimately determine the potential air : water balance.

In its simplest explanation, the physical composition of your substrate consists of solid particles and space, the space in the substrate is referred to as porosity.

In somewhat of a contradictory sense, it is the empty spaces (pore) that are the functional component of your substrate, not the physical particles! It is these pores that hold the essential elements for healthy roots and plant growth- water (including your dissolve nutrients) and oxygen.

Many of the physical measures we make will be dynamic and can change through the life of a crops cycle, this will be explained for each component.

Bulk Density (BD)

BD is defined as the mass per unit volume (grams/cm^3) of your substrate, typically measured in a moist state (e.g., not completely dry).

Whilst an important fundamental in developing substrates for container cultivation in general, BD is typically not a key concern for growers in hydroponic systems, where almost all substrates of choice are considered to have a low [2]BD and the focus is on other attributes explained below.

Total Porosity (TP

The TP of a hydroponic substrate is defined as the amount of space in a substrate measured as a percentage of the total volume. This is the combined space occupied by both gaseous and aqueous phases. In general, BD and TP are inversely related, that is- substrates with a low BD typically have a high TP.

TP is determined by the size and shape of solid particles (known as the Particle Size Distribution or PSD). The TP of hydroponic substrates will be much higher than a natural soil, typically in the range of 60-75%.

TP is generally measured with fresh substrate; however, it is considered a dynamic measurement as it can change. For example:

- Root growth will inevitably fill some of the pores
- Organic substrates (like coir, peat, saw dust etc) will gradually decomposes, which impacts the particle size and reduces TP.
- Some of these organic components will expand during watering and contract during drying.
- Substrate can ‘settle’ over time reducing the TP.

In summary, TP will generally decrease over time, not increase!

How to calculate the TP of your substrate can be found in Appendix 1.

Air Filled Porosity (AFP)

The AFP is expressed as a percentage calculated as the volume of air held within the substrate after saturation and allowing to drain relative to the total volume of the substrate.

In most situations, growers using substrate based hydroponic production systems will desire an AFP of between ~20-30%. Whilst not a hard rule for success, an AFP <20% would be considered low, and an AFP >30% would be considered high, both of which can cause management challenges.

A low AFP will have less air spaces and can produce conditions like water logging and low aeration. The result is poor root growth and the promotion of root pathogens, both of which reduce the performance of the crop and may even result in premature termination/death of plants.

AFP testing is quite simple and inexpensive to carry out and can easily be combined with a WHC test.

[2] There are exceptions to this, however they are not commonly used in Australia.

It is important to note whilst measuring AFP is a standardised process, container design has a significant effect on AFP. Taller containers will drain more readily and have a higher AFP, whilst short, squat containers will drain a little less resulting in a lower AFP.

How to calculate the AFP of your substrate can be found in Appendix 2.

Water Holding Capacity (WHC)

Growing media must contain enough water to prevent stress at the irrigation frequency used. The measurement of this is referred to as the WHC.

Like AFP, WHC is a standardised measurement expressed as a percentage calculated as the volume of water held within the substrate after saturation and allowing to drain relative to the total volume of the substrate.

The WHC of most hydroponic substrates will be between 40-60%. The WHC is useful in considering the scheduling of your irrigation. Substrates with a low WHC will need more frequent irrigation than those with a high WHC.

Just like AFP, container design has a significant effect on WHC. Taller containers will drain more readily and have a lower WHC, whilst short, squat containers will drain a little less resulting in a higher WHC.

How to calculate the WHC of your substrate can be found in Appendix 3.

Available Water Content

It is important to remember that not all water in the substrates pores is readily available to the plants, that is the plant available water is always less than the WHC.

Moisture will be held in pores due to both cohesive (water-water) and adhesive (water-substrate) forces. The adhesive forces are the strongest factor that binds the water to the substrate, and this force increases the smaller the pores are.

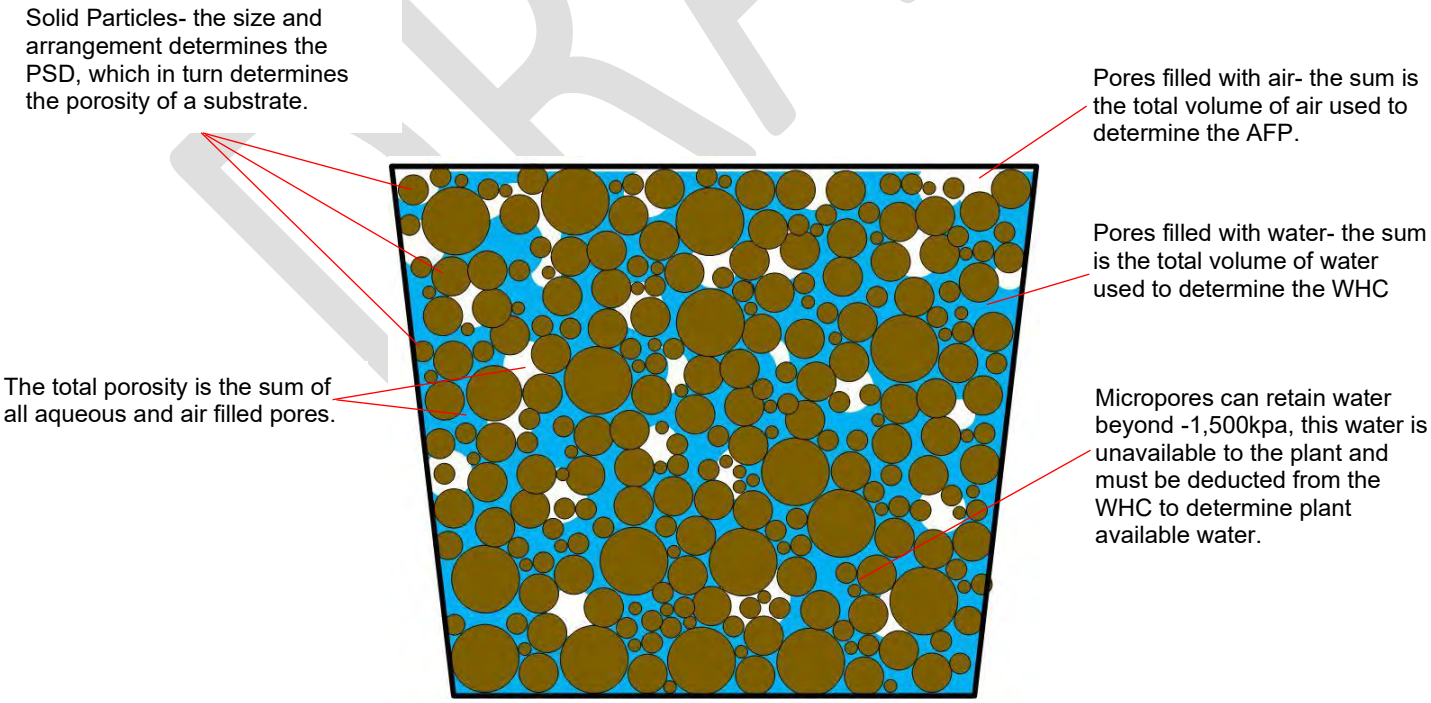
Plants can create a negative pressure in their roots via plant transpiration allowing them to overcome some of the binding forces. However, when the vacuum pressure required to break the cohesive force is less than -1,500kpa, the water is considered unavailable to the plant.

When a substrate contains a lot of micropores the water can be too tightly bound for the plant reducing the amount of available water.

Conversely when the substrate has only large macropores, all the water is easily available. This may sound ideal, however it creates a situation with limited range meaning a plant can very rapidly shift from the initial signs of water stress to physiological damage.

The most practical substrates will have a reasonable range of pore sizes, without too many micropores.

Measuring AWC is not simple and requires laboratory grade equipment, however you can estimate the AWC by sacrificing living plants.



The shape of the container can also alter the WHC and AFP.
More water will drain from a taller container (= higher AFP and lower WHC).
More water is held in a shorter container (= lower AFP & higher WHC).

Hydraulic Conductivity (HC)

HC describes the ease of which water moves within pores of a substrate (the mass of water passing through a given area in time).

The practical implications of HC are most important when we understand that some substrates will have a sharp change as the substrate dries out, making them very difficult to wet up again if allowed to become too dry.

That is, as the substrate dries off the HC will decrease, making it both harder for a plant to access the remaining water and making it much harder to re-wet the substrate. It is the latter which many growers may be familiar with.

In substrates such as coir and peat a sharp reduction in HC can occur as the substrate becomes too dry. This can have severe ramification-

- The response may not be uniform across the entire crop and plants that reach the sharp decline in HC will stop rewetting and the problem is exasperated.
- In some cases, the inability to absorb the water due to a low HC can result in seeing ‘false drain’ where water passes through the growing container without wetting up the substrate or reaching the plant.
- The impact on these plants is twofold, it has a lower availability of water (harder to access), and the substrate will become difficult to rewet, this can be perceived as a ‘hydrophobic’ response where the substrate struggles to rewet and correcting the problem can be difficult.

In the event of low HC due to excessive drying, the remedy is to apply very small volumes of water to the substrate over a long time (this can take a full day or more). This will allow for the slower infiltration of water and will eventually bring the uniformity of water back to the entire crop. Once the HC increases and uniformity is achieved you can resume normal irrigation practices again.

Measuring HC is not simple and requires laboratory grade equipment. The most important aspect of HC is understanding they a wet media will typically have a higher HC whilst a dry media will have a lower HC.

Matching Irrigation Emitter Rates with Substrate

The PDS (shape, size, and placement of particles) will influence the wetting capacity of a substrate and the HC.

Substrates with large particles will typically have a higher risk of channelling- this occurs when the inflow of water is too fast, and it finds the path of least resistance- flowing through the pores rapidly. The result is a ‘false’ drain and does not create an even wetting profile in the substrate.

When designing a system or changing your substrate you should also consider your dripper emitter rates and number of emitters.

- Large particles may require a lower emitter rate (say for coarse pearlite you might want a 1.1L/hour emitter) and perhaps more emitters per growing container. This will result in both a slower influx of water (allowing it to spread) and more points of delivery covering a larger surface area.
- Smaller particles may be able to use a higher emitter rate (say for stonewool a 2.2L/hour emitter is fine). In this case the sideways water movement will be increased, and a larger surface area can be covered with a lower number of emitters with the same result.

If you have already installed you system and find channelling issues due to applications rates that are too high for your substrate, the next best remedy is to decrease the volume per application. Whilst this may not be a perfect solution, it can greatly reduce the issue in an established system.

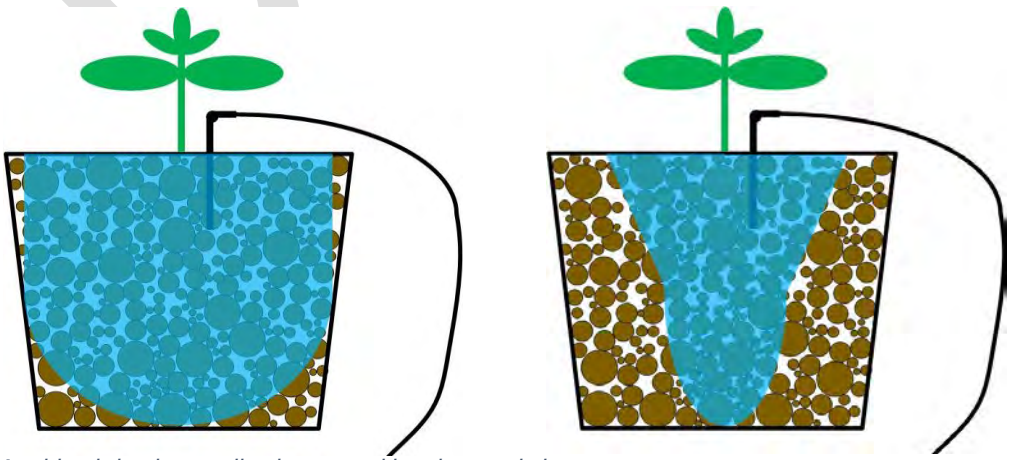


Figure 2. Matching irrigation application rate with substrate is important.
Left: Irrigation rate is matched with substrate creating an even wetting profile throughout most of the substrate.
Right: Irrigation rate is too fast water channels through, leaving much of the substrate dry.

Matching Irrigation Application Frequency with Substrates

The maximum frequency of your irrigation will be determined by the WHC of your substrate and its volume. It is important to consider the impact of both.

If a substrate has a low WHC (e.g., coarse pearlite) then the irrigation frequency must be quite high as there is very little water retained in the media between irrigation cycles. Substrates with a high WHC (such as coir fines) will likely benefit from large gaps between cycles to ensure aeration to the rootzone, and there will be little risk of moisture stress due to the larger volume of water available.

The total volume of substrate for your given cropping area (typically expressed as litres/m^2) will also influence the frequency of your irrigation shots. A larger volume of substrate has the potential to retain more moisture than the same substrate in a smaller volume.

In terms of substrate volume, most systems these days tend to run at between ~9-14L/m^2 of growing area.

Examples of how you might adjust your irrigation based on WHC and substrate volume are presented below. Assuming a mature crop during peak summer in 1,100watts of radiation (6.6j/minute = 396j/hour) and 3 x 2.2L/hr drippers per m2.

High Frequency

- In the case of low WHC and/or low substrate volume a high frequency application in smaller shots will be required.
- The crop could be irrigating every 80joules meaning ~5 shots per hour, and around 100ml per shot.
- The crop would receive about 3.8ml/j/m2, sufficient for a high drain of >40% during this time.

Low Frequency

- In the case of high WHC and/or low substrate volume a lower frequency application in larger shots will be preferred.
- In this case the crop could be irrigated say ever 100joules meaning ~4 shots per hour, and around 120ml per shot.
- The crop would still receive about 3.8ml/j/m2, sufficient for a high drain of >40% during this time.

If you change your substrate dramatically in terms of either volume or WHC then you will likely need to adjust your irrigation strategy to get the optimal results.

Summary of Physical Characteristics

- The physical properties of your substrate including the size, shape, and variation of solid particles, will influence the TP, AFP and WHC. Unlike TP, the WHC and AFP can be further influenced by the shape and volume of your growing container (bag, pot, or slab).
    - Taller containers will drain more readily and have a lower WHC and higher AFP, whilst short, squat containers will drain a little less resulting in a lower AFP and higher WHC.
    - If growing with a taller container you may look to a lower AFP mix with higher WHC, and in shorter containers you will likely preference a higher AFP mix.
- Large particles (referred to as coarse) typically result in a high TP and AFP, yet relatively low WHC as they drain very freely.
- Smaller particles (often referred to as fine) typically result in a low TP and AFP but can give a relatively high WHC as the smaller pores created hold the water.
- Mixed substrates can behave quite differently, and each should be assessed directly. For example, a high percentage of large particles would expect a high TP and AFP, but if the distribution of the smaller fragments results in these pore spaces being filled you can get a very low AFP mix and even a low TP. Sometimes adding more coarse portions can unexpectedly result in a decrease in AFP as the nature of the aggregation of particles combined is different to what you expect!
- The science behind substrate development is complex and requires rigorous testing and development, with a change of any input potentially significantly altering the end product. If making blends you need to test functions like AFP and WHC for any change.
- In substrates such as coir and peat a sharp reduction in HC can occur as the substrate becomes too dry. This can have severe ramifications and a grower should always work to keep the substrate in the correct moisture range, otherwise remedial action may be required.
- Understanding the physical characteristics of your substrate will help you refine your irrigation application rates, including system establishment, frequency of irrigations and volume of each irrigation.
- Different substrates require different approaches to irrigation and water management. It is not a fair trial or comparison of a media if you cannot adjust your watering strategy to suit to product being used.

Chemical Properties

Unlike soils, substrates used in hydroponic production are not considered to provide nutrition to the crop, however the chemical properties of a substrate can have an impact on the availability of nutrients in a hydroponic system.

Cation Exchange Capacity

Firstly, what is a cation?

Cations are ions with a net positive charge, whilst anions are ions with a net negative charge. In a hydroponic solution, we will have a balanced formula with ~equal amounts of cations and anions.

The positive charge of a cation enables them to bind to (typically) negatively charged particles in the substrate. Anions on the other hand do not bind and will stay in solution within the media or easily flow through in the drain.

The CEC is therefore a measure how readily the cation nutrients are held and released from the substrate to the surrounding environment for access by plants.

Cations	Anions
Potassium Calcium Magnesium Ammonium Sodium (Iron, Manganese, Zinc and Copper)	Nitrate Phosphate Sulphate

In general, organic materials will have more negative charges on their surface resulting in a higher CEC than mineral based materials. The low CEC of most mineral substrates is the reason they are considered inert.

As a grower you should be aware of your substrates CEC characteristics to help you consider adjustments to recipes, particularly during the wetting up phase and crop establishment where nutrients you are supplying may be bound up to the substrate until the sites are saturated or displaced by other cations.

Inert substrates like rockwool and perlite have a very low CEC so there will be almost no impact on cation availability, and they will all be held in solution and relatively available. However, substrates such as coir and peat will hold a strong negative charge (high CEC) and can require a more assiduous approach, especially during establishment.

pH

The ideal pH of your substrate root zone solution for optimal nutrient uptake in most hydroponic crop species will be in the range of 5.5-6.0. Outside of this range you can experience issues with nutrient availability and plant health.

As a grower you will adjust your rootzone pH via managing the recipe supplied, including adjusting the pH directly and varying the composition of the nutrients. The substrate's starting pH is therefore not of such a concern.

However, you should be mindful that substrates have differing pH buffering capacities. Substrates like perlite and rockwool typically have a low buffering capacity meaning you can more easily change the rootzone pH. Organic substrates like composted products have a high buffering capacity meaning altering the rootzone requires more acid/base additions to alter.

In summary the most important aspect of pH management is understanding that some substrates will be more stable and resistant to change, meaning pH drift will take longer to correct.

Taking Samples

For many of the basic tests (EC and pH) a simple 1:1.5 extraction test is the easiest way to collect and measure a sample against industry accepted benchmarks.

The procedure for this can be found in Appendix 4

Root Zone Microbiology

Root zone microbiology has historically been ignored in hydroponic production, perhaps with the exception of microbial pathogens.

However, in recent years the impact of microbes in the rhizosphere is becoming recognised as being important in all production systems, even hydroponics.

Nature implores a vacuum, and any substrate that is sterile or devoid of life will rapidly be colonised once water, nutrients and an organic carbon source is present. Whether this colonisation is beneficial or detrimental can be influenced by the grower.

Microbes and Plants

Organic substrates may start out 'sterilised', however the moment nutrients and water are added, all the essential elements for microbial life are also present (even before the plant is introduced).

Inorganic substrates may start out sterile, and with no organic carbon, however, the latter is present the moment a plant is introduced in the form or root matter and root exudates.

Once a plant is in the substrate, be it organic or inorganic there is a constant influx of readily available carbon in the form or root exudates. These exudates will be used by microbes.

In nature, plants have evolved to have relationships with the microbial communities that naturally develop in the rhizosphere. To give some content here, we can personify the plant microbe relationship-
Plants pay a 'tax' in the form or root exudates rich in assimilates to their microbial communities and in return they receive benefits equivalent to the human tax interaction; such as:

- Healthcare- defence against pathogens.
- Communication- microbial networks act like the internet connecting plants and allowing communication.
- Transport services- microbes help plants acquire nutrients, and plants can preference payment of assimilates to microbes that provide such services.

Regardless of receiving benefit or not, plants are programmed to deliver these exudates to the rhizosphere. If the beneficial microbes are not present, then these exudates may be utilised by less beneficial organisms or even pathogenic organisms.

Eventually our media will be colonised, our approach can influence the negative or positive outcomes associated with this formation of microbial life.

A Complex Topic

The plant-microbe relationship and the impact of substrates and hydroponic techniques is a complex topic that is constantly evolving. It is not the intent of this paper to try to explain this process, instead we introduce this topic as a catalyst for thought, and something we explore in future papers.

Whilst growers will attempt to start sterile/clean and employ many ongoing treatment solutions to keep it this way (such as UV treatment), the fact is, life will always find a way.

Once you introduce the elements of life to your substrate microbial communities will flourish. The choices we as growers make in terms of selecting our substrates and managing our crops can assists us in developing a healthier rhizosphere preferencing beneficial microbes and reducing the conditions that promote pathogens and unwanted microbes.

A healthy microbiota has been proven in many studies to be effective at supressing plant diseases, even in inorganic growing media. However, the mechanisms behind this are relatively poorly understood/documented.

The Basics

One of the simplest steps we can take as a grower when selecting our substrate, (be it inorganic or organic), is ensuring we have a product and management technique that facilities an aerobic environment – the presence of free oxygen.

Many pathogenic microbes and those associated with poor plant health will preference and proliferate in low oxygen and even anerobic environments. in contrast, many of the microbes associated with beneficial plant interactions preference aerobic conditions.

The fundamentals to promoting a healthy rhizosphere community include-

- Purchase substrate from a reputable supplier, ensuring the product is free of disease and contaminants when you start.
- Select substrates with physical properties that ensure a sufficient AFP, typically in the range of 20-30%. Be mindful of substrates that can settle or break down resulting in a reduced AFP or anaerobic pockets as time goes on, consider you container design in the same way.
- Match your irrigation strategy to your substrate. If you have a low AFP and high WHC product, make sure the time between irrigations is sufficient to create good air exchange.
- Consider the addition of biological control agents (BCA) to promote the development of a stable beneficial microbial community.
- Developing active blends with composted products is proven to be beneficial, however, this is a complex topic in its own right!

Summary of Substrates

Now that we understand the fundamentals, let's talk about some of the most common substrates used today.

As the saying goes, 'there are many roads to Rome' and ultimately most of the listed substrates can result in commercially viable crops, however an understanding of the nuances of each will enable you to choose what suits your system and adapt management techniques to achieve the best results.

It is important to note that within each type of substate there is typically a variety of choices in terms of blends and particle sizes, washed or non-washed, and slabs, bags or lose product. You need to select the appropriate choice to match your growing system and techniques.

The most important factor is likely not what media you chose, but rather than you acquire it through a reputable supplier with appropriate quality control measures and adapt your strategy to suit.

The latter point is very important to note. Typically, you cannot trial a new substrate effectively without having a specific irrigation program that you can adjust specific to the needs of that substrate.

Whilst the list of possible substrates is quite large, these days most commercial operations in Australia utilised a select few. Currently, the mid to high-tech sector typically utilise rockwool or coir slabs, whilst the lower tech sector will typically use sawdust or coir in bags or pots.

Organic

Coir (Coco Peat)

A product that was once an abundant waste product of the coconut industry, it is now a valuable input as a substrate and blended products.

Coir is mostly made up of lignin and cellulose. It is very stable, offers high TP and AFP with a very high WHC, factors that make it quite ideal.

The particle size can be made of a varied mix of coarse chips, fibres, and fines (pith). By varying these components manufactures can tailor mixes for specific needs.

Coir also can create cost saving options. With the ability to purchase compressed slabs or blocks (around 12-20% of their total size) they can reduce transport costs and make placement in the greenhouse very easy, reducing labour. Upon hydration they expand to their full size.

Coir also has a high CEC and pH buffering capacity. Whilst many organic substrates will have a reasonably high CEC, it is coir that generally presents the most confusion for growers.

Coir is typically grown and processed in locations with natural salt (e.g., coastal tropics). This means that coir's cation exchange sites are naturally saturated with sodium and potassium. The result is in its natural state coir can have salinity issues and can also experience binding up of calcium and magnesium as they replace some of the attached potassium.

To alleviate this issue, all quality coir suppliers now provide a washed product (with fresh water) and sometimes pre-buffered with a solution containing calcium (and sometimes magnesium).

Using coir does not have to be a daunting process and there are some simple steps that will ensure you have a product suitable for vegetable crops:

1) Only purchase your from a reputable supplier.
2) Select a blend suitable for your crop- the correct physical characteristics of TP, AFP and WHC.
3) Ensure it is prewashed. The 1:1.5 extract should result in an EC <1.0 dS/m.
4) After receiving your product, do a basic check using a 1:1.5 substrate extract method. If the EC is >1.0, do not use, contact your supplier.
5) If you have not purchased a buffered product, your first wetting up cycle/hydration process will be the buffering step. This can be carried out with a calcium nitrate solution or even a standard recipe, sometimes adjusted with elevated calcium and magnesium. Most coir suppliers will provide guidance on how to carry out this process with the products they supply. Do not use the drain water from this process.
6) After a correct hydration/buffer process the coir will ready for use.

NB: Typically for the first 4-6 weeks there will be significant tannin leached out. Treatment with UV sterilisation is not normally possible due to low transmission during this time.

Figure 3. Coir slab showing root development in a pepper crop.

Saw Dust and Wood Products

A by-product of the timber industry, historically this was a popular product, though is now only really used in low-tech systems and is losing favour to alternatives like coir.

It was popular in Australia as a local, cheaper alternative to peat, a product shipped from the northern hemisphere at great cost.

In their raw form, these products have a high TP, high AFP, but relatively low WHC. It is typically an affordable option (cheap), but due to other less desirable traits its suitability is questionable.

Saw dust products are typically variable in quality. Add to this the low WHC and the fact that they will decompose (consuming nitrogen, reducing in volume, and reducing aeration) means it is not an ideal growing media, and one must question if it is actually good value for money?

These days growers are transitioning to more stable alternative (such as coir or blends) or looking to advancements made with modified wood waste products now entering the market that alleviate the issues of raw sawdust type products.

Figure 4. Melon crop being grown in plastic bags filled with sawdust.

Peat

Peat is not simply one product but is highly variable with different options available for growers depending on how it was formed and processed.

Peat is created via the decomposition of mosses and sedges of swampy ecosystems in acidic conditions. Peat takes a long time to form under unique conditions, meaning global demand has put a question the sustainability of this product from some regions.

Whilst peat has many highly desirable characteristics, it is not really used in its pure form in Australian vegetable hydroponic production. Instead, peat is usually part of a blended substrate used in seedling, nursery, or soft fruit production systems.

Most of the global peat produciton is in high northern latitudes. Due to the bulky nature of the product and long distances of travel, freight cost can make peat prohibitively expensive in Australia.

Figure 5. Peat is a common ingredient in blends.

Barks and Composted Products

Whilst potentially an ideal addition to potting media, the inherent variability of these products makes it difficult to uniformly classify them for controlled hydroponic produciton systems.

Whilst there is no doubt many products will be functional and useful additions or on their own, the broad classification of these products makes it a difficult task to recommend to growers in hydroponic systems.

Growers wishing to develop blends themselves or in conjunction with a supplier should have a thorough understanding of the science behind developing a substrate as previously described, along with an understanding of composting and decomposition processes.

Each specific batch and recipe will have unique characteristics that need to be tested and verified.

Figure 6. Cucumber crop in solid containers being grown in a blended substrate.

Inorganic

Stonewool (Rockwool)

Going by a variety of names and brands, much like we call an icebox an Esky (after the historic brand) stonewool has generally adopted the name rockwool, derived from the Danish Grodan branded products.

It is a lightweight fibrous material formed by spinning molten rock and has many highly desirable characteristics- a high TP, AFP and WHC. It is also light in weight and often delivered in prewrapped slabs ready for use that are easy to place out.

It has a very low CEC and pH buffering capacity and is typically considered inert. There is almost no locking up of cations and typically all nutrients are held in solution available for plant use.

It can be supplied in a variety of forms, constructions and volumes and is a very popular choice in high-tech greenhouses. It is the most common product in markets such the Netherlands.

The main negatives associated with stonewool are the fact it is a lightweight high-volume product typically produced in Europe. Thus, like peat the transport costs play a major role in domestic pricing (as you ship air) making it an expensive option.

In Europe there are many options for recycling waste product, though this is not yet available in Australia and disposal can be trickier than some organic products.

Figure 7. Capsicum crop growing in stonewool slabs.

Perlite

A very lightweight material, perlite is formed by super heating a glassy siliceous rock until it expands and ‘pops’ much like popcorn.

Perlite can be supplied in various sizes and blends that alter the physical characteristics. However, in general it has a very high TP, AFP and reasonable WHC. Like stonewool it has a very low CEC and pH buffering capacity, so it is easy to adjust, and nutrients will be available in solution.

It is lightweight product and holds structure well, though is also delicate and excessive handling will physically break it down.

If using in slabs it has similar labour handling properties to stonewool, however in loose form is quite difficult to handle and adds labour costs.

In Australia there are some growers using pure perlite, however most of the time it is part of a blend and is common in nursery mixes and soft fruit blends. In the latter instances care must be taken when mixing to avoid breaking down the product.

Very low pH (<3.0) can result in high aluminium levels released from the product; however this is only really a risk in acid loving/tolerating species like blueberry.

Figure 8. Perlite is typically used in blends but can be used in pure form.

Vermiculite

Vermiculate is derived from natural clay (mica), and like perlite and stonewool is created using high temperatures. The process creates expansion and a layering effect resulting in highly porous granules between 1-8mm in size. It is an easily recognised product that appears like a golden multilayered granule.

Vermiculite has a very high CEC and pH buffering capacity. Whilst it also offers a high TP, moderate AFP and high WHC it is not an ideal product for applications in hydroponic vegetable production.

Vermiculite is very fragile and easily breaks down. It easily loses structure over time and the high CEC can cause some challenges for growers.

Its is commonly used as an addition to blends for nursery production and seedlings. Fine grade vermiculite is a very popular choice for top dressing seedling trays.

Figure 9. Vermiculite is a popular top-dressing agent on seedlings.

Scoria and Pumice

Both Scoria and pumice are volcanic rocks in their unmodified form (except for sizing). They have very high TP, AFP and relatively low WHC.

The main difference is that scoria is heavy and has a reasonable CEC, whilst pumice is very light with a very low CEC.

They are not a common choice in commercial vegetable production in Australia, however, in regions where they are naturally common (pumice in New Zealand and Japan).

Both products will also break down over time, and like perlite, if you expose pumice to very low pH levels (<3.0) it can release aluminium.

Figure 10. Scoria is not commonly used in Australia.

Gravel and Sand

Sand and gravel are raw products that share some common traits. Typically, they both present very high drainage and potentially high AFP (when using coarse particles) and low WHC, though sand will normally be higher than gravel.

The main draw backs are the very high BD (heavy) and variability of natural forms.

Whilst they can be an effective substrate, they are not widely used in commercial systems and instead tend to end up in blends for nursery production.

Figure 11. Gravel has a very high BD and is not common in commercial settings.

Expanded Clay

These are semi-round expanded clay granules typically about 8-15m in size. They are derived from small pieces of clay processed at extremely high temperatures.

They have a very low WHC and high AFP. The CEC is low and they have a moderate BD. They have numerous large air spaces making it almost impossible to overwater.

They are typically considered as a reusable substrate that is washed and sterilised between crops. They are not readily used in commercial settings except for some flood and drain production, and typically see use in home hydroponic systems.

Figure 12. Expanded clay pellets are used in flood and drain and home hydroponics.

Appendix 1- Calculating Total Porosity

Calculating Total Porosity

How to Calculate TP
(Suitable for bags and pots, not easily done with slabs)

1) Take your growing container (pot or bag), block the holes off with a waterproof product; such as using a tape on a bag or a liner in a pot.
2) Fill the container with water to the level you would normally see the substrate depth. Transfer this to a measuring jug and record the volume. This is the Container Volume (CV).
3) Leaving the holes covered, now fill the container to the same level with substrate.
4) Slowly fill the container with water being sure to measure how much you add. Add water until a thin film is visible on the surface of the substrate. Sit the container aside for 2-3hours.
5) Check the substrate, add more water if required until the substrate is once again saturated (visible film of water on top of the substrate).
6) Record the total volume of water added (TVW)

$$\text{TP (\%)} = \frac{\text{TVW}}{\text{CV}} \times 100$$

Whilst TP is an important function in developing a substrate, growers rarely if ever talk about TP, instead we discuss the two physical components that fill these pores-

1) Air- the component of the total porosity that is filled with air is referred to as the Air Filled Porosity (AFP).
2) Water- the component of the total porosity that is filled with water is referred to as the Water Holding Capacity (WHC)

Appendix 2- Calculating Air Filler Porosity

Industry Accepted AFP Testing

An AFP test is a common procedure in nurseries production facilities who wish to adjust substrate blends or verify the quality of a delivered product. To carry out a standalone AFP test a simple device must be constructed.

Equipment

1) AFP Device
    a. Base = 120mm long x 90mm pipe, sealed end cap, cut outs for fingers and 4 x 9mm holes
    b. Top = 120mm long x 90mm pipe with joiner connected
2) Stocking and rubber band
3) 10L bucket
4) Knife
5) Catchment container x 2
6. Measuring cylinder

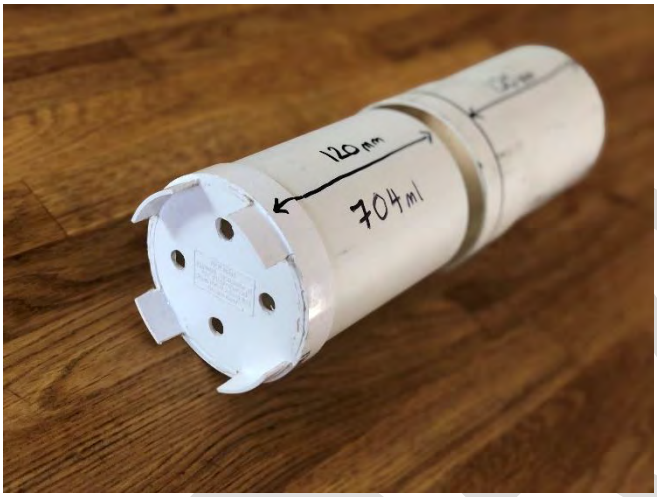


Figure 13. An AFP measuring device is cheap and easy to make and is an invaluable tool for substrate testing.

Measuring AFP

1) Pre-moisten media and allow to settle overnight (targeting around only 50% moisture content)
2) Measure the volume of the base of your AFP device by filling with water and measuring in measuring cylinder
    a. Record this value (should be ~700ml)
3) Connect top and base of AFP device
4) Fill apparatus with moistened media and settle
    a. Drop from 5cm x 5 times to settle mix
    b. Soak and Drain Process- Note- during soaks you may need a weight to keep the device steady and not floating.
5) Soak 1-
    a. Place apparatus in bucket and fill with water- ensuring the water level is to the top of the soil. Soak for 30mins
    b. Drain- remove apparatus and sit in drain tray for 5mins (not captured)
6) Soak 2
    a. Place apparatus in bucket and fill with water- ensuring the water level is to the top of the soil
    b. Soak for 10mins
    c. Drain- remove apparatus and sit in drain tray for 5mins (not captured)
7) Soak 3
    a. place apparatus in bucket and fill with water ensuring the base section is fully submerged.
    b. Soak for 10mins
    c. Drain- remove apparatus and sit in drain tray for 5mins (not captured)
8) Separate top from base
    a. Carefully scrape away potting mix to the top of the base ensuring you don't compact the media
    b. Cover with gauze/stocking and fix with a rubber band to stop soil coming out
9) Final Soak Place apparatus in bucket
    a. Fill with water ensuring water is around 20-40mm above the top of the Apparatus
    b. Soak for 10 mins
10) Final Drain (4th)- Captured
    a. Carefully lift base in bucket, keeping the top under water
    b. Cover finger holes (x4)
    c. Continue to remove base fully out of bucket keeping fingers over the holes
    d. Allow any drips to run off
    e. Drain 30 minutes (CAPTURED)
        i. Place in shallow container
        ii. Place on a small stand keeping bottom of base out of container to avoid wicking
        iii. Leave to drain for 30min
11) Measure volume
    a. Remove base from container
    b. Measure drainage water in a measuring cylinder and record value

$$\text{AFP(\%)} = \frac{\text{Volume of drain water}}{\text{Volume of container}} \times 100$$

Appendix 3- Calculating Water Holding Content

WHC

WHC can be easily calculated and is best carried out in the same moment as carrying out and industry standard AFP test as the same basis equipment and substrate sample can be used.

1) Use your same AFP test kit.
2) After carrying out your AFP test, place moistened media into a tray and record its weight in grams
3) Dry the media until there is no free moisture in the media- the fastest way to do this is hold the substrate in an over overnight at 50C.
4) Record the dry weight of the media in grams

$$\text{WHC (\%)} = \frac{\text{(Wet weight of media – dry weight media)}}{\text{Volume of AFP Device (ml)}} \times 100$$

Appendix 4- 1:1.5 Extraction Samples

You can determine many properties of your potting mix by using a simple water extraction process. This method can be used to assess new media for factors such as pH, nutrient content.

It is also a useful tool during cropping to help assess the actual state of the media; this is important as often our drain measurements do not perfectly represent what is going on in the media, especially those with a high buffering capacity and CEC (like coco peat); the pH and EC of the drain water generally deviates from the actual root situation, as the media is able to retain and release elements.

Taking a Sample

1) You need make a representative sample of the mix- if this is during cropping you should take multiple samples using a coring tool or spoon and combine these.
2) First you must set the base moisture content appropriately before starting the test-
    a. First check it already has enough moisture- if moisture disappears between your fingers when you squeeze it in your hand this is about right.
    b. If too dry you need to add more moisture- The easiest way to do this is to slowly add deionised water to it until you get the moisture content high enough that you can just squeeze out a little water (as above).
3) Measure 100ml of this moistened mix and put it into a container that will easily hold >250ml.
4) Add 1.5 x the media volume of deionised water (150ml).
5) Shake or stir the mixture several times.
6) It is recommended to let the mixture sit for 1hour, the mix again prior to testing.
7) We would also suggest holding the mixture and check again after a total of 2hour, some substrates like Coco peat can be slow in releasing all the dissolved salts in the media.

You the most important aspect of such testing is to keep a relatively constant process, so all results are comparable.

Measuring Samples

pH

You can measure the pH directly simply by inserting the probe into the solution,

EC

For EC and other chemical testing, it is recommended to filter the solution first using filter paper or simple coffee filters. This solution is now suitable for inserting an EC probe.

Chemical Testing

The same solution used for EC will normally be clear enough to use with reagent test kits. If you have used a coarse filter and the solution is still discoloured, you will need to filter using filter paper (Whatman No. 54 or 42), held in a small funnel. There are various off the shelf tests available (including reagents and strips) and you can measure factors such as Ammonium, Nitrate, Phosphates etc. Some of these test may require a dilution procedure.

Hydroponic Irrigation

Drip Irrigated Substrate

National Vegetable Extension Network

Strictly speaking, hydroponics is the science of growing plants in water culture without any soil or substrate. However, in commercial terms it is accepted that plants may be grown in a substrate that is relatively inert and devoid of nutrients, with the nutritional needs of the crop provided by elements dissolved in the irrigation water.

This paper provides guidance on both establishment and ongoing management of drip irrigated hydroponic production in substrate filled bags, slabs, or pots. It is relevant to crop species such as cucumber, capsicum, and egg plants.

Introduction

Protected cropping hydroponic farming is intensive by name and nature. Whilst inputs are extreme, it offers far higher efficiencies when compared to traditional field production (in respect to output relative to land mass and water use). However, to achieve the highest yields requires an assiduous approach to system establishment and ongoing monitoring.

A tool common across all levels of technology is that of irrigation management. Regardless of using simple netted structures or sophisticated high-tech glasshouses, all growers can use irrigation control to help get the most out of their crops.

Irrigation regimes are not standardised for a crop or condition, though require consideration and adjustment based on the balance of the plant (strong vs weak, generative vs vegetative), the environmental conditions (such as light, temperature, humidity), and finally, balancing the irrigation with other aspects of the grower's strategy towards overall crop management (this can include how and when you use heating pipes, screens, fans etc).

Irrigation monitoring and management is critical to the health and economic performance of the crop. Plants that are out of balance will produce less than well-balanced plants. At the extreme end, over or underwatering can kill your crop.

Key Messages

- **Site establishment can ultimately determine the yield potential of your crop, getting this right is essential! Key considerations include:**
  - **Total water requirements**
  - **Water quality (salinity, alkalinity etc)**
  - **System capacity (peak demand)**
- **Verify system capacity and uniformity through physical checks such as drip uniformity and flow variance. Carry this out after installation, maintenance and before each crop cycle.**
- **Fertigation units must be well designed and maintained. Regular preventive maintenance and calibration is required.**
- **There is no blueprint for irrigation, you must adapt the strategy to suit your crop and conditions.**
- **Irrigation monitoring is critical, there is no substitute for correct drip and drain data, this will ultimately guide your irrigation strategy.**

Hort Innovation Strategic levy investment | VEGETABLE FUND

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

NSW GOVERNMENT Local Land Services Greater Sydney

Site Establishment- a Foundation for Success

Correct irrigation control and management starts before you begin growing. How you design and establish your growing system will ultimately set the foundations (and limitations) for future control.

Whilst it is possible to grow with suboptimal water management solutions, peak yield potential is achievable only when the system can meet basic requirements.

Specialist greenhouse technical companies will be able to assist you in your design and installation, however for farmers wishing to better understand their system, this section of the paper will help present the basics of establishing a water management solution.

Water Consumption

This is of course the critical requirement for success! As a grower you need to ensure you have enough water (in the correct quality parameters) for your cropping system.

Whilst rainwater is normally an ideal source, many regions in Australia do not receive enough rainfall for self-sufficiency.

A typical vegetable crop will take up ~1,000L/m^2 per year, and when we account for losses to drain and cooling solutions (fogging or misting) annual water use can exceed 2,000L/m^2. In this case, most regions of Australia will have insufficient annual rainfall, and alternate sources (such as bore, dam or river) are required.

There are many methods to estimate your sites water needs quite accurately, however, a simple water budget (for crop use only) can be developed using solar radiation data derived from the Bureau of Meteorology (BOM) website.

An established vine crop species will consume around 1.7-2.0ml/j/m^2 based on average daily sunlight. E.g., a long-term tomato crop in Coffs Harbour could receive around 587,000j during its cropping period x 1.7ml per joule = 997Litres/m^2 of water uptake. If the grower used a run to waste system averaging 25% drain, they would require 1,330Litres/m^2 in total.

These types of models can be adapted to monthly or even daily estimates. You can then calculate your water storage needs.

Peak daily demand (not average) should also be considered. In this instance a well-established vine crop in peak summer conditions can see a daily application rate exceeding 10L/m^2, however in these conditions the grower will expect a drain level of ~50%, with plant uptake typically peaking at around 5-6L/m^2/ in even the most extreme conditions.

Water Quality

Source water needs to meet basic requirements such as being clean and clear (e.g., no colloidal matter) and free of pathogens and pollutants.

However, the water quality requirements for hydroponic production are far stricter than that of a comparable soil crop, this is particularly true for factors such as salinity and alkalinity. Therefore, when using sources other than rainfall we also need to carry out a comprehensive water analysis.

There are many reputable laboratories around the country that can perform a full chemical analysis to determine the suitability of your water for hydroponic use, and for refining your recipes. Many of these labs will provide advice, however basic parameters are presented in Table 1, Table 2 and Table 3.

If your water is not within the advised parameters, then you should discuss pre-treatment solutions with a specialist provider. This could include functions such as removal of colloidal material or iron, UV sterilisation for pathogens or even reverse osmosis (RO) for water high in sodium and chloride.

Alkalinity Management

Alkalinity management is often overlooked but can be required for some water sources. Alkalinity is an important consideration as it acts like a buffer and affects how much acid is required to change the pH.

Too high alkalinity and you will not be effective in reducing your pH and a too low alkalinity will make the adjustments volatile and potentially delivering a low pH to the crop.

Typically, high alkalinity issues occur when you use bore water that is highly alkaline, and therefore needs to be treated prior to fertigation using an acid dosed into your storage tank.

Conversely, where RO has been used, the pure water has almost no buffering capacity and will need to be amended. This process can be managed by adding a small quantity of your raw water (if salinity permits), or alternatively via the addition of an alkalising agent added (such as potassium bicarbonate). Similar issues can occur when using only pure rainwater that also has little to no buffering capacity.

Alkalinity measurements will be provided in a comprehensive water test. The recommended range presented in Table 1 provides guidance, if your final treated water source falls outside of these recommendations you should consider some form or alkalinity management prior to fertigation.

Water Quality Guidelines

The following guidelines provide general advice in respect to the suitability of water for optimal crop performance.

Table 1. Basic water quality parameters for hydroponic use.

Analyte	Optimal	Moderate	Excessive	Comment
pH	5.6	5.0 – 7.5	>8.0 <5.0	This is normally controlled at the storage system and irrigation units; hence we can handle quite a large range.
Alkalinity ($CaCO_3$ equivalent ppm)	30-100	100-150	>150ppm	Linked to pH, higher levels would have to be managed with some acid additions prior to the fertigation units. Low alkalinity makes pH unstable and may need buffering.
Hardness ppm (Ca and Mg)	50-100	100-150ppm	>150ppm	Equipment clogging and staining > 150ppm.
EC (dS/m)	<0.5	0.5 - 1.1	>1.1	Optimal is required for recirculating. Moderate is typically only suitable for run-to-waste systems. Excessive you would not use in hydroponics
*Sodium (ppm)	See Table X			
*Chloride (ppm)				
Dissolved oxygen (mg/L)	7+ (~100%)	5 - 7	<5	We recommend not using water with a do level below 5mg/L
Iron (ppm)	<0ppm	0- 0.3	0.3ppm or >1ppm	Less than 0.3 for micro drippers or you can get clogging. Above 1ppm and you can get staining when using sprinklers.

Table 2. Salinity guidelines.

Class	System	EC (dS/m)	Sodium		Chloride		Crop Suitability
			mmol -1	ppm	mmol -1	ppm	
1.1	Substrate with recirculation	<0.5	0.2	5	0.2	7	All Crops
1.2		<0.5	0.5	11	0.5	18	Salt sensitive crops
1.3		<0.5	1.0	23	1.0	35	Salt tolerant crops
2.1	Substrate with free drain <20%	<0.5	1.0	23	1.0	35	All Crops
2.2		<0.5	2.0	46	2.0	71	Salt sensitive crops
2.3		<0.5	3.5	80	3.5	124	Salt tolerant crops
3.1	Substrate with free drain >20%	0.5-1.0	1.5	34	1.5	53	All Crops
3.2		0.5-1.0	3.0	69	3.0	106	Salt sensitive crops
3.3		0.5-1.0	4.5	103	4.5	160	Salt tolerant crops
4.1	Soil crops	1.0-1.5	1.5	34	1.5	53	All Crops
4.2		1.0-1.5	3.0	69	3.0	106	Salt sensitive crops
4.3		1.0-1.5	4.5	103	4.5	160	Salt tolerant crops

Table 3. Crop Salinity sensitivity matrix

Crop Type	Salt Tolerance Classification		
	Very Sensitive	Sensitive	Tolerant
Vegetables	Bean Strawberry	Cucumber Capsicum Aubergine (eggplant) Melon Lettuce Blueberry Ginger/Turmeric	Tomato Spinach Endive Radish Lambs lettuce/Corn Salad

System Capacity

The water supply system needs to be built to deliver water effectively to the plants, this includes correct hydraulic design. Generally, this is reverse engineered based on the needs of your crop (e.g., the flow rate is determined by the capacity and number of emitters utilised in each valve).

Most systems will use pressure compensated (PC) or pressure compensated no-drain (PCND) emitters. These systems ensure uniformity of water distributions when all other factors are correctly designed. Typical application rates are 1 dripper per plant, with an emitter rating of ~1-2.2L/hour.

The Number of separate valves and total capacity must be carefully managed to ensure the system can supply the plants water needs in the most extreme conditions. If you have too many valves to rotate between, then you can find yourself in a situation of not being able to apply the required water.

As a rule, for vine crops this means being able to delivery between 3.5-4.0ml of water per joule/m^2 during the middle of the sunniest days. This supply rate will ensure sufficient water availability for plant use and drain.

In Australia we can experience light intensities of around 1,100w/m^2/second which equates to around 6.6j/cm2/minute of accumulated light energy. In peak demand this means a system should be designed to deliver a minimum of 3.5ml x 6.6j x 60min = 1,386ml/m^2/hour.

As a grower the combination of dripper number, dripper capacity and total valves to rotate between need to be considered to ensure your water deliver meets these needs.

Fertigation Dosing System

To supply nutrients to the crop we must have a suitable dosing system to accurately deliver our stock concentrated nutrient solutions (held in our A and B tanks). Furthermore, final pH control is generally carried out via the addition of an acid (and less commonly alkalising agent).

Due to this, a typical fertigation system will consist of at least 3 dosing channels (A + B + Acid), a mixing method and a monitoring and control system for EC and pH.

It is important that these systems are well designed and calibrated to ensure not only the correct EC and pH are being delivered to the crop, but also that the levels of A and B solution are evenly supplied. If the system does not have automated monitoring, then manual checks should regularly be carried out to verify even drawn down of both solutions.

Periodic maintenance and regular calibration of pH and EC monitoring meters is required, this should be carried out in accordance with the standard operating procedures supplied with the device. Furthermore, checking system measurements with drip station samples will help identify any deviation from target figures.

Typically, between the fertigation unit and the irrigation emitters will be a filtration device, normally when using a modern drip irrigated system, the level of filtration will be around 150um or finer.

Uniformity Check

After installation, repairs, or major maintenance, and before the start of each subsequent season, it is recommended that you carry out a uniformity check to ensure the system is achieving its desired flow parameters. Incorrect flow can be a result of poor design or blockages and will impact crop performance as some plants can receive too much water, and others too little.

The most common methods for testing this are distribution uniformity (DU) or flow variation (FV). Whilst both can be useful tools, DU can be misleading as it does not describe the full variation between the highest and lowest solution, for this you need FV.

Both calculations can be carried out with the same testing protocol. You should expect a well-designed system to achieve a FV of ≤10%, with a DU always >90%. Indicating there is less than 10% difference between lowest and highest watered plants.

Lower tech solutions may have more variation, and a system with a DU of 80-90% is still manageable, but below optimal.

Methodology:

1) Set out 20 sample bottles throughout each valve within the greenhouse (include front, middle and back of lines), place an emitter in each bottle.
2) Run the system for a time that would be representative of your growing solution (e.g., 100ml shot).
3) Measure the volume in each container and sort the results from highest to lowest.
4) %DU is calculated as follows:
    a. Calculate the average of the lowest quartile (AvgLQ), in this case the lowest 5 samples
    b. Calculate the average of all measurements (AvgT)
    c. DU% = AvgLQ / AvgT x 100
5) %FV is calculated as follows:
    a. (Max Vol – Min Vol) / Max Vol x 100

If your system has a DU of <80% we would strongly recommend addressing the underlying issues prior to planting.

Basic Principles

Irrigation monitoring and management is critical to the health and economic performance of the crop. Plants that are out of balance will produce less than well-balanced plants.

Developing and refining your irrigation strategy requires consideration and adjustment based on the balance of the plant (strong vs weak, generative vs vegetative), the environmental conditions (such as light, temperature, humidity), and finally, balancing the irrigation with other aspects of the grower's strategy towards overall crop management (how and when you use heating pipes, screens, fans etc).

The Basics

There is no blueprint for irrigation, instead the grower should monitor and adjust the strategy and set points to meet the needs of the developing crop. Some general Terms and principle to understanding irrigation control are outlined below:

- All the plants nutritional needs are delivered via the water; therefore, accurate control of recipes (concentration and pH) is imperative to crop health.
- Measuring the concentration of nutrients in our water is carried out using an EC measurement. EC gives a general indication of the total dissolved solids (TDS) in the solution.
- Generally speaking, irrigation is only applied when a crop is active- that is when transpiration is occurring (there are some exceptions). Therefore, we will normally commence irrigation after sunrise and stop again before sunset. How soon before or after can be determined by the direction we are trying to steer the crop and your climatic conditions.
- To control the root zone in drip irrigated substrate you must apply more than the plants water needs, the excess water is what is referred to as 'drain'. The amount of drain is adjusted based on climate conditions, roots zone/drain measurements and plant balance.
    - Systems that recapture and use at least a portion of this water are called recirculating or closed.
    - Systems that discharge this water are called run-to-waste or open.
- The most common method for irrigation control is using sunlight as a trigger, in this case we use accumulated solar energy (measured in joules) to trigger our irrigation. The benefit of this approach is that it will adjust both throughout the day and between high and low light conditions. Using a time-based method only is not recommended and is far less effective than using solar radiation.
- Always work to make gradual changes and avoid large fluctuations such as:
    - Rapid changes of water source (try to blend water over several days if you change sources).
    - Variation in pH. Target a stable drip pH, making sure your fertigation unit delivers on the target in a stable manner.
    - Rapid changes in EC both within the day or over a course of time.
    - Large variation in moisture content and EC. If you provide water before a plant is transpiring or apply water with too low of an EC you can cause root pump, a process whereby there is a rapid net influx of water to the plant, this can cause issues like cracking or splitting in fruit and increased sensitivity to botrytis.
- Blending drain water
    - If you intend to reuse drain water, blend the source water based on EC to give around 30% drain and ~70% new fertiliser.
- Under extreme conditions (heat) and small substrate volumes a night shot may be required. If you give a night shot always supply at your growing EC, never provide a night shot of fresh water.

Wetting up and Drying Down

Careful management of the substrate moisture content will result in the most productive crops, this means considering when and how much we irrigate.

Generally speaking, irrigation should only take place during the day, leaving the night as a time to dry the substrate down and allow root growth and development whilst maximising air in the slab. There are some circumstances that can require what is called a 'night shot' but this is generally the exception to the rule and will normally be applicable in extreme climates and / or very porous (e.g., pearlite) and/or low volume substrates.

There is no hard and fast rule for the 'optimal dry down' as this must be determined by both the type of substrate and the intended balance of the crop. An indicative (only) figure for common substrates is 10 - 15%.

Irrigating too late into the day will have a negative effect on the crop resulting in substrate that is too wet overnight resulting in root die back / lack of new root growth. It is for this reason growers must monitor and adjust the stop time of the irrigation; this can be based on climate and / or plant balance:

- Dark /overcast- stop earlier
- Sunny and hot- stop later
- To steer more generatively- stop earlier
- To steer more vegetatively- stop later

Measurements and Feedback

It is imperative that you continuously measure and analyse your irrigation strategy to help steer crops effectively. The correct approach requires regular data collection which will help build a picture of crop performance and provide guidance for adjusting your strategy.

What to Measure?

Table 4 provides a list of key parameters and the frequency of measurement. Sticking to a regular schedule of events will bring the most benefits, particularly when it comes to drip and drain station monitoring.

Table 4. Irrigation monitoring is crucial. We recommend the following schedule:

What to Measure		Frequency	Comment
Source Water (Water supply)	Full nutrient analysis	As water source changes	Measure when you have conditions that will impact your source water quality.
Irrigation	Volume application	Daily	Measure first thing in the morning to determine the day prior. Must be done before irrigation commences.
	EC	Daily	
	pH	Daily	
	Full nutrient analysis	Fortnightly – recirculation Monthly- Run to waste	Recirculating systems require more frequent monitoring. This can be reduced as experience is gained with variety and conditions.
Drain	Volume drain	Daily	Measure first thing in the morning to determine the day prior. Must be done before irrigation commences.
	EC	Daily	
	pH	Daily	
	Time of first drain	Daily- can be reduced as you get a better feel for the crop and strategy.	Check daily whilst you set up new strategies. Record the time and the number of irrigations prior (from the number calculate volume).
	Full nutrient analysis	Fortnightly – recirculation Monthly- Run to waste	Recirculating systems require more frequent monitoring. Can be reduced as experience is gained with variety and conditions.
Slab or pot weight	General check (feel)	During crop walks	The simple act of walking throughout your greenhouse and randomly lifting pots/slabs and checking the weight by feel is a great way to assess both wetness and uniformity. It is a subjective, yet very effective!

Setup- Drip and Drain Stations

Drip and drain stations are arguably the most important tool in terms of managing irrigation in drip irrigated substrate production. All growers from low tech to high tech will benefit from effective utilisation of these techniques.

Measuring Equipment
You will need measuring jugs/cylinders and a quality handheld EC and pH meter.

Drain Stations
Select representative sites around the Greenhouse, it will be the average of these sites that will give you a representative value for the crop total.

Set up a water catchment gutter under you sample slabs/bags/pots. Normally each sample point will be for 1 slab or 1 to 3 pots. This gutter must collect ALL drain water and direct it to a catchment measuring jug.

Drip Stations
At each drain point also take a single dripper and place this into a measuring jug/bucket. Ideally this will be at the same height as the slab to avoid any difference in drain out from the dripper.

Figure 1.Drip and drain stations do not need to be complicated, but they are essential in crop management.

Collecting Samples and Data Recording

The process of sample collection and data recording does not need to be a complicated affair, however consistency in taking results is the most important aspect.

Data should be recorded daily.

1. Print off a drain record sheet for each week (see example in Appendix 1).
2. At the beginning of each day before any irrigations have commenced you must go to each drain station and measure the samples as per Table 4.
   NB: At the beginning of the crop or in low water times it is recommended to carry a measuring cylinder to improve the accuracy of recording the volumes of drip and drain. For high volumes use a measuring jug.
3. At each drain station you will also measure the drip samples.
4. After measuring, pour out the water (normally into the drain gutter) and replace the vessels for the current days collection.
5. Enter the data to calculate the averages and transfer these averages into your climate registration tables (see below).

What to Calculate

From our measurements we can make calculations to standardise our values and use this for mapping our crops, guiding strategies, and comparing with neighbours or consultants. Normally you should use several stations throughout the crop and average the values to be more representative.

Irrigation Supply/Drip Volume
From the collection of the dripper volumes we can work out our application volume per m^2.
Application Volume Litres/m^2 (A) = mls per dipper x drippers per m^2 / 1,000

Drain Volume
Our drain volume will be collected from 1 -3 slabs or pots at a time normally.
Drain Volume Litres/m^2 (B) = Total Drain Volume (ml)/ # of slabs collected x # slabs per m^2

Drain %
Drain % is a very important measurement that will be used to steer the crop
Drain % (C) = B/A x 100

Plant Water Uptake
This is an important calculation that will be even more apparent when related to light.
Plant Update L/m^2 (D) = A-B
Plant Uptake ml/m^2/Joule (E) = D x 1,000 / radiation sum as joules/cm^2

General Parameters

Most common greenhouse crops species (e.g., cucumber, capsicum, and eggplant) will respond similarly to environmental conditions once established. This means a grower can start to adjust their strategy and consider their data in respect to some standardised figures. Whilst there will be adjustments and variation required for each crop, the general principles remain the same.

Some general guidance for expected conditions is presented below. These are not hard and fast rules and serve only to give you some guidance on general parameters. Collecting your own data and observing trends in your crop will help you gain a better understanding for your own conditions.

Table 5. General values for plant water parameters.

Variable	Conditions	Value
Irrigation Application Volumes general light (Indicative ranges only)	Day Temperatures 18°C - 25°C	2-2.5ml/m^2/joule
	Day Temperatures > 25°C	3ml/ m^2/joule
	Day temperatures 30°C – 40°C	4ml/ m^2/joule
Expected Plant Uptake (ml/joule/m^2)	Low light days	Up to 3.5
	Normal light conditions moderate temperature	1.6-1.8
	Normal light conditions high temperature	1.8 – 2.0
	High light days in moderate climate	Down to 1.5
Drain % per Day	Cloudy- overcast	0 – 15%
	Normal (<28°C)	20 – 30%
	Hot (28-35°C)	30 – 40%
	Exceptionally Hot (<35°C)	40 – 50%
Dain % throughout the day	Sunrise to 2nd/3rd Irrigation	0%
	Midmorning to mid afternoon	20 – 40%
	Mid-afternoon to ~2hrs before sunset	5 – 10 %
	~2hrs before sunset to next morning	No irrigation so no drain. If a night shot is given it should still be no drain typically.
pH Drip	General	5.6-5.8
pH Drain	General	5.6 – 6.2
EC Drip	General	Crop specific (Typical range around 1.8 – 3.5)
EC Drain	General	Around 30% above drip EC

Table 6. Irrigation influence on crop balance

Variable	Vegetative	Generative	Min – Max Range
Drip Volume (per shot)	Less	More	75- 250cc/Plant
Drip frequency	More frequent	Less Frequent	75-200joules
Max pause	Shorter	Longer	15minutes – 2 hours
Min pause	Shorter	Longer	15minutes – 2 hours
Start time	Earlier	Later	1 - 3hours after sunrise
Stop Time	Later	Earlier	1 - 3hours before sunset

Appendix 1- Example Drip and Drain Sheet

Week Number:

Monday **Date:**

Drain Station	Drain Volume	EC	pH	Drip Volume	EC	pH
1						
2						
3						
4						
5						
6						
Average						

Tuesday **Date:**

Drain Station	Drain Volume	EC	pH	Drip Volume	EC	pH
1						
2						
3						
4						
5						
6						
Average						

Wednesday **Date:**

Drain Station	Drain Volume	EC	pH	Drip Volume	EC	pH
1						
2						
3						
4						
5						
6						
Average						

Tuesday **Date:**

Drain Station	Drain Volume	EC	pH	Drip Volume	EC	pH
1						
2						
3						
4						
5						
6						
Average						

Thursday **Date:**

Drain Station	Drain Volume	EC	pH	Drip Volume	EC	pH
1						
2						
3						
4						
5						
6						
Average						

Friday **Date:**

Drain Station	Drain Volume	EC	pH	Drip Volume	EC	pH
1						
2						
3						
4						
5						
6						
Average						

Saturday **Date:**

Drain Station	Drain Volume	EC	pH	Drip Volume	EC	pH
1						
2						
3						
4						
5						
6						
Average						

Sunday **Date:**

Drain Station	Drain Volume	EC	pH	Drip Volume	EC	pH
1						
2						
3						
4						
5						
6						
Average						

Biofumigation

National Vegetable Extension Network
NEW SOUTH WALES

What is biofumigation

Biofumigation is the use of specialised cover crops which are grown, mulched and incorporated into the soil to aid in weed, pest and disease suppression and enhance the nutrients for following cash crops.

High biomass, especially roots, can provide the traditional benefits of green manure crops. Biofumigant cover crops must be mulched and incorporated into the soil because the active compounds need to be trapped beneath the soil surface to be effective.

What are the benefits of bio-fumigant crops?

Soil biology

- Break crops – disrupt life cycle of pests and diseases
- Biocidal toxicity (direct)
- Changes in soil fauna and microbial communities (indirect)
- Promote beneficial microorganisms

Weed suppression

- Outcompete weeds
- Release isothiocyanates (ITCs) resulting in biocidal burning of weed seedlings

Soil organic matter (SOM)

- Replenish SOM

Nutrient cycling

- Access to nutrients stored deeper in the soil profile
- Nutrients available to next cash crop

Figure 1: Incorporation of a biofumigant caliente cover crop

Hort Innovation Strategic levy investment | VEGETABLE FUND

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

NSW GOVERNMENT | Local Land Services Greater Sydney

生物熏蒸

National Vegetable Extension Network
NEW SOUTH WALES

什么是生物熏蒸

生物熏蒸是使用专门的覆盖作物，种植、切碎并与土壤混合，以帮助抑制杂草和病虫害，并提高后续经济作物的养分。

高生物量，尤其是根系，可提供绿肥作物的传统益处。生物熏蒸覆盖作物必须切碎并与土壤混合，因为活性化合物需要留在表层土壤以下才能发挥作用。

生物熏蒸作物有哪些益处？

土壤生物学

- 破坏作物——破坏病虫害的生命周期
- 生物杀灭制品的毒性（直接）
- 土壤动物和微生物群落的变化（间接）
- 促进有益微生物

抑制杂草

- 战胜杂草
- 释放异硫氰酸盐（ITCs），使杂草幼苗受到生物杀灭性灼伤

土壤有机质（SOM）

- 补充土壤有机质

养分循环

- 可获得储存在土壤深处的养分
- 养分可用于随后种植的经济作物

图 1： 采用生物熏蒸覆盖作物

Hort Innovation Strategic levy investment | VEGETABLE FUND

该项目由园艺创新公司（Hort Innovation）利用蔬菜研发税和澳大利亚政府的资金资助。有关资金和战略税收投资的更多信息，请访问 horticulture.com.au

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ជីវចំហាយឧស្ម័ន

National Vegetable Extension Network
NEW SOUTH WALES

តើអ្វីទៅជាជីវចំហាយឧស្ម័ន

ជីវចំហាយឧស្ម័ន គឺជាការប្រើប្រាស់នៃបច្ចេកទេសដំណាំដាំគ្របដីដែលដាំ ធ្វើជាសារធាតុគម្រប ហើយលាយបញ្ចូលសារធាតុទៅក្នុងដី ដើម្បីជួយកំចាត់រុក្ខជាតិតូចៗឥតប្រយោជន៍ សត្វល្អិតចង្រៃ និងជំងឺ ហើយបង្កើនសារធាតុចិញ្ចឹមសម្រាប់ដំណាំដាំលក់។

ជីវម៉ាសខ្ពស់ ជាពិសេសឫស អាចផ្តល់នូវអត្ថប្រយោជន៍តាមប្រពៃណីនៃដំណាំជីវបៃតង។ ដំណាំដាំគ្របដីជីវចំហាយឧស្ម័នត្រូវតែបានធ្វើជាសារធាតុគម្រប ហើយបញ្ចូលសាធាតុទៅក្នុងដី ពីព្រោះសមាសធាតុសកម្មចាំបាច់ត្រូវជាប់នៅក្រោមផ្ទៃដី ដើម្បីឱ្យមានប្រសិទ្ធភាព។

តើដំណាំដាំគ្របដីជីវចំហាយឧស្ម័នមានអត្ថប្រយោជន៍អ្វីខ្លះ?

ជីវវិទ្យាដី

- បំបែកដំណាំ - រំខានដល់វដ្តជីវិតនៃសត្វល្អិតចង្រៃ និងជំងឺ
- ការបំពុលសម្លាប់តាមបែបជីវសាស្ត្រ (ដោយផ្ទាល់)
- ការផ្លាស់ប្តូរពពួកសត្វរស់នៅក្នុងដី និងក្រុមមីក្រុប(ដោយប្រយោល)
- លើកកម្ពស់មីក្រូសរីរាង្គដែលមានប្រយោជន៍
- ការបង្ក្រាបស្មៅ
- យកឈ្នះរុក្ខជាតិតូចៗឥតប្រយោជន៍
- បញ្ចេញ isothiocyanates (ITCs) ដែលហេតុបណ្តាលឱ្យខ្លោចងាប់កូនរុក្ខជាតិតូចៗឥតប្រយោជន៍តាមបែបជីវសាស្ត្រ

សារធាតុសរីរាង្គដី (SOM)

- បំពេញឡើងវិញ SOM
- វដ្តសារធាតុចិញ្ចឹម
- ទទួលបានសារធាតុចិញ្ចឹមដែលបានរក្សាទុកយ៉ាងជ្រៅក្នុងទម្រង់ដី
- សារធាតុចិញ្ចឹមដែលអាចរកបានសម្រាប់ដំណាំដាំលក់បន្ទាប់។

រូបភាពទី 1:
ការបញ្ចូលសារធាតុដំណាំដាំគ្របដីជីវចំហាយឧស្ម័ន (biofumigant caliente)

Hort Innovation VEGETABLE FUND
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NSW GOVERNMENT Local Land Services Greater Sydney

Cover Crops

National Vegetable Extension Network
NEW SOUTH WALES

What are cover crops?

Cover crops are one of the best tools for improving the structure and health of soil, controlling soilborne disease and weeds, reducing erosion and nutrient loss and adding nitrogen to the soil.

Cover crops are planted with the intention of being incorporated back into the soil or being left on the soil surface to form a mulch. The plants should be incorporated or sprayed before they go to seed.

Cover crops can be legumes, grasses or broadleaf plants, and can provide different benefits for a farm's efficiency and productivity.

Some cover crops, known as biofumigants, produce 'toxins' which can control soil-borne disease and kill weed seeds.

What are the benefits of cover crops?

- Improved soil health which, in turn, provides improved water storage and infiltration capacity
- Improved soil structure which can reduce tillage costs – fewer number of passes, less fuel and less time required
- Reduced soil erosion
- Improved nutrient cycling, especially nitrogen – potential decrease in fertiliser inputs
- Increase in quality/pack-out percentage
- Yield increase (potentially)
- Some are biofumigants and suppress weeds, pests and diseases – reduced pesticides input (as long as you adjust your chemical inputs).

There are many different cover crops. Some are better for some soil management aims than others. Table 1 gives brief information on popular cover crops. However, for more comprehensive information, summer and winter cover crop factsheets are available.

Table 1: Seed cost and characteristics of some common cover crops

	Tillage Radish™	RootMax™	Sorghum	Rye corn	Morgan Field Peas	Caliente 199™
	Daikon radish	Lolium rigidum	Sorghum bicolor	Secale Cereale	Pisum sativum	Brassica juncea
Cost of seed ($/ha)	$50-70	$65	$100-130	$144	$140-150	$210-250
Fertiliser?	Not essential	Not essential	Recommended	Not essential	Not essential	Recommended
Cultivation	2 passes	2 passes	2 passes	2 passes	2 passes	2 passes
Builds organic matter	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓
Reduces erosion	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Recovers nutrients	✓✓✓	✓✓✓	✓✓	✓✓	✓	✓✓✓
Fixes nitrogen	✘	✘	✘	✘	✓✓✓	✘
Biofumigant	✓	✘	✘	✘	✘	✓
Soil Compaction	✓✓✓	✓✓	✓✓	✓✓	✓✓	✓✓
Broadleaf weed control	✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓✓
Grass weed control	✓✓✓	✓	✓✓	✓	✓✓✓	✓✓✓
Specialised equipment?	✘	✘	✘	✘	✘	✓

Note: Cultivation, irrigation and fertiliser requirements are unique to each scenario, so these costs are not considered here.

Hort Innovation Strategic levy investment | VEGETABLE FUND

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NSW GOVERNMENT | Local Land Services Greater Sydney

覆盖作物

National Vegetable Extension Network
NEW SOUTH WALES

什么是覆盖作物？

覆盖作物是改善土壤结构和健康、控制土壤传播病害和杂草、减少侵蚀和养分流失以及增加土壤中的氮含量的最佳方式之一。

种植覆盖作物的目的是将其混入土壤或留在土壤表面形成覆盖层。这些植物在结籽之前应与土壤混合或喷洒去除。

覆盖作物可以是豆科植物、禾本科植物或阔叶植物，可以为农场的效率和生产力提供不同的益处。

一些被称为生物熏蒸剂的覆盖作物产生“毒素”，可以控制土壤传播的疾病并杀死杂草种子。

覆盖作物有哪些益处？

- 改善土壤健康，从而
  改善储水和渗透能力
- 改良土壤结构，减少耕作成本——减少耕作次数、燃料和时间
- 减少土壤侵蚀
- 改善养分循环，特别是氮——可能减少肥料投入
- 提高质量/可出售产品百分比
- 增加产量（有可能）
- 有些是生物熏蒸剂，可以抑制杂草、害虫和疾病——减少农药投入（如果您调整化学投入）。

有许多不同的覆盖作物。一些覆盖作物在土壤管理方面表现更为出色。表 1 简要介绍了常见覆盖作物。但是，如需更全面的信息，请查看夏季和冬季覆盖作物情况说明。

表 1：一些常见覆盖作物的种子成本和特性

饲料 萝卜 TM		RootMax™	高粱	黑麦玉米	Morgan Field 豌豆	Caliente 199™
	萝卜	硬直黑麦草	高丹草	黑麦属	豌豆	芸苔属植物
种子成本（$/公顷）	$50-70	$65	$100-130	$144	$140-150	$210-250
是否可作为肥料?	非必要	非必要	推荐	非必要	非必要	推荐
种植	一年两次	一年两次	一年两次	一年两次	一年两次	一年两次
构建有机质	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓
减少水土流失	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
恢复养分	✓✓✓	✓✓✓	✓✓	✓✓	✓	✓✓✓
固氮	✗	✗	✗	✗	✓✓✓	✗
生物熏蒸	✓	✗	✗	✗	✗	✓
土壤压实	✓✓✓	✓✓	✓✓	✓✓	✓✓	✓✓
抑制阔叶杂草	✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓✓
抑制禾木科杂草	✓✓✓	✓	✓✓	✓	✓✓✓	✓✓✓
需要专门设备吗?	✗	✗	✗	✗	✗	✓

注：种植、灌溉和肥料的需求每种情况都不同，因此这里不考虑这些成本。

Hort Innovation | VEGETABLE FUND
Strategic levy investment

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ដំណាំដាំគ្របដី

National Vegetable Extension Network
NEW SOUTH WALES

តើដំណាំដាំគ្របដីជាអ្វី?

ដំណាំដាំគ្របដី គឺជាវិធីសាស្ត្រដ៏ល្អបំផុតមួយដើម្បីកែលម្អរចនាសម្ព័ន្ធ និងសុខភាពដី គ្រប់គ្រងជំងឺក្នុងដី និងរុក្ខជាតិតូចៗឥតប្រយោជន៍ កាត់បន្ថយការសំណឹក និងការបាត់បង់សារធាតុចិញ្ចឹម ហើយបន្ថែមអាសូត(នីត្រូហ្សែន)ទៅដី។

ដំណាំដាំគ្របដី ត្រូវបានគេដាំដោយមានបំណងលាយបញ្ចូលសារធាតុចូលទៅក្នុងដីវិញ ឬទុកចោលលើផ្ទៃដីដើម្បីបង្កើតជាសារធាតុគម្របៗ រុក្ខជាតិគួរតែបានលាយបញ្ចូលសារធាតុ ឬបាញ់ថ្នាំមុនពេលវាចាប់ដុះគ្រាប់។

ដំណាំដាំគ្របដី អាចជាពពួកសណ្តែក ស្មៅ ឬរុក្ខជាតិស្លឹកធំ ហើយអាចផ្តល់អត្ថប្រយោជន៍ផ្សេងៗគ្នា សម្រាប់ប្រសិទ្ធភាព និងផលិតភាពរបស់កសិដ្ឋាន។

ដំណាំដាំគ្របដី មួយចំនួនដែលគេស្គាល់ថាជីវចំហាយឧស្ម័ន (biofumigants) បង្កើត 'ជាតិពុល' ដែលអាចគ្រប់គ្រងជំងឺបង្កក្នុងដី និងសម្លាប់គ្រាប់ រុក្ខជាតិតូចៗឥតប្រយោជន៍។

តើដំណាំដាំគ្របដីមានអត្ថប្រយោជន៍អ្វីខ្លះ?

- ឱ្យប្រសើរឡើងដល់សុខភាពដី ជាលទ្ធផលផ្តល់នូវការផ្ទុកទឹកកាន់តែប្រសើរ និងសមត្ថភាពជ្រាបទឹកចុះក្រោមចូលទៅក្នុងដី
- ធ្វើឱ្យប្រសើរឡើងនូវរចនាសម្ព័ន្ធដី ដែលអាចកាត់បន្ថយការចំណាយលើការក្ហួរាស់ដី - ចំនួនការឆ្លងកាត់តិច ប្រើអស់ប្រេងឥន្ធនៈតិច និងត្រូវការពេលវេលាតិច
- កាត់បន្ថយសំណឹកដី
- ការធ្វើឱ្យប្រសើរឡើងនូវរដ្ឋសារធាតុចិញ្ចឹម ជាពិសេសអាសូត - ការថយចុះសក្តានុពលនៃការដាក់ជី
- បង្កើនគុណភាព/ភាគរយនៃការវេចខ្ចប់
- បង្កើនទិន្នផល (សក្តានុពល)
- ខ្លះជាជីវចំហាយឧស្ម័ន ហើយបង្ក្រាបស្មៅ សត្វល្អិតចង្រៃ និងជំងឺ - កាត់បន្ថយការប្រើប្រាស់ថ្នាំសម្លាប់សត្វល្អិត (ដាវបណាអ្នកកែតម្រូវការដាក់បញ្ចូលសារធាតុគីមីរបស់អ្នក)។

មានដំណាំដាំគ្របដីផ្សេងៗគ្នាជាច្រើន។ ខ្លះទៀតល្អសម្រាប់គោលបំណងគ្រប់គ្រងដីខ្លះ ជាងដំណាំផ្សេងទៀត។ តារាងទី 1 ផ្តល់ព័ត៌មានសង្ខេបអំពីដំណាំដាំគ្របដីពេញនិយម។ ទោះយ៉ាងណាក្តី ដើម្បីទទួលបានព័ត៌មានទូលំទូលាយ អាចរកបាននៅក្នុងខិត្តប័ណ្ណព័ត៌មានអំពីដំណាំដាំគ្របដីសម្រាប់រដូវស្លឹករឈើជ្រុះ និងរដូវរងា។

តារាងទី 1៖ តម្លៃគ្រាប់ពូជ និងលក្ខណៈពិសេសនៃដំណាំដាំគ្របដីខ្លះទៅមួយចំនួន

Tillage Radish™		RootMax™	Sorghum	Rye corn	Morgan Field Peas	Caliente 199™
	Daikon radish	Lolium rigidum	Sorghum bicolor	Secale Cereale	Pisum sativum	Brassica juncea
តម្លៃគ្រាប់ពូជ ($/ha)	$50-70	$65	$100-130	$144	$140-150	$210-250
ជី?	មិនចាំបាច់	មិនចាំបាច់	ត្រូវបានណែនាំ	មិនចាំបាច់	មិនចាំបាច់	ត្រូវបានណែនាំ
ការដាំដុះ:	2 ការឆ្លងកាត់	2 ការឆ្លងកាត់	2 ការឆ្លងកាត់	2 ការឆ្លងកាត់	2 ការឆ្លងកាត់	2 ការឆ្លងកាត់
បង្កើតសារធាតុសរីរាង្គ	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓
កាត់បន្ថយសំណឹក	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
ស្តារឡើងវិញនូវសារធាតុចិញ្ចឹម	✓✓✓	✓✓✓	✓✓	✓✓	✓	✓✓✓
ជួសជុលអាសូត	✘	✘	✘	✘	✓✓✓	✘
Biofumigant	✓	✘	✘	✘	✘	✓
កំហាប់ដី	✓✓✓	✓✓	✓✓	✓✓	✓✓	✓✓
គ្រប់គ្រងរុក្ខជាតិស្លឹកធំ	✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓✓
គ្របគ្រងស្មៅ និងរុក្ខជាតិតូចៗឥតប្រយោជន៍	✓✓✓	✓	✓✓	✓	✓✓✓	✓✓✓
ឧបករណ៍ឯកទេស?	✘	✘	✘	✘	✘	✓

កំណត់ចំណាំ៖ តម្រូវការដាំដុះ: ការស្រោចស្រពទឹក និងជី មានលក្ខណៈពិសេសចំពោះសេណារីយ៉ូនីមួយៗ ដូច្នេះការចំណាយទាំងនេះមិនបានពិចារណានៅទីនេះទេ។

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NSW GOVERNMENT Local Land Services Greater Sydney

NSW GOVERNMENT Department of Primary Industries

PESTICIDES REGISTERED IN NSW FOR THE CONTROL OF DISEASES OF CUCUMBER
CURRENT AT 10/09/2021#. ALWAYS READ THE LABEL.

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	Rate per		Withholding period (days)	Critical Use Comments/Restraints
		100 L	ha		
ALTERNARIA LEAF BLIGHT *(Alternaria cucumerina)*					
Chlorothalonil (500 g/kg) (Gp M5)*	Whack 500	—	2.4 - 3.6 L	1	• Do not add wetting agents or crop oils.
Chlorothalonil (720 g/L) (Gp M5)*	Bravo Barrack	—	1.6 - 2.5 L		
Chlorothalonil (900 g/kg) (Gp M5)*	Echo 900	—	1.3 - 2.1 kg		
ANGULAR LEAF SPOT (*Pseudomonas syringae* pv *lachrymans*)					
Copper based fungicides (Gp M1)*	Nufarm Champ 500WG Fungicide	105 g	—	1	• Do not apply under poor drying conditions. • Do not apply during the hottest part of the day when temperatures exceed 35˚C. • Do not apply if hot or frost prone conditions prevail. • Do not apply to wet crops. • Test for possible phytotoxicity on a few plants before full application. • Apply at the first sign of disease and repeat- every 7-10 days while conditions allow infection.
ANTHRACNOSE (*Colletotrichum orbiculare*)					
Chlorothalonil (500 g/L) (Gp M5)*	Whack 500	—	2.4 - 3.6 L	1	• Do not add wetting agents or crop oils.
Chlorothalonil (720 g/L) (Gp M5)*	Bravo Barrack	—	1.6 - 2.5 L	1	• Do not add wetting agents or crop oils.
Chlorothalonil (900 g/L) (Gp M5)*	Echo 900 Whack 900	—	1.3 - 2.1 L	1	• Do not add wetting agents or crop oils.
Mancozeb (750 g/kg) & (800 g/kg (Gp M3)*	Mancozeb Dithane Rainshield Neo Tec Fungicide	150 - 200 g	1.7 - 2.2 kg	7	• Apply at the first sign of disease and repeat- every 7-10 days while conditions allow infection.
Propineb (560 g/kg) + Oxadixyl (80 g/kg) (Gp M3 + Gp 4)*	Rebound	250 g	2.5 kg	3	• Do not use as a curative.

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	Rate per		Withholding period (days)	Critical Use Comments/Restraints
		100 L	ha		
Zineb (800 g/kg) (Gp M3)*	Zineb	150 g	—	7	
BACTERIAL LEAF SPOT *(Xanthomonas campestris)*					
Copper based fungicides (Gp M1)*	Nordox 750 WG Copper Fungicide	105 g		1	• Apply at the first sign of disease and repeat- every 7-10 days while conditions allow infection.
BOTRYTIS ROT / GREY MOULD *(Botrytis cinerea)*					
Captan (800 g/kg or 900 g/kg) (Gp M4)* **APVMA permit 14326** **expires 30/06/2024**	Captan	125 g for 800 g/kg product or 110 g for 900 g/kg product	—	7	• Apply a maximum three (3) foliar spray applications per crop, with a re-treatment interval of 7 – 14 days using suitable air-blast sprayer, ground boom sprayer, or similar equipment. • Apply at critical times when conditions favour disease development. Captan is a protective fungicide and must be applied to crops prior to symptoms of the disease appearing to be fully effective. • Complete and thorough coverage of foliage and other parts of the crop is essential to achieve good control. Apply spray diluent to the point of run-off.
Cyprodinil (375 g/kg) + Fludioxonil (250 g/kg) (Gp 9 + Gp 12)*	Switch	—	800 g – 1 kg	3	• Apply at onset of disease. • Repeat 7-10 day interval. • Apply no more than 3 sprays per crop. • Maximum 3 sprays / crop.
Fenhexamid 500 g/L (Gp 17)*	Imtrade Fenhexamid 500 SC	100 mL	1 L	3	• Apply prior to or at the onset of disease. • A repeat application can be made at least 7 -10 days apart. • DO NOT apply more than two applications per crop. • Follow a complete disease management program for Botrytis by rotating with fungicides from unrelated chemical groups as per the CropLife fungicide resistance management guidelines. • Add non-ionic surfactant at recommended rates.
Iprodione (250 g/L) (500/g/L) (Gp 2)* **APVMA permit 81589** **Expires 30/6/2026**	Various	200 mL for 200 g/L product or 100 mL for 500 g/L product	250 g/L at 2 L/ha or 500 g/L at 1 L/ha	7	• Apply as a foliar spray when conditions favour disease development. • Apply no more than three (3) applications per crop using boom sprayer, with a 14-day interval between treatments. • Use sufficient spray volume to ensure thorough coverage of plants.

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	Rate per		Withholding period (days)	Critical Use Comments/Restraints
		100 L	ha		
Mancozeb (750 g/kg) (Gp M3)* **APVMA permit 14046 expires 31/03/2023**	Dithane Mancozeb	150 - 200g	1.7 - 2.2g	7	• Do not apply more than 8 applications per crop.
Penthiopyrad (200 g/L) (Gp 7)*	Fontelis	—	1.75 L	1	• Begin applications prior to disease development & continue on 7-10 day interval. • Use shorter intervals if disease pressure is high. • Do not apply more than 2 consecutive applications of this product or other Group 7 fungicides – change to a fungicide from another activity group.
Pyrimethanil (400 g/L) (600 g/L) (Gp 9)* **APVMA permit 7909 expires 30/09/2022**	Scala 400 Scala 600	200 mL or 125 mL	2 L or 1.25 L	1	• Apply during flowering when conditions favour disease development. • Repeat after a minimum 7-day re-treatment interval. • Use water volumes of 400 to 1000 L/Ha depending on equipment and crop stage to ensure adequate penetration of the canopy and coverage of foliage and flowers and/or fruit. • Non-ionic wetting agents may be used. • DO NOT apply more than two applications of Scala (or other group 9 fungicides).
DAMPING OFF (*Phytophthora* and *Pythium* spp.)					
Metalaxyl (50 g/kg) (Gp 4)*	Medley 50G	Refer to label		7	• Soil treatment only. • Apply pre-planting only.
Metalaxyl-M (25 g/kg) (Gp 4)*	Ridomil Gold 25G	Refer to label			• Add to seedling mix. • Apply pre-planting only.
DOWNY MILDEW (*Pseudoperonspora cubensis*)					
Azoxystrobin (250 g/L) (Gp 11)*	Amistar	80 - 120 mL	—	1	• Apply a maximum of 4 sprays per crop. • Do not apply more than 2 consecutive sprays. • Rotate with different fungicide group.
Azoxystrobin (155 g/L) + Oxathiapiprolin (15g/L) (Gp 11 + Gp 49)*	Orondis Flexi	—	800 - 1000 mL	3	• Maximum 2 sprays/crop.
Chlorothalonil (500 g/L) (Gp M5)*	Whack 500	—	2.4 - 3.6 L	1	• Do not add wetting agents or crop oils.

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	Rate per		Withholding period (days)	Critical Use Comments/Restraints
		100 L	ha		
Chlorothalonil (720 g/L) (Gp M5)*	Bravo Barrack	—	1.6 - 2.5 L	1	• Do not add wetting agents or crop oils.
Chlorothalonil (900 g/L) (Gp M5)*	Echo 900 Whack 900	—	1.3 - 2.1 L	1	• Do not add wetting agents or crop oils.
Copper fungicide (as copper ammonium acetate) (93 g/L) (Gp M1)*	Liquicop Cop-It	400 mL	2.5 L	1	
Copper fungicide (as copper octanoate) (18 g/L) (Gp M1)*	Tricop	1 L	—	1	• Do not apply under poor drying conditions. • Do not apply if hot or frost prone conditions prevail. • Do not apply to wet crops. • Test for possible phytotoxicity on a few plants before full application.
Dimethomorph (500 g/kg) (Gp 40)*	Acrobat	—	360 g	7	• Mix with mancozeb or propineb according to label. • Apply a maximum of 4 sprays per crop. • Apply 2 consecutive sprays then rotate with different fungicide group.
Mancozeb (750 g/kg) (Gp M3)*	Penncozeb Dithane Rainshield Neo Tec Fungicide	150 - 200 g	1.7 - 2.2 kg	7	• Apply at the first sign of disease and repeat- every 7-10 days while conditions allow infection.
Mancozeb (640 g/kg) + Metalaxyl (80 g/kg) (Gp M3 + Gp 4)*	Maxyl	250 g	—	7	• Begin applications prior to disease development & continue on 7-10 day interval. • Use non-ionic wetter.
Metalaxyl (50g/kg) + Copper hydroxide (600g/kg) (Gp 4 + Gp M1)	Ridomil Gold Plus	—	2 kg	7	
Metiram (700 g/kg) (Gp M3)*	Polyram	200 g	2.2 kg	2	• Add non-ionic surfactant.
Oxathiapiprolin (100 g/L) (Gp 49)*	DuPont Zorvec Enicade	—	350 mL	1	• Do not use on hydroponic crops. • Use with a protectant fungicide. • Apply 2 consecutive sprays 7-10 days apart then rotate with different fungicide group. • Do not apply more than 3 sprays to each crop.
Phosphorous acid (400 g/L) (Gp P07)*	Sprayphos 400	—	4.5 L	Nil when used as directed	•Test for possible phytotoxicity on a few plants before full application.

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	Rate per		Withholding period (days)	Critical Use Comments/Restraints
		100 L	ha		
Phosphorous acid (600 g/L) (Gp 33)*	Agri-Fos 600	—	3 L	Nil when used as directed	•Test for possible phytotoxicity on a few plants before full application.
Propamocarb (625 g/L) + Fluopicolide (62.5 g/L) (Gp 28 + Gp 43)*	Infinito SC	—	1.2 - 1.6 L	1	• Apply in protectant program with 2 consecutive sprays 7-10 days apart then rotate with different fungicide group.
Propineb (560 g/kg) + Oxadixyl (80 g/kg) (Gp M3 + Gp 4)*	Rebound	250 g	2.5 kg	3	• Do not use as a curative.
Propineb (700 g/kg) (Gp M3)*	Antracol	200 g	2 kg	3	
Zineb (800 g/kg) (Gp M3)*	Zineb	150 g	—	7	
GUMMY STEM BLIGHT (Stagonosporopsis spp.)					
Azoxystrobin (250 g/L) (Gp 11)*	Amistar & others	120 mL	—	1	• Apply a maximum of 4 sprays per crop. • Do not apply more than 2 consecutive sprays. • Rotate with different fungicide group.
Azoxystrobin (155 g/L) + Oxathiapiprolin (15g/L) (Gp 11 + Gp 49)*	Orondis Flexi	—	800 - 1000 mL	3	• Suppression only. • Maximum 2 sprays/crop.
Chlorothalonil (500 g/L) (Gp M5)*	Whack 500	—	2.4 - 3.6 L	1	• Do not add wetting agents or crop oils.
Chlorothalonil (720 g/L) (Gp M5)*	Bravo Barrack	—	1.6 - 2.5 L		
Chlorothalonil (900 g/L) (Gp M5)*	Echo 900	—	1.3 - 2.1 L		
Mancozeb (750 g/kg) & (800 g/kg) (Gp M3)*	Mancozeb Dithane Rainshield Neo Tec Fungicide	150 - 200 g	1.7 - 2.2 kg	7	
Metiram (700 g/kg) (Gp M3)*	Polyram	200 g	2.2 kg	2	• Add a non-ionic surfactant

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	Rate per		Withholding period (days)	Critical Use Comments/Restraints
		100 L	ha		
Penthiopyrad (200g/L) (Gp 7)*	Fontelis	—	1.75 L	1	• Begin applications prior to disease development & continue on 7-10 day interval. • Use shorter intervals if disease pressure is high. • Do not apply more than 2 consecutive applications of this product or other Group 7 fungicides – change to a fungicide from another activity group.
Propineb (560 g/kg) + Oxadixyl (80 g/kg) (Gp M3 + Gp 4)*	Rebound	250 g	2.5 kg	3	• Do not use as a curative
Azoxystrobin (250 g/L) (Gp 11)*	Amistar and others	80 - 120 mL	—	1	• Apply a maximum of 4 sprays per crop. • Do not apply more than 2 consecutive sprays.
Azoxystrobin (155 g/L) + Oxathiapiprolin (15g/L) (Gp 11 + Gp 49)*	Orondis Flexi	—	800 - 1000 mL	3	• Suppression only. • Maximum 2 sprays/crop.
Bupirimate (250 g/L) (Gp 8)*	Nimrod	60 mL	600 mL	1	• Do not apply in hot, cold or slow drying conditions. • Maximum 4 sprays per crop at 7 day intervals.
Copper) (as copper octanoate) (18 g/L) (Gp M1)*	Tricop	1 L	—	1	• Do not apply under poor drying conditions. • Do not apply if hot or frost prone conditions prevail. • Do not apply to wet crops. • Spray at first sign of disease. • Test for possible phytotoxicity on a few plants before full application.
Cyflufenamid (50 g/L) (Gp U6)*	Flute Cyflamid	25 mL	250 mL	1	• Apply when conditions favour disease at 7-10 day intervals. • Apply to the point of run-off. • Do not apply more than 2 sprays per crop.
Hydrogen peroxide (320 g/L) + Peroxy acetic acid (80 g/L) (No FRAC Gp)*	Peratec Plus	1 L	—	1	• Use 2 consecutive sprays at 5 day intervals. • Use shorted spray intervals on heavy infestations. • No more than 4 sprays used per crop. • Use in a disease management strategy with applications made to maintain low disease pressure.
Metrafenone (500 g/L) (Gp 50)*	Vivando	—	150 - 300 mL	7	• Apply as a preventative before disease commences. • Apply 2 consecutive sprays with 7-10 day intervals. • Do not apply more than 4 sprays per crop.

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	Rate per		Withholding period (days)	Critical Use Comments/Restraints
		100 L	ha		
Penthiopyrad (200g/L) (Gp 7)*	Fontelis	—	1.75 L	1	• Begin applications prior to disease development & continue on 7-10 day interval. • Use shorter intervals if disease pressure is high. • Do not apply more than 2 consecutive applications of this product or other Group 7 fungicides – change to a fungicide from another activity group.
Proquinazid (200 g/L) (Gp 13)*	Talendo	—	250 mL	1	• Use as protectant treatment only • Repeat at 10-14 day intervals. • Do not apply more than 3 sprays per crop and no more than 2 consecutive sprays.
Potassium bicarbonate (3.8 g/L potassium salt) (No FRAC Gp)*	Eco-Fungicide	—	—	Nil when used as directed	• Do not apply to plants under moisture or heat stress. • Apply at first sign of disease. • For protected cropping only.
Potassium bicarbonate (940 g/kg) (No FRAC Gp)*	EcoCarb	300-400 g	—	Nil when used as directed	• Use with 200 mL/100L Synertrol Horti-Oil. • Apply at first sign of disease and repeat ensuring thorough coverage of all plant surfaces. • Do not use within 10 days of applying chlorothalonil. • Avoid use in hot and humid greenhouses.
Potassium bicarbonate (633g/kg) + Potassium silicate (312g/kg) (No FRAC Gp)*	EcoCarb Plus	300-400 g	—	Nil when used as directed	• Use with 200 mL/100L Synertrol Horti-Oil. • Apply at first sign of disease and repeat ensuring thorough coverage of all plant surfaces. • Do not use within 10 days of applying chlorothalonil. • Avoid use in hot and humid greenhouses.
Pyriofenone (300 g/L) (Gp 50)*	Kusabi	50 mL	300-500 mL	Nil when used as directed	• Apply when conditions favour disease with other fungicides at 7-10 day intervals. • Do not apply more than 3 sprays per crop.
Tea Tree Oil (222 g/L) (Gp 46)*	Timorex Gold	—	1 – 2 L	Nil when used as directed	• Apply in 7-10 day intervals.
Triadimefon (125 g/L) (Gp 3)*	4 Farmers Triadimefon 125	40 mL	400 mL	1	• Rotate with different fungicide groups. • Maximum 4 sprays / crop.
Triadimenol (250 g/L) (Gp 3)*	Bayfidan Tridim	40 mL	400 mL	1	

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	Rate per		Withholding period (days)	Critical Use Comments/Restraints
		100 L	ha		
Trifloxystrobin (500 g/kg) (Gp 11)* **APVMA permit 14050 expires 30/6/2023**	Flint	—	105 - 140 g	3	• Alternate with different fungicide groups. • No more than two (2) applications per crop.
SCLEROTINIA ROT (*Sclerotinia sclerotiorum*)					
Iprodione (250 g/L) (Gp 2)* **APVMA permit 81589 expires 30/6/2026**	Various	200 mL	2 L	7	• Apply as a foliar spray when conditions favour disease development. • No more than three (3) applications per crop using boom sprayer, with a 14 day interval between treatments. • Use sufficient spray volume to ensure thorough coverage of plants.
Azoxystrobin (155 g/L) + Oxathiapiprolin (15g/L) (Gp 11 + Gp 49)*	Orondis Flexi	—	800 - 1000 mL	3	• Suppression only • Maximum 2 sprays/crop.
Virus Management					
1. Control vectors e.g. aphids, whiteflies, thrips **2.** Sanitise pruning and picking equipment **3.** Use resistant varieties, if available					

Discard this table if a more up-to-date table is available.

 **Safe for Bees.**

 **Can be used in IPM programs, may affect some beneficial insects and mites.**

*Prevent resistance by rotating between different chemical groups. (FRAC Chemical groups can found at CropLife Australia | Resistance Management).

Or enter into web browser:
https://www.croplife.org.au/resources/programs/resistance-management/

Where to get more information:

1. Australian Pesticide & Veterinary Medicines Authority (APVMA) website: www.apvma.gov.au for current use permits, chemical residue limits, chemical recalls and reviews.
2. Agricultural chemical companies and their distributors.
3. http://www.croplifeaustralia.org.au/industry-stewardship/resistance-management

How to reduce excess chemical residues and safe use of chemicals in my crop:

- Use only registered chemicals.
- Apply at the label or permit rate following correct calibration of equipment.
- Follow the withholding period.
- Follow all other directions on the label/permit and the Material Safety Data Sheets (MSDS).

Always read the label

Users of agricultural or veterinary chemical products must always read the label and any permit, before using the product, and strictly comply with the directions on the label and the conditions of any permit. Users are not absolved

from compliance with the directions on the label or the conditions of the permit by reason of any statement made or not made in this publication.

Not all registered chemicals are listed in the table. This table is to be used as a guide only and not a recommendation. The product trade names in this publication are supplied on the understanding that no preference between equivalent products is intended and that the inclusion of a product name does not imply endorsement over any equivalent product from another manufacturer.

Recognising that some of the information in this document is provided by third parties, the State of New South Wales, the author and the publisher take no responsibility for the accuracy, currency, reliability and correctness of any information included in the document provided by third parties.

Information provided in this table is based on information available at the time of printing and users of this information are not absolved from compliance with the direction on the label or permit by reason of any statement made or omitted from this publication.

NSW GOVERNMENT Local Land Services Greater Sydney

PESTICIDES REGISTERED IN NSW FOR THE CONTROL OF INSECT PESTS OF CUCUMBER CURRENT AT 21/09/2021#. ALWAYS READ THE LABEL.

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
APHIDS								
Aphids – general (Refer to labels for species)	Botanical oil (850g/L)	Eco-Oil			500 mL	-	Nil when used as directed	• **Test on small area for possible phytotoxicity before full application** • Do not apply if temperatures exceed 35°C or if plants are stressed
	Beauveria bassiana	Velifer Biological Insecticide			50 mL	-	0	• **Suppression Only** • **Susceptible to UV damage use only in protected situations or spray in late afternoon or evening** • Do not use while bees are foraging • Check critical comments carefully
	Maldison (440 g/L) (1B)	Fyfanon 440 EW Inescticide			140 – 230 mL	-	3	• Toxic to bees – do not spray near hives or when bees are foraging. Known resistance in aphid populations
	Paraffinic oil (815 g/L) (830 g/L) & Petroleum oil (840 g/L) (998 mL/L)	Bioclear Paraffinic Oil Sacoa Biopest Paraffinic Oil BioCover Horticultural Oil			1 - 2 L	-	1	• **Test on small area for possible phytotoxicity before full application** • Do not apply if temperatures exceed 32°C or if plants are stressed • Apply a maximum of 4 sprays per season
	Pesticidal soaps (285g/L) (Potassium salts of fatty acids)	Natrasoap Insecticidal Soap Spray Multicrop Bugguard Insecticide Concentrate			1.5 - 3 L	-	Nil when used as directed	• **Test on small area for possible phytotoxicity before full application** • Do not apply during hot part of day or if plants are stressed

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Aphids – general (Refer to labels for species)	Pirimicarb (500 g/kg) (1A)	Aphidex WG Insecticide Pirimor WG Aphicide			50 g	0.5 - 1 kg	2	• Use higher rate if temperatures below 20°C
	Flonicamid (500 g/kg) (29)	MainMan 500 WG Insecticide			-	100-140 g	1	• Minimum re-treatment interval of 2 weeks
	Cyantraniliprole 100 g/L (28)	Benevia Insecticide			-	500 mL	1	• **Do not use on Container or Hydroponic crops**
	Cyantraniliprole (80 g/L) (28) + Diafenthiuron (400 g/L) (12)	Minecto Forte Insecticide			-	500 mL	1	• **Use in field only, DO NOT use in protected cropping e.g. greenhouse, tunnels, igloos etc.** • Do Not apply using a backpack sprayer • Highly toxic to bees
Green Peach Aphids	Afidopyropen 100 g/L (9D)	Versys Insecticide			100 mL	-		• Residual control for aphids up to 21 days. Rotate mode of action after 2 sprays (maximum)
	Imidacloprid (200 g/L) (4A)	Confidor 200 SC Insecticide Nufarm Nuprid 200 SC Insecticide			25 mL	300 mL	1	• Many active strengths, application methods. • Highly toxic to bees • Soil drench or drip safest for beneficials
	Sulfoxaflor (240 g/L) (4C)	Transform Isoclast active Insecticide			200 – 400 mL	-	1	• Highly toxic to bees
	Spirotetramat (240 g/L) (23)	Movento 240 SC Insecticide			20 mL + adjuvant	200 - 300 mL + adjuvant	1	• Do not apply more than 3 sprays per crop • Do not apply when crops are flowering and bees are active

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Green Peach Aphids	Pymetrozine (500 g/L) (9B)	Chess Insecticide **(NEW CHEMISTRY)**			-	200 g + Adjuvant	3	
CATERPILLARS								
Caterpillars – General	*Bacillus thuringiensis* (11C)	Dipel DF biological insecticide dry flowable			25 - 100 g	0.5 - 2 kg	Nil when used as directed	• Do not apply during the day in hot weather
Heliothis **(Helicoverpa spp.)** **(refer to labels for additional lepidoptera species)**	Spinetoram (120 g/L) (23)	Success Neo Jemvelva Active Insecticide			-	200 – 400 mL	3	• Low toxicity to bees, but avoid applications when bees are foraging
	Spinosad (240 g/L) (5)	Entrust Organic Qalcova Active Insecticide			-	200-400 mL	3	• Low toxicity to bees, but avoid applications when bees are foraging
	Flubendiamide (480 g/L) (28)	Belt 480 SC Insecticide			10 mL	75 or 100 mL	1	• 3 applications per crop maximum including all group 28 insecticides
	Nuclear Polyhedrosis Virus of *H. armigera* (31)	Vivus Gold Helicoverpa Biocontrol Gemstar LC biological insecticide			-	375 - 750 mL	Nil when used as directed	• Most effective on small larvae • Use as part of IPM strategy
		Vivus Armigen Helicoverpa Biocontrol				100 – 200 mL		
	Bifenthrin (250 g/L) (3A)	Talstar 250 EC Astral 250 EC Insecticide			16 – 24 mL	160 – 240 mL	1	• **Use in field only, DO NOT use in protected cropping e.g. greenhouse, tunnels, igloos etc.** • **Check crop safety for each variety** • No more than two consecutive applications

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Heliothis **(Helicoverpa spp.)** **(refer to labels for additional lepidoptera species)**	Emamectin (44 g/Kg) (6)	Proclaim Opti Insecticide			-	150 - 250 mL	3	• Do NOT target large larvae
	Cyantraniliprole (80 g/L) + Diafenthiuron (400 g/L)	Minecto Forte Insecticide			-	500 mL	1	• **Use in field only, DO NOT use in protected cropping e.g. greenhouse, tunnels, igloos etc.** • Highly toxic to bees
	Cyantraniliprole (100 g/L) (28)	Benevia Insecticide			-	500 mL + Adjuvant	1	• DO NOT spray flowering crops when bees are actively foraging • **Do not use on Container or Hydroponic crops**
	Chlorantraniliprole (200 g/L) (28)	Coragen Insecticide			10 mL + Adjuvant	100 mL + Adjuvant	1	• **Use in field only, DO NOT use in protected cropping e.g. greenhouse, tunnels, igloos etc.** • Apply no more than 3 sprays per crop • Allow minimum of 7 days between sprays
	Methomyl (225g/L)	Lannate-L Insecticide			100-200 mL + Adjuvant	-	3	• **APVMA 82428 permit expires 31/03/2024** • **Use in field only, DO NOT use in protected cropping e.g. greenhouse, tunnels, igloos etc. or Hydroponics** • Highly toxic to bees
Caterpillar Cutworms	Diazinon (800 g/L) (1B)	Farmoz Diazol 800 Insecticide			-	700 mL – 1.4 L	14	• Vary rate according to size of plant
	Methomyl (225g/L)	Lannate-L Insecticide			100-200 mL + Adjuvant	-	3	• **APVMA 82428 permit expires 31/03/2024** • **Use in field only, DO NOT use in protected cropping e.g. greenhouse, tunnels, igloos etc. or Hydroponics** • Highly toxic to bees

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
MITES								
Mites – general	Paraffinic oil (815 g/L) (830 g/L) Petroleum oil (840 g/L) (998 mL/L)	Bioclear Paraffinic Oil Sacoa Biopest Paraffinic Oil BioCover Horticultural Oil			1 - 2 L	-	1	• **Test on small area for possible phytotoxicity before full application** • Do not apply if temperatures exceed 32°C or if plants are stressed • Apply a maximum of 4 sprays per season
	Beauveria bassiana	Velifer Biological Insecticide			50 mL	-	0	• **Suppression Only** • **Susceptible to UV damage use only in protected situations or spray in late afternoon or evening** • Do not use while bees are foraging • Check critical comments carefully
	Pesticidal soaps (285g/L) (Potassium salts of fatty acids)	Natrasoap Insecticidal Soap Spray Multicrop Bugguard Insecticide Concentrate			1.5 - 3 L	-	Nil when used as directed	• **Test for possible phytotoxicity on small area before full application** • Do not apply during hot part of day or if plants are stressed
	Botanical oil (850g/L)	Eco-Oil			500 mL	-	Nil when used as directed	• **Test for possible phytotoxicity on small area before full application** • Do not apply if temperatures exceed 35°C or if plants are stressed
Two-spotted mite	Bifenazate (480 g/L) (20D)	Acramite Miticide			65 mL	-	1	• Coverage is essential • One application per season
	Tebufenpyad 200 g/kg (21A)	Sipcam Pyranica Miticide **(NEW CHEMISTRY)**			25-50 g		14	• Apply once per season

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Two-spotted mite	Abamectin (18g/L) (36g/L) (6)	Vertimec Miticide/Insecticide; Vantal Upgrade Miticide/Insecticide			-	18g/L product: 300 or 450 mL 36g/L product: 150-225 mL	H: 3 G: 3	• No more than 2 sprays per crop • Allow 28 days between consecutive crops
	Cyantraniliprole (80 g/L) + Diafenthiuron (400 g/L)	Minecto Forte Insecticide			-	750 mL	1	• **Use in field only, DO NOT use in protected cropping e.g. greenhouse, tunnels, igloos etc.** • Highly toxic to bees
Mites **(Refer to labels for species)**	Tebufenpyad 200 g/kg (21A)	Sipcam Pyranica Miticide **(NEW CHEMISTRY)**			25-50 g		14	• Apply once per season
	Bifenazate (480 g/L) (20D)	Acramite Miticide			65 mL	-	1	• Coverage is essential • One application per season
	Propargite (300 g/kg) (14A)	Betamite 300 WG Miticide Omite 300 W Wettable Powder Miticide			100 g	-	7	
	Etoxazole (110 g/L)	Paramite selective Miticide			35 mL	350 mL	7	• **APVMA permit 82460 expires 31/07/2022**
	Hexythiazox (100 g/L) (10A)	Calibre 100 EC Miticide			25 mL	-	3	• **APVMA permit 14765 expires 30/09/2023**
Tomato Red Spider Mite	Abamectin (18g/L) (36g/L) (6)	Vertimec Vantal			-	300 or 450 mL 150-225 mL	3	• **APVMA permit 14722 expires 31/07/2025** • No more than 2 sprays per crop • Allow 28 days between consecutive crops

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Tomato Red Spider Mite	Bifenazate (480 g/L) (20D)	Acramite Mafente Xtra			65 mL	-		• **APVMA permit 82341 expires 30/04/2025** • Coverage is essential • One application per season
THRIPS								
Thrips	Diazinon (800 g/L) (1B)	Farmoz Diazol 800 Insecticide			30 mL	350 mL	14	• Do not use with IPM programs • Apply when flowering and thrips are in damaging numbers. • **Dangerous to bees:** DO NOT spray flowering crops when bees are foraging
	Beauveria bassiana	Velifer Biological Insecticide			50 mL	-	0	• **Suppression Only** • **Susceptible to UV damage use only in protected situations or spray in late afternoon or evening.** Do not use while bees are foraging • Check critical comments carefully
	Paraffinic oil (815 g/L) (830 g/L) Petroleum oil (840 g/L) (998 mL/L)	Bioclear Paraffinic Oil Sacoa Biopest Paraffinic Oil BioCover Horticultural Oil			1 - 2 L	-		• **Test for possible phytotoxicity on small area before full application** • Do not apply if temperatures exceed 32°C or if plants are stressed • Apply a maximum of 4 sprays per season
	Pesticidal soaps (285g/L) (Potassium salts of fatty acids)	Natrasoap Insecticidal Soap Spray Multicrop Bugguard Insecticide Concentrate			1.5 - 3 L	-	Nil when used as directed	• **Test for possible phytotoxicity on small area before full application** • Do not apply during hot part of day or if plants are stressed
Western flower thrips (WFT)	Spinetoram (120 g/L) (5A)	Success Neo Jemvelva Active Insecticide			-	400 mL	3	• Target sprays at eggs and newly-hatched larvae • Apply a maximum of 4 sprays per crop or per year • See label for WFT resistance management strategy
	Spinosad (240 g/L) (5)	Entrust Organic Qalcova Active Insecticide			-	400 mL + Wetter	3	• Low toxicity to bees, but avoid applications when bees are foraging

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Western flower thrips (WFT)	Cyantraniliprole 100 g/L (28)	Benevia Insecticide			-	500ml + Adjuvant	1	• **Do not use on Container or Hydroponic crops** • **Suppression only** • DO NOT spray flowering crops when bees are actively foraging
	Abamectin (36g/L) (6)	Vantal Upgrade Miticide/Insecticide			45 mL	225 mL	H: 3 G: 3	• No more than 2 sprays per crop
	Cyantraniliprole (80 g/L) + Diafenthiuron (400 g/L)	Minecto Forte Insecticide			-	750 mL	1	• **Suppression only** • **Use in field only, DO NOT use in protected cropping e.g. greenhouse, tunnels, igloos etc.** • Highly toxic to bees
	Methomyl (225g/L)	Lannate-L Insecticide			100-200 mL+ Adjuvant	-	3	• **APVMA 82428 permit expires 31/03/2024** • **Use in field only, DO NOT use in protected cropping e.g. greenhouse, tunnels, igloos etc. or Hydroponics** • Highly toxic to bees
WHITEFLIES								
Greenhouse whitefly **(refer to label and permits)**	Chlorpyrifos (500 g/L) (1B)	Strike-out 500 ec Insecticide			50 - 100 mL	-	5	
	Buprofezin (440 g/L) (16)	Applaud Insecticide			-	500 mL	1	• **APVMA permit 82467 expires 30/06/2025** • Two applications per season maximum
	Botanical oil (850g/L)	Eco-Oil			375 - 500 mL	-	Nil when used as directed	• **Use only in protected cropping e.g. greenhouses & hydroponics** • Do not apply if temperatures exceed 35°C or if plants are stressed • **Test for possible phytotoxicity on small area before full application**

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Greenhouse whitefly **(refer to label and permits)**	Pesticidal soaps (285g/L) (Potassium salts of fatty acids)	Natrasoap Insecticidal Soap Spray Multicrop Bugguard Insecticide Concentrate (Permit Use)			1.5 - 3 L	-	Nil when used as directed	• **APVMA permit 13920 expires 31/03/2023** • **Use only in protected cropping e.g. greenhouses & hydroponics** • Do not apply during hot part of day or if plants are stressed • **Test for possible phytotoxicity on small area before full application**
	Sulfoxaflor (240 g/L) (4C)	Transform Isoclast Active Insecticide			-	400 mL	1	• Highly toxic to bees • **Ensure accurate species identification**
	Pymetrozine (500 g/L) (9B)	Chess Insecticide **(NEW CHEMISTRY)**			-	200 g + Adjuvant	3	• **Suppression only** • Do not apply more than 2 applications per crop • Apply SLW resistance management strategy
Silverleaf whitefly (refer to labels for additional whitefly and insect control)	Botanical oil (850g/L)	Eco-Oil			500 mL	-	Nil when used as directed	• **APVMA permit 14077 expires 30/09/2023** • **Use only in protected cropping e.g. greenhouses & hydroponics** • Do not apply if temperatures exceed 35°C or if plants are stressed • **Test for possible phytotoxicity on small area before full application**
	Imidacloprid (200 g/L) (4A)	Confidor 200 SC Insecticide Nufarm Nuprid 200 SC Insecticide			25 mL	250 mL	1	• Apply no more than 2 sprays / crop • Highly toxic to bees Soil drench or drip safest for beneficials
	Spirotetramat (240 g/L) (23)	Movento 240 SC Insecticide			30 - 40 mL + Adjuvant	300 - 400 mL + Adjuvant	1	• Do not apply more than 3 sprays per crop
	Afidopyropen (100 g/L) (9D)	Versys Insecticide			-	350 mL .2% v/v Hasten	1	• **Suppression only** of both adult and nymph SLW
	Pymetrozine (100 g/L) (9D)	Chess Insecticide **(NEW CHEMISTRY)**			-	200 g + Adjuvant	3	• **Suppression only** • Do not apply more than 2 applications per crop • Apply SLW resistance management strategy

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Silverleaf whitefly **(refer to labels for additional whitefly and insect control)**	Beauveria bassiana	Velifer Biological Insecticide			50 mL	-	0	• **Use only in protected cropping** • Susceptible to UV damage use only in protected situations or spray in late afternoon or evening • Do not use while bees are foraging • Check critical comments carefully
	Buprofezin (440 g/L) (16)	Applaud insecticide			-	500 mL	1	• **APVMA permit 82467 expires 30/06/2025** • Two applications per season maximum
	Flonicamid (500 g/kg) (29)	MainMan 500 WG Insecticide			200g + Hasten 2mL	-	1	• Minimum re-treatment interval of 2 weeks
	Cyantraniliprole 100 g/L (28)	Benevia Insecticide			-	500 mL	1	• DO NOT spray flowering crops when bees are actively foraging • **Do not use on Container or Hydroponic crops**
	Cyantraniliprole (80 g/L) + Diafenthiuron (400 g/L)	Minecto Forte Insecticide			-	500 mL	1	• **Use in field only, DO NOT use in protected cropping e.g. greenhouse, tunnels, igloos etc.** • Highly toxic to bees
	Bifenthrin (250 g/L) (3A)	Talstar 250 EC Astral 250 EC Insecticide			24 – 32 mL	240 - 320 mL	1	• **Use in field only, DO NOT use in protected cropping e.g. greenhouse, tunnels, igloos etc.** • **Check crop safety for each variety** • No more than two consecutive applications
	Pesticidal soaps (285g/L) (Potassium salts of fatty acids)	Natrasoap Insecticidal Soap Spray Multicrop Bugguard Insecticide Concentrate			1.5-3 L	-	Nil when used as directed	• **APVMA permit 13920 expires 31/03/2023** • **Use only in protected cropping e.g. greenhouse & hydroponics** • Do not apply during hot part of day or if plants are stressed • **Test for possible phytotoxicity on small area before full application**
OTHER INSECT PESTS								
Cucumber fruit fly	Clothianidin (500 g/L) (4A)	Sumitomoto Samurai Systemic Insecticide			-	225 g	7	• **APVMA permit 80101 expires 30/09/2023** • Residues may remain toxic to bees for several days after application

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Cucumber fruit fly	Maldison (Malathion) (440 g/L) (1B)	Fyfanon 440 EW Insecticide			295 mL	-	1	• **Use in field only, DO NOT use in protected cropping e.g. greenhouse, tunnels, igloos etc.** • Highly toxic to bees
Fungus gnats	*Bacillus thuringiensis* (11C)	Vectobac WG Biological Larvicide Water Dispersable Granule			100 - 200 g	-	Nil when used as directed	• **APVMA permit 14694 expires 30/06/2024** • Apply by drench to soil or growing media • Spray to depth of 3-4 cm • For existing infestations, make 3 weekly sprays at higher rate
Green vegetable bug **Pumpkin Beetle**	Maldison (Malathion) (440 g/L) (1B)	Fyfanon 440 EW Insecticide			140-230 mL	-	3	• **Use in field only, DO NOT use in protected cropping e.g. greenhouse, tunnels, igloos etc.** • Highly toxic to bees
Green vegetable bug	Trichlorfon (500 g/L) (1B)	Dipterex 500 SL Insecticide Lepidex 500 Insecticide			150 mL	1.75 L	2	
	Carbaryl (500 g/L) (1A)	Bugmaster Flowable Insecticide			200 mL	-	3	• Only use PRIOR to flowers • **Highly toxic to bees**
Rutherglen bug **(refer to labels for all insects controlled or suppressed)**	Maldison (Malathion) (440 g/L) (1B)	Fyfanon 440 EW Insecticide			140-230 mL	-	3	• **Use in field only, DO NOT use in protected cropping e.g. greenhouse, tunnels, igloos etc.** • Highly toxic to bees
	Trichlorfon (500 g/L) (1B)	Dipterex 500 SL Insecticide Lepidex 500 Insecticide			125 mL	-	2	
	Sulfoxaflor (240 g/L) (4C)	Transform Isoclast Active Insecticide			300 – 400 mL	-	1	• **Suppression only** • Highly toxic to bees
	Carbaryl (500 g/L) (1A)	Bugmaster Flowable Insecticide			200 mL	-	3	• Only use PRIOR to flowers • Highly toxic to bees

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Rutherglen bug **(refer to labels for all insects controlled or suppressed)**	Methomyl (225 g/L)	Lannate-L Insecticide			100-200 mL	-	3	• **APVMA permit 82428 expires 31/03/2024** • **Use in field only, DO NOT use in protected cropping e.g. greenhouse, tunnels, igloos etc. or Hydroponics** • Dangerous to bees
Jassids / Leafhoppers **(refer to labels for all insects controlled or suppressed)**	Paraffinic oil (815 g/L) (830 g/L) Petroleum oil (840 g/L) (998 mL)	Bioclear Paraffinic Oil Sacoa Biopest Paraffinic Oil BioCover Horticultural Oil			1 - 2 L	-	1	• **Test for possible phytotoxicity on small area before full application** • Do not apply if temperatures exceed 32°C or if plants are stressed • Apply a maximum of 4 sprays per season
Root Knot Nematode	Fluazaindolizine (Unknown MOA)	Salibro Reklemel Active Nematicide **(NEW CHEMISTRY)**			Refer to label		Nil	• Do not use in hydroponic systems • Can be used in field and protected cropping situations
	Fluensulfone (480 g/L) (Unknown MOA)	Nimitz 480 EC Nematacide **(NEW CHEMISTRY)**				4 – 8 L	Nil when used as directed	• Apply a maximum of 8L per hectare per year and not more than one application per crop • Very toxic to aquatic life
	Abamectin (18 g/L) (6)	Vertimec Vantal Sorcerer			-	Planting hole drench = 400 mL/1000	Nil when used as directed	• 120 mL per 100 metre row thru drip • Multiple applications at 14-day intervals
Vegetable Leafminer & Serpentine Leafminer	Cyantraniliprole 100 g/L (28)	Benevia Insecticide			-	750 ml	1	• **APVMA permit 90387 expires 31/12/2023** • DO NOT spray flowering crops when bees are actively foraging • **Do not use on Container or Hydroponic crops**
	Abamectin (18 g/L) (36g/L) (6)	Vertimec Miticide/Insecticide Vantal Upgrade Miticide/Insecticide			-	18 g/L product: 1.2 L 36 g/L product: 600 mL	7	• **APVMA permit 81876 expires 30/04/2024** • **Suppression ONLY**

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Vegetable Leafminer & Serpentine Leafminer	Cyromazine (150 g/kg) (17)	Diptex 150 WP Insect Growth Regulator			150g	1 kg	7	• **APVMA permit 81867 expires 30/11/2023** • Managing drift is very important • Hazardous to Bees

Discard this table if a more up-to-date table is available.

*Prevent resistance by rotating between chemical groups with different mode of action.

For chemical mode of action (MoA) group classification go to web site:
CropLife Australia | Resistance Management

Or enter into web browser:
https://www.croplife.org.au/resources/programs/resistance-management/

 **Safe for Bees.**

 **Can be used in IPM programs, may affect some beneficial insects and mites.**

Where to get more information:

1. Australian Pesticide & Veterinary Medicines Authority (APVMA) website: www.apvma.gov.au for current use permits, chemical residue limits, chemical recalls and reviews.
2. Agricultural chemical companies and their distributors.
3. NSW Department of Primary Industries. www.dpi.nsw.gov.au/agriculture/horticulture

How to reduce excess chemical residues and safe use of chemicals in my crop.

- Use only registered chemicals.
- Apply at the label or permit rate following correct calibration of equipment.
- Follow the withholding period.
- Follow all other directions on the label/permit and the Material Safety Data Sheets (MSDS).

Always read the label

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NSW GOVERNMENT Department of Primary Industries

PESTICIDES REGISTERED IN NSW FOR THE CONTROL OF DISEASES OF BRASSICA
CURRENT AT 21/09/2021#. ALWAYS READ THE LABEL.

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	Rate per		Withholding period (days)	Critical Use Comments/Restraints
		100 L	ha		
BACTERIAL SPOTS/BLIGHT					
Bacillus amyloliquefaciens (Gp BM2)* **APVMA PERMIT 87630 Expires 30 June 2022**	Serenade Opti Biofungicide	150-200 g	—	0	• Use as a preventative beginning soon after emergence. • Trial on a small area before applying to whole crop.
Copper hydroxide, Copper oxychloride, Tribasic copper sulphate (various formulations) (Gp M1)*	Various	See product label		1	• Test for possible phytotoxicity on a few plants before full application. • Do not apply if hot or frost prone conditions prevail.
FUNGAL LEAF SPOTS (*Alternaria* spp. plus others)					
Triadimenol 250 g/kg (Gp 3)*	Bayfidan 250 EC Fungicide	—	200 or 400 mL	7	***Ring Spot only*** • Use with wetting agent.
Chlorothalonil (Gp M5)* **APVMA PERMIT 82895 Expires 31/8/2025**	Chlorothalonil various products	See produce label		7	***Alternaria (leafy brassicas), and Ring Spot and Botrytis rots*** • Maximum 4 applications per crop.
Copper hydroxide, Copper oxychloride, Tribasic copper sulphate (various formulations) (Gp M1)*	Various	See product label		1	
Azoxystrobin (250 g/L) (Gp 11)*	Amistar 250 SC Fungicide	—	400 – 500 mL + Adjuvant	7	***Alternaria Leaf Spot only*** • Apply a maximum of 2 sprays per crop. • Do not apply more than 2 consecutive sprays. • Apply sprays 7-14 days apart. • Rotate with a different fungicide group.
Azoxystrobin (155g/L) plus Oxathiapiprolin (15g/L) (Gps 11 + 49)*	Orondis Flexi Fungicide	—	800-1000 mL	3	***Suppression of Alternaria leaf spot*** • Maximum 3 sprays/crop. • Use with non-ionic wetter on varieties with waxy leaves.
Copper as copper ammonium complex (93 g/L) (Gp M1)*	CopperGuard Copper Fungicide	500 mL	—	1	• Apply every 10-14 days. • Do not apply if hot or frost prone conditions prevail. • Do not apply to wet crops. • Test for possible phytotoxicity on a few plants before full application.

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	Rate per		Withholding period (days)	Critical Use Comments/Restraints
		100 L	ha		
Difenoconazole (250 or 400 g/L) (Gp 3)* **APVMA PERMIT 87973** **Expires 31/8/2025**	Nufarm Digger Fungicide + other registered products	—	250 g/L products 400 mL/ha or 400 g/L products 250 mL/ha	3	***Ring spot only*** • Do not apply more than 2 consecutive sprays. • Do not apply more than 3 times per crop. • Alternate with a different fungicide group.
Mancozeb (625, 750 or 800 g/kg) (Gp M3)*	Various	See product label		7	***Alternaria & Ring spot*** • Apply a maximum of 4 sprays per crop. • Apply sprays more than 7 days apart.
CLUB ROOT (*Plasmodiophora brassicae*)					
Fluazinam (500 g/L) (Gp 29)*	Emblem Fungicide	25-50 mL/1000 plants	Band 3 L/ha	0	***Brussel sprouts, cabbage, broccoli, cauliflower & kohlrabi only*** • Seedling drench at transplanting or pretransplanting band.
Amisulbrom (500g/kg) (Gp 21)*	NuFarm Amishield 500WG Fungicide	20-40 g/1000 plants	—	0	• Apply to seedlings prior to planting. • Ensure drenching of root ball.
DAMPING OFF (*Phytophthora* spp.) (*Pythium* spp.)					
Amisulbrom (500g/kg) (Gp 21)	NuFarm Amishield 500WG Fungicide	20-40 g/1000 plants	—	0	***For Pythium and Phytophthora rots*** • Apply to seedlings prior to planting. • Ensure drenching of root ball.
Phosphorous (Phosphonic) Acid present as mono-dipotassium phosphonate (400; 600 or 620 g/L) (Gp P07)* **APVMA PERMIT 14184** **Expires 30/6/2022**	Various	See product label		0	**Leafy Brassicas only** • Apply a maximum of 4 sprays per crop. • Apply sprays more than7 days apart. • Test for possible phytotoxicity on a few plants before full application.
DOWNY MILDEW *(Hyaloperonospora brassicae [syn. H. parasitica])*					
Mancozeb (625, 750 or 800 g/kg) (Gp M3)*	Various	See product label		14	• Apply a maximum of 4 sprays per crop. • Apply sprays more than 7 days apart.
Metiram (700g/kg) (Gp M3)*	Polyram DF Fungicide	200-300 g	2.2-3.5 kg	7	• Use with non-ionic wetter.
Oxathiapiprolin (100 g/L) (Gp 49)*	Zorvec Enicade Fungicide	—	350 mL + Protectant Fungicide	3 for leafy 0 for heading	• Also maintain regular protectant chemical spray program. • Apply a maximum of 3 sprays per crop. • Apply sprays 7-10 days apart. • Apply 2 consecutive sprays then rotate with different chemical group.

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	Rate per		Withholding period (days)	Critical Use Comments/Restraints
		100 L	ha		
Azoxystrobin (155g/L) plus Oxathiapiprolin (15g/L) (Gps 11 + 49)*	Orondis Flexi Fungicide	—	800-1000 mL	3	• Maximum 3 sprays/crop.
Amisulbrom (32g/kg) tribasic copper sulphate (180 g/L) (Gp 21 and M1) *	Amicus Blue Fungicide	—	2L/ha	0	• Apply as a protectant Spray program. • Do not apply more than three applications per crop.
Copper fungicide (as copper hydroxide, oxychloride, oxide, or tribasic copper sulphate) (various formulations (190; 200; 375; 500; 750 g/kg) (Gp M1)* **APVMA PERMIT 14038** **Expires 30/9/2023**	Various	Check product label		1	***All Brassicas registered*** ***Permit for Leafy brassicas only*** • Do not apply under poor drying conditions. • Do not apply if hot or frost prone conditions prevail. • Do not apply to wet crops. • Test for possible phytotoxicity on a few plants before full application.
Copper as Copper Ammonium Complex (93 g/L) (Gp M1)*	CopperGuard Copper Fungicide	500 mL	—	1	• Apply every 10-14 days. • Do not apply if hot or frost prone conditions prevail. • Do not apply to wet crops. • Test for possible phytotoxicity on a few plants before full application.
Cyazofamid (400g/L) (Gp 21)*	Ranman 400 SC Fungicide	—	150-200 mL	0	***Brassica seedlings & leafy brassicas*** • Apply maximum of 6 sprays/season.
Dimethomorph (500 g/kg) (Gp 40)* PLUS Mancozeb (750-800 g/kg) **APVMA PERMIT 14958** **Expires31/12/2022**	Acrobat SC Fungicide + Mancozeb Product	See product labels		14	• Mix with mancozeb according to label. • Apply a maximum of 4 sprays per crop. • Apply 2 consecutive sprays then rotate with different fungicide group.
Hydrogen peroxide (320g/L) + Peroxyacetic acid (80g/L) No FRAC number	Peratec Plus Fungicide	1 L	—	1	• Maximum 4 sprays/crop.
Propamocarb hydrochloride + Fluopicolide (Gp 28+Gp 43)*	Infinito SC Fungicide	—	1.2-1.6 L	0	• Maximum 3 sprays/crop. • Use with non-ionic wetter.
Phosphorous acid (400 or 600 g/L) (Gp P07)* **APVMA PERMIT 11951** **Expires 31/3/2025**	Various	See product label		1	***Broccoli, Cauliflower & Brussels Sprouts only*** • Test for possible phytotoxicity on a few plants before full application.
Mandipropamid (250 g/L)* (Gp 40)*	Revus Fungicide	—	400-600 mL	1	***Leafy Brassicas only*** • No more than 4 applications per crop.

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	Rate per		Withholding period (days)	Critical Use Comments/Restraints
		100 L	ha		
Metalaxyl-M (50g/kg) + Copper (390g/kg)	Ridomil Gold Plus Systemic Fungicide	—	2 kg	14	• Maximum 2 sprays/year. • Use with surfactant as per label.
Zineb 800g/kg) (Gp M3) **APVMA PERMIT 10845** **Expires 31/5/2025**	Barmac Zineb Fungicide	150-175 g	—	10	• Use with surfactant.
POWDERY MILDEW (*Erysiphe* spp.)					
Potassium bicarbonate (940 g/kg) (Gp NC)* **APVMA PERMIT 13695** **Expires 31/7/2025**	Ecocarb Fungicide	400 g plus 200 mL vegetable oil adjuvant	—	0	***Leafy brassicas only*** • Do not apply to plants suffering from environmental stress.
SCLEROTINIA ROT (*Sclerotinia sclerotiorum* & *S. minor*)					
Fludioxonil (250 g/L) Pydiflumetofen (150 g/L) (Gp 7 and 12)*	Miravis Prime Adepidyn Technology Fungicide	—	1L		• Field and protected cropping uses. • Do not apply more than 2 applications per season. • Also controls Botrytis cinereal.
Cyprodonil (375 g/kg) + Fludioxonil (250 g/kg) (Gps 9 + 11)*	Switch Fungicide Plus Others	—	0.8 - 1 kg	7	***Leafy brassicas and Chinese cabbage*** • Apply a maximum of 2 sprays per crop. • Do not apply more than 2 consecutive sprays. • Apply sprays 7-14 days apart. • Rotate with a fungicide from a different activity group.
Azoxystrobin (250 g/kg) (Gp 11)*	Amistar 250 SC Fungicide	—	500 mL	7	• Apply a maximum of 2 sprays per crop. • Do not apply more than 2 consecutive sprays. • Apply sprays 7-14 days apart. • Rotate with a different fungicide group.
Azoxystrobin (155g/L) plus Oxathiapiprolin (15g/L) (Gps 11 + 49)*	Orondis Flexi Fungicide	—	800-1000 mL	3	• Maximum 3 sprays/crop.
Boscalid (500 g/kg) (Gp 7)*	Filan Fungicide	—	1 kg	7	• Apply a maximum of 4 sprays on the same bed per year. • Apply sprays 7-14 days apart.
Penthiopyrad (200 g/L) (Gp 7)*	Fontelis Fungicide	—	1.75 L	0	• Apply a maximum of 3 sprays per season. • Apply sprays 7-14 days apart. • Do not apply more than 2 consecutive sprays.
WHITE BLISTER (*Albugo candida*)					
Amisulbrom (32g/kg) tribasic copper sulphate (180 g/L) (Gp 21 and M1) *	Amicus Blue Fungicide	—	2L/ha	0	• Protectant Spray program. • Do not apply more than three applications per crop.

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	Rate per		Withholding period (days)	Critical Use Comments/Restraints
		100 L	ha		
Azoxystrobin (250 g/L) (Gp 11)*	Amistar 250 SC Fungicide	—	500 mL	7	• Apply a maximum of 2 sprays per crop. • Apply second spray after 7 days. • Do not add wetting agents or crop oils.
Azoxystrobin (155g/L) plus Oxathiapiprolin (15g/L) (Gps 11 + 49)*	Orondis Flexi Fungicide	—	800-1000 mL	3	• Maximum 3 sprays/crop.
Cyazofamid (400g/L) (Gp 21)*	Ranman 400 SC Fungicide	—	150-200 mL	0	***Broccoli only*** • Apply maximum of 6 sprays/season.
Propamocarb hydrochloride + Fluopicolide (Gp 28 + Gp 43)*	Infinito SC Fungicide	—	1.6 L	0	• Maximum 3 sprays/crop. • Use with non-ionic wetter.
Hydrogen peroxide (320g/L) + Peroxyacetic acid (80g/L) (No FRAC group number)	Peratec Plus Fungicide	1 L	—	1	• Maximum 4 sprays/crop.
Dimethomorph (500 g/kg) (Gp 40)* PLUS Mancozeb (750-800 g/kg) **APVMA PERMIT 14958 Expires 31/12/2022**	Acrobat SC Fungicide + Mancozeb Product	—	360 mL	14	• Mix with mancozeb according to label. • Apply a maximum of 4 sprays per crop. • Apply 2 consecutive sprays then rotate with different fungicide group.
Metalaxyl-M (50g/kg) + Copper (390g/kg)	Ridomil Gold Plus Systemic Fungicide	—	2 kg	14	• Maximum 2 sprays/year. • Use with surfactant as per label.
Virus Management					
1. Control vectors e.g. aphids, whiteflies, thrips **2.** Sanitise pruning and picking equipment **3.** Use resistant varieties, if available					

Discard this table if a more up-to-date table is available.

*Prevent resistance by rotating between different chemical groups. (FRAC Chemical groups can found at CropLife Australia | Resistance Management).

Or enter into web browser:
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Local Land Services Greater Sydney

PESTICIDES REGISTERED IN NSW FOR THE CONTROL OF INSECT PESTS OF BRASSICA LEAF VEGETABLES

CURRENT AT 21/09/2021#. ALWAYS READ THE LABEL.

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
APHIDS								
Aphids - General	Pesticidal soaps (285g/L) (Potassium salts of fatty acids) (UNE	Natrasoap Insecticidal Soap Spray Multicrop BugGuard Insecticed Concentrate			1.5 - 3 L	-	Not required when used as directed	•Do not spray when bees are actively foraging •Do not apply during hot part of day or if plants are stressed •**Test for possible phytotoxicity on a few plants before full application**
	Pymetrozine (500 g/Kg) (9B)	Chess Insecticide			-	200 g	3	•No more than two application per crop, minimum 7-day retreatment interval
	Spirotetramat (240 g/L) (23)	Movento 240 SC Insecticide			-	200 – 300 mL + Adjuvant	3	•Toxic to aquatic organisms. •Do not re-apply within 7 days of a previous Movento spray. •Do not apply more than 2 applications per crop
	Sulfloxaflor (240 g/L) (4C)	Transform Isoclast Active Insecticide			-	200 - 300 mL + Adjuvant	3	•Test for phytotoxicity in protected situations prior to use •Highly toxic to bees.
	Beauveria bassiana	Velifer Biological Insecticide			50 mL	-	0	• **Suppression Only** • **Suseptible to UV damage use only in protected situations or spray in late afternoon or evening.**Do not use while bees are foraging •Check critical comments carefully

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Aphids - General	Petroleum Oil (840 g/L) (UNE)	BioCover Horticultural Oil			1 – 2 L	-	1	•APVMA PERMIT 12221. **Expires 30/11/2022.** •Do not apply while bees are actively foraging •Use the higher rate when pest pressure is high •Do NOT spray when temperature exceed 32˚C in the shade •Apply to foliage up to the point of run-off •Avoid mixing with sulfur and soap products
	Imidacloprid (200 g/L) (4A)	Confidor 200 SC Insecticide			25 mL	300 mL	3	•APVMA PERMIT 14584. **Expires 31/01/2024. (Refer to crops list on permit)** • Apply by boom spray only •Apply to run off, ensure good coverage on underside of leaves
	Thiamethoxam (200 g/L) (4A Chlorantraniliprole (100 g/L) (28)	Durivo Insecticide			22 mL per 1000 seedlings	-	28	•Applied as a seedling drench • Rotate to alternative mode of action insecticides as per label
Green peach aphid	Pirimicarb (800 g/Kg) (1A)	Aphidex WG Insecticide Pirimor WG Aphicide			65 – 125 g	315 or 625 g	2	•**Do NOT use in protected cropping situations.** •Use the higher rate if temperature falls below 20˚C •Some Green Peach aphids have developed resistance to this active ingredient
	Pymetrozine (500 g/Kg) (9B)	Chess Insecticide			-	200 g	3	•No more than two application per crop, minimum •7-day retreatment interval
	Sulfoxaflor (240 g/L) (4C)	Transform Isoclast Active Insecticide			-	200 mL	3	•Highly toxic to bees •**Do NOT use in covered or protected cropping situations.**
	Spirotetramat (240 g/L) (23)	Movento 240 SC Insecticide			-	200 – 400 mL	3	•Do not apply more than 2 applications per crop •Toxic to aquatic organisms •Do not re-apply within 7 days of a previous Movento spray

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Green peach aphid	Afidopyropen (100 g/L) (9D)	Versys Insecticide			-	100 mL	1	• **Do NOT use in protected cropping situations.** • Residual control of aphids out to 21 days. Repeat applications after 14 days where necessary. Do not apply more than 4 applications per crop • Do NOT apply while bees are actively foraging. • Very toxic to aquatic life
CATERPILLARS								
Heliothis *(Helicoverpa spp.)*	Helicoverpa armigera NPV (31)	Vivus Gold Helicoverpa Biocontrol Gemstar LC Biological Insecticide			-	375 - 750 mL	Not required when used as directed	• Thorough coverage of the crop is essential. NPV is most effective on smaller larvae (< 7 mm)
	Helicoverpa armigera NPV (31)	Vivus Armigen Helicoverpa Biocontrol			-	100 – 200 mL	Not required when used as directed	• Thorough coverage of the crop is essential. NPV is most effective on smaller larvae (< 7 mm)
	Cypermethrin (200 g/L) (3A)	Imtrade Cypershield 200 Insecticide			20 mL	160 mL		• Kale and head brassica only.
	Indoxacarb (320 g/L) (15) Novaluron 80 g/L (22A)	Plemax Insecticide			-	200 mL	3	• Do not use in protected situations
	Indoxacarb (300 g/Kg) (22A)	Avatar Insecticide			-	170 g	3	• **Do NOT use in protected cropping situations** • Do not retreat within 7 days, maximum of 3 applications to any one crop • Dangerous to bees. Do not apply when bees are actively foraging
	Esfenvalerate (50 g/L) (3A)	Sumi-Alpha Flex Insecticide			-	380 mL	2	• Kale and head brassica only.
	Sugar (600 g/L) Petroleum Oil (175 g/L)	Optimol biological insecticide optimise			-	1 or 2 L		• No insecticidal properties on its own, ONLY for application with Helicoverpa NPV biocontrol to enhance NPV performance

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Heliothis *(Helicoverpa spp.)*	Flubendiamide (480 g/L) (28)	Belt 480 SC Insecticide			10 mL	75 or 100 mL	1	•Very toxic to aquatic invertebrates, do not drift toward aquatic habitats
	Bacillus thuringiensis Bt kurstaki (ABTS-351) (11A)	Dipel DF biological insecticide dry flowable			25 - 100 g dilute 100 - 1000 g concentrate	0.5 - 2 kg	Not required when used as directed	•Begin sprays at egg hatch or first instar •Thorough coverage in late afternoon when larvae are actively feeding
	Spinetoram (120 g/L) (5)	Success Neo Jemvelva Active Insecticid			-	200 - 400 mL	3	•Do not make more than four applications to any crop in one season
	Bacillus thuringiensis Bt aizawai (ABTS-1857) (11A)	Xentari WG Bta biological insecticide			50 g	500 – 700 g	Not required when used as directed	•**APVMA PERMIT 87670.** **Expires31/07/2024** •Apply in minimum of 150 L/ha water, do NOT apply during the day in hot weather. •Add wetting agent
	Bacillus thuringiensis Bt aizawai (GC-91) (11A)	Campbell Bacchus WG Biological Insecticide			50 – 200 g	1 – 4 kg	Not required when used as directed	•**APVMA PERMIT 87670.** **Expires 31/07/2024** •Apply in minimum of 150 L/ha water, do NOT apply during the day in hot weather •Add wetting agent
	Emamectin (44 g/Kg) (6)	Proclaim Opti Insecticide			-	250 – 300 g	1	•**APVMA PERMIT 14907.** **Expires 30/11/2024** •Allow a minimum of 7 days between applications and a maximum of 4 applications per year
	Amorphous silica (450 g/L)	Abrade			-	2.5 – 5 L	Not required when used as directed	•**ONLY FOR HEAD BRASSICA *(Not Leaf Brassica)*** •Do not apply if rain is expected within 48 hours •Best if applied to eggs or early hatchlings
	Chlorantraniliprole (200 g/L) (28)	Coragen Insecticide			10 mL + Adjuvant	100 mL + Adjuvant	3	•**Do NOT allow effluent to run-off from protected cropping systems** •Very toxic to aquatic life
	Thiamethoxam (200 g/L) (4A) Chlorantraniliprole (100 g/L) (28)	Durivo Insecticide			22 mL per 1000 seedlings	-	28	•Applied as a seedling drench. Rotate to alternative mode of action insecticides as per label

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Cabbage moth	Esfenvalerate (50 g/L) (3A)	Sumi-Alpha Flex Insecticide			25 mL	250 mL	2	•Kale crops only.
	Trichlorfon ◆ (500 g/L) (1B)	Dipterex Lepidex			150 mL	1.7 L	2	•Apply when pests are first seen and repeat at 7-10 day intervals
Cabbage white butterfly	Chlorantraniliprole 200 g/L (28)	Coragen Insecticide			10 mL + Adjuvant	100 mL + Adjuvant	3	•**Do NOT allow effluent to run-off from protected cropping systems** •Very toxic to aquatic life •Apply no more than 3 sprays per crop •Allow minimum of 7 days between sprays
	Indoxacarb (320 g/L) (15) Novaluron 80 g/L (22A)	Plemax Insecticide				200 mL	3	•Do not use in protected situations
	Esfenvalerate (50 g/L) (3A)	Sumi-Alpha Flex Insecticide			25 mL	380 mL	2	•Kale crops only.
	Deltamethrin ◆ (27.5 g/L) (3A)	Ballistic Elite Insecticide			50 mL	500 mL	2	•**ONLY FOR HEAD BRASSICA *(Not Leaf Brassica)*** •Add wetting agent
	Thiodicarb ◆ (375 g/L) (1A)	Shutdown Larvin 375			-	1 - 2 L	7	•**ONLY FOR HEAD BRASSICA *(Not Leaf Brassica)*** •Do not add to water with pH below 3 or above 8.5 •Do not store prepared spray for more than 6 hours
	Thiodicarb ◆ (800 g/L) (1A)	Confront Larvin 800			-	470-940 g		
	Trichlorfon ◆ (500 g/L) (1A)	Dipterex 500 SL insecticide Lepidex 500 Insecticide			150 mL	1.7L	2	•Apply when pests are first seen and repeat at 7-10 day intervals
Diamondback moth	Amorphous silica (450 g/L)	Abrade			-	2.5 - 5 L	Not required when used as directed	•**ONLY FOR HEAD BRASSICA *(Not Leaf Brassica)*** •Do not apply if rain is expected within 48 hours •Best if applied to eggs or early hatchlings

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Diamondback moth	Indoxacarb (320 g/L) (15) Novaluron 80 g/L (22A)	Plemax Insecticide				200 - 300 mL	3	•Do not use in protected situations
	Chlorantraniliprole 200 g/L (28)	Coragen Insecticide	e		10 mL+ Adjuvant	100 mL + Adjuvant	3	•**Do NOT allow effluent to run-off from protected cropping systems** •Very toxic to aquatic life •Apply no more than 3 sprays per crop •Allow minimum of 7 days between sprays
	Bacillus thuringiensis Bt aizawai (ABTS-1857) (11A)	Xentari WG Bta Biological Insecticide			50 g	500 – 750 g	Not required when used as directed	•**APVMA PERMIT 87670.** **Expires 31/07/2024.** •Apply in minimum of 150 L/ha water, DO NOT apply during the day in hot weather •Add wetting agent
	Bacillus thuringiensis Bt aizawai (GC-91) (11A)	Campbell Bacchus WG Biological Insecticide			50 – 200 g	1 – 4 kg	Not required when used as directed	•**APVMA PERMIT 87670.** **Expires 31/07/2024.** •Apply in minimum of 150 L/ha water, DO NOT apply during the day in hot weather •Add wetting agent
	Bacillus thuringiensis Bt kurstaki (ABTS-351) (11A)	Dipel DF biological insecticide dry flowable			25 - 100 g dilute 100 - 1000 g concentrate	0.5 - 2 kg	Not required when used as directed	•Begin sprays at egg hatch or first instar •Thorough coverage in late afternoon when larvae are actively feeding
	Thiamethoxam (200 g/L) (4A) Chlorantraniliprole (100 g/L) (28)	Durivo Insecticide			22 mL per 1000 seedlings	-	28	•Applied as a seedling drench. Rotate to alternative mode of action insecticides as per label
	Emamectin (44 g/Kg) (6)	Proclaim Opti Insecticide			-	250 – 300 g	Field: 3 Protected:1	•**Registered use: Field only** •**APVMA PERMIT 14907.** **Expires 30/11/2024** •Allow a minimum of 7 days between applications and a maximum of 4 applications per year

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Diamondback moth	Flubendiamide (480 g/L) (28)	Belt 480 SC Insecticide			10 mL	75 or 100 mL	1	•Very toxic to aquatic invertebrates, do not drift toward aquatic habitats
Loopers	Thiamethoxam (200 g/L) (4A) Chlorantraniliprole (100 g/L) (28)	Durivo Insecticide			22 mL per 1000 seedlings	28	-	•Applied as a seedling drench. Rotate to alternative mode of action insecticides as per label
	Bacillus thuringiensis Bt aizawai (ABTS-1857) (11A)	Xentari WG Bta biological insecticide			50 g	500 – 750 g	Not required when used as directed	**APVMA PERMIT 87670.** **Expires 31/07/2024** •Apply in minimum of 150 L/ha water, DO NOT apply during the day in hot weather •Add wetting agent
	Bacillus thuringiensis Bt kurstaki (ABTS-351) (11A)	DiPel DF Biological Insecticide Dry Flowable			25 – 100 g dilute 100 – 1000 g concentrate	0.5 – 2 kg	Not required when used as directed	•Begin sprays at egg hatch or first instar. Thorough coverage in late afternoon when larvae are actively feeding
	Bacillus thuringiensis Bt aizawai (GC-91) (11A)	Campbell Bacchus WG Biological Insecticide			50 – 200 g	1 – 4 kg	Not required when used as directed	•**APVMA PERMIT 87670.** **Expires 31/07/2024** •Apply in minimum of 150 L/ha water, DO NOT apply during the day in hot weather. Add wetting agent
	Chlorantraniliprole 200 g/L (28)	Coragen Insecticide			10 mL+ adjuvant	100 mL + Adjuvant	3	•Do NOT allow effluent to run-off from protected cropping systems •Apply no more than 3 sprays per crop •Allow minimum of 7 days between sprays •Very toxic to aquatic life
	Emamectin (44 g/Kg) (6)	Proclaim Opti Insecticide			-	250 – 300 g	Field Grown: 3 Protected: 1	•**Registered use: Field only** •**APVMA PERMIT 14907.** **Expires 30/11/2024** •Allow a minimum of 7 days between applications and a maximum of 4 applications per year

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Loopers	Flubendiamide (480 g/L) (28)	Belt 480 SC Insecticide			10 mL	75 or 100 mL	1	•Very toxic to aquatic invertebrates, do not drift toward aquatic habitats
	Spinetoram (120 g/L) (5)	Success Neo Jemvelva Active Insecticide			-	200 mL + Adjuvant	3	•Do not make more than four applications to any crop in one season
	Bacillus thuringiensis Bt aizawai (ABTS-1857) (11A)	Xentari WG Biological Insecticide			50 g	500 – 700 g	Not required when used as directed	•**APVMA PERMIT 87670.** **Expires 31/07/2024** •Apply in minimum of 150 L/ha water, DO NOT apply during the day in hot weather. Add wetting agent
Cluster caterpillar	Chlorantraniliprole 200 g/L (28)	Coragen Insecticide			10 mL + Adjuvant	100 mL + Adjuvant	3	•**Do NOT allow effluent to run-off from protected cropping systems** •Apply no more than 3 sprays per crop •Allow minimum of 7 days between sprays •Very toxic to aquatic life
	Thiamethoxam (200 g/L) (4A) Chlorantraniliprole (100 g/L) (28)	Durivo Insecticide			22 mL per 1000 seedlings	-	28	•Applied as a seedling drench. Rotate to alternative mode of action insecticides as per label
	Thiodicarb (375 g/L) (1A)	Shutdown Larvin			-	1-2 L	7	•**ONLY FOR HEAD BRASSICA *(Not Leaf Brassica)*** •Do not add to water with pH below 3 or above 8.5 •Do not store prepared spray for more than 6 hours
	Thiodicarb ◆ (800 g/L) (1A)	Confront Larvin 800			-	470-940 g		
Fall Army Worm	Chlorantraniliprole 200 g/L (28)	Coragen Insecticide			10 mL + Adjuvant	100 mL + Adjuvant	3	•**APVMA PERMIT 89259.** **Expires 31/03/2023** •**Do NOT allow effluent to run-off from protected cropping systems** •Apply no more than 3 sprays per crop •Allow minimum of 7 days between sprays •Very toxic to aquatic life

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Fall Army Worm	Emamectin (44 g/Kg) (6)	Proclaim Opti Insecticide			-	250 – 300 g	3	•**APVMA PERMIT 89263. Expires 31/03/2023** •Allow a minimum of 7 days between applications and a maximum of 4 applications per year
	Emamectin (44 g/Kg) (6)	Proclaim Opti Insecticide			-	250 – 300 g	1	•***Brassica leaf vegetable, various species, (see permit)*** •**For use in protected cropping** •**APVMA PERMIT 89285.** **Expires 31/03/2023** •Allow a minimum of 7 days between applications and a maximum of 4 applications per year
	Indoxacarb (300 g/Kg) (22A)	Avatar Insecticide			-	170 g	3	•***Brassica leafy vegetables*** •**APVMA PERMIT 89278.** **Expires 31/03/2023** •Do not retreat within 7 days, maximum of 3 applications to any one crop •Dangerous to bees. Do not apply when bees are actively foraging
	Indoxacarb (300 g/Kg) (22A)	Avatar Insecticide			-	250 g	3	•***Broccoli, brussels sprouts, cabbage, cauliflower only (closed head varieties only)*** •**APVMA PERMIT 89278.** **Expires 31/03/2023** •Do not retreat within 7 days, maximum of 4 applications to any one crop •Dangerous to bees. Do not apply when bees are actively foraging
	Thiamethoxam (200 g/L) (4A) Chlorantraniliprole (100 g/L) (28)	Durivo Insecticide			22 mL per 1000 seedlings	-	28	•**APVMA PERMIT 89280.** **Expires 31/03/2023** •Applied as a seedling drench. Rotate to alternative mode of action insecticides as per label

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Fall Army Worm	Methomyl (225 g/L) (400 g/L) (1A)	Lannate-L Insecticide			-	1.5 – 2 L Or 0.84 – 1.13 kg	Head: 3 Leafy: 14	•**APVMA PERMIT 89293.** **Expires 30/04/2023**
	Spinosad (240 g/L) (5)	Entrust Organic Insecticide			-	400 mL	3	•**APVMA PERMIT 89870.** **Expires 31/07/2023** •DO NOT make more than 4 applications to any crop in any one season
	Spinetoram (120 g/L) (5)	Success neo Insecticide			-	400 mL + Adjuvant	3	•**APVMA PERMIT 89241.** **Expires 31/03/2023** •Do not apply while bees are actively foraging •DO NOT make more than 4 applications to any crop in any one season
MITES								
Mites - General	Pesticidal soaps (285g/L) (Potassium salts of fatty acids) (UNE)	Natrasoap Insecticidal Soap Spray Multicrop BugGuard Insecticide Concentrate			1.5 L – 3 L	-	Not required when used as directed	•Do not spray while bees are actively foraging •Do NOT use during the hot part of the day
	Beauveria bassiana	Velifer Biological Insecticide			50 mL	-	0	• **Suppression Only** • **Suseptible to UV damage use only in protected situations or spray in late afternoon or evening.**Do not use while bees are foraging •Check critical comments carefully

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Mites - General	Petroleum Oil (840 g/L) (UNE)	Biocover Horticultural Oil			1 – 2 L	-	1	•**APVMA PERMIT 12221.** **Expires 31/11/2022** •Do not apply while bees are actively foraging •Use the higher rate when pest pressure is high •Do NOT spray when temperature exceed 32˚C in the shade •Apply to foliage up to the point of run-off •Avoid mixing with sulfur and soap products
Redlegged earth mite					-	-		•**Nothing currently registered**
THRIPS								
Thrips - General	Imidacloprid (200 g/L) (4A)	Confidor 200 SC Insecticide			25mL	300mL	3	•**APVMA PERMIT 14584.** **Expires 31/01/2024. (Refer to crops list on permit)** •Apply by boom spray only •Apply to run off •Ensure good coverage on underside of leaves •Do not apply for control of Western Flower Thrips
	Beauveria bassiana	Velifer Biological Insecticide			50 mL	-	0	• **Suppression Only** • **Suseptible to UV damage use only in protected situations or spray in late afternoon or evening.**Do not use while bees are foraging •Check critical comments carefully
	Pesticidal soaps (285g/L) (Potassium salts of fatty acids) (UNE)	Natrasoap Insecticidal Soap Spray Multicrop BugGuard Insecticide Concentrate			1.5-3 L	-	Not required when used as directed	•Do not apply during hot part of day or if plants are stressed •**Test for possible phytotoxicity on a few plants before full application**

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Western flower thrips (WFT)	Abamectin (36 g/L) (6)	Vantal Upgrade Miticide/Insecticide			-	150 – 225 mL	3	•Chemicals alone will not control WFT. Use IPM. Allow at least 28 days between applications and do not make more than two applications per crop
	Spinetoram (120 g/L) (5)	Success Neo Jemvelva Active Insecticide			-	400 mL	3	•Do not use on seedlings for transplant •Do not make more than four applications to any crop in one season
	Thiamethoxam (200 g/L) (4A) Chlorantraniliprole (100 g/L) (28)	Durivo Insecticide			22 mL per 1000 seedlings	-	28	•Applied as a seedling drench. Rotate to alternative mode of action insecticides as per label
WHITEFLIES								
Whitefly	Sulfloxaflor (240 g/L) (4C)	Transform Isoclast active Insecticide			-	400 mL + Adjuvant	3	•Test for phytotoxicity in protected situations prior to use •Highly toxic to bees.
	Imidacloprid (200 g/L) (4A)	Confidor 200 SC Insecticide			25mL	300mL	3	•**APVMA PERMIT 14584.** **Expires 31/01/2024. (Refer to crops list on permit).** •Apply by boom spray only •Apply to run off •Ensure good coverage on underside of leaves
	Beauveria bassiana	Velifer Biological Insecticide			50 mL	-	0	• **Suppression Only** • **Susceptible to UV damage use only in protected situations or spray in late afternoon or evening.** Do not use while bees are foraging •Check critical comments carefully
	Pesticidal soaps (285g/L) (Potassium salts of fatty acids) (UNE)	Natrasoap Insecticidal Soap Spray Multicorp BugGuard Insecticide Concentrate			1.5-3 L	-	Not required when used as directed	•Do not apply during hot part of day or if plants are stressed •**Test for possible phytotoxicity on a few plants before full application**

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Silverleaf Whitefly	Thiamethoxam (200 g/L) (4A) Chlorantraniliprole (100 g/L) (28)	Durivo Insecticide			22 mL per 1000 seedlings	-	28	•Applied as a seedling drench. •Rotate to alternative mode of action insecticides as per label
	Beauveria bassiana	Velifer Biological Insecticide			50 mL	-	0	• **Suppression Only** •**Susceptible to UV damage use only in protected situations or spray in late afternoon or evening.** •Do not use while bees are foraging •Check critical comments carefully
	Spirotetramat (240 g/L) (23)	Movento 240 SC Insecticide			-	300 – 400 mL + Adjuvant	3	•Toxic to aquatic organisms. •Do not re-apply within 7 days of a previous Movento spray
	Imidacloprid (200 g/L) (4A)	Confidor 200 SC			25 mL	300 mL	3	•**APVMA PERMIT 14584. Expires31/01/2024**
	Afidopyropen (100 g/L) (9D)	Versys Insecticide			-	350 mL + Hasten oil	1	•**Do NOT use in protected cropping situations** •**Suppression ONLY** for Silverleaf Whitefly •Do not apply more than 4 applications per crop •Do NOT apply while bees are actively foraging •Very toxic to aquatic life
OTHER INSECT PESTS								
Green Vegetable Bug	Trichlorfon ◆ (500 g/L) (1B)	Dipterex 500 SL insecticide Lepidex 500 Insecticide			150 mL	1.7 L	2	•Apply when pests are first seen and repeat at 7-10 day intervals
	Thiamethoxam (200 g/L) (4A) Chlorantraniliprole (100 g/L) (28)	Durivo Insecticide			22 mL per 1000 seedlings	-	28	•Applied as a seedling drench. Rotate to alternative mode of action insecticides as per label

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Rutherglen bugs	Sulfloxaflor (240 g/L) (4C)	Transform Isoclast Active Insecticide			-	150 - 400 mL	3	•**Suppression ONLY** •Highly toxic to bees. DO NOT use in covered or protected cropping situations
	Trichlorfon ◆ (500 g/L) (1B)	Dipterex 500 SL Insecticide Lepidex 500 Insecticide			125 mL	-		•Spray when pest outbreak occurs and repeat if reinvaded. Also spray nearby weeds
	Pyrethrins (13 g/L) (3A)	Pyganic Organic Insecticide			-	2.4 L	Nil	•Dangerous to bees. Do NOT spray while bees are foraging •Use to remove insects just prior (3 - 12 hours) to harvest
Spiders and Fruit Fly	Pyrethrins (13 g/L) (3A)	Pyganic Organic Insecticide			-	2.4 L	1	•Dangerous to bees. Do NOT spray while bees are foraging •Use to remove insects just prior (3 - 12 hours) to harvest
Vegetable Leafminer & Serpentine Leafminer *(Liriomyza spp.)*	Emamectin (44 g/Kg) (6)	Proclaim Opti Insecticide			-	250 – 300 g	3	•**APVMA PERMIT 87563.** **Expires 30/06/2024** •**Suppression ONLY** •Allow a minimum of 7 days between applications and a maximum of 4 applications per year •**NOT spraying protects natural enemies**
	Cyromazine (150 kg/L) (17)	Diptex 150 WP Insect Growth Regulator Plus Other Products			150 g	1 kg	7	•***Broccoli only*** •**APVMA PERMIT 81867.** **Expires 30/11/2023** •**Suppression ONLY** •Apply first spray when leaf miners first appear •DO NOT apply more than 6 applications per crop with a minimum 7-day re-treatment interval •Managing drift is very important •Hazardous to Bees •**NOT spraying protects natural enemies**

Insect Pest	Registered insecticide	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
					100 L	ha		
Vegetable Leafminer & Serpentine Leafminer *(Liriomyza spp.)*	Abamectin (18 g/L) (36g/L) (6)	Vertimec Miticide/Insecticide Vantal Upgrade Miticide/Insecticide			-	18 g/L product: 1.2 L 36 g/L product: 600 mL	7 - 14	•***Leafy vegetables and Cabbage head only*** •**APVMA PERMIT 81876.** **Expires 30/04/2024** •**Suppression ONLY** •Apply first spray when leaf miners first appear •Hazardous to Bees •DO NOT apply more than 2 applications per crop •DO NOT apply less than 7 days after the initial treatment. •Re-apply at a 7-14 day interval •**NOT spraying protects natural enemies**

Discard this table if a more up-to-date table is available.

◆ *Prevent resistance by rotating between chemical groups with different mode of action.

For chemical mode of action (MoA) group classification go to web site:
CropLife Australia | Resistance Management

Or enter into web browser:
https://www.croplife.org.au/resources/programs/resistance-management/

 **Safe for Bees.**

 **Can be used in IPM programs, may affect some beneficial insects and mites.**

Where to get more information:

1. Australian Pesticide & Veterinary Medicines Authority (APVMA) website: www.apvma.gov.au for current use permits, chemical residue limits, chemical recalls and reviews.
2. Agricultural chemical companies and their distributors.
3. NSW Department of Primary Industries. www.dpi.nsw.gov.au/agriculture/horticulture

How to reduce excess chemical residues and safe use of chemicals in my crop.

- Use only registered chemicals.
- Apply at the label or permit rate following correct calibration of equipment.
- Follow the withholding period.

- Follow all other directions on the label/permit and the Material Safety Data Sheets (MSDS).

Always read the label

Users of agricultural or veterinary chemical products must always read the label and any permit, before using the product, and strictly comply with the directions on the label and the conditions of any permit. Users are not absolved from compliance with the directions on the label or the conditions of the permit by reason of any statement made or not made in this publication.

Not all registered chemicals are listed in the table. This table is to be used as a guide only and not a recommendation. The product trade names in this publication are supplied on the understanding that no preference between equivalent products is intended and that the inclusion of a product name does not imply endorsement over any equivalent product from another manufacturer.

Recognising that some of the information in this document is provided by third parties, the State of New South Wales, the author and the publisher take no responsibility for the accuracy, currency, reliability, and correctness of any other information included in the document provided by third parties.

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NSW GOVERNMENT Department of Primary Industries

PESTICIDES REGISTERED IN NSW FOR THE CONTROL OF DISEASES OF LETTUCE CURRENT AT 1/09/2021#. ALWAYS READ THE LABEL.

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
				100 L	ha		
ANTHRACNOSE (*Microdochium panattonianum*)							
Azoxystrobin (155 g/L) + Oxathiapiprolin (15 g/L) (Gp 11 + Gp 49)*	Orondis Flexi				800-1000 mL	3	• Not for leafy varieties or hydroponic crops • No more than 3 sprays/crop • Suppression only
Chlorothalonil Various concentrations (Gp M4) **APVMA PERMIT 14964** **Expires 31/7/2026**	Several trade names			Refer to label		21	• Apply at nursery stage • No more than 4 sprays/ crop
Copper based fungicides As any one of: copper ammonium complex, cuprous oxide, cupric hydroxide, copper oxychloride or tribasic copper sulphate at various concentrations (Gp M1)*	Several trade names			Refer to label		1	• Do not apply if hot or frost prone conditions prevail • Test on a few plants for possible phytotoxicity
Fludioxonil (250 g/kg) + Cyprodinil (375 g/kg) (Gp 12 + Gp 9)	Switch Cyprofludo Missile				800-1000 g	7	• No more than 2 sprays/crop
Mancozeb (750 g/kg) (Gp M3)*	Dithane Manzate			150-200 g		14	

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
				100 L	ha		
Prochloraz (462 g/kg) (Gp 3)*	Stanza WP			50 g		7	• Not for protected cropping or hydroponics • Use only on field and nursery seedlings before transplanting • Use only on heading varieties
Prochloraz (462 g/kg) (Gp 3)* **APVMA PERMIT 81131** **Expires 31/12/2023**	Several trade names				200 g	7	• Leafy lettuce only • No more than 4 sprays/crop
BACTERIAL LEAF SPOT (*Xanthomonas campestris* subspecies)							
Bacillus amyloliquifaciens (Gp BM 02)* **APVMA PERMIT 87630** **Expires 30/6/2022**	Serenade Opti Biofungicide			150-200 g		0	• For leafy lettuce • Preventative for suppression of disease
Copper based fungicides Various concentrations (Gp M1)*	Several trade names			Refer to label		1	• Do not apply if hot or frost prone conditions prevail • Test on a few plants for possible phytotoxicity
BOTRYTIS ROT /GREY MOULD (*Botrytis cinerea*)							
Captan (800 or 900 g/kg) **APVMA PERMIT 14326** **Expires 30/6/2024**	Captan			Refer to label		7	• For leafy lettuce • Do not apply more than 3 sprays/crop
Fenhexamid (750 g/kg) (Gp 17)*	Teldor 500			100 mL	1 L	3	• For heading and leafy varieties • Apply no more than 2 sprays/crop • Rotate with fungicides from different activity groups • Add a non-ionic surfactant
Fludioxonil (250 g/kg) + Cyprodinil (375 g/kg) (Gp 12 + Gp 9)	Switch Cyprofludo Missile				800-1000 g	7	• No more than 2 sprays/crop

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
				100 L	ha		
Fludioxonil (250 g/L) + Pydiflumetofen (150 g/L) (Gp 12 + Gp 7)*	Miravis Prime				1 L	3	• No more than 2 sprays/crop
Penthiopyrad (200 g/L) (Gp 7)*	Fontelis				1.75 L	3	
Pyrimethanil (400g/L) (Gp 9)* **APVMA PERMIT 12565** **Expires 30/6/2025**	Scala 400 SC			200 mL	2 L	3	• No more than 3 sprays/crop
BOTTOM ROT *(Rhizoctonia spp.)*							
Quintozene (750 g/kg) (Gp 14)	Terraclor			100-150 g		28	• Apply to soil – see label
Tolclofos-methyl (500 g/kg) (Gp 14) **APVMA PERMIT 14431** **Expires 30/6/2022**	Rizolex Liquid Tolex Liquid				120 mL	Nil when used as directed	• See label for instructions • 30 cm band prior to irrigating & transplanting • In-furrow or plughole drench at transplanting • Do not mix with alkaline water
DAMPING-OFF (*Pythium* and *Phytophthora spp.)*							
Metalaxyl- M (480 g/L) (4)* **APVMA PERMIT 14318** **Expires 30/09/2022**	Ridomil Gold				6.25 mL/100 m row	Nil when applied as directed	• For winter crops in clay soils • 30 cm band prior to irrigation & planting

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
				100 L	ha		
DOWNY MILDEW (*Bremia lactucae*)							
Azoxystrobin (155 g/L) + Oxathiapiprolin (15 g/L) (Gp 11 + Gp 49)*	Orondis Flexi				800-1000 mL	3	• Not for leafy varieties or hydroponic crops • No more than 3 sprays/crop
Copper based fungicides Various concentrations (Gp M1)*	Several trade names			Various Refer to label		1	• Do not apply if hot or frost prone conditions prevail • Test on a few plants for possible phytotoxicity
Dimethomorph (500 g/L) or 500 g/L (Gp 40)*	Acrobat				360 g or 360 mL	14	• For heading varieties only • Mix with mancozeb at label rate • Not for protected or hydroponic crops • No more than 4 sprays/crop
Mancozeb (750 g/kg) (Gp M3)	Dithane Kencozeb			150-200 g		14	
Mancozeb (640 g/kg) + Metalaxyl-M (40 g/kg or 80 g/kg) (Gp M3 + Gp 4)*	Several trade names			Refer to label		14	• Use as preventative • No more than 4 sprays/season • Not for greenhouse crops
Mandipropamid (250 g/L) (Gp 40)*	Revus				400-600 mL	1	• No more than 4 sprays/crop
Metiram (700 g/kg) (M3)*	Polyram			200 g		7	
Oxathiapiprolin (100 g/L) (Gp 49)*	Zorvec Enicade				350 mL		• Use as protectant • Not more than 3 sprays/crop

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
				100 L	ha		
Phosphorous acid (400 g/L) (33)* APVMA permit 7905, expires 30/09/2012 **Maybe 11951??**	Agri-Fos 400 Aus-phoz						
Phosphorous acid (600 g/L) (33)* APVMA permit 7905, expires 30/09/2012	Agri-Fos 600 Sprayphos						
Propamocarb (625 g/L) + Fluopicolide (62.5 g/L) (Gp 28 + Gp 43)*	Infinito					7	• Use a protectant • No more than 3 sprays/crop
SCLEROTINIA ROT (DROP; WHITE MOULD) (*Sclerotinia sclerotiorum* and *Sclerotinia minor*)							
Azoxystrobin (250 g/L) (Gp 11)*	Several trade names			50-60 mL		14	• Suppression only • No more than 3 sprays/crop
Azoxystrobin (155 g/L) + Oxathiapiprolin (15 g/L) (Gp 11 + Gp 49)*	Orondis Flexi				800-1000 mL	3	• Not for leafy varieties or hydroponic crops • No more than 3 sprays/crop • Suppression only
Filan (500 g/kg) (Gp 7)*	Boscalid					7	• Apply at transplanting • No more than 4 sprays/paddock/year
Fludioxonil (250 g/kg) + Cyprodinil (375 g/kg) (Gp 12 + Gp 9)	Switch Cyprofludo Missile				800-1000 g	7	• No more than 2 sprays/crop

Active chemical *FRAC Activity Group in brackets	Some common trade names ®	IPM Friendly	Bee Friendly	Rate per		Withholding period (days)	Critical Use Comments/Restraints
				100 L	ha		
Fludioxonil (250 g/L) + Pydiflumetofen (150 g/L) (Gp 12 + Gp 7)	Miravis Prime				1 L	3	• No more than 2 sprays/ crop • No more than 2L/paddock/year
Fluopyram (250 g/L) + Trifloxystrobin (250 g/L) (Gp 7 + Gp 11)*	Luna Sensation				800 mL	7	• No more than 2 sprays/year in same block
Iprodione 250 g/L or 500 g/L (Gp 2)*	Various product names			Refer to label			
Mandestrobin (250 g/L) (Gp 11)*	Intuity				1.2 L	7	• No more than 3 sprays/ crop
Penthiopyrad (200 g/L) (Gp 7)*	Fontelis				1.75 L	3	
Tebuconazole 430 g/L or 750 g/kg	Various product names			Refer to label		5 weeks	• Not for greenhouse or hydroponic crops • Use in early crop stages • No more than 2 sprays/ crop
SEPTORIA LEAF SPOT *(Septoria lactucae)*							
Mancozeb (750 g/kg) (Gp M3)	Dithane Kencozeb			150-200 g		14	
Metiram (700 g/kg) (M3)*	Polyram			200 g		7	
Virus Management							
1. Control vectors e.g. aphids, whiteflies, thrips **2.** Sanitise pruning and picking equipment **3.** Use resistant varieties, if available							

Discard this table if a more up-to-date table is available.

 **Safe for Bees.**

 **Can be used in IPM programs, may affect some beneficial insects and mites.**

*Prevent resistance by rotating between different chemical groups. Chemical groups found in ( ).
INSERT DISCLAIMER HERE – Currently under review by NSW DPI

NSW GOVERNMENT Department of Primary Industries

primefact

Management of Serpentine Leafminer

December 2020, Primefact PUB20/933, First edition

Sylvia Jelinek, Jonathan Eccles, Local Land Services, Sydney

Serpentine leafminer

Serpentine leafminer (*Liriomyza huidobrensis)* was detected on vegetable crops in the Sydney Basin in October 2020. It had not been detected previously in Australia and is considered an Emergency Plant Pest in Australia. It has also been detected in Southern Queensland.

Serpentine leafminer (SLM) is one of several pest leafminer species around the world significantly impacting horticultural industries.

It is a small black fly that feeds and lays eggs on plant leaves. When the larvae hatch they "mine" through the inside of the leaf leaving behind tell-tale serpentine tunnels which are easily visible to the naked eye.

High levels of larval infestations affect the plant's ability to photosynthesise, reducing plant growth and crop yields.

SLM pupates on the underside of the leaf (small brown cocoons 1-3mm long) but they can be easily knocked to the ground or fall into crevices of leafy vegetables.

The host range of SLM is extensive including vegetables, ornamentals and many weed species. Effective control of this pest is challenging.

*Figure 1 Serpentine Leafminer (*Liriomyza huidobrensis*)*

Integrated Pest Management

An effective integrated pest management (IPM) approach is the best long term approach to managing SLM.

IPM involves managing pests using a combination of techniques such as biological control, modifying cultural practices, monitoring pests and using IPM friendly insecticides.

In many countries overseas, over reliance on insecticide use has led to a rise in resistance within SLM leading to increased levels of plant damage by heavy pest pressure. Chemical use targeting other pest species, particularly broad-spectrum insecticides, can interfere with IPM programs and can lead to secondary outbreaks of SLM in the absence of beneficial predators. If chemicals are used as a control option, select ones that are IPM friendly.

There are a number of parasitoid wasp species that target leafminers already present in Australia and provide an effective non-chemical control option.

Parasitoid wasps can reach the SLM larvae within the leaf, laying their eggs on or in the larvae (figure 2). A well-managed IPM system can see mortality rates of SLM as high as 80 percent.

There are over 50 species of parasitoid wasp that target leafmining flies however four are particularly good at targeting SLM:

- *Opius* spp.
- *Diglyphus isaea*
- *Hemiptarsenus varicornis*
- *Zagrammosoma latilineatum*

Cultural Control

The best way to control SLM is to reduce the risk of the pest entering your property.

- Wherever possible, purchase planting stock from a Nursery Industry Accreditation Scheme Australia (NIASA) accredited supplier. If sourcing from a non-accredited supplier, ask for verification that the business has adequate pest, disease and weed management plans in place.
- Inspect all incoming stock for pests, diseases and weeds. Separate new stock from crops until it has been confirmed free from SLM symptoms.
- Control weeds surrounding crops and gardens especially those which are known hosts of SLM.
- Regularly monitor plant leaves for SLM mines.
- After harvest, immediately incorporate crop residues at depth.
- Floating row covers over susceptible crops can prevent flies from laying eggs.

Figure 2 Parasitic wasp Zagrammosoma latilineatum

- Floors and pathways in greenhouses should be designed to prevent flies from pupating in soil. Black plastic, aggregated gravel to a min 75mm deep or concrete helps prevent contamination and improves general hygiene
- Remove all green waste such as prunings and spent leaf material and bury.
- Purchase bagged media from a reputable supplier. Source loose media from a NIASA accredited supplier or pasteurise before use.
- If growing a single crop, once the crop is finished, cease irrigation and close up the house to increase interior temperature. High temperatures are lethal to SLM.
- Benches and hard surfaces should be cleaned between crops.

Produce Management

At risk properties (those who grow host plant species) must actively manage SLM along the entire supply chain to manage SLM in production regions.

Control options for SLM do not stop at the crop. Managing the biosecurity risk of SLM within plant produce is a vital part of our General Biosecurity Duty to ensure that SLM is not accidentally transported to new production regions.

Elements of the pest biology may hamper control efforts. SLM is frost tolerant and pupae can survive temperatures down to -

20°C with eggs being the most resistant life stage. Cold storage is not a good control option for vegetables, particularly as very low temperatures may risk damaging the produce.

Chemical Options

There are some chemical control options for SLM. However, only a few are compatible with IPM.

The larvae, living inside the leaf, are largely protected from many conventional insecticide sprays. Systemic and translaminar insecticides are better as they can reach the larvae.

Many insecticides will have a negative impact on beneficial predators of SLM such as parasitoid wasps. An incorrect spray program will adversely affect IPM programs and potentially lead to an increase in SLM numbers.

Chemical selection and rotating insecticides from different chemical groups is critical in reducing the risk of SLM developing insecticidal resistance. SLM has been known to develop resistance to many chemicals overseas and the resistance mode differs from country to country based on the dominant spray regime.

NSW DPI's Insecticide Resistance Unit is assessing the NSW population of SLM to identify if resistance to any chemicals is already present. If this is detected, chemical control recommendations will be adjusted accordingly.

An up to date list of registered chemical options and off-label permits for SLM can be found at NSW DPI Chemical management of leafminer webpage and Australian Pesticides and Veterinary Medicines Authority Registrations and permits webpage.

General Biosecurity Duty

Part 3 of the *Biosecurity Act* (2015) describes how people have a General Biosecurity Duty to prevent, eliminate or minimise the risk of SLM in NSW.

People dealing with SLM host plants which have visible signs of leafminer damage must act to ensure they are meeting this General Biosecurity Duty. Put simply, you must always act to prevent further spread of SLM in NSW, eliminate heavy infestations of the pest and minimise the impacts of SLM in plant production systems.

This duty may be met by any number of means that are considered Best Management Practice for SLM including

- not selling heavily infested SLM host plants,
- through the use of IPM to minimise the impact of SLM in the production system,
- adhering to industry standards such as Biosecure HACCP or market access arrangements like ICA29,
- treating host produce and plants with approved insecticides, fumigation or irradiation to prevent spread.

The General Biosecurity Duty for SLM is a legislative mechanism due to the risk of an adverse effect on the economy and the community that arises from the presence, spread or increase of serpentine leafminer within New South Wales.

Acknowledgements

Figure 1 courtesy of Merle Shepard, Gerald R.Carner, and P.A.C Ooi, Insects and their Natural Enemies Associated with Vegetables and Soybean in Southeast Asia, Bugwood.org

Figure 2 courtesy of Dr Elia Pirtle, Cesar

PUB20/933

NSW GOVERNMENT Department of Primary Industries

primefact

New Pest Alert: Serpentine leafminer

November 2020, Primefact 1584, First edition

Plant Biosecurity & Product Integrity, Orange

Serpentine leafminer (*Liriomyza huidobrensis*) is an insect pest that has been detected in NSW.

This insect pest poses a serious threat to Australian **agricultural and horticultural industries.**

Please report suspect detections in NSW **immediately** to the Exotic Plant Pest Hotline on 1800 084 881

Serpentine leafminer

Serpentine leafminer was detected in an area of western Sydney on 22 October 2020.

Serpentine leafminer is a small fly whose larvae feed internally on plant tissue, particularly the leaf.

It affects a number of vegetable crops as well as a number of ornamental plants including cut flowers.

What should I look for?

A Serpentine leafminer infestation would most likely be detected through the presence of the mines in leaf tissue. Adult flies and larvae are not likely to be seen due to their size.

Figure 1 Mining damage caused by Serpentine leafminer larvae on cucumber leaf

Figure 2 Mining damage caused by Serpentine leafminer larvae on tomato leaf

Figure 3 Mining damage caused by Serpentine leafminer larvae on cos lettuce

Figure 4 Exotic serpentine leafminer adult fly

Description

Larvae

The larvae of *Liriomyza* species are yellow to white and usually concealed beneath the leaf surface in tunnels where they feed.

More visible than the larvae themselves are the patterns created in the surface of infested leaves by their tunnelling (Figure 1, 2 & 3). The twisting trails appear whitish on the surface of the leaf and become longer and wider as the larva grows. Heavily mined leaves may also show large whitish blotches.

Adults

The adult flies of *Liriomyza* species are very similar in appearance. The flies are small (<3 mm) and grey-black with yellow markings. Usually there is a prominent yellow area at the base of the wings (Figure 4).

Damage

The larvae of all *Liriomyza* species 'mine' in the leaves of host plants. The larvae feed by tunnelling through the leaf tissue.

Extensive tunnelling across leaf surfaces reduces the ability of the plant to photosynthesise and produce energy. Severe damage can result in leaf death or premature leaf drop.

If severe mining occurs early in the fruiting period, defoliation can reduce yield and fruit size and expose fruit to sunburn.

Lifecycle

Female flies use their ovipositor to puncture the leaves of host plants and deposit eggs. The eggs are inserted just below the leaf surface. Many eggs may be laid on a single leaf.

There are three larval stages that feed within the leaves. The larvae usually fall from the plant to the soil to pupate.

The entire life cycle can be completed in as little as two weeks. If conditions are favourable, the flies can reproduce all year round and sustain five to ten generations per year.

Spread

Spread of leafminer flies is most likely to occur with the transport of plant host material containing eggs or larvae.

The adults are capable of flight but are not very active fliers. They tend to fly within a crop but rarely between crops. Localised spread of the pest is most likely to occur

through wind dispersal or on contaminated plant material or equipment.

Hosts

Serpentine leafminer is a significant pest of a number of vegetable crops including beans, cabbage, capsicum, celery, chilli, cucumber, eggplant, lettuce, onions, peas, potatoes and tomatoes.

A number of ornamental plants including cut flowers such as chrysanthemums and gerberas are also known to host Serpentine leafminer.

Distribution

Liriomyza huidobrensis was found in western Sydney in 2020 and is currently being responded to.

Liriomyza trifolii is found worldwide except for Australia. *Liriomyza bryoniae* is present in Europe, Asia and North Africa *and L. cicerina* is present in Africa, Europe and the Middle East.

Liriomyza sativae was found on Cape York, Queensland in 2015 and is under management to prevent further spread.

Actions to minimise risk

Production nurseries and growers should check their crops regularly for signs of plant pests and disease.

Good on-farm biosecurity practices are vital to preventing incursions of plant pests and diseases. Put in place biosecurity best practice actions to prevent entry, establishment and spread of pests and diseases:

- practise "Come clean, Go clean"
- ensure all staff and visitors are instructed in and adhere to your business management hygiene requirements
- monitor your crops regularly
- monitor and control volunteer plants that can harbour the pest
- source plant material of a known high health status from reputable suppliers
- keep records

Reporting

If you suspect an exotic leaf miner infestation, you should **report it immediately** to the Exotic Plant Pest Hotline on **1800 084 881**.

Email clear photos with a brief explanation and contact details to biosecurity@dpi.nsw.gov.au

Acknowledgements

Figure 1 Photo Merle Shepard, Gerald R.Carner, and P.A.C Ooi, Insects and their Natural Enemies Associated with Vegetables and Soybean in Southeast Asia, Bugwood.org

PUB 20/92

Industry field day: Pest and disease management

Is you business prepared?

AUSVEG, NSW LLS, and NSW DPI will be holding a pest and disease management workshop on Friday 19 March 2021.

Stay up to date with information on:

- Serpentine leafminer
- Fruit fly management
- Viral, bacterial, and fungal disease management

Hands-on activities include:

- Sample collection techniques
- Farm walk and in-field demonstrations

DETAILS

Date

Friday 19 March 2021

Time:

12pm - 4.00pm

Lunch and afternoon tea included

Location:

Greater Sydney Demonstration Farm, 40 Edwards Road, Richmond Lowlands NSW 2753.

Due to Covid-19 requirements, you must register to attend this event: Please email or call Madeleine Quirk at madeleine.quirk@ausveg.com.au or 0437 004 174.
Please include dietary requirements.

Australian Government
Department of Agriculture, Water and the Environment

AUSVEG

National Vegetable Extension Network
NEW SOUTH WALES

NSW GOVERNMENT Department of Primary Industries

NSW GOVERNMENT Local Land Services

This workshop follows strict Covid-19 safety measures and requirements. A Covid-safe plan has also been developed.