



Final Report

Soil Condition Management – Extension and Capacity Building

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Applied Horticultural Research & RMCG

Project Number: VG13076

VG13076

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Summary

Between 2014 and 2017 the Soil Condition Management – Extension and Capacity Building project (VG13076), known as Soil Wealth, developed a strong presence in the vegetable industry. Soil Wealth communicated good practical soil management information to Australian vegetable growers, for a better economic outcome through:

- Building soil organic matter and structure
- Covering the soil (mulches, cover crops)
- Less tillage (controlled traffic, reduced-till, GPS guidance)
- Correct nutrition.

A digital summary of the achievements of the Soil Wealth and Integrated Crop Protection projects from 2014–2017 can be viewed here: <https://youtu.be/HJE6ICMf6Ok>.

Delivering practical soil management knowledge to advisers and growers

Soil Wealth tapped into a clear need for technically sound and practical soil management options delivered Nationally across the vegetable industry.

Soil Wealth, together with the companion Integrated Crop Protection project (VG13078) connected with more than 1,900 growers and industry people over the three-year period. More than 1,000 people attended farm walks at demonstration sites, 150 attending workshops, 80 attending the in-depth masterclasses and 320 attending webinars. The project provides electronic access to the information with the website attracting more than 850 users per month, 6,600 video views, 3,500 webinar views, 1,700 Facebook followers and 560 Twitter followers.

The Soil Wealth and ICP projects undertook a survey of 165 growers and advisers during May 2017 to determine the impact and effectiveness of the project over the last three years. Almost half (40%) of survey respondents felt well informed about the latest advancements in the vegetable industry, while a further 45% felt somewhat informed.

Both growers and advisers indicated that strong knowledge gains were made in the soil management areas of cover crops, compost, precision farming and soil biology.

Growers adopting or trialling new soil management practices

One of the key aims of the projects was to influence decision-making and practices on vegetable farms. Almost half the growers (47%) identified undertaking, or planning to undertake, activities aimed at improving soil health on their farm, because of the Soil Wealth project. A further 43% of growers were undertaking, or planning to undertake, changes but not directly due Soil Wealth project.

Eighty-six percent of growers considered it was very likely (61%) or likely (25%) that soil-health practice changes would be implemented mainly related to:

- Cover crops (44%)
- Compost (25%)
- Reducing tillage (19%)
- Crop rotation (9%)
- Biofumigation (3%)

Reconnecting the vegetable industry to the wealth of Australian and global soil research

The innovation system requires linkages between the three components of research, development and extension. The gradual decline in state-funded extension services has resulted in a reduction in extension activities aimed at the vegetable industry. As a result, the linkage between the considerable research and development effort, both in Australia and internationally, and the vegetable industry was at best very weak. This was particularly so for cultural practices to improve soil condition, such as cover crops, tillage, compost and rotation, where there is a clear and real “market failure” in providing technical information to the vegetable industry.

The Soil Wealth project has played an important technical role in rebuilding the linkage between research, development and extension components of the innovation system in those cultural practices areas. As a result, the vegetable industry has become more receptive to new soil management research and development.

The technical capacity of the Soil Wealth team to take research-proven principles and work with the vegetable industry to make these into practical on-farm management actions was an important aspect of the success of the project.

Keywords

Soil, tillage, nutrition, soil testing, cover crops, biofumigation, compost, weeds, precision agriculture, soil biology, soil-borne disease.

Introduction

The Soil condition management – extension and capacity building (VG13076) project ran from May 2014 to May 2017, with a six-month extension through to November 2017. The project, known as Soil Wealth, arose from the keen interest of Australian vegetable growers in soil-health management. The vegetable industry had identified management of soil-borne disease, biofumigation, interpretation of soil-test reports and training in soil biology (e.g. organic supplements or activators) as areas where they want to improve their skills. Growers want information to be in an accessible form, practical and relevant to individual commercial farming operations. Previous studies had found that a large body of information on soil condition management for vegetable farms exists, but that extension and adoption on-farm could be greatly improved.

Australian vegetable farms operate under a wide range of environmental and business conditions. Therefore, any extension activities in soil needed to use a tiered approach that effectively accommodated the varying needs, capacities and diversity of the vegetable industry. The one-size-fits-all optimum soil health status is not a realistic concept. Growers need to know how they can manage their farm's soil resources under their own conditions to maintain or improve resource-use efficiency and maximise profitability. It is important to recognise that growers need to meet market demands and cost pressures, and have differing approaches to running their farms.

A key feature of the project was to work directly with commercial agronomists who provide professional advice to the vegetable industry. Agronomists already have an intimate knowledge of the individual preferences of their farming clients and can deliver information in a personalised way to stakeholders. The project aimed to provide information on soil management practices with a focus on cultural options where “market failure” occurs.

The overall aims of the Soil Wealth project were to:

- Help vegetable growers use relevant soil management tools and resources on their farms; not simply to produce another compilation of information – our focus was on distilling relevant soil information and tools in a way that addresses the needs highlighted by growers, targeting different scales of operation, available resources and crops
- Develop capacity among growers, agronomists and advisers and thereby support soil management that achieves long-term crop returns for growers
- Strengthen the linkage between soil health and management of soil-borne diseases that has been clearly demonstrated
- Recognise that soil health management cannot be an aim in itself, but has to have a clear purpose, i.e. reduce pest, weed and disease pressure, reduce machinery and other input costs (fertilisers, pesticides), and save time or improve marketable yield or quality.

Soil Wealth, together with the companion Integrated Crop Protection (VG13078) was delivered by RMCG and AHR. The two companies combined to provide the necessary technical and extension expertise to deliver the Soil Wealth project on a national scale.

Project Team

Soil Wealth, together with the companion Integrated Crop Protection (VG13078) was delivered by Applied Horticultural Research (AHR) and RM Consulting Group (RMCG). The two companies combined to provide the necessary technical and extension expertise to deliver the Soil Wealth project on a national scale.

The Soil Wealth team was:

Dr Gordon Rogers (AHR)	Project leader
Dr Kelvin Montagu (AHR)	Project manager, masterclass coordination, demonstration sites management and technical soils input.
Dr Doris Blaesing (RMCG)	RMCG lead, soils, compost and nutrition specialist, and co-coordinator.
Donna Lucas (RMCG)	Communications, grower liaison, reporting and workshops.
Marc Hinderager (AHR)	Vegetable agronomist, training, soil testing and crop nutrition programs. Technical support for sites.
Dr Anne-Maree Boland (RMCG)	Project integration with VG13078 and review.

The project team delivered the project outcomes using the following strategies:

- Deliver extension and capacity-building using a tiered approach
- Assist growers to effectively use existing soil-management information
- Develop demonstration sites in different regions to showcase and quantify benefits or targeted soil improvements
- Encourage innovative growers to champion key aspects of soil management
- Develop a network of reference farms for benchmarking
- Engage with, and assist existing providers of agronomic advice and farm agronomists
- Document the project delivery framework including KPIs and assess effectiveness through monitoring, evaluation, reporting and improvement (MERI).

Project Reference Group

The project team worked with the Project Reference Group (PRG), which was the same for VG13078 and VG13076. The PRG was made up of three growers, two agronomy advisers, an AUSVEG representative and two Hort Innovation representatives, and the project teams for VG13076 and VG13078.

The purpose of the PRG was to provide feedback, advice and input to work plans throughout the project and to provide feedback on how the project was contributing to the higher-level impacts of the three goals which are outlined below.

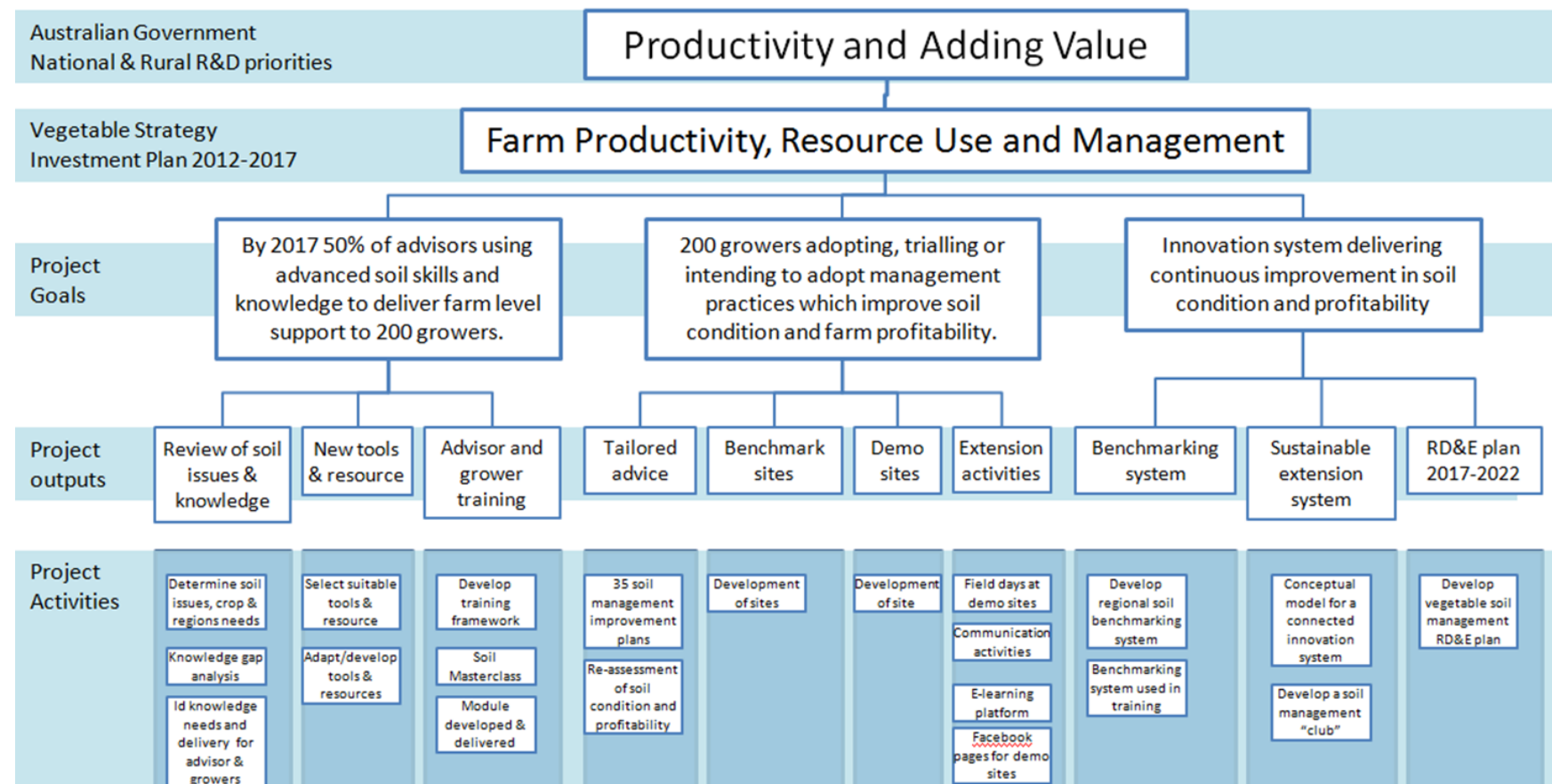
Project Logic

The project logic for Soil Wealth is outlined in Figure 1. The diagram shows how the project fits within the Vegetable Strategic Investment Plan and the broader National & Rural R&D Priorities for the Australian Government.

The project outcome was achieved by improving the accessibility and utility of information about soil management (Goal 1), and by improving growers and adviser's capacity to use that information (Goal 2). By delivering practical, usable soil management it was expected that this would also build greater interest among growers in new soil management practices.

The project also aims to take the first steps in the creation of a vegetable soil-management innovation system that will continue to support improved soil management (Goal 3). Rather than simply focus on research needs, this innovation system focuses on connecting all players in the innovation system so that research flows to practice and practice flows back to research.

Figure 1. Program logic for Soil Condition Management – VG13076



Outputs

Between 2014 and 2017 the Soil Wealth and Integrated Crop Protection (ICP) projects developed a wide range of outputs that are relevant to all major vegetable growing regions in Australia. The main topics covered by these resources include crop management, pest and disease management, and soil, nutrition and compost. Below these are summarised with details provided in the Appendices.

Demonstration sites

The Soil Wealth – ICP projects built a national network of 14 demonstrations (Figure 1) on commercial farms. Five of these were focused on soil management, with a further nine demonstrating integrated soil and ICP practices. The demonstration sites were (**location** – main practice):

1. **Bowen** (N Qld) – Compost
2. **Kalbar** (SE Qld) – Compost, cover crops, controlled traffic, soil-borne disease
3. **Cowra** (NSW) - Reduced tillage, controlled traffic, biofumigation, compost
4. **Bathurst** (NSW) – Reduced till, cover crops
5. **Sydney Basin** (NSW) – Using IPM and managing soil-borne disease
6. **East Gippsland** (Vic) – Reduced tillage, controlled traffic
7. **Koo Wee Rup** (Vic) – Biofumigation/cover crops, soil-borne disease control
8. **Werribee** (Vic) – Reduced till, cover crops
9. **Mt Barker** (SA) – Cover crops, nutrient management
10. **Forthside** (Tas) – Soil amendments
11. **Forthside** (Tas) – cover crops
12. **Manjimup** (WA) – Soil-borne diseases, biofumigation, nutrient management
13. **Gin Gin** (WA) – Compost and soil-borne diseases
14. **Darwin** (NT) – Soil carbon, IPM and cover crops

These sites were at the core of the project, where growers and advisers can see how different soil practices can be implemented on commercial farms and, importantly, talk to leading growers and advisers about their experiences.

Soil Wealth and Integrated Crop Protection Demonstration Sites

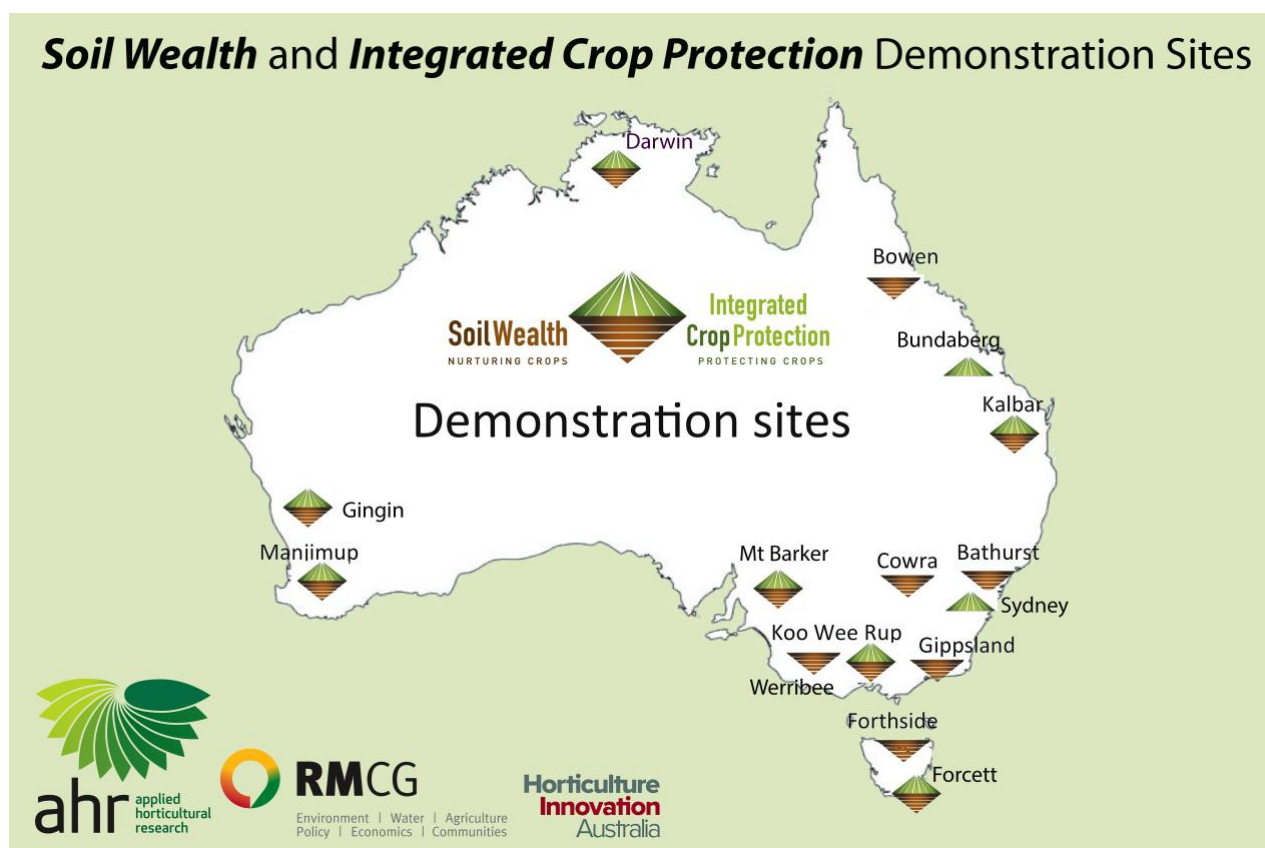


Figure 1. The location of Soil Wealth and Integrated Crop Protection demonstration sites.

The range of management practices being showcased across the demonstration sites are summarised in Table 1. The analysis of the impact on soil properties, crop performance and economics forms the basis for many of the fact sheets and case studies summarised in Appendix 1.

Table 1. Summary of management practices being showcased across the 14 demonstration sites.

Demo Site	State	Management practice								
		Cover crop	Biofumigation	Compost	Biologicals	Biochar	Reduced-till	No-till	Netting	IPM
Darwin	NT	✓				✓			✓	
Bowen	QLD	✓		✓	✓					
Kalbar	QLD	✓		✓	✓					
Cowra	NSW	✓	✓	✓			✓			
Bathurst	NSW	✓					✓	✓		
Sydney	NSW		✓							✓
Gippsland	VIC	✓					✓	✓		
Koo Wee Rup	VIC	✓	✓							
Werribee	VIC			✓			✓	✓		
Forthside	TAS			✓		✓				
Forcett	TAS	✓								
Mt Barker	SA	✓								
Manjimup	WA		✓							

New tools and resources and communication

Jointly the two projects developed:

- Soil Wealth – Integrated Crop Protection website (www.soilwealth.com.au)
- 59 fact sheets (Crop management 8; Pest and disease management 31; Soil, nutrition and compost 20),
- 12 case studies
- 36 videos, webinars and apps (Crop management 5; Pest and disease management 15; Soil, nutrition and compost 16)
- 26 Soil Wealth and ICP E-newsletters
- 15 Facebook pages for the demonstration sites, with more than 1,750 “likes”
- 2 Twitter accounts with more than 1,700 followers

These resources and communication outputs are summarised in Appendix 1 and can be found at www.soilwealth.com.au under the resources tab or in each topic area.

Masterclasses

Soil Wealth also ran the in-depth masterclasses:

1. Soil Biology Masterclass 8–9 October 2014. To test the applicability of the masterclass framework to vegetable consultants, three vegetable agronomists attended a Soil Biology Masterclass, run by Dr Kelvin Montagu for the Hawkesbury Institute for the Environment, UWS.
2. Soil-borne Diseases Masterclass 1–2 September 2015, Mornington Peninsula, Victoria. The masterclass covered topics such as biology and life cycles of key diseases, non-chemical management strategies, information on new and developing technologies, the role of soils and how to put all the information together to form a management strategy
3. Second Soil-borne Diseases Masterclass 16–17 August 2016, Ipswich Queensland.
4. Third Soil Soil-borne Diseases Masterclass 30–31 August 2017, Devonport, Tasmania.

Information from the Masterclass have also been delivered in the webinar series (Appendix 1) and a video was produced on the masterclass “Soil-borne Disease Masterclass for the Vegetable Industry – Experiences from Growers” (Appendix 1).

The soil-borne diseases masterclasses were attended by more than 80 participants, of whom 36% were growers, 42% agronomists, and 22% from R&D, NRM and service industries.

Farm walks and field days

The Soil Wealth team ran or contributed to 31 farm walks or field days, with more than 1,000 growers and advisors attending. The farm walks covered a range of soil-management practices across all states and the Northern Territory, including:.

1. Cowra NSW, 11 September 2014. Permanent beds and reduced-tillage practices.
2. East Gippsland Vic, 21 May 2015. Reduced tillage.
3. Kalbar Qld, 30 June 2015. Compost.
4. Kalbar Qld, 30 July 2015. Hort Convention Field trip.
5. Manjimup WA, 17 September 2015. Biofumigation.
6. Forthside Tas, 24 November 2015. Soil amendments.
7. Bindoon WA, 25 November 2015. Soil management.
8. Bundaberg Qld, 17 February 2016. Soil management.
9. Gympie Qld, 18 February 2016. Soil management.
10. Bowen Qld, 30 March 2016. Compost.
11. Cora Lynn, Vic, 6 April 2016. Cover crops.

12. Bathurst NSW, 27 April 2016. Cover crops.
13. Cowra NSW, 28 April 2016. Cover crops and compost.
14. Camden NSW, 17 Jun 2016. Soil management and irrigation.
15. Kalbar Qld, 26 June 2016. Hort Convention field day.
16. Lambells Lagoon NT, 18 August 2016. Cover crops.
17. East Gippsland Vic, 3 August 2016. Reduced tillage.
18. Werribee Vic, 2 September 2016. Reduced tillage.
19. Gawler River SA, 18 October 2016. Soil-borne diseases.
20. Forthside Tas, 9 November 2016. Soil management.
21. Nambeelup WA, 16 November 2016. Compost.
22. Richmond NSW, 12 December 2016. Reduced tillage and biofumigation.
23. Cambridge Tas, 21 February 2017. Cover crops.
24. Cowra NSW, 2 May 2017. Compost.
25. Bathurst NSW, 3 May 2017. Compost.
26. Central Mangrove NSW, 4 May 2017. Compost.
27. Adelaide SA, 15 May 2017. Hort Connections field day.
28. Richmond NSW, 23 June 2017. Soil-borne diseases.
29. Richmond NSW, 21 July 2017. Cover crops.
30. Devonport Tas, 16 August 2017. Soil improvement plans.
31. Cecil Park NSW, 29 September 2017. Soil testing.

A series of seven case studies (Table 4; Appendix 1) and five videos (Table 7; Appendix 1) were developed based on demonstration site growers and the information presented at the farm walks and field days.

Soil Wealth Check

The Soil Wealth team reviewed the wide range of soil health assessments available and developed a simplified Soil Wealth Check (Appendix 2). The aim was to get useful information that allows advisers to measure/assess understand and communicate specific soil condition issues that have an impact on production costs and or marketable yield.

Soil Wealth Checks were undertaken at all demonstration sites. However, agronomists did not take up the Soil Wealth Check as part of the normal soil testing service. Based on the feedback from events such as the nutrition webinars, further training and extension in crop nutrition and the impact of good soil health will be required in Phase 2.

Soil Improvement Plans

A Soil Improvement Plan template was developed and used by the project (Appendix 3). The Soil Improvement Plans provide a structured approach to identifying soil issues and developing a management plan to address these issues. The Soil Improvement Plan was also translated into Khmer for use with Cambodian growers at a workshop.

The Soil Improvement Plans were undertaken for the demonstration sites and used in a number of workshops with growers and agronomists. The Soil Improvement Plans will be a useful resource for future demonstration sites and workshops in Phase 2.

Outcomes and Evaluation

Achievements Phase 1 video

The achievements of the first phase of the project 2014–2017 have been captured in a video as a digital executive summary of this final report (Figure 2; <http://www.soilwealth.com.au/resources/videos-and-apps/soil-wealth-and-icp-achievements-phase-1/>). This showcases the engagement, training and events, demonstration sites, communication products, outcomes, and next steps of the projects for the Australian vegetable industry. A range of grower and participant testimonials have been included throughout along with infographic animations to clearly summarise the outcomes of the Soil Wealth and ICP projects.



Figure 2: Soil Wealth and ICP Achievements Phase 1 video.

Soil Wealth Outcomes

Soil Wealth had three project outcomes, as outlined in the project logic (Figure 1). To assess how the project activities contributed to these outcomes an impact survey was undertaken in May 2017. The survey was predominately administered online through existing industry communication channels with some responses sought face-to-face at the Hort Connections conference in Adelaide from 15 to 17 May 2017. Participation was voluntary, and all responses remained confidential. A total of 165 responses were received (Appendix 4).

Outcome 1. By 2017 50% of advisers with the advanced soil skills and knowledge delivering farm level support to 200 growers

The project has tapped into a clear need for nationally focused industry development for specific technical issues associated with farm productivity resources use and management including soil management. As a result, Soil Wealth achieved a very good profile in the vegetable industry.

Of the 66 advisers surveyed, 71% had received the e-newsletter “The Bulletin”, 56% had attended a farm walk or training event, almost half (45%) had accessed material from the website (www.soilwealth.com.au), and 33% had participated in a webinar.

Traditional print and radio only reached 11% of advisers. Social media was used by 19% of advisers surveyed. Video case studies, while produced later in the project, were viewed by 15% of respondents. Seventeen percent of advisers had not been reached by one of the designated channels.

Through the demonstration sites and training activities, the project achieved a good level of engagement with advisers and growers. The provisions of training events and information in multiple formats (farm walks, fact sheets and case studies, workshops, masterclasses and webinars) allows advisers to access new tools, information and skills in soil management.

This is evidenced by the more than 600 people who have attended farm walks, 150 attending workshops, 80 attending the masterclasses and 320 attending webinars. The project provides electronic access to the information with the website attracting more than 850 users per month, 6,600 video views, 3,500 webinar views, 1,700 Facebook followers and 560 Twitter followers.

The project increase advisers soil knowledge (Table 2). The largest gains in knowledge were made in the cover crops, compost and precision farming areas. These areas were where advisers knowledge was least developed. Crop nutrition knowledge was the most developed, with the project only slightly increasing adviser knowledge in this area.

Table 2. Changes in the advisers' soil knowledge following interaction with the project. Advisers self-assessed their knowledge before and after interactions with the project (1 being no knowledge and 5 being high level of knowledge).

Soil management area	Self-assessed knowledge score		
	Before project	After project	Change
Cover crops and biofumigation	3.40	3.98	0.57
Compost and soil amendments	3.60	4.04	0.45
Soil biology	3.79	4.04	0.26
Precision farming	3.13	3.53	0.40
Reduced tillage	3.49	3.79	0.30
Soil-borne diseases	3.68	3.89	0.21
Crop nutrition, soil testing and fertiliser	4.30	4.38	0.09

With the level of engagement and knowledge improvement (Table 2), we consider the project achieved outcome 1.

Outcome 2. 200 growers adopting, trialling or intending to adopt management practices which improve soil condition and farm profitability

One of the key aims of the projects was to influence decision-making and practices on vegetable farms. Almost half the growers (47%) identified changes to improve soil health on their farm because of being involved in the Soil Wealth project (wholly or partly; Figure 3a). A further 43% of respondents were undertaking, or planning to undertake changes, but not because of the project.

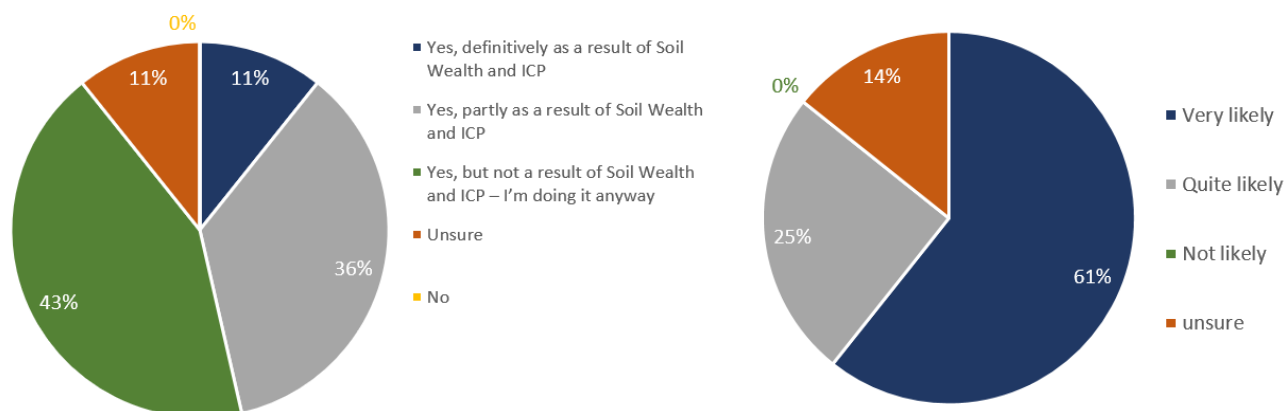


Figure 3. Growers Practice change as a result of the project (3a left), and likelihood change will occur in two to three years (3b right) (n=30 growers).

Eighty-six percent of growers surveyed considered it was very likely (61%) or likely (25%) that soil health practice changes would be implemented in the next two to three years because of both project and other influences (Figure 3).

These changes mainly related to at least one of the following soil management practices (n =30 growers):

- Cover crops (44%)
- Compost (25%)
- Reducing tillage (19%).
- Crop rotation (9%)
- Biofumigation (3%)

The project also contributed to increases growers soil-management knowledge (Table 3). Growers had the least knowledge of cover crops prior to the Soil Wealth project. The greatest increase in grower knowledge was observed for cover crops. Good gains in grower knowledge were also made in the areas of compost, soil biology and precision farming. Growers were strongest in the crop nutrition area, with only a small increase in their knowledge attributed to the Soil Wealth project.

Table 3. Changes in the growers' soil knowledge following interaction with the project. Growers self-assessed their knowledge before and after interactions with the project (1 being no knowledge and 5 being High level of knowledge).

Soil management area	Self-assessed knowledge score		
	Before project	After project	Change
Cover crops and biofumigation	3.04	3.59	0.56
Compost and soil amendments	3.30	3.74	0.44
Soil biology	3.22	3.59	0.37
Precision farming	3.33	3.70	0.37
Reduced tillage	3.44	3.74	0.30
Soil-borne diseases	3.22	3.52	0.30
Crop nutrition, soil testing and fertiliser	3.74	3.85	0.11

Based on the improvements in soil management knowledge (Table 3. Changes in the growers' soil knowledge following interaction with the project. Growers self-assessed their knowledge before and after interactions with the project (1 being no knowledge and 5 being High level of knowledge).Table 3), and the positive contribution by the Soil Wealth project to the growers who intend to change their soil-management practices, we consider that the project has achieved outcome 2.

Outcome 3. Innovation system delivering continuous improvement in soil condition and profitability

The innovation system requires linkages between the three components of research, development and extension. The gradual decline in state-funded extension services has resulted in a reduction in extension activities aimed at the vegetable industry. As a result, the linkage between the considerable research and develop effort, both in Australia and internationally, and the vegetable industry was at best very weak. This was particularly so for cultural practices to improve soil condition, such as cover crops, tillage, compost and rotation, where there is a clear and real "market failure" in providing technical information to the vegetable industry.

The Soil Wealth project has played an important technical role in rebuilding the linkage between research, development and extension components of the innovation system in those cultural practices areas. As a result, the vegetable industry has become more receptive to new research and development. This is reflected in a Queensland DAF researcher commenting "*the Soil Wealth project has effectively built demand for the R&D we are now doing in soils and precision agriculture*".

An ongoing technical capacity is required to ensure that R&D is tightly linked to extension. A technical knowledge is required so that clear practical messages can be delivered on what growers can do on their farm to improve soil conditions and profitability.

At the end of Phase 1, of the major topic areas covered by Soil Wealth the following have specific research projects:

- Soil-borne diseases (VG15010 and VG15009)
- Biofumigation and cover crops (VG16068)

- Weeds (VG15070)
- Precision Agriculture (VG16009)
- Composts and soil amendments (VG15037).

In addition, the national extension network, VEGNET, is playing an important role in facilitating the extension of current research projects to industry.

Discussion

When the Soil Wealth and Integrated Crop Protection projects commenced in 2014, the vegetable industry was hungry for information and more receptive to sharing information and working together on technical issues. The industry has undergone rationalisation, with larger farms often across regions, and fewer growers. Supermarkets emerged as key buyers, requiring continuity of supply and with demanding crop specifications. State-based extension services had been wound back.

Into this environment the Soil Wealth project developed a strong national presence in the vegetable industry. The activities outlined in the outputs section were delivered in partnership with leading growers and service providers, across all states and the Northern Territory. The Soil Wealth team worked hard to communicate good practical soil management information to Australian vegetable growers with an eye on better economic outcomes, through:

- Maintaining and building soil organic matter and structure
- Covering the soil (mulches, cover crops)
- Less tillage (controlled traffic, reduced-till, GPS guidance)
- Correct nutrition.

After three years the project, together with Integrated Crop Protection (VG13078), has identified a number of delivery lessons, which are outlined below.

Delivery lessons from Phase 1 and relevance to industry

There are a number of lessons for the delivery of extension projects in the Australian vegetable industry, which include:

- The project teams had the necessary technical knowledge to interpret the research literature and work with the vegetable industry to adapt this to practical management actions that can be done on-farm, within the context of a commercial operation
 - Demonstration sites and the involvement of the grower in field days provides a powerful communication combination, and allows growers to talk directly to other growers, although, the resources and time taken to establish and operate these sites should not be underestimated
 - Using a range of communication and engagement approaches to connect with the different levels of the industry e.g. face-to-face, written, social media, videos and webinars and website
 - Developing inclusive working relationships with project partners to bring about practice change – again, building this trust takes time and was underestimated at the inception of the project.
 - Extension and training needs to be targeted to the needs of the various supply-chain sectors and regions, so that effective project team can be established, with sub-consultants who have clear roles, responsibilities, technical/topic strengths, plus, a geographical spread to ensure national coverage
 - The importance of practical and useful monitoring and evaluation to support continuous improvement and demonstrate impact of the investment to industry where the key components include a clear program logic, key evaluation questions, MERI framework and event feedback from templates developed at the start of the project.
-
- Some principles of extension that have been consolidated during the Phase 1 of Soil Wealth/ICP include:

- Understand and respect the target audience
- Segment the target audience and identify expected outcomes
- Understand motivations for adoption of an innovation
- Utilise a range of extension methods/models
- Consider range of different learning styles
- Ensure clarity of objectives/activities and alignment with partners/target audience
- Appreciate complexity of decision-making
- Focus on capacity building
- Utilise trusted service providers with appropriate skills
- Adopt a flexible and responsive approach.

Recommendations

Following the advice from the SIAP for an extension of Soil Wealth and ICP for Phase 2, the recommendations below are based on the lessons learnt from Phase 1, feedback from the PRG and key stakeholders, and an understanding of industry R&D needs.

1. Objectives for Phase 2 and building on the success of Phase 1

The objectives of the Soil Wealth/ICP Phase 2 project outlined in the RFQ (dated 25 May 2017) are to:

1. Increase industry awareness of the latest relevant R&D outcomes related to improved integrated soil and crop management on-farm.
2. Coordinate improved-practice information delivery to the Australian vegetable industry in a timely and strategic way.
3. Deliver improved-practice information using existing and new innovative methods. Methods would include regionally based demonstration sites, field days, training events and be supported by electronic resources (e.g. website, social media, videos, webinars) and print materials where necessary.
4. Complement and utilise the existing industry information delivery channels of the AUSVEG National Communications Program (VG15027) and the National Vegetable Extension Network (VegNET).

2. Phase 2 themes

The project should be guided by four major themes, reflecting recent developments in technology and industry needs:

- Proactively scan and review new developments in technological fields (e.g. use of drones, satellite data, robots, soil and crop-health management equipment) and present information to growers in a reviewed (validated), easy-to-use, adoptable and/or adaptable format.
- A production systems approach reflecting the increase in challenges and sophistication of vegetable farming, the need for consistent, good-quality produce as well as capturing comprehensive information to meet the needs of customers (including compliance), and remain adaptive.
- Innovations in soil and crop-health management which can increase productivity/pack out rates (e.g. reduce waste, have more product meeting specification, improve quality) and/or reduce input/variable costs.
- Improve sustainability and robustness of vegetable farming systems, especially under adverse conditions including the impacts of increased climate variability and extreme weather events and minimising impacts on the environment.

3. Phase 2 technical focus areas

The project team has identified eight technical focus areas which are based on feedback from growers and advisers from Soil Wealth/ICP Phase 1. The nominated areas will be part of a production systems approach rather than stand-alone disciplines. The proposed technical focus areas are:

1. Biological products and soil amendments. For example: composts, biological enhancers, soil conditioners, bio-pesticides, plant defence enhancers, mycorrhizal products, PGPR, beneficial nematodes. How to use and evaluate in vegetable cropping systems.
2. Soil biology. Role of organic matter, mycorrhizal fungi, bacteria, impact on soil-borne disease. What are the fundamentals and new developments?
3. Improved tillage. Precision agriculture, strip tillage, deep placement of organic matter (e.g. biochar and compost), softer tillage, managing cover crop residues and crop protection. What are the new

developments and practices?

4. Nutrient management. Developing a fertiliser program, soil and plant-test interpretation, interactions between crop nutrition and soil health. Variable application rate technology – link to Precision Ag.
5. Irrigation management. Irrigation scheduling and monitoring approaches and how they can be managed to reduce soil-borne diseases and nutrient losses. New tools, e.g. ET_o tools including Irrisat®, The Yield®, soil moisture monitoring tools e.g. WildEye®, Sentek® All-in-one.
6. Integrated management of pests, diseases and weeds including new genetics (resistant or tolerant varieties), improving disease resistance, crop biotechnology, area-wide management, integration of biological options.
7. Crop monitoring: Pest and disease scouting with a focus on integrating a crop protection program with other farm activities. New pest biotypes such as lettuce aphid and spinach mite.
8. New technology that provides real-time information about how a crop is performing and their use in production systems (e.g. drones, satellites, sensors, robots, apps).

4. Phase 2 demonstration sites

Demonstration sites were a major contributor to the Soil Wealth and ICP phase 1 projects. In recognition of the significant time, resources and knowledge that these growers are prepared to share with the industry, a great level of financial support for demonstration site growers from the phase 2 project is recommended.

5. Phase 2 Soil Wealth Check and Soil Improvement Plans

The Soil Wealth Phase 1 project attempted to build a system for tailored advice on soil management through the Soil Improvement Plans and Soil Wealth Checks. The interest and uptake of these was low during Phase 1, despite considerable promotion. Based on the experience from Phase 1 the Soil Wealth team doesn't support this approach being continued in Phase 2. Instead the Soil Wealth Check and Soil Improvement Plans will be used internally by the project on demonstration sites and will be made available on the Soil Wealth website.

Intellectual property/commercialisation

Intellectual property developed by the project included:

1. Soil Wealth trade mark 1648460 (**Error! Reference source not found.**)
2. www.soilwealth.com.au
3. www.soilwealth.net.au

Scientific Refereed Publications

Larsen, C., Montagu, K., Lucas, D., Blaesing, D., Boland, A-M. & Rogers, G. (2017) New methods of delivering extension to Australian vegetable grower and advisers, International Conference of the Australasia-Pacific Extension Network Conference proceedings, Townsville, 12–15 September 2017. (Appendix 5)

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Appendices

Appendix 1 Summary of Resources and Communications.

Appendix 2 Soil Wealth Check instructions and guidance.

Appendix 3 Soil Improvement Plan.

Appendix 4 Impact survey report.

Appendix 5 Larsen, C., Montagu, K., Lucas, D., Blaesing, D., Boland, A-M. & Rogers, G. (2017) New methods of delivering extension to Australian vegetable grower and advisers, International Conference of the Australasia-Pacific Extension Network Conference proceedings, Townsville, 12–15 September 2017



Summary of Resources and Communication

Handy hints and where to find useful information May 2014 - November 2017

Overview

This guide summarises useful information developed by the Soil Wealth and Integrated Crop Protection (ICP) projects from 2014-2017, and where to find it. These resources are relevant to all major vegetable growing regions in Australia. The resources developed includes fact sheets (51), case studies (12), videos and apps (36), e-newsletters (32 editions), as well as demonstration site information. The main topics covered by these resources include crop management, pest and disease management, and soil, nutrition and compost.

All the resources in this guide can be found on the project website at www.soilwealth.com.au.

Fact sheets

The fact sheets developed covered a range of issues relating to the needs of the industry, which are outlined in Tables 1, 2 and 3. Information is provided in an easy to understand format that is accessible to growers and industry service providers. The 51 fact sheets are arranged by topic, each with a brief summary and link to the full version.



Table 1: Crop management fact sheets

FACT SHEET	SUMMARY	ACCESS
Use a Partial Budget to Assess Practice Change on Vegetable Farms	This fact sheet provides information on assessing changes made in farming enterprises through conducting a partial budget. It addresses additional revenue and reduced revenue, and additional costs and reduced costs to determine a change in net profit.	http://www.soilwealth.com.au/imagesDB/news/Partialbudgetingfactsheet_FINAL.pdf
Reducing Transplant Shock in Lettuce	Information regarding what transplant shock is, and the precautionary steps to take to avoid it.	http://www.soilwealth.com.au/imagesDB/news/Reducingtransplantshockinlettuce.pdf
Management of Blindness in Lettuce Seedlings	This fact sheet provides information on the potential problems related with blindness in lettuce seedlings, what it looks like, what causes it and how to control it.	http://www.soilwealth.com.au/imagesDB/news/Managementofblindnessinlettuceseedlings.pdf
Pre-Harvest Effects on the Quality of Babyleaf Spinach	A fact sheet that provides information on how to best extend the shelf-life of babyleaf spinach, by addressing pre-harvest factors.	http://www.soilwealth.com.au/imagesDB/news/ICP_PreHarvestBabyleaf_web.pdf



Summary of resources and communication

FACT SHEET	SUMMARY	ACCESS
Pre-Harvest Effects on Lettuce Quality	Information regarding pre-harvest management to address key quality attributes in lettuce varieties.	http://www.soilwealth.com.au/imagesDB/news/ICP_PreHarvestLettuce_web.pdf
Blankets for Vegetables: Using Frost Cloth to Protect Plants from Weather	This fact sheet provides information on the use of floating row covers to protect against weather extremities, as well as how to implement it into a farming system.	http://www.soilwealth.com.au/imagesDB/news/ICP_BlanketsforVegetables_web.pdf
Weed Management in Vegetables	A fact sheet that provides information on the economic impact of weeds, effectiveness and affordability of various control methods, and information regarding the implementation of an Integrated Weed Management (IWM) program.	http://www.soilwealth.com.au/imagesDB/news/Weedmgtinvegetables_FINAL.pdf
Internal Rot in Capsicum: Causes and Control	An analysis of the contributing factors to and varying control methods for internal rot in capsicum.	http://www.soilwealth.com.au/imagesDB/news/ICP_CapsicumRot_FINAL_Email.pdf



Table 2: Pest and disease management fact sheets

FACT SHEET	SUMMARY	ACCESS
Biocontrol Products in Australia	Overview of specific biocontrol products and biopesticides, including developments, current status, challenges, advantages and disadvantages.	http://www.soilwealth.com.au/resources/fact-sheets/pest-and-disease-management/biocontrol-products-in-australia/
Damping Off in Spinach	This fact sheet provides information on the causes of damping off, the signs and symptoms to observe, and the management techniques that can be implemented to help control the various pathogens that lead to damping off.	http://www.soilwealth.com.au/imagesDB/news/SWICP_Dampingoffinspinach_Factsheet_Mar2017_Updatedfooter_FINAL.pdf
Pythium in Carrots: Cavity Spot and Forking in Carrots	This fact sheet contains an in-depth analysis of the two Pythium species that cause the majority forking and cavity spots of carrots in Australia. It also provides information regarding the factors affecting cavity spot development and management approaches for control.	http://www.soilwealth.com.au/imagesDB/news/VG15010factsheet-Pythiumincarrots_May2017.pdf
Adjuvants: a Guide to Oils, Surfactants and Other Additives	Information regarding how adjuvants work, what types are available, and recommendations regarding which ones to use.	http://www.soilwealth.com.au/imagesDB/news/ICP_Adjuvants-Aguidetooilssurfactantsandotheradditives_1.pdf
Managing Onion Maggot in Vegetables	An overview of the damage caused by onion maggots, information regarding its life cycle and various control methods to manage populations.	http://www.soilwealth.com.au/imagesDB/news/ICP_ManagingOnionMaggot_FINAL.pdf

Summary of resources and communication



FACT SHEET	SUMMARY	ACCESS
Brassica Whitefly Control in Vegetables	A comprehensive guide that assesses the damage caused by, the ecology of, and management practices involved with, controlling brassica whitefly in vegetable crops.	http://www.soilwealth.com.au/imagesDB/news/ICP_Brassicawhiteflycontrol_2.pdf
How Can I Control Pests? Options for Controlling High Priority Pests in Capsicums and Chillies	A fact sheet that provides information on varied control methods for high priority pests in capsicums and chillies.	http://www.soilwealth.com.au/imagesDB/news/PeppersFINAL_28012016_1.pdf
How Can I Control Pests? Options for Controlling High Priority Pests in Lettuce	A fact sheet that provides information on varied control methods for high priority pests in lettuce.	http://www.soilwealth.com.au/imagesDB/news/LettuceFINAL_28012016.pdf
How Can I Control Pests? Options for Controlling High Priority Pests in Cucumbers	A fact sheet that provides information on varied control methods for high priority pests in cucumbers.	http://www.soilwealth.com.au/imagesDB/news/CucumberFINAL_28012016.pdf
How Can I Control Pests? Options for Controlling High Priority Pests in Celery	A fact sheet that provides information on varied control methods for high priority pests in celery.	http://www.soilwealth.com.au/imagesDB/news/CeleryFINAL_28012016.pdf
How Can I Control Pests? Options for Controlling High Priority Pests in Carrots	A fact sheet that provides information on varied control methods for high priority pests in carrots.	http://www.soilwealth.com.au/imagesDB/news/CarrotsFINAL_28012016.pdf
How Can I Control Pests? Options for Controlling High Priority Pests in brassica	A fact sheet that provides information on varied control methods for high priority pests in brassica vegetables.	http://www.soilwealth.com.au/imagesDB/news/BrassicaFINAL_28012016.pdf
How Can I Control Pests? Options for Controlling High Priority Pests in brassica leafy vegetables	A fact sheet that provides information on varied control methods for high priority pests in brassica leafy vegetables.	http://www.soilwealth.com.au/imagesDB/news/BrassicaleafyFINAL_09022016.pdf
Management of Lettuce Anthracnose	Guidelines on how to effectively manage the threat of anthracnose in lettuce farming. Information includes a range of cultural and chemical controls.	http://www.soilwealth.com.au/imagesDB/news/Management-of-lettuce-anthracnose.pdf
Managing Insect Contaminants in Processed Leafy Vegetables: a Best Practice Guide	This fact sheet contains information on the best practices to administer to avoid insect contamination in leafy vegetables.	http://www.soilwealth.com.au/imagesDB/news/ICP_BestPractice_250815.pdf
Managing Pesticide Resistance	This fact sheet provides information on what pesticide resistance is, how to monitor it, and the steps to take to avoid it.	http://www.soilwealth.com.au/imagesDB/news/ManagingPesticideResistance2015.pdf
Alternatives to Metham Sodium	A fact sheet that explores the alternatives to the industry standard soil fumigant, metham sodium (MS). It explains the need for an alternative and the potential environmental and human health impacts MS can have.	http://www.soilwealth.com.au/imagesDB/news/MethamSodium.pdf
Spray Application Basics	This fact sheet outlines the appropriate methods involved in chemical application to help maximise the amount of chemical reaching the plant and help minimise the amount lost in the process.	http://www.soilwealth.com.au/imagesDB/news/SprayApplicationBasics_Mar2015.pdf
Mega Pests: The Basics of Protecting your Crops	This fact sheet contains information regarding adoption of an ICP program, the key components of an ICP program as well as information on other crop management options available.	http://www.soilwealth.com.au/imagesDB/news/MegaPests-Thebasicsofprotectingyourcrops2015_2.pdf

Summary of resources and communication

FACT SHEET	SUMMARY	ACCESS
Mega Pests: Managing Major Chewing and Biting Insects	A fact sheet that provides information on controlling corn earworm, native budworm and diamondback moth with beneficial organisms and biopesticides.	http://www.soilwealth.com.au/imagesDB/news/MegaPestsChewingandBiting2015.pdf
Mega Pests: Managing Sucking Pests	This fact sheet covers a range of issues regarding the control of sucking pests, including the use of predators and parasitoids.	http://www.soilwealth.com.au/imagesDB/news/MegaPestsSuckingPests2015.pdf
Mega Pests: Managing Foliar Diseases	This fact sheet covers a range of issues relating to the management of foliar diseases including: the use of resistant varieties, irrigation scheduling and farm sanitation.	http://www.soilwealth.com.au/imagesDB/news/MegaPestsManagingFoliarDiseases2015.pdf
Mega Pests: Managing Soilborne Diseases	This fact sheet provides information on managing clubroot, Pythium, fusarium, rhizoctonia and sclerotinia.	http://www.soilwealth.com.au/imagesDB/news/Megapests_Soilbornediseases2015.pdf



Table 3: Soil, nutrition and compost fact sheets

FACT SHEET	SUMMARY	ACCESS
Making the Most of your Nitrogen	This fact sheet provides information on the need for nitrogen application, how it can improve vegetables farming systems, and the correct applications to administer to increase production and reduce leaching and run-off.	http://www.soilwealth.com.au/imagesDB/news/SW_MakingthemostofNitrogen_FINAL.pdf
Managing Cover Crop Residues in Vegetable Production	A fact sheet that outlines the three key factors in managing crop residues in vegetable production: cover crop chemistry, how it is terminated, and tillage.	http://www.soilwealth.com.au/imagesDB/news/ManagingCoverCropResiduesSWICP.pdf
Soil Testing and Interpretation for Vegetable Crops	This comprehensive guide provides a wide range of information on soil testing including: the reasons to test, choosing the right testing service, and Interpreting tests.	http://www.soilwealth.com.au/imagesDB/news/SW_SoilTestInterpretation_FINAL.pdf
Forthside Demonstration Site: Soil Amendments on Vegetable Crops	This fact sheet provides information on a three-year trial on the benefits of pyrethrum marc as a soil conditioner on a range of horticultural crops.	http://www.soilwealth.com.au/imagesDB/news/SW_ForthsideDemonstrationSiteFactSheet.pdf
From Health to Wealth: Looking after Soils for Vegetable Production	A fact sheet that shows what healthy soils are, why they are important and how to create them.	http://www.soilwealth.com.au/imagesDB/news/SW_FromHealthtoWealth.pdf
Nitrous Oxide Emissions from Vegetable Soils: What's all the fuss about?	This fact sheet shows the harmful effects nitrous oxide has on the environment and how to reduce and manage emissions.	http://www.soilwealth.com.au/imagesDB/news/SWNitrousoxideemissionsfromvegetablesoils.pdf

Summary of resources and communication



FACT SHEET	SUMMARY	ACCESS
Using Compost Safely: A Guide for the use of Recycled Organics in Horticulture	A guide that outlines the materials and methods behind using compost in a safe manner.	http://www.soilwealth.com.au/imagesDB/news/AHRCompost_growersV3.pdf
Safe Compost for Fruit and Vegetables: A Guide for the Supply of Recycled Organics to Fresh Produce	This guide describes how the producers of recycled organic products can meet the requirements of food safety programs.	http://www.soilwealth.com.au/imagesDB/news/AHRCompost_producers.pdf
Anhydrous Ammonia for Vegetable Crops: Could it be a Viable Proposition?	This fact sheet provides a wide range of information on anhydrous ammonia and the range of benefits it provides when incorporated into a vegetable cropping system.	http://www.soilwealth.com.au/imagesDB/wysiwyg/AnhydrousAmmoniafactsheetFINAL.pdf
Summer Cover Crops	This brief guide matches the main aims of soil management in farming systems with specific summer crops.	http://www.soilwealth.com.au/imagesDB/news/SummerCoverCrops_July2016.pdf
Calcium Cyanamide use in vegetables	Calcium cyanamide, also known as nitrolime, has been used as slow release nitrogen / calcium fertiliser with liming effect for over 100 years. Because of its negative effect on many soil borne diseases it is now often applied to prevent yield and quality losses during increasingly tight crop rotations.	http://www.soilwealth.com.au/resources/fact-sheets/soil-nutrition-and-compost/calcium-cyanamide-use-in-vegetables/
Silicon for Crop Health	This fact sheet outlines the benefit of silicon application on crop health and pest and disease resistance.	http://www.soilwealth.com.au/imagesDB/news/ICP_Siliconforcrophealth_FINAL.pdf
Nutrient Element Functions in Vegetable Crops	This fact sheet provides a comprehensive guide to the functions, methods of uptake and deficiency symptoms of various nutrients in vegetable crops.	http://www.soilwealth.com.au/imagesDB/news/NutrientElement_July2016.pdf
Taking Soil Samples	This fact sheet outlines the materials and methods involved, and the correct way to analyse soil samples.	http://www.soilwealth.com.au/imagesDB/news/SW_Takingsoilsamples_July2016.pdf
Winter Cover Crops	This brief guide matches the main aims of soil management in farming systems with specific winter crops.	http://www.soilwealth.com.au/imagesDB/news/WinterCoverCrops_July2016.pdf
Carbon Storage in Vegetable Soils	This fact sheet summarises the importance of soil carbon, as well as management techniques involved in mitigating or sequestering it.	http://www.soilwealth.com.au/imagesDB/news/SW_SoilcarbonfactsheetWEB.pdf
Erosion: How to Protect Your Soil	This fact sheet provides information on managing soil erosion as well as addressing the two key areas that cause it: wind and water.	http://www.soilwealth.com.au/imagesDB/news/SW_SoilErosionv3.pdf
Biofumigation	A fact sheet that outlines common biofumigant crops, the benefits of using them and how to manage them.	http://www.soilwealth.com.au/imagesDB/news/SW-ICP-biofumigation-factsheet-150216-FINAL.pdf
Reduced Till in Vegetable Production	This fact sheet contains information on the benefits and challenges with implementing a reduced till system. It includes a summary of a case study of a trial conducted in Cowra NSW, as well as links to videos that describe the reasoning behind reduced till farming systems.	http://www.soilwealth.com.au/imagesDB/news/RedtillSW12150203.pdf
Quick Guide to Farm Nitrogen	This guide contains information regarding the 4R principle of applying nitrogen fertilisers: right source, right amount, right place and right time.	http://www.soilwealth.com.au/imagesDB/news/Nitrogen150213.pdf

Summary of resources and communication



Case studies

The following 12 case studies provide growers and industry professionals practical insights on cover crops, IPM and compost management. Each of the case studies listed in Table 4 are from a Soil Wealth and ICP demonstration sites and contain first-hand experience from growers. The table contains a brief summary of each case study and link to the full version.



Table 4: Case studies

CASE STUDY	SUMMARY	ACCESS
Three Vital Practice Changes at Rob Hinrichsen's Kalfresh: A Case Study	Provides insights into some of the main changes involving controlled traffic, cover crops and compost at the Kalfresh demonstration site in Queensland.	http://www.soilwealth.com.au/resources/articles-publications-and-case-studies/three-vital-practice-changes-at-rob-hinrichsens-kalfresh-a-case-study/
Koo Wee Rup Demonstration Site: Practice Change Case Study	Provides an overview and lessons learnt from trialling different cover crops at the Schreurs & Sons demonstration site in Cora Lynn, Victoria.	http://www.soilwealth.com.au/resources/articles-publications-and-case-studies/koo-wee-rup-demonstration-site-practice-change-case-study/
Mt Barker Demonstration Site: Practice Change Case Study	Presents insights and lessons from trialling different cover crops and IPM at the Eastbrook Vegetable Farms demonstration site in Mt Barker in South Australia.	http://www.soilwealth.com.au/resources/articles-publications-and-case-studies/mt-barker-demonstration-site-practice-change-case-study/
Reducing Tillage in Vegetable Crops: Is It Worthwhile?	Outlines the pros and cons of reducing the intensity of cultivation in vegetable production systems. It is based on lessons learnt from three demonstration sites under the projects.	http://www.soilwealth.com.au/resources/articles-publications-and-case-studies/reducing-tillage-in-vegetable-crops-is-it-worthwhile/
What is Compost Worth? Using Compost in Australian Vegetable Systems	This case study outlines the economic considerations when using compost in vegetable production systems. It outlines the costs and benefits that were determined through trials conducted on demonstration sites over Western Australia, NSW and Queensland, from 2014 to 2016.	http://www.soilwealth.com.au/images/DB/news/ICP_SW_Composteconomics_v3.pdf
What is a Cover Crop Worth? Cover Crops in Australian Vegetable Systems	This case study outlines economic considerations when using cover crops in vegetable systems. It includes information on various case studies conducted throughout Australia as well as information on what cover crops are and how best to use them to maximise profit.	http://www.soilwealth.com.au/imagesDB/news/Covercropseconomics_Mar2017.pdf

Summary of resources and communication



CASE STUDY	SUMMARY	ACCESS
Implementing IPM on farm – Experiences from Leading Growers: Houston's Farms, Tasmania	This case study outlines the challenges experienced by leafy salad producer Houston's farm after the detection of the Lettuce Aphid in 2004. Houston's Farms were unable to export produce, and looked to IPM as an option to control the insect.	http://www.soilwealth.com.au/imagesDB/news/ICP_CaseStudy-IPM-HoustonsFarmsV3.pdf
Implementing IPM on Farm – Experiences from Leading Growers: Jerome Thompson, Werribee South Farm Supplies, Werribee South VIC	This case study showcases Jerome Thompson, Werribee South Farm Supplies CRT branch manager, who supplies agricultural products to approximately 110 vegetable growers in the Werribee South region. It discusses Jerome's observations in changes in approach, challenges and achievements to do with the implementation of IPM programs.	http://www.soilwealth.com.au/imagesDB/news/ICP_IPMCaseStudy_WerribeeSouthFarmSupplies.pdf
Implementing IPM on farm - experiences from leading growers: Daniel Fragapane, Werribee South VIC	Werribee South vegetable grower, Daniel Fragapane, runs a 42 hectare farm growing cauliflowers and broccoli for supermarket chain ALDI. He adopted IPM on his Werribee South farm following a recommendation from his cousins. Read this practical case study to learn more from leading growers.	http://www.soilwealth.com.au/imagesDB/news/ICP_IPMCaseStudy_DanielFragapane_1.pdf
Implementing IPM on Farm – Experiences from Leading Growers: Peter Schreurs and Son, Devon Meadows VIC	This case study gives an overview of the adoption of an IPM program on the Schreurs farm south east of Melbourne. After first discovering two-spotted mite in their leek and parsnip crop in the early 90's, the Schreurs tried a range of chemicals controls without much success. In 2000, they implemented an IPM program and haven't looked back.	http://www.soilwealth.com.au/imagesDB/news/ICP_IPMcasestudy_PeterSchreursandSonsFINAL.pdf
Implementing IPM on farm - experiences from leading growers: Schreurs and Sons, Clyde VIC	Schreurs and Sons are one of the largest celery producers in Australia. Production of celery by the family business has relied on IPM for well over a decade. The original drivers for exploring an IPM option were borne out of problems relying on a pesticide-based strategy. Find out more by reading this case study.	http://www.soilwealth.com.au/imagesDB/news/ImplementingIPM onfarmexperiencesfromleadinggrowers-SchreursandSons_1.pdf
Soil and Plant Health Benefits from using Compost: A Long-Term Case Study on Baldvis Farms	This case study provides a long-term perspective on the benefits of integrating compost into a vegetable farm. Whilst providing information on materials, methods and results of the long-term trial, it also provides information on what to ask your supplier, things to consider when implementing it into your farming system, and the overall value it's likely to have on your farm.	http://www.soilwealth.com.au/imagesDB/news/ICP_SW_BaldivisFarmCompostFINALV3.pdf

Summary of resources and communication

Videos and apps

A series of short videos, webinar recordings and apps designed to aid the Australian vegetable industry in plant health and soil management are outlined in Tables 5, 6 and 7. The 36 videos and apps are arranged by topic (crop management, pest and disease management, and soil, nutrition and compost), each with a brief summary and link to the video.



Table 5: Crop management videos and apps

TITLE	SUMMARY	ACCESS
Soil Wealth and ICP Achievements Phase 1	A short video showing the advancements in various projects over the past three years in the horticultural industry.	http://www.soilwealth.com.au /resources/videos-and-apps/soil-wealth-and-icp-achievements-phase-1/
Precision Agriculture Technology in Vegetable Production Systems	A webinar recording that looks at the future of precision agriculture in horticulture sector.	http://www.soilwealth.com.au /resources/videos-and-apps/precision-agriculture-technology-in-vegetable-production-systems-webinar-recording/
Integrated Weed Management for the Australian Vegetable Industry with Dr Paul Kristiansen, Dr Kelvin Montagu and Marc Hinderager	This webinar focusses on strategies used when implementing an integrated weed management program.	http://www.soilwealth.com.au /resources/videos-and-apps/integrated-weed-management-for-the-australian-vegetable-industry-with-dr-paul-kristiansen-dr-kelvin-montagu-and-marc-hinderager-webinar-recording/
Southern Fields Vegetable Farm demonstration site – Experiences from Leading Growers	This short video covers the demonstrations being conducted on Colin Houston's Tasmanian farm.	http://www.soilwealth.com.au /resources/videos-and-apps/southern-fields-vegetable-farm-demonstration-site-experiences-from-leading-growers/
Managing Plant Health and Soils in Vegetables – Experiences from Growers	This video involves conversations with growers about managing plant and soil health through the implementation of integrated crop protection and soil management programs.	http://www.soilwealth.com.au /resources/videos/managing-plant-health-and-soils-in-vegetables-experiences-from-leading-growers/

Summary of resources and communication



Table 6: Pest and disease management videos and apps

TITLE	SUMMARY	ACCESS
Nematodes in Vegetable Soils – Managing the Bad and Good Ones with Dr Sarah Collins	A webinar recording of nematode specialist Dr Sarah Collins outlining the importance of understanding the life cycles of nematodes	http://www.soilwealth.com.au/resources/videos-and-apps/nematodes-in-vegetable-soils-managing-the-bad-and-good-ones-with-dr-sarah-collins-webinar-recording/
Pesticides and insect pest control in vegetables with Dr Siobhan de Little	This webinar covers the risk profile of different modes of action on both insect pests and beneficial species, and how this influences resistance management as well as informing the implementation of IPM.	http://www.soilwealth.com.au/resources/videos-and-apps/pesticides-and-insect-pest-control-in-vegetables-with-dr-siobhan-de-little-webinar-recording/
Green Peach Aphid Resistance Management with Dr Siobhan de Little	A webinar recording looking at the life cycle, damage and potential control methods of green peach aphid.	http://www.soilwealth.com.au/resources/videos-and-apps/green-peach-aphid-resistance-management-with-dr-siobhan-de-little-webinar-recording/
Managing Fruit Fly in Vegetable Crops with Dr Jenny Ekman	A webinar presented by Dr Jenny Ekman on strategies available to growers to manage fruit fly in vegetable crops, including the fruit fly lifecycle, monitoring, use of protein baiting, male annihilation techniques and netting.	http://www.soilwealth.com.au/resources/videos-and-apps/managing-fruit-fly-in-vegetable-crops-with-dr-jenny-ekman-webinar-recording/
Nutrition Management and Plant Disease with Dr Len Tesoriero	A webinar recording looking at nutrition and disease relationships, and the effect nutrients have on soil borne diseases.	http://www.soilwealth.com.au/resources/videos-and-apps/nutrition-management-and-plant-disease-with-dr-len-tesoriero-webinar-recording/
Managing Insect Pests in Greenhouses with Andy Ryland	This webinar focusses on whitefly, thrips and mites and covers a range of IPM techniques.	http://www.soilwealth.com.au/resources/videos-and-apps/managing-insect-pests-in-greenhouses-with-andy-ryland-webinar-recording/
Managing Pesticide Resistance in Vegetable Crops with Dr Paul Horne	This webinar looks at how resistance arises, developing a resistance management strategy, and understanding control options available.	http://www.soilwealth.com.au/resources/videos-and-apps/managing-pesticide-resistance-in-vegetable-crops-with-dr-paul-horne-webinar-recording/
How to control Pythium in vegetable crops with Dr Len Tesoriero	Vegetable pathologist, Dr Len Tesoriero and AHR's Dr Kelvin Montagu, discuss how to manage the soil borne disease Pythium in vegetable crops in this webinar recording.	http://www.soilwealth.com.au/resources/videos-and-apps/how-to-control-pythium-in-vegetable-crops-with-dr-len-tesoriero-webinar-recording/
Pest Management – what are the options? With Dr Paul Horne	This presentation looks at the options for controlling pests in vegetable crops through a range of chemical, cultural and biological options.	http://www.soilwealth.com.au/resources/videos-and-apps/pest-management-what-are-the-options-with-dr-paul-horne-webinar-recording/



Summary of resources and communication

TITLE	SUMMARY	ACCESS
How to manage Sclerotinia in vegetable crops with Dr Len Tesoriero	A webinar on sclerotinia management presented by Dr Len Tesoriero.	http://www.soilwealth.com.au/resources/videos-and-apps/how-to-manage-sclerotinia-in-vegetable-crops-with-dr-len-tesoriero/
Soilborne Disease Master Class for the Vegetable Industry –Experiences from Growers	This short video involves first-hand experience from growers outlining the benefits gained from attending soilborne disease master classes.	http://www.soilwealth.com.au/resources/videos-and-apps/soilborne-disease-master-class-for-the-vegetable-industry-experiences-from-leading-growers/
Veg Pest ID app	Veg Pest ID helps farmers and agricultural professionals identify pests on Australian vegetable crops. Even tricky insects, diseases and disorders can be found with a few taps or keyword search.	http://www.soilwealth.com.au/resources/videos-and-apps/pest-and-disease-identifier-app-veg-pest-id/
Natural control of insect pests in lettuce, Devon Meadows	Vegetable grower Peter Schreurs talks about how he controls insect pests using natural predators.	http://www.soilwealth.com.au /resources/videos/natural-control-of-insect-pests-in-lettuce/
Natural control of insect pests in vegetables, Mornington Peninsula	Vegetable grower Paul Gazzola talks about how he controls insect pests using natural predators.	http://www.soilwealth.com.au /resources/videos/natural-control-of-insect-pests-in-vegetables-mornington-peninsula/
Natural control of insect pests in Broccoli, Werribee	Fresh Select vegetable agronomist Stuart Grigg talks about how he controls insect pests using natural predators.	http://www.soilwealth.com.au /resources/videos/natural-control-of-insect-pests-in-broccoli-werribee/

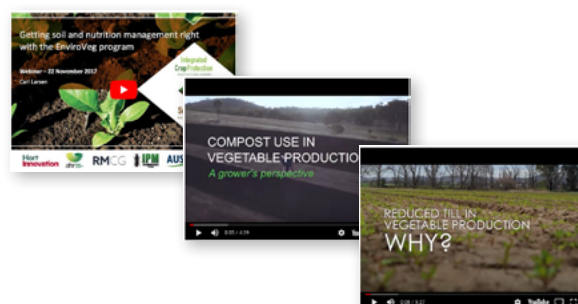


Table 7: Soil, nutrition and compost videos and apps

TITLE	SUMMARY	ACCESS
Getting soil and nutrition management right with the EnviroVeg program	Healthy soil and correct nutrition management is essential to a productive vegetable business and protecting the natural environment. View this informative and interactive webinar to get the latest updates from vegetable industry experts.	http://www.soilwealth.com.au/resources/videos-and-apps/getting-soil-and-nutrition-management-right-with-the-enviroveg-program-webinar-recording
Controlled traffic in vegetable production: A grower's perspective	Hear from Rob Hinrichsen of Kalfresh in QLD about using controlled traffic in commercial vegetable production systems.	http://www.soilwealth.com.au/resources/videos-and-apps/controlled-traffic-in-vegetable-production-a-growers-perspective/
Cover crops in vegetable production: A grower's perspective	This video captures Rob Hinrichsen 's experiences in using different types of cover crops such as tillage radish and sun hemp to achieve different objectives, some of the benefits of using cover crops such as increased soil carbon and crop resilience, as well as providing advice to those starting out.	http://www.soilwealth.com.au/resources/videos-and-apps/cover-crops-in-vegetable-production-a-growers-perspective/



Summary of resources and communication

TITLE	SUMMARY	ACCESS
Compost use in vegetable production: A grower's perspective	Hear from Rob Hinrichsen of Kalfresh in QLD about using compost in commercial vegetable production systems. This video captures Rob's experiences in soil biology, short and long-term compost, the financial implications of using compost, and advice for starting out.	http://www.soilwealth.com.au/resources/videos-and-apps/compost-use-in-vegetable-production-a-growers-perspective/
Using Compost in Commercial Vegetable Production with Dr Doris Blaesing	This webinar recording looks at the benefits of using compost on commercial farms.	http://www.soilwealth.com.au/resources/videos-and-apps/using-compost-in-commercial-vegetable-production-with-dr-doris-blaesing-webinar-recording/
Biofumigation Cover Crops in Vegetable Production with Julie Finnigan	This webinar covers issues regarding the benefits of biofumigation, how to use it effectively and the different varieties of biofumigant cover crops available.	http://www.soilwealth.com.au/resources/videos-and-apps/biofumigation-cover-crops-in-vegetable-production-with-julie-finnigan-webinar-recording/
Rediscovering Cover Crops with Dr Kelvin Montagu	A webinar that covers a range of issues relating to integrating cover crops into vegetable production systems.	http://www.soilwealth.com.au/resources/videos-and-apps/rediscovering-cover-crops-with-kelvin-montagu-webinar-recording/
Developing a fertiliser program for Vegetable Crops with Bruce Scott & Dr Doris Blaesing	This webinar focusses on nutrient management of vegetable crops using plant testing and the 4R principle (right source, right rate, right time and right place).	http://www.soilwealth.com.au/resources/videos-and-apps/developing-a-fertilizer-program-for-vegetable-crops-with-bruce-scott-doris-blaesing-webinar-recording/
Soil Testing for Vegetable Crops with Dr Doris Blaesing and Dr Gordon Rogers	A webinar that looks at how to get the most out of your soil testing results.	http://www.soilwealth.com.au/resources/videos-and-apps/soil-testing-for-vegetable-crops-with-doris-blaesing-and-gordon-rogers-webinar-recording/
Leaf Sap Testing for Managing Vegetable Crop Nutrition with Bruce Scott, Dr Doris Blaesing and Dr Gordon Rogers	This webinar focusses on managing fertiliser inputs through leaf and sap testing.	http://www.soilwealth.com.au/resources/videos-and-apps/leaf-and-sap-testing-for-managing-vegetable-crop-nutrition-with-bruce-scott-doris-blaesing-and-gordon-rogers-webinar-recording/
Understanding Manures & Composts	A two-minute summary of Dr Doris Blaesing's presentation 'Understanding Manures & Composts' delivered at the Fertilizer Australia Conference 2015.	http://www.soilwealth.com.au/resources/videos-and-apps/understanding-manures-composts/
Biofumigation crop management for maximum impact	Dale Gies outlines the importance of correct establishment and water and nutrient requirements of biofumigant crops.	http://www.soilwealth.com.au/resources/videos-and-apps/biofumigation-crop-management-for-maximum-impact/
Development of biofumigant cover crops and their potential benefits	Listen to Dale Gies outline the development of high glucosinolates varieties for soilborne disease and nematode suppression.	http://www.soilwealth.com.au/resources/videos-and-apps/development-of-biofumigant-cover-crops-and-their-potential-benefits/
Introduction to Green Crops and Biofumigation	A short presentation by Dale Gies from High Performance Seeds discussing the benefits of green manure crops.	http://www.soilwealth.com.au/resources/videos-and-apps/introduction-to-green-crops-and-biofumigation/
Reduced Till in Vegetable Production – why?	A short video that explains the reasons behind and benefits of using a reduced till system in vegetable production.	http://www.soilwealth.com.au/resources/videos/reduced-till-in-vegetable-production-why/
Reduced Till in Vegetable Production – how?	A short video that shows how to implement a reduced till system in vegetable production.	http://www.soilwealth.com.au/resources/videos/reduced-till-in-vegetable-production-how/

Summary of resources and communication

Communication channels

The Soil Wealth and ICP projects utilised a range of communication channels to promote the adoption of improved soil management and plant health practices by the vegetable industry. A compiled list of e-newsletter and social media communication is provided in Tables 8 and 9. These channels provided regular updates on events, demonstration site news, resources developed by the projects, as well as articles of interest. Channels are arranged by topic and heading, and contain a brief summary and link to the full version.



Table 8: E-newsletter, Facebook and Twitter communication

TITLE	SUMMARY	ACCESS
Soil Wealth and ICP Bulletin	The Soil Wealth and Integrated Crop Protection Bulletin is a monthly e-newsletter that communicates information on upcoming events, new resources and information of demonstration sites located around the country	http://www.soilwealth.com.au /resources/ bulletin-enewsletter/
Facebook Demonstration Site pages	The Facebook demonstration site pages provide ongoing live information on the progress of various trials at each of the sites around the country, from IPM and reduced tillage, to cover crops and compost.	http://www.soilwealth.com.au /demo-sites/
Twitter	The Soil Wealth and ICP Twitter accounts provide up to date information regarding a range of important issues, international research and articles relating to the vegetable industry.	https://twitter.com/ProtectingCrops https://twitter.com/SoilWealth

Summary of resources and communication

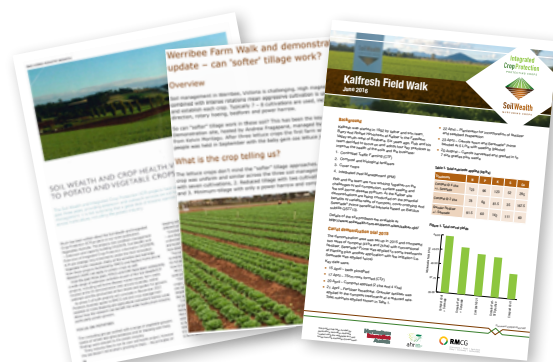


Table 9: Articles and other publications

TITLE	SUMMARY	ACCESS
Soil Wealth and Crop Health: Vital Components to Potato and Vegetable Crops	This article provides information on soil health, crop nutrition and crop health in potatoes, using the principles developed by the projects in vegetables.	http://www.soilwealth.com.au/imagesDB/news/Potatoes-Australia-Sep-Oct-2017_SWICPsummaryarticlescanned.pdf
Eastbrook Vegetable Farms Demonstration Site: Overview, May 2017	A fact sheet outlining the Mt Barker demonstration site, trials and lessons learnt used as a handout at the Horticulture Field Day in conjunction with Hort Connections 2017.	http://www.soilwealth.com.au/imagesDB/wysiwyg/ICP_SW_EastbrookVegetableFarmsDemonstrationSiteOverviewMay2017.pdf
Updates on Cover Crops and Soil Borne Disease in WA Grower Magazine	Coverage of the economic case study for cover crops, as well as a demonstration site update on the compost trials from Gingin in Western Australia in the WA Grower magazine.	http://www.soilwealth.com.au/resources/articles-publications-and-case-studies/updates-on-cover-crops-and-soil-borne-disease-in-wa-grower-magazine/
Soil Borne Disease Management in Vegetable Crops with Dr Len Tesoriero	Soil borne diseases are a serious concern for the vegetable industry, but can be managed, according to NSW Department of Primary Industries Senior Plant Pathologist, Dr Len Tesoriero.	http://www.soilwealth.com.au/resources/articles-publications-and-case-studies/soil-borne-disease-management-in-vegetable-crops-with-dr-len-tesoriero/
Biochar Showing Positive Benefits for Organic Vegetable Grower in Darwin	An article that outlines organic approaches to increasing soil health at the Darwin project demonstration site.	http://www.soilwealth.com.au/imagesDB/wysiwyg/DarwinupdateDecember2016v2.pdf
Soil Wealth: AORA Field Day at the Greater Sydney Local Land Services Demonstration Farm	An article with information regarding the multiple Soil Wealth demonstration sites located around Australia	http://compostforsoils.com.au/soilwealth.html
Werribee Farm Walk and Demonstration Site Update – can ‘Softer’ Tillage Work?	An overview of results taken from a demonstration site in Werribee in regard to tillage strengths.	http://www.soilwealth.com.au/resources/article-publication/werribee-farm-walk-and-demonstration-site-update-can-softer-tillage-work/
Kalfresh Farm Walk and Demonstration Site Update: June 2016	An update on the progress made on a demonstration site in South East Queensland.	http://www.soilwealth.com.au/resources/article-publication/kalfresh-farm-walk-and-demonstration-site-update-june-2016/
Lettuce Grower David East: Use of Biofumigant Mustard	The project’s facilitated a field day at David’s property where he spoke about the benefits he has observed using caliente and gave some tips on implementing the practice. Check out the article to see what David has learnt.	http://www.soilwealth.com.au/resources/article-publication/lettuce-grower-david-east-use-of-biofumigant-mustard/

Summary of resources and communication

TITLE	SUMMARY	ACCESS
Building Soil Wealth in the South-West of WA	WA Grower magazine article on the field day on biofumigation at David and Lee East's Bewray farm at Manjimup, which attracted over 45 growers and industry specialists.	http://www.soilwealth.com.au/resources/article-publication/building-soil-wealth-in-the-southwest-of-wa/
Legume Cover Crops can Increase Spinach Yield	Information about a cover crop trial developed at the Cowra NSW demonstration site.	http://www.soilwealth.com.au/resources/article-publication/legume-cover-crops-can-increase-spinach-yield/
Pests, Diseases and Disorders of Sweetpotato: A field identification guide	This guide enables field identification of the insects, diseases and disorders of sweetpotato by providing photos, written description, damage symptoms, and season when commonly found.	http://www.soilwealth.com.au/resources/article-publication/pests-diseases-and-disorders-of-sweetpotato-a-field-identification-guide/
Pests, Diseases and Disorders of Sweet Corn: A field identification guide	This guide enables field identification of the insects, diseases and disorders of sweet corn by providing photos, written description, damage symptoms, and season when commonly found.	http://www.soilwealth.com.au/resources/article-publication/pests-diseases-and-disorders-of-sweet-corn-a-field-identification-guide/
Pests, Diseases and Disorders of Carrots, Celery and Parsley: A field identification guide	This guide enables field identification of the insects, diseases and disorders of carrots, celery and parsley by providing photos, written description, damage symptoms, and season when commonly found.	http://www.soilwealth.com.au/resources/article-publication/pests-diseases-and-disorders-of-carrots-celery-and-parsley-a-field-identification-guide/
Pests, Diseases and Disorders of Babyleaf Vegetables: A field identification guide	This guide enables field identification of the insects, diseases and disorders of babyleaf vegetables by providing photos, written description, damage symptoms, and season when commonly found.	http://www.soilwealth.com.au/resources/article-publication/pests-diseases-and-disorders-of-babyleaf-vegetables-a-field-identification-guide/
Pests, Diseases and Disorders of Brassica Vegetables: A field identification guide	This guide enables field identification of the insects, diseases and disorders of brassica vegetables by providing photos, written description, damage symptoms, and season when commonly found.	http://www.soilwealth.com.au/resources/article-publication/pests-diseases-and-disorders-of-brassica-vegetables-a-field-identification-guide/
Soil guru shows how it's done at National Horticulture Convention	"Soil health to create wealth" was the motto at an AUSVEG farm tour, as the tour visited a large scale market garden in Kalbar.	http://www.soilwealth.com.au/resources/article-publication/soil-guru-shows-how-its-done-at-national-horticulture-convention/
Bugs in the system at Bulmer Farms at Lindenow	Read the Weekly Times article about the Gippsland demonstration site.	http://www.soilwealth.com.au/resources/article-publication/bugs-in-the-system-at-bulmer-farms-at-lindenow/



Soil Wealth Check – Instructions & guidance

The Soil Wealth Check is undertaken following the Soil Improvement Plan. The Soil Improvement Plan focuses on one area/paddock, the Soil Wealth Check should be done on this paddock. The SWC should be able to be completed in 1-1.5 hours.

A brief summary of the tests and visual observations are provided below. These instructions assume you have a good working knowledge of soil sampling procedures. If more detail is required, then “Healthy Soils for Sustainable Vegetable Farms: Ute Guide” and “Visual Soil Assessment: Annual Crops” should be consulted.

Soil Improvement Plan Paddock Summary

For each paddock the following summary information is required for each Soil Wealth Check. Below is some brief guidance on what is required. Avoid wet conditions.

Grower name: <i>record the grower name/property name</i>	Date:
Farm location: <i>Record the nearest town</i>	Assessors name:
Paddock name/ID: <i>Records the paddock name/location</i>	Last cultivation (weeks):
GPS reference: <i>record GPS coordinates in decimal units, take in middle of sampling area</i>	Last cultivation (type): <i>note the time since last cultivation and the type of cultivation if possible. Take pictures of tillage equipment if possible.</i>
Current/last crop: <i>note the current crop & date of establishment. If fallow note this and harvest date of last crop.</i>	Soil moisture: dry / moist / wet <i>note the soil moisture conditions at sampling</i>
Soil Texture, 0-15cm: <i>Sand; sandy loam; Loam; silt loam; sandy clay loam; clay loam; light clay; medium to heavy clay loam. Use the “Healthy Soils for Sustainable Vegetable Farms: Ute Guide” to determine field texture.</i>	Leaf defic. symptoms / crop visual assessment: <i>If a crop is present record any general observations</i>
Soil Texture, 15-30cm: <i>repeat as for 0-15</i>	
Other notes:	

Four soil pits for visual observations

Four soil pits need to be dug to a minimum of 30cm across the Focus Area. If the Soil Improvement Plan has identified subsoil issues the pits should be dug to show this. Clean up the profile to show soil structure (ie expose natural surface by using a knife to leverage away the soil along natural fissures; remove loose soil with brush).

Soil Samples for analysis

Soil analysis from previous soil tests can be used if from the same area. However, if Liable Carbon and Aggregate Stability tests were not undertaken an addition sample will be required.

If a soil sample is required, then this will be collected from the 4 soil pits **plus** at least 26 additional samples from cores based on good sampling practice. These will be bulked to give 1 soil sample from each depth (0-15; 15-30cm) for analysis. From each of the soil pits take at least 2 good hand-fulls of soil from each depth and place in a bucket for mixing. Add additional samples for each depth from coring. For each depth the bulked sample should be at around 1.5 kg of soil. Mix the soil well and place more than 700 gms into a **labeled** zip lock bag (Date, Growers name, Collectors name, depth). Send this to

Liam Southam-Rogers

Applied Horticultural Research

Suite 352, Biomedical Building,

1 Central Avenue, Australian Technology Park, Eveleigh N.S.W. 2015.

Checklist

CHECK-LIST	# 1	# 2	# 3	# 4	Paddock
Photograph - overall paddock	<i>Take a general overview of the paddock eg from back of ute or opposite hill.</i>				
Photograph - soil surface (at least 1 sample site)	<i>Take pictures of the soil surface to show general condition (eg capping, worm casts). Make sure you have something to give scale</i>				
Photograph - soil pit (at least 1 sample site)	<i>Place a ruler in the hole. Take pictures taking care to good light in hole to show the profile.</i>				
Photograph – roots (at least 1 sample site)	<i>Take pictures of representative plant roots in the soil pit</i>				
Soil sub-sample collected 0-15cm (all 4 sample sites)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Soil sub-sample collected 15-30cm (all 4 sample sites)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Visual assessment 0-15cm

Use the attached charts to assess the soil condition for Surface Crusting and Soil Structure (2 charts).

TEST	Poor	Fair	Good	Test scores					Comments
				# 1	# 2	# 3	# 4	Av.	
Surface crusting See chart	crusting >5 mm thick, little cracking	crusting 2-3 mm thick, significant cracking	Little or no crusting						<i>This can only be done after the soil surface has dried following rain or irrigation. Use the chart pictures to score the soil surface condition Score 0-1-2 as per chart</i>
Soil structure See chart	large compact clods, few crumbs	some clods	Friable, aggregated, breaks into crumbs						<i>Based on the soil texture use either the clay loam scorecard (clay loam to medium to heavy clay) or sandy loam – Loam score chart (Sand-sandy clay loam) – 1-2-3-4-5 as per chart</i>
Earthworms Spade – 30x30cm	0 -No worms per spade-full; no channels or castings	1 -1-4 worm per spadeful; few channels or castings	2 ->4 worms per spadeful; many channels & castings						<i>Earthworm numbers and activities are very soil moisture and temperature dependent. If not comparing treatments at same moisture and temperature conditions, then you should aim to sample at the same time each year. Score 0-1-2 for Poor-Fair-Good</i>
Roots	0 -Weak root dev., no soil sticking to rhizosphere	1 -Moderate root dev.; small amount of soil sticking to rhizosphere	2 -Strong roots; soil sticking to root rhizosphere						<i>Make general observation on root occurrence and health. Score 0-1-2 for Poor-Fair-Good</i>

Visual assessment 15-30cm

TEST	Poor	Fair	Good	Test scores (0-2)					Comments
				# 1	# 2	# 3	# 4	Av.	
Compaction layers See chart	0 -Strong hardpan; little to no roots, worm channels, or cracks.	1 -Moderately dev. hardpan; few roots, worm channels, or cracks.	2 -No hardpan; roots, worm channels, & cracks common						<i>In the soil pit rapidly jab the face of the pit with the knife, starting at the top and working quickly down to the bottom. Note if there are rapid changes. Record the depth where any change occurs. Score based on the Chart 4. NB soil strength is very water dependent, make sure the general soil moisture is noted in the summary information. Score 0-1-2</i>
Soil structure See chart	large compact clods, few crumbs	some clods	Friable, aggregated, breaks into crumbs						<i>Based on the soil texture use either the clay loam scorecard (clay loam to medium to heavy clay) or sandy loam – Loam score chart (Sand-sandy clay loam) – 1-2-3-4-5 as per chart</i>
Earth-worms	0 -No worms or signs of worm activity (channels or castings)	1 -Some worms or signs of worm activity (channels or castings)	2 -Abundant worms or signs of worm activity (channels or castings).						<i>Earthworm numbers and activities are very soil moisture and temperature dependent. If not comparing treatments at same moisture and temperature conditions, then you should aim to sample at the same time each year. Score 0-1-2 for Poor-Fair-Good</i>
Roots	0 -No roots	1 -Moderate root dev at this depth	2 -Strong roots development at this depth						<i>Make general observation on root occurrence and health. If a clear root depth is observable in the soil pit record the depth. If the roots continue to depth then record > than the hole depth (cm). Score 0-1-2 for Poor-Fair-Good</i>

Equipment required

1. Field sheets
2. Camera
3. GPS (set to give decimal coordinates)
4. Spade
5. 2 buckets or large plastic bags (about 750 x 500 mm) for bulking soil samples clearly labelled 0-15 cm; 15-30 cm and subsoil if identified as an issue in the Soil Improvement Plan.
6. 2-soil sample bags– for sending 700g subsample to the lab for analysis
7. Knife (200mm blunt blade)
8. Brush (for cleaning loose soil of the soil profile)
9. Tape measure for photos and measuring depths
10. Water bottle for field textures
11. Paper towels
12. Chart 1 – Surface crusting chart
13. Chart 2 – Soil field texture chart
14. Chart 3a – clay loam structure score chart
15. Chart 3b – Sandy loam – loam structure score chart
16. Chart 4 – Compact layer chart
17. Chart 5 – Root development chart

SOIL IMPROVEMENT PLAN

STEP1 – My property

Completed by:

Date:

Property / Location

Farm size and area used for vegetables:

STEP 2 My soil issue

What are your top 3 soil issues (1= most important)

Rank	Soil constrains	Reason for constraint
	Loss of organic matter	
	Soil borne diseases	
	Problem weeds	
	Soil structure issues:	
	Poor root growth	
	Soil nutrient issues	
	Acidification (pH drop)	
	High pH	
	Salinity (high EC)	
	Sodicity (high ESP)	
	Soil loss	
	Soil biology	
	Other	

STEP 3 My current paddock management

Paddock – where will you change management?

Paddock history e.g. rotations, break/cover crops, fallows etc.

Year	Winter (Jun-Aug)	Spring (Sept-Nov)	Summer (Dec-Feb)	Autumn (Mar-May)

Main soil type and texture of paddock

Soil management:

e.g. list tillage equipment and passes / timing etc.

Nutrition management:

e.g. soil testing, plant testing, fertiliser programs, soil amendments, fertigation, foliar fertilisers

Irrigation management:

e.g. irrigation system, scheduling, monitoring etc

STEP 4 – My new paddock management

Main issues - summarise the main issues from STEP 2

What do you hope to achieve by addressing the soil issue identified above?

- Increased marketable yield, pack out of high grade product, or total yield.
- Decrease input costs, machinery use or labour.
- Improve soil and environment.
- Reduce soil loss and impact of flooding/extreme weather.
- Learn new things and build skills.

Main benefits of fixing the soil issue

What practice do you think you need to try to improve your soil?

- Cover/break cops
- Rotation & planting dates
- Biofumigation
- Organic amendments
- Reduce tillage
- Controlled traffic/Permanent beds
- Precision farming (yield monitoring, soil mapping etc)
- Nutrition monitoring & management
- Soil moisture monitoring & management

Main practices to improve your soil

STEP 5 My Soil Improvement Plan

What are you going to do?

When and How (e.g. rotation, rates, timing, species, transitions, machinery, suppliers, issues to manage)

Cost/ha

Benefit

Monitoring to Manage

Will you monitor changes to see if it improves returns or soil?

What	When	How often

Send to email address for review by the Soil Wealth Team

Soil Wealth and ICP Impact Survey

Horticulture Innovation Australia
May 2017

Introduction and purpose

The Soil Wealth and Integrated Crop Protection (ICP) projects provide R&D extension services, products and communication on improved soil management and plant health to the Australian vegetable industry.

Over the past 3-years, AHR and RMCG have delivered the extension projects on behalf of Horticulture Innovation Australia, and consulted with a wide range of growers and industry stakeholders to determine their impact and value.

The impact survey was open from 1 to 24 May 2017 and took respondents less than 10 minutes to complete. It was predominately administered online through existing industry communication channels with some responses sought face-to-face at the Hort Connections conference in Adelaide from 15 to 17 May 2017. Participation was voluntary and all responses remained confidential. A total of 165 responses were received.

This paper documents the survey findings.

Findings

RESPONDENT OVERVIEW

A large variety of stakeholders from all states and territories responded to the survey, which provided a strong and representative basis for the findings (Figure 1). This was predominately comprised of advisors (40%) and vegetable growers (18%). The category 'Other' (11%) mainly comprised of natural resource management (NRM) agency staff, extension officers and community organizations.

The grower respondents grew a wide variety of crops including lettuce (17%), baby leaf (14%), leeks (14%), beans (11%), broccoli (11%), cabbage (11%) and Brussels sprouts (6%) covering some 24,118 hectares (n = 35).

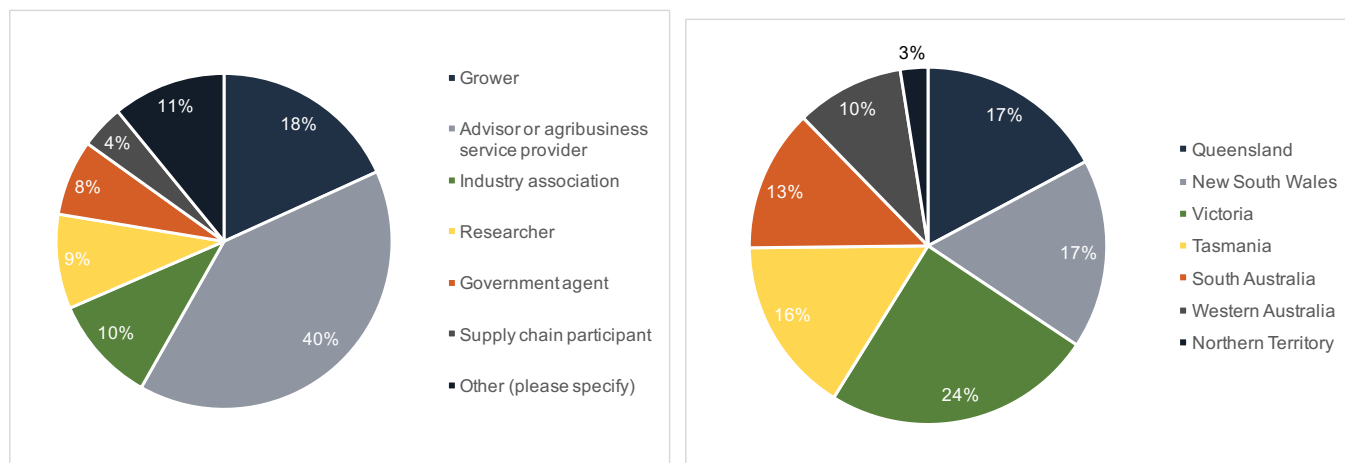


Figure 1: Survey respondent type (left) and location (right) (n = 165)

AWARENESS AND KNOWLEDGE

The projects have engaged with growers and industry stakeholders in a variety of ways. More than half (56%) of respondents were involved in a workshop, field day or training event, while one-third (33%) participated in a webinar (Figure 2). The least number of people were engaged in grower groups (6%) due to the relatively discrete nature of this activity.

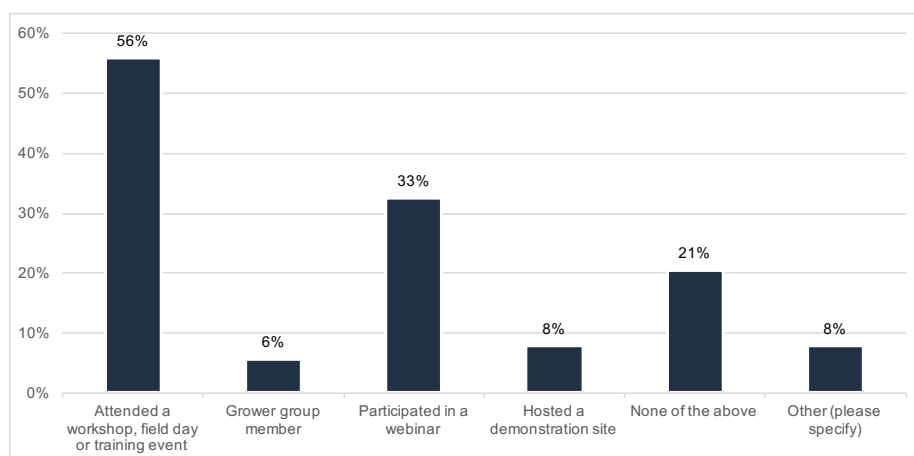


Figure 2: Project engagement methods (n = 141)

There has been a strong focus on communication products and resource development during the first phase of the projects. Three-quarters (75%) of respondents had received the e-newsletter 'The Bulletin' and almost half (49%) had accessed material from the website (www.soilwealth.com.au) (Figure 3). Social media was relatively popular for demonstration updates on Facebook (21%) and news and events on Twitter (11%). Video case studies, while produced later in the project, were viewed by 19% of respondents. Positively, only few (10%) had not been communicated with through one of the designated channels.

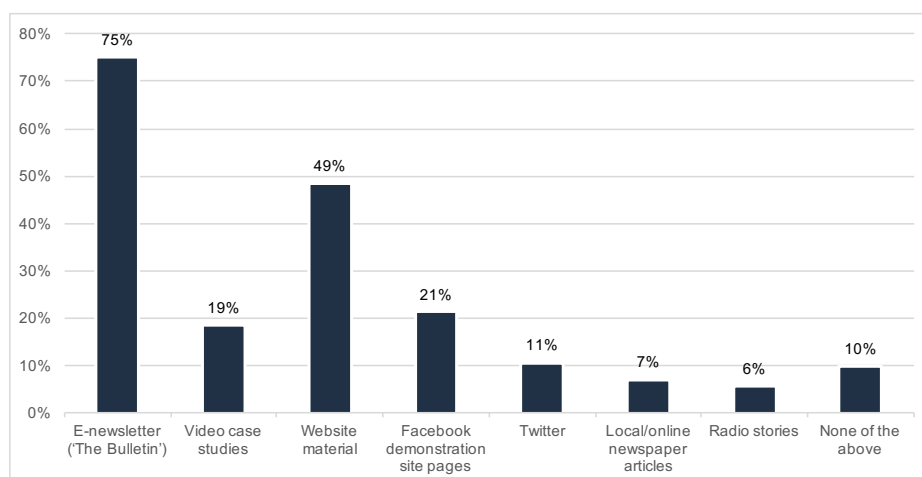


Figure 3: Communication channels (n = 140)

Respondents were asked to rate their level of knowledge in key areas before and after being involved in the project (Figure 4). Importantly, gains across all 12 key topics were demonstrated, particularly in relation to biofumigation and cover crops (0.46 weighted average change), compost and soil amendments (0.33), and precision farming (0.33). There were less significant gains in weeds (0.05), crop nutrition, soil testing and fertiliser (0.09), and identification of pest, disease or weeds (0.14). This may have been due to a higher level of knowledge in that areas prior to being involved in the project.

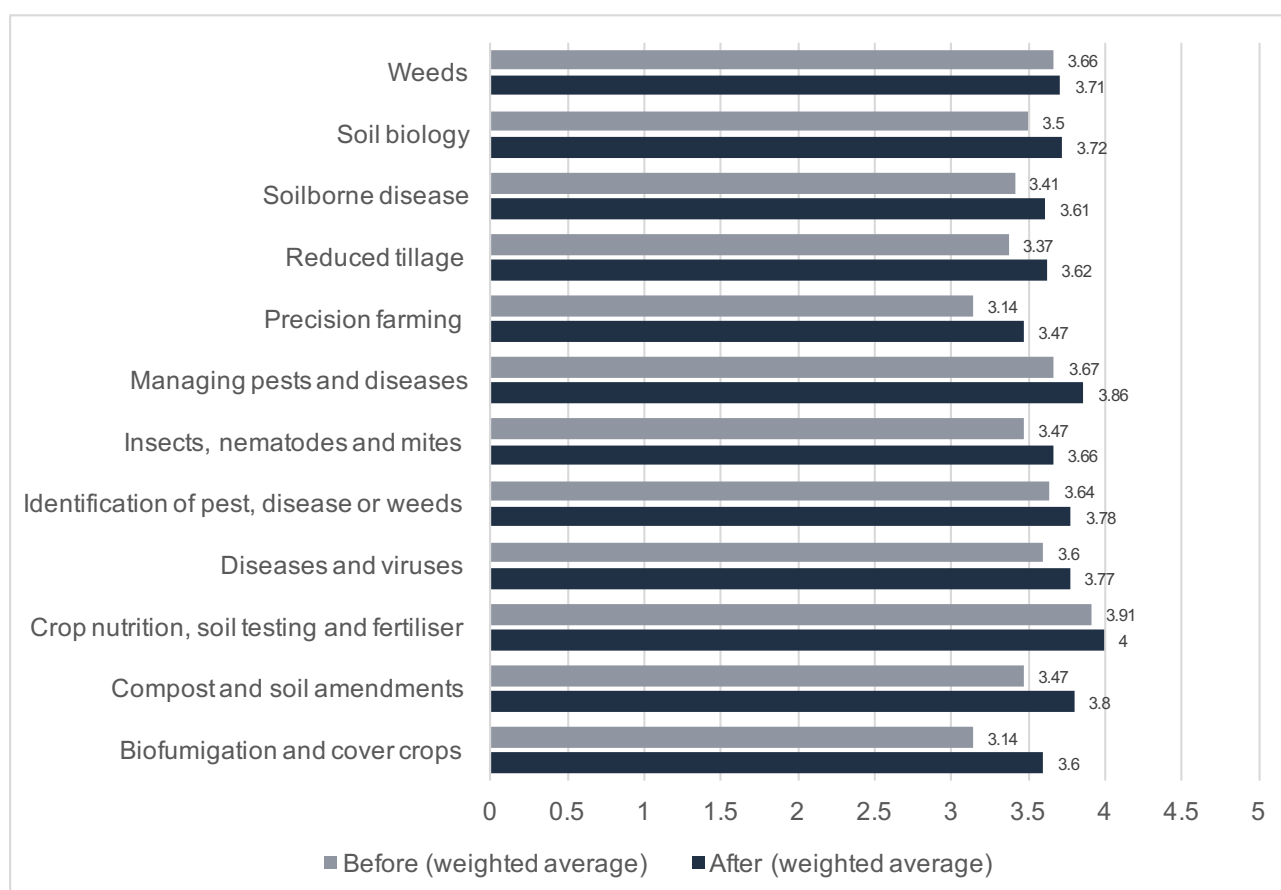


Figure 4: Change in knowledge before and after project involvement (n = 138)

PRACTICE CHANGE OR INTENT TO CHANGE

One of the key aims of the projects was to influence decision-making and practices on vegetable farms. Almost half the respondents (44%) identified undertaking, or planning to undertake, activities aimed at improving soil health and/or crop protection on their farm / or in the advice they provide because of being involved in the Soil Wealth and ICP projects (wholly or partly) (Figure 5). A further 39% of respondents were undertaking, or planning to undertake, changes but not as a result of the projects. It was very likely (69%) or likely (20%) these changes would be implemented in the next two to three years.

These changes mainly related to (n = 83):

- General soil health (28%) e.g. biology, physical properties, testing
- Cover crops (27%)
- Compost (23%)
- Biofumigation (12%)
- Crop rotation (10%)
- Green manure crops (6%)
- Undertaking trials on-farm (5%)
- Controlled traffic (2%)
- Reducing tillage (2%).

Only very few (7%) weren't planning to make changes, while 10% were unsure. This may be due to needing further support, resources and/or capacity to make the required change.

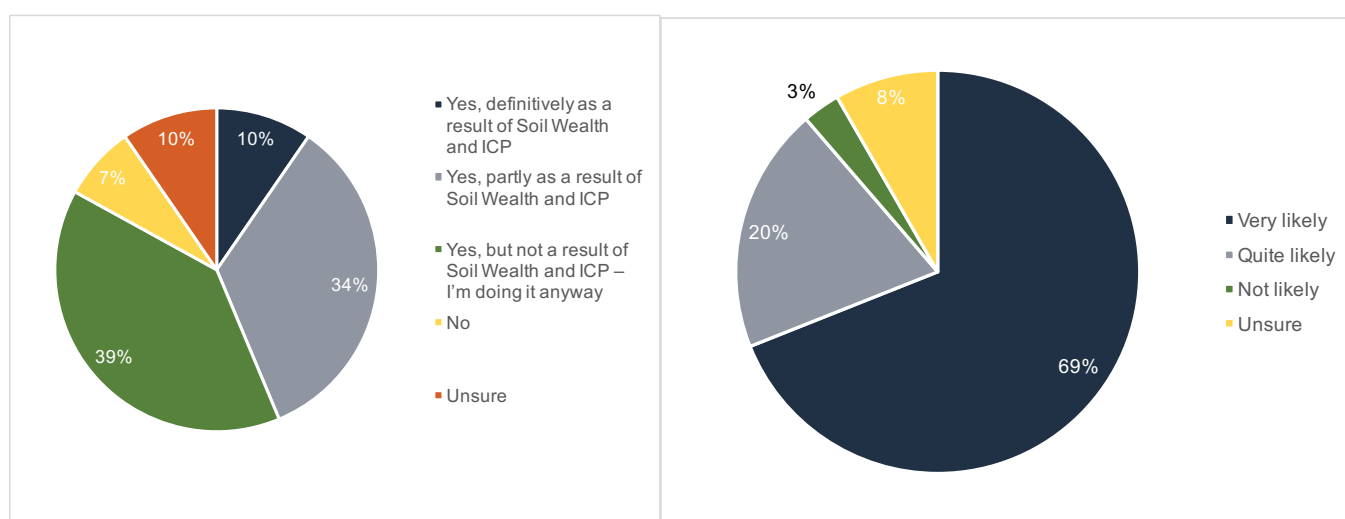


Figure 5: Practice change as a result of the projects (left) and likelihood change will occur in two to three years (right) (n = 135)

EFFECTIVENESS OF THE PROJECT

The projects placed a high degree of importance on providing scientifically sound and timely services and communication relating to soil management and plant health. The majority of survey respondents found the support and information provided through Soil Wealth and ICP very useful (30%) or quite useful (50%) (Figure 6). Only very few (7%) did not find the support and information useful.

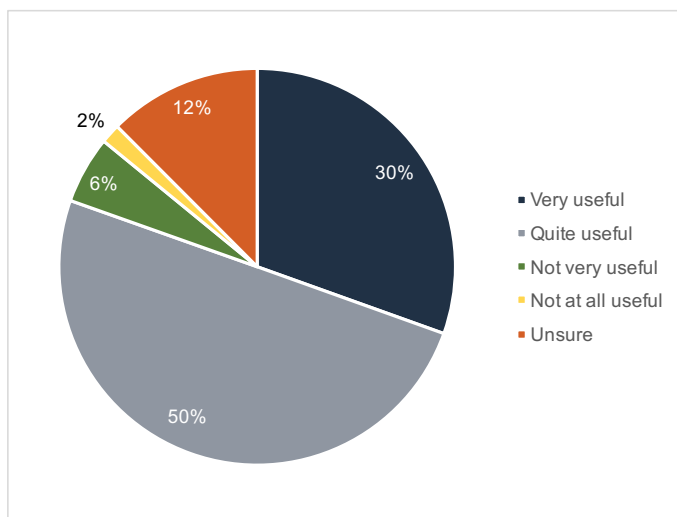


Figure 6: Usefulness of support and information provided by the projects (n = 128)

Almost half (40%) of survey respondents felt well informed about the latest advancements in the vegetable industry, while a further 45% felt somewhat informed (Figure 7). This was usually due to receiving information via the preferred method (e.g. e-newsletter, workshop) that was high quality (n = 19).

A small proportion (9%) felt they had not been kept informed or were unsure (5%). The reasons respondents provided for this were already having a high degree of knowledge in the area, not having sufficient time to investigate the full suite of project resources, or the complexity of the topics covered (n = 19).

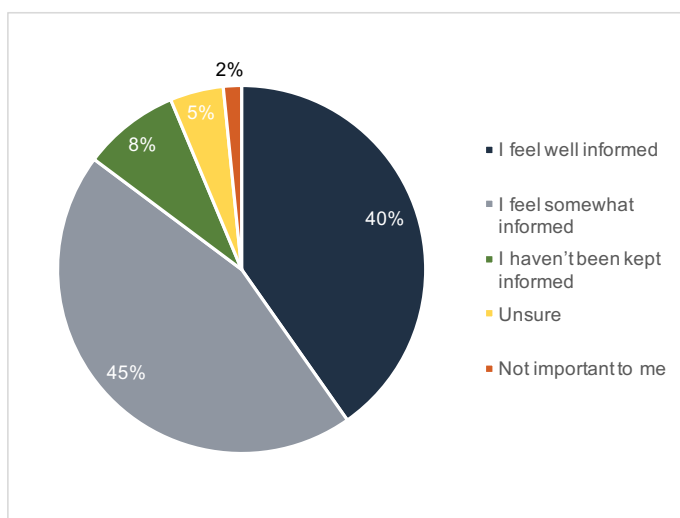


Figure 7: Extent to which respondents felt informed about the latest advancements in the vegetable industry (n = 129)

Respondents were invited to provide qualitative feedback on the benefits and areas for improvement for the projects. The main benefits for respondents being involved in the Soil Wealth or ICP projects were (n = 80):

- Improved knowledge and confidence (23%)
- Improved soil health and management practices (16%)
- Relevance and specificity to the vegetable industry (11%)
- Networking opportunities with like-minded people (10%)
- Practical demonstrations, advice and solutions (6%)

- Linking with the latest research (5%).

While relatively minor compared to the benefits, the following issues or problems were identified by respondents (n = 53):

- Maintaining equitable and targeted geographic coverage and linking with the most appropriate state or regional providers (9%)
- Further work could have been undertaken on specific soil types as well as understanding the economic considerations of soil management practices (7%)
- Maintaining grower interest in project activities (6%)
- Providing compensation or incentives for demonstration site growers
- Webinars being postponed or cancelled.

LOOKING TO THE FUTURE

The survey provided the opportunity to inform the topic coverage of the second phase of the projects. Respondents identified the following additional topics that could be covered in the future (n = 51):

- General soil health (39%) e.g. biology, compaction, soil carbon, test result interpretation
- Disease control and management (14%)
- Compost and soil amendments (12%)
- Management changes and how these fit into the farm (8%)
- Resistance management for insecticides and herbicides (8%)
- Nematode control and management (6%)
- Biofumigation and impact on soil microbes and farm budget (6%).

Additional comments from respondents were largely positive and related to the work of the project team (12%), and good program delivery, resources (e.g. website) and organisation (9%) (n = 32).

Conclusions and recommendations

A representative survey of 165 Soil Wealth and ICP participants has found the projects have achieved a reasonable level of extension of R&D in the 3-years from 2014 to 2017. This can be considered both in terms of the reach of project information across all major vegetable growing regions around Australia with various available communication channels, as well as the rate of adoption of soil management and crop protection management practices or advice being provided, predominately due to the practical demonstration site delivery mechanism.

The projects have been effective in delivering scientifically sound and timely services and communication, which has benefitted participants by being relevant to the vegetable industry, providing useful networking opportunities, and practical solutions to farm production system problems.

There is also broad support for continuation of the projects that cover a broader range of soil management and plant health topics. The second phase of the project needs to continue to respond to grower and industry needs, engaging a new segment of the target audience, while providing equitable geographic coverage.

New methods of delivering extension to Australian vegetable growers and advisors

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Abstract. The Soil Wealth and Integrated Crop Protection projects have struck a chord with growers and advisors alike, filling a need in the provision of practical and useful information in a new way for the Australian vegetable industry. The projects have developed innovative approaches to deliver information on soil, pest and disease management to growers. Methods focus on engaging directly with growers and advisors; demonstrating new innovations on the farms of leading growers; social media (Twitter, Facebook and YouTube) and webinars. More conventional methods have also been used, including workshops, farm walks, fact sheets, videos and a central website. This paper discusses the key success factors of the projects in engaging with the target audience and promoting the adoption of research and development.

Keywords: soil management, plant health, vegetable production, capability, demonstration sites, e-extension

Introduction

The Soil Wealth and Integrated Crop Protection (ICP) projects provide research and development (R&D) extension services, products and communication on improved soil management and plant health to the Australian vegetable industry.

Over the past three years from 2014 to 2017, RMCg and AHR have delivered the projects for Hort Innovation. The project team played a knowledge brokering role between researchers, growers and other industry stakeholders to ensure adoption of R&D on-farm. The key technical areas included cover crops, biofumigation, reduced tillage, compost and soil biology, control methods for specific pests and diseases, integrated pest management (IPM) and pesticide application technology.

The Australian vegetable industry is the largest of the horticultural industries with a farm gate value of \$3.7 billion, and invests \$12-14 million in research, development and extension each year. For many years, the information generated by R&D in soil health, pest and disease and soil-borne disease management has not always been communicated to growers and advisors in an effective way.

Funding for R&D in the vegetable industry is sourced through a levy system administered by the Research and Development Corporation (RDC) Hort Innovation. The levy covers 42 commodity groups including most vegetables, some of which have their own separate funds.

Commercial vegetable growing operations vary in scale, commodity type and location however they share intensive production systems and tight crop rotations. This diversity increases the complexity of the extension effort while the intensive nature of production heightens the importance of sustainable soil management and plant health practices.

The key success factors for the project in engaging with the target audience and promoting the adoption of R&D on-farm include:

- Integrate a range of communication platforms and engagement methods to improve awareness and knowledge
- Drive practice change through demonstration – ‘make it real and relevant’
- Build a trusted voice – scientifically sound and timely services and communication.

These themes are discussed in turn below and supporting evidence is provided from an impact survey undertaken by the project team with growers, advisors and key industry stakeholders. This was a representative sample (n = 165) and covered all major vegetable growing regions in Australia.

Integrate a range of communication platforms and engagement methods

The projects needed to integrate a number of communication platforms and engagement methods due to the broad geographic coverage and large amount of historic R&D on soil

management and plant health. This meant the projects played a knowledge brokering and prioritisation role, with a focus on quality rather than quantity. The different tools and methods used by the project team included:

- Demonstration sites
- Grower groups
- Master classes and networking opportunities
- Training and events: workshops, field days, farm walks, webinars
- Benchmarking activities and economic case studies
- Publications and videos
- Online communication and knowledge management: website, social media (Facebook, Twitter, YouTube), e-news

The projects have connected with growers and industry stakeholders in a variety of ways, with 1,934 unique growers and industry stakeholders engaged from 2014 to 2017. More than half (56%) of respondents to the impact survey were involved in a workshop, field day or training event, while one-third (33%) participated in a webinar (Figure 2). The least number of people were engaged in grower groups (6%) due to the relatively discrete nature of this activity.

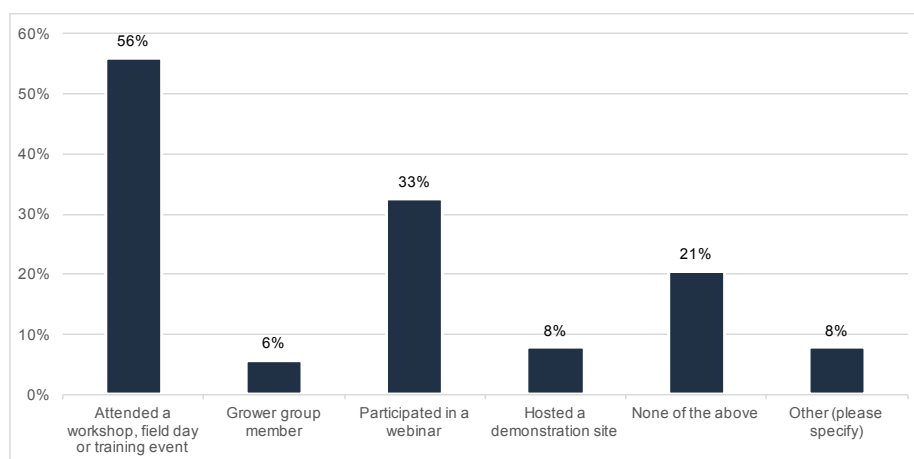


Figure 1: Project engagement methods (n = 141)

There has been a strong focus on communication products and resource development during the first phase of the projects. Three-quarters (75%) of respondents had received the e-newsletter 'The Bulletin' and almost half (49%) had accessed material from the website (www.soilwealth.com.au and www.integratedcropprotection.com.au) (Figure 3). Social media was relatively popular for demonstration site updates on Facebook (21%) and news and events on Twitter (11%). Video case studies, while produced later in the project, were viewed by 19% of respondents. Positively, only few (10%) had not been communicated with through one of the designated channels.

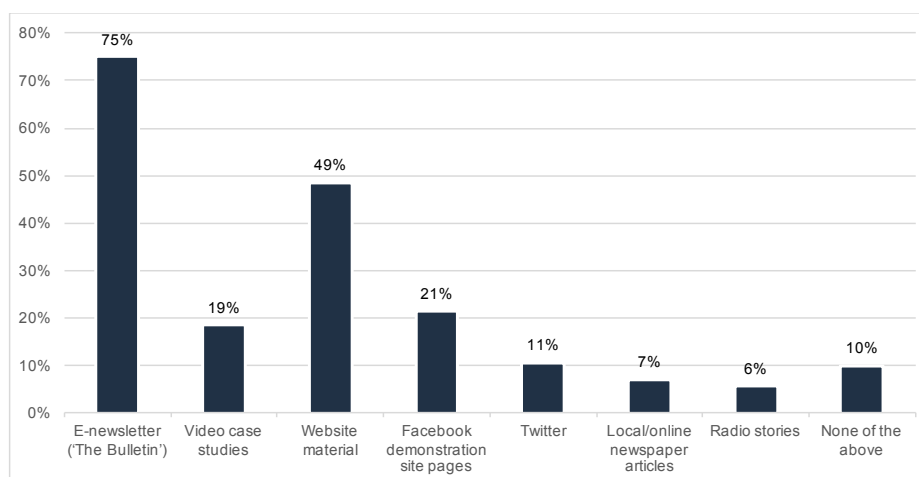
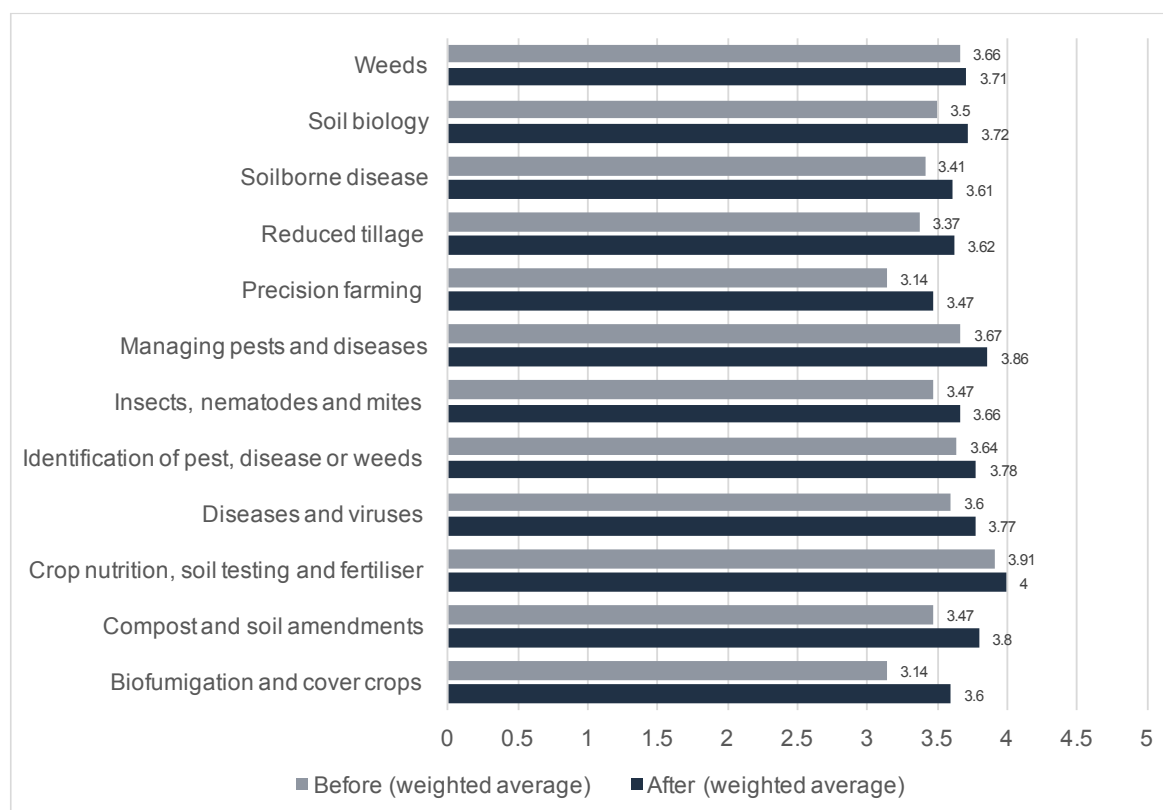


Figure 2: Communication channels (n = 140)

Respondents were asked to rate their level of knowledge in key areas before and after being involved in the project (Figure 4). Importantly, gains across all 12 key topics were demonstrated, particularly in relation to biofumigation and cover crops (0.46 weighted average change), compost and soil amendments (0.33), and precision farming (0.33). There were less significant gains in weeds (0.05), crop nutrition, soil testing and fertiliser (0.09), and identification of pest, disease or weeds (0.14). This may have been due to a higher level of knowledge in these areas prior to being involved in the project.

**Figure 3: Change in knowledge before and after project involvement (n = 138)**

Drive practice change through demonstration – ‘make it real and relevant’

A central engagement method and corner-stone of the extension projects were 15 on-ground demonstration sites in every major vegetable growing region of Australia (Figure 4). These sites provided the ‘practical sand pit’ for leading growers, researchers and other industry stakeholders to put R&D into practice.

The demonstration sites were the ‘practical hook’ for the delivery of workshops and farm walks, as well as the development of resources such as fact sheets, case studies and videos. These sites covered a number of different technical areas based on the specific objectives and interest area of the host grower including cover crops, biofumigation, reduced tillage, compost and soil biology, control methods for specific pests and diseases, integrated pest management (IPM) and pesticide application technology.

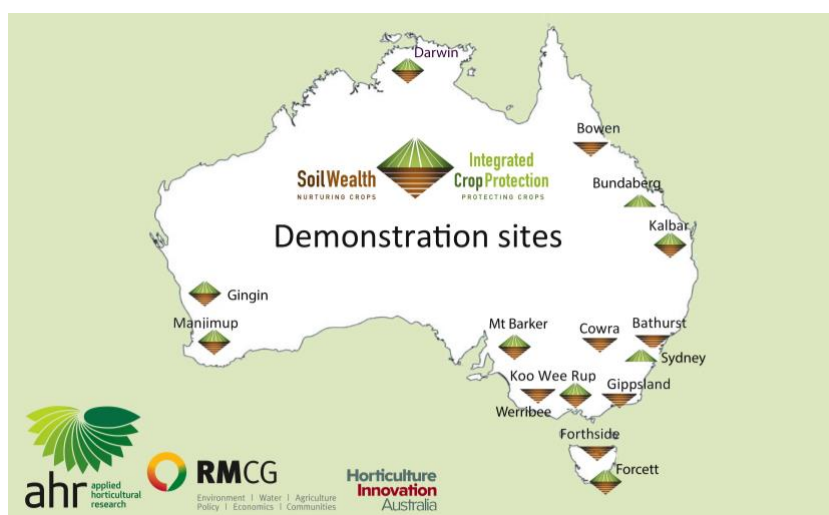


Figure 4: Location of demonstration sites

One of the key aims of the projects was to influence decision-making and practices on vegetable farms. Almost half the survey respondents (44%) identified undertaking, or planning to undertake, activities aimed at improving soil health and/or crop protection on their farm or in the advice they provide due to their involvement in the Soil Wealth and ICP projects (wholly or partly) (Figure 5). A further 39% of respondents were undertaking, or planning to undertake, changes but not as a direct result of the projects. It was very likely (69%) or likely (20%) these changes would be implemented in the next two to three years.

These changes mainly related to (n = 83):

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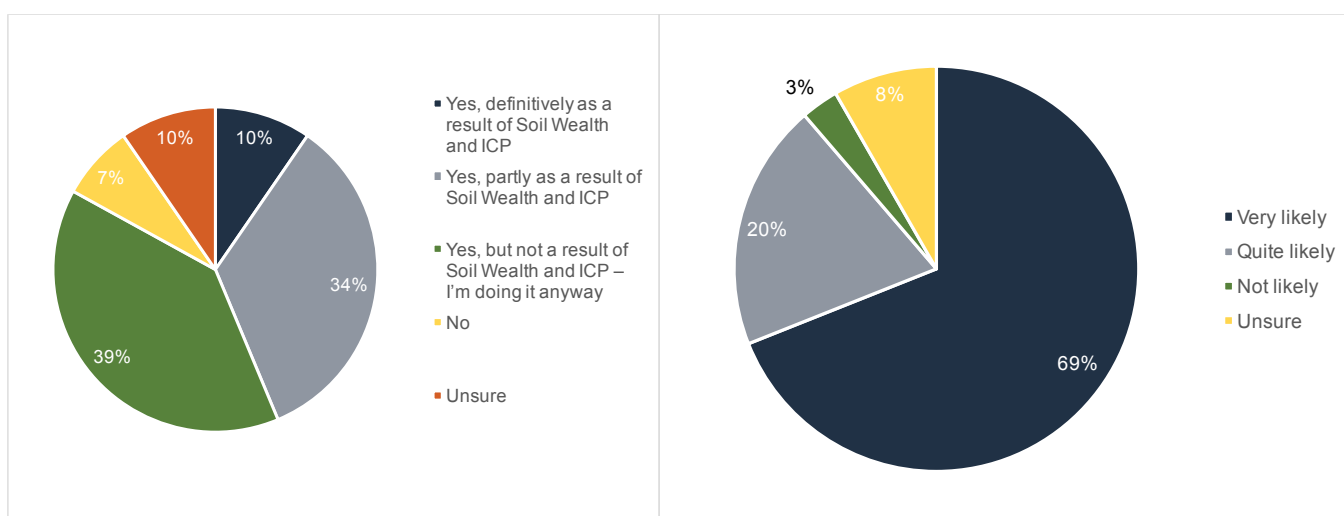


Figure 5: Practice change as a result of the projects (left) and likelihood change will occur in two to three years (right) (n = 135)

Build a trusted voice – scientifically sound and timely

The projects placed a high degree of importance on providing scientifically sound and timely services and communication relating to soil management and plant health. The principles of approach to information provision during the project period included:

- Understand the audience and segmentation to inform a tailored and targeted approach - based on production system, location, information needs, cultural background and individual drivers
- Quality over volume – prioritisation of content
- Focus on engagement to complement communication
- Integration of platforms to build presence – various communication platforms for different segments (Stirling et al. 2015).

The majority of survey respondents found the support and information provided through Soil Wealth and ICP very useful (30%) or quite useful (50%) (Figure 6). Only very few (8%) did not find the support and information useful.

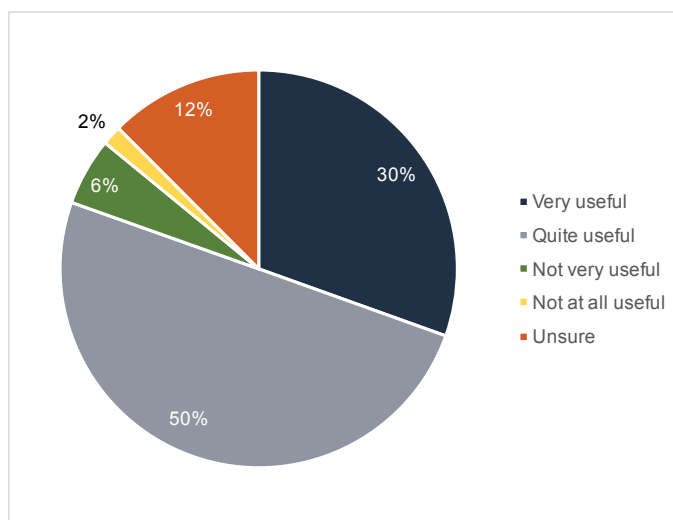


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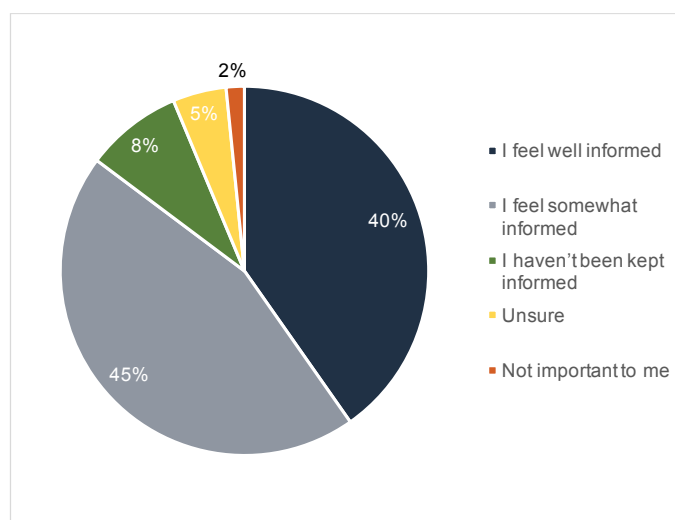


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Conclusions

The Soil Wealth and ICP projects have achieved a reasonable level of extension of R&D in the 3-years from 2014 to 2017. This can be considered both in terms of both the:

- reach of project information across all major vegetable growing regions around Australia with various available communication channels, and
- rate of adoption of soil management and crop protection management practices or advice being provided, predominately due to the practical demonstration site delivery mechanism.

The projects have been effective in delivering scientifically sound and timely services and communication, which has benefited participants by being relevant to the vegetable industry, providing useful networking opportunities, and practical solutions to farm production system problems.

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Acknowledgements

The project team would like to thank the vegetable growers and advisors who hosted demonstration sites and contributed to the Project Reference Group.

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