



# FINAL REPORT 2016/025

## Masterclasses in Soil Health and Soil Biology for the Sugar Industry

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## ABSTRACT

A total of 252 sugar growers, productivity services staff and others attended a series of Master Classes in Soil Health/Soil Biology that were held in 2017 and 2018. During those classes they had the opportunity to see some of the microscopic organisms that are found in soil and learn how sugar farming systems could be modified to improve soil biological health.

The classes were run by Dr Graham Stirling (Biological Crop Protection), Dr Anthony Young (University of Queensland), Dr Jay Anderson (University of Queensland) and Mr Sebastien Garcia-Cuenca (Sugar Research Australia). However, the highlight of each class was the presentation by one of three growers: Ashley Petersen, Tony Chapman and Simon Mattsson. They explained how they were able to modify their farming system and discussed the soil health and economic benefits they had obtained.

Each class concluded with a discussion on how growers could move forward and improve the health of their soils. The process involved identifying the key soil constraints that were limiting productivity; developing an action plan to rectify the problems; modifying the farming system in some way; and then instigating a monitoring program to confirm that benefits had been obtained.

Feedback from the participants indicated that the classes were a resounding success. Comments were overwhelmingly positive and compliments such as “excellent course: engaging and interesting”, “the use of microscopes, practical application was great!” and “continue this every year!” were received. Those who attended clearly enjoyed the classes and most indicated that they were willing to accept the challenge of implementing a soil improvement plan.

## EXECUTIVE SUMMARY

The aim of this project was to improve sugar growers' knowledge of soil biology and soilborne diseases and provide them with a holistic understanding of the management practices required to improve the health of their soils.

Between February 2017 and March 2018, a total of 15 Sugarcane Soil Health Masterclasses were delivered to 231 participants across 6 regional venues in Queensland and NSW. The 2017 venues were Mackay, Ballina (Pimlico) and Ingham, the Masterclasses in 2018 were delivered in Childers, Mourilyan and the Burdekin (Ayr), and based on early demand, two additional classes for extension staff were funded through the Wet Tropics Sugar Industry Partnership (WTSIP) and the Department of Agriculture and Fisheries and were held in 2017 at Gordonvale and Tully. Half of all participants were growers (49%), but the sessions were also attended by grower advisors (37%) and other industry representatives (14%).

The Sugarcane Soil Health Masterclasses provided intensive workshop-style training sessions covering key aspects of sugarcane soil health. The sessions were designed to be interactive and practical, and aimed at challenging participant knowledge and inspiring adoption of on-farm practices that deliver improved soil health outcomes. Key to the success of the program was the hands-on examination of material significant to soil health, including bacteria, fungi, oomycetes, nematodes, microarthropods and larger fauna. Participants also looked at healthy and unhealthy sugarcane roots, they were shown how the biological status of soil could be assessed; and took part in practical planning sessions improving on-farm practice. For many who attended the classes it was the first time they had successfully used microscopes. This element was of critical value because it had a transformative effect on the participants who were then inspired to better understand the biology of the land they work or have influence over.

The interactive sessions were delivered by a small team of professionals comprising Dr. Graham Stirling (Biological Crop Protection), Dr. Jay Anderson (The University of Queensland, UQ), Dr. Anthony Young (UQ), and Mr. Sebastien Garcia-Cuenca (Sugar Research Australia, SRA). Ms. Andrea Evers (SRA) ensured that all the logistics required for successful participant engagement and material delivery were met. Each presenter delivered content in their specialist field and also provided support during the practical sessions when a range of soil organisms were being inspected.

Prior to the commencement of the classes, soil samples were collected from each location and various analyses of biological health were undertaken to provide local data for discussion in the class. The analyses and interpretations for each location were included in a workbook provided to each participant so that they could refer to the analyses at a later date and also see data from other locations.

All participants were strongly encouraged to engage with the presenters, particularly when there were concerns about the utility of particular practices in their unique growing conditions. While several themes associated with soil health were delivered (e.g. soil carbon, compaction, root pathogens), there was a strong focus on the practicality of practice change. Without question, instrumental to this were the presentations made by growers who had adopted the key elements of an Improved Farming System: Simon Mattson, Ashley Peterson and Tony Chapman. These growers demonstrated to the participants that meaningful improvements to soil health could be achieved, and that this translated to improved economic returns to the farming business.

The Masterclasses were an overwhelming success. Feedback forms were offered to participants following most classes and 100% of the respondents considered the training activity useful, interesting and engaging. Just 2 respondents (0.6%) stated that they would take no action to improve soil health following the Masterclasses. Informal feedback received from participants indicated that they considered the Sugarcane Soil Health Masterclasses one of the most valuable industry workshops they had ever attended. In 2018, of the 51 respondents we put the question: *Do you have any suggestions to improve this course?* 67% provided extremely positive feedback, 31% offered constructive comments and only one person was negative.

Following negotiation with SRA during project inception, it was considered worthwhile to include an Action Plan session so as to generate tangible outcomes for growers and advisors. While efforts were made to incorporate this outcome, it proved difficult to achieve because the day was already very intensive. In hindsight, it was probably too much to expect participants to develop an appreciation for the biological properties of soil and also generate a soil improvement plan in one day. Part of the success of the Sugarcane Soil Health and Biology Masterclasses was that they inspired the participants to investigate their own soil health. Change will obviously take time, but after the principles of soil health are instilled, it's likely that in many small and large ways, the grower participants will incorporate some of what they learned into their farming practice.

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## 1. BACKGROUND

The link between soil health and sustainable agriculture, and the critical role of the soil biota, was first recognised in the mid-1990s (Doran & Parkin, 1994; Doran *et al.*, 1996; Karlen *et al.* 1997). Since then, agricultural industries around the world have been attempting to restore the productive capacity of their soils and better understand the biological processes that contribute to soil health. During this process, a huge amount of scientific literature has been generated and two recent reviews (Lehman *et al.*, 2015; Stirling 2017) provide a good summary of what has been learnt in the last 20 years.

What is clear from the soil health literature is that the practices used to grow crops must be viewed from both a production and environmental perspective. In addition to producing vigorous, high-yielding crops, the farming system must nurture the soil and safeguard the surrounding environment from degradation. Soil is a non-renewable resource and cannot be considered healthy unless it fulfils a range of functions that are vital for crop production (absorption and infiltration of water, storage and release of nutrients, suppression of pests and diseases) and also sequesters carbon, maintains biodiversity, detoxifies harmful chemicals, maintains water quality, prevents nutrient and sediment loss to waterways and minimises greenhouse gas emissions. These fundamental ecosystem services, which are crucial for a well-functioning soil and the basis of agricultural sustainability, are provided in a multifaceted manner by the soil biological community (Lehman *et al.* 2015).

Since agricultural management practices influence the biomass, numbers, diversity and activity of soil organisms, they have flow-on effects to soil health. Those effects are now widely recognised and are summarised in Table 1. Three of the most important soil improvement practices (minimal soil disturbance, permanent plant residue cover and crop rotation) form the basis of conservation agriculture, an agricultural production system that has been adopted by many farmers throughout the world (Hobbs *et al.* 2008; Kassam *et al.*, 2008).

Table 1. Generalised effects of agricultural management practices on soil health (modified from Lehman *et al.*, 2015).

Practices that tend to reduce soil health	Practices that tend to promote soil health
Aggressive tillage	No-till or conservation tillage
Annual/seasonal fallow	Cover crops or relay crops
Monoculture	Diverse crop rotations
Random trafficking with heavy machinery	Controlled traffic
Annual crops	Perennial crops
Excessive inorganic fertiliser use	Organic fertiliser use (manures)
Excessive crop residue removal	Crop residue retention
Broad spectrum fumigants/pesticides	Integrated pest management
Broad spectrum herbicides	Weed control by mulching and/or cultural tactics

The Australian sugar industry has known for many years that soil bio-physical factors were reducing the yield potential of sugarcane. Garside *et al.* (1996) reviewed the early literature and noted a report by Maxwell (1900) which concluded that poor and declining yields were due to soil-related factors. Bell (1935, 1938) made observations in the Bundaberg-Gin-Gin region and noted that “the native fertility is being rapidly lost by growing a crop which is a gross feeder and requires constant cultivation which brings about fertility depletion and soil erosion: the soil is becoming dead”.

More recent work has also shown that the sugar industry has major soil physical and chemical problems. Soils under long-term sugarcane culture are heavily compacted, highly acidic, suffer surface crusting and hard setting problems, are low in labile and total carbon, have low cation exchange capacities and do not infiltrate and store water readily (Bell et al. 2001; Garside et al., 2005; Stirling et al. 2010). Soil biological health is also poor, as microbial biomass is relatively low and most soils have high numbers of plant-parasitic nematodes and fungal and oomycete pathogens that destroy roots (Magarey and Croft, 1995; Stirling et al. 2001; Pankhurst et al. 2005 a, b; Blair & Stirling 2007; Stirling 2008).

The Sugarcane Yield Decline Joint Venture (SYDJV) was set up in 1993 to find solutions to the yield decline problem and after 13 years of research, an alternative sugarcane farming system was proposed. This system was based on four basic principles: organic matter conservation, breaking the monoculture, controlling traffic and minimising tillage (Garside et al. 2005). Although the farming system included many of the practices listed in Table 1 as promoting soil health, it has not been widely implemented. Rotation crops are not always grown, most sugarcane soils are routinely tilled, harvest traffic is not always controlled, high rates of inorganic fertilisers are used, pesticides are regularly applied for soilborne pests and disease control, and crop residues are not always retained.

If the sugar industry is to have a sustainable future, it must do a better job at addressing its soil health problems. Thus, growers must face the challenge of adopting a farming system that will result in soils with the following characteristics: 1) a physical structure that will infiltrate water, drain readily and provide homes for the soil fauna that are partly responsible for disease suppression; 2) levels of soil organic matter that are high enough to stimulate biological nutrient cycling processes and improve the supply of nutrients to plants; 3) a large and diverse population of beneficial soil organisms to cycle nutrients, decompose organic matter, improve soil structure and suppress pathogens and pests.

In the second phase of the Sugar Yield Decline Joint Venture (1999 to 2006), more than 30 meetings and workshops were held to inform sugar growers, productivity services officers and extension staff of the practices required to improve soil health and sustain productivity in the long-term. Also, more than 25 extension articles were published in Australian Sugarcane and the BSES Bulletin. Since then, the same messages have been promoted in many other forums (e.g. Smart Cane Best Management Practices Project and associated booklet series (Schroeder et al. 2008), SRA BMP Soil Health Workshops (SRA - McGuire 2015, MSF Project Uplift Initiative, 2016)). However, adoption rates have been slow and have arguably reached a plateau, with only a small proportion of growers having integrated all the required crop and soil management practices into their farming system.

Garside et al. (2005) pointed out that the farming system proposed by the SYDJV was not prescriptive and that many variations would be acceptable. However, growers can only make appropriate changes to their farming system if they are aware that their management practices are degrading their soil and understand how to manipulate the community of organisms that play a key role in improving their soil's physical, chemical and biological properties. The soil health Master Classes discussed in this report aimed to overcome this knowledge gap using a range of modes of delivery. These included presentations from three experienced soil biologists, all of whom drew heavily from a book on soil health that was provided to each participant; hands-on learning using display material that many participants would have not had an opportunity to see before; hearing the experiences of growers who have implemented improved farming practices; discussions with



other participants with regard to their experiences in dealing with soil health problems; and conversations with growers about developing and implementing a soil health action plan.

## 2. PROJECT OBJECTIVES

The Masterclasses in soil health/soil biology targeted sugar growers together with extension personnel, productivity services staff, retailers and consultants working in the sugar industry. The key objectives were:

- To improve sugar grower's knowledge of soil biology and soilborne diseases and provide them with a holistic understanding of the management practices required to improve the health of their soils.
- The one-day classes were to be held in the main sugar-growing regions and targeted growers, extension and productivity services staff and consultants working in the sugar industry. All participants received a copy of a recently-published book that provided the basis for the Masterclasses: Stirling GR, Hayden H, Pattison T & Stirling M (2016) Soil health, soil biology, soilborne diseases and sustainable agriculture. A guide. CSIRO Publishing, Melbourne, 280 pp.).
- One class was to be held in February, another in March and a third in April each year, with each class catering for 15-17 participants. In 2017, classes were to be held at Ingham, Mackay and in northern NSW while in 2018 the locations were north Queensland, Ayr and the Bundaberg. At each location, two or three classes would be held in the same week so that about 50 people were catered for.
- During the classes, participating growers were expected to develop a long-term plan to improve the health of their soils. A local extension officer was to be nominated to link with these growers, and their role was to help the growers implement their management plans and assess practice change after 1, 2 and 5 years.

## 3. OUTPUTS, OUTCOMES AND IMPLICATIONS

### 3.1. Outputs

Two kinds of outputs were envisaged at the start of the project: 1) tangible resources would be produced for the workshop and they would be available for future use; and 2) growers, extension personnel and productivity staff would learn to think more holistically about issues related to soil health and be motivated to make improvements on their farms or assist growers who want to make improvements.

The material which was developed for the Masterclasses included:

- 1) A PowerPoint presentation covering all of the material presented at each class. Slight changes were made for each location to best meet the needs of the local growers.
- 2) A workbook given to each participant at the start of the class. It contained summary slides with key points, regional data sheets (see next point), action plan templates and space for the participants to take notes.
- 3) Data sheets for each location developed specifically for the Masterclasses. Samples from local sites and trials were taken, various assessments of biological health were made and the data and interpretations were included in the Handbook. This information was discussed in the classes and also used to support points made throughout the class.
- 4) An action plan template.
- 5) A list of materials used in the practical sessions, and placemats with photographs showing some of this material on display.

Whilst all of the above material is available for any further classes (see section 11.2), it should be noted that many of the specimens presented in the practical sessions were alive, and were specifically sourced or cultivated for the classes. If further Masterclasses are to be undertaken, some lead time and expertise will be required to obtain specimens for the practical sessions.

A total of 252 participants attended the Sugarcane Soil Health Masterclasses and undertook the training and it stands to reason that they are now more informed about soil biology and the practices that should be adopted to improve the health of their soils. Details about how much practice change occurred as a result of the classes are discussed in section 3.2.

### 3.2. Outcomes and Implications

The Master Classes were set up in the hope that they would encourage more growers to take the steps required to implement the recommendations from the SYDJV to improve the health of their soils. Whilst the primary objective was knowledge and capacity building (i.e. improve sugarcane growers' and other participants' knowledge of soil health and biology), a secondary objective was to provide some measure of impact and change. To that end, a soil health improvement action plan template was developed, presented and discussed at each class.

In an attempt to determine whether growers who attended a class had prepared an action plan or needed support to develop and implement such a plan, Sebastien Garcia-Cuenca consulted regional advisory groups, including productivity services and SRA adoption staff, to organise grower visits and follow-up actions. He also prepared tracking sheets after the 2016 classes so that progress could be monitored. The Adoption Officer in Mackay, the Project Catalyst Extension Officer in Herbert, and the Soil Health Officer in that region then undertook some follow-up work as part of their respective projects or their one-on-one extension role. However, despite their attempts to follow through with the action plan process, it was difficult to monitor progress or determine whether the action plan was having any real impact.

In retrospect, the action plan component of the project may have had more impact if it had been formalised as an SRA template and placed on the SRA website so that it was available for both growers and advisors to download and use on a voluntary basis. Furthermore, it is more likely that the planning template/tool would be used if a Productivity Services staff member was nominated to help the grower implement his/her action plan. The action plan template, or something similar, should also be integrated into on-farm projects such as the soil health project currently underway in the Burdekin and Herbert.

Throughout the day, but particularly after the participating growers' presentations, there was much discussion about local limitations that were preventing the adoption of practices that benefit soil biological health. There was often a perception that certain practices could not be used in the local region, but during those discussions, a range of modifications that could be tried were usually suggested by participating growers. One way of dealing with such issues in future would be to utilise local growers who can show that these problematic practices can be successfully integrated into a farming system.

While the main benefits from this project will not be seen for years, some of the participants have already taken some positive steps following the classes. As a direct result of the Masterclasses, growers and extension staff have shown increasing interest in some of the beneficial organisms in soil, their impacts, and their relevance when general soil health is being assessed. They have also been interested in the sampling and processing methods that can be used to assess a soil's biological

properties. For instance, the NSW Productivity Services team in collaboration with SRA are now planning a nematode and soil biology survey across 45 sites. Concurrently, Burdekin growers have asked if they could get support or have access to CO<sub>2</sub> respiration test kits. CO<sub>2</sub> respiration tests are also being undertaken in Mossman. Furthermore, individual presenters have been asked to provide information on particular topics to interested participants (e.g. *Metarhizium* and its use for canegrub control; issues that must be considered when row spacing is modified).

One lesson learnt from the classes was that collaboration with local extension groups and feedback from the early classes made a big difference to the number of growers who attended. In 2017, growers made up 41% of attendees whereas in 2018, 53% of attendees were growers. In 2017, two Masterclasses were held in each region, while in 2018, three classes were held per region due to the increased demand. In both Mourilyan and the Burdekin, it was necessary to turn people away because there was no ability to accommodate the extra numbers.

Following the delivery of the Masterclasses in 2017, engagement increased due to the positive feedback received, and a number of organisations made contact keen to support the 2018 classes. For example, the classes held in Childers were supported by the Burnett Mary Landcare Group (BMRG) who sponsored growers financially (\$100.00 per grower) so that individuals needed to pay only \$50.00 rather than \$150.00. Through this engagement with industry, Isis Productivity Services was able to support the Masterclasses in its region, assist with promotion and encourage individual growers to attend. In addition, WTSIP with funding from DAF, requested that two additional Masterclasses be held in North Queensland specifically for extension staff that support the sugar cane and banana industries. This led to very positive interactions with CANEGROWERS and WTSIP extension staff who also promoted the classes amongst their growers.

## 4. INDUSTRY COMMUNICATION AND ENGAGEMENT

### 4.1. Industry engagement during course of project

The personal interactions between the project team and industry that occurred during the promotion and delivery of the Masterclasses were the primary form of industry engagement during the project. Initially, this engagement was facilitated through the publication of articles and promotional materials across a number of channels.

- An information pack for SRA Adoption Officers was prepared and distributed to SRA Adoption team members. They were also given a copy of the soil health book, and all attended the Masterclass that was run in their region.
- Several Cane Connection articles were produced to promote the Masterclasses:
  - Summer 2016 edition - Mastering your soils for greater productivity and profitability - by Sebastien Garcia-Cuenca
  - Spring 2017 edition - On level ground - by Andrea Evers & Sebastien Garcia-Cuenca
  - Summer 2017 edition - What lies beneath - by Dr Anthony Young
  - Autumn 2018 edition – Soil health fitting all the pieces together – by Brad Pfeffer

All Masterclasses were individually promoted and advertised through the SRA eNewsletter, and all SRA digital channels. As noted above, collaboration with the local extension groups made a big difference to the number of growers who attended the Masterclasses.

The final Masterclass in the Burdekin was set aside for the demonstration growers, mentor growers, extension staff and field staff who are participating in a new Soil Health Project (2017/005).

## 4.2. Industry communication messages

As only a small proportion of cane growers attended the Masterclasses, it is important that the following messages continue to be passed onto the sugar industry.

- Sustainable agriculture is not a prescribed set of practices. It is a concept that challenges growers to:
  - Understand that management practices not only influence the crop, but also soil properties, the soil's organic matter status, and the soil biological community
  - Recognise that biological processes play a key role in maintaining the soil resource
  - Balance the requirements for productivity and profitability with the need to care for the soil and protect the wider environment
- Healthy soils are an integral component of sustainable agriculture, but soil health can only be improved by nurturing the microorganisms and soil animals that maintain the soil's structural integrity, help plants acquire nutrients, and regulate populations of pests and pathogens.
- Sugar growers do not have to live with soils that are functionally impaired. Provided they are prepared to marry their ingenuity and practical skills with the scientific knowledge that is available, they can improve the health of their soils. In the first instance, this means learning how to incorporate the following practices into the farming system.
  - Controlled traffic
  - Minimum tillage
  - A diverse rotation sequence
  - A permanent cover of crop residues on the soil surface
  - Integrated pest management
- Improving soil health and making an agricultural enterprise more sustainable is a long-term process. Nevertheless, once the above practices are integrated into the farming system, a range of economic benefits will be seen (e.g. reduced fuel costs, lower labour costs, income from rotation crops and reduced fertiliser and pesticide costs). Within 5-10 years, soil health will begin to improve and it will be manifested in a number of ways:
  - Less soil erosion
  - Increased soil carbon levels, particularly near the soil surface
  - Better soil structure and improved tilth
  - Higher rainfall infiltration rates and increased water-holding capacity
  - Improved root health
  - Higher microbial biomass and greater biological diversity

## 5. METHODOLOGY

Masterclasses were held in all the main sugar-growing regions, with locations and dates listed below:

- Mackay: 14 and 15 March 2017
- Ingham: 20 and 21 March 2017
- Ballina: 28 and 29 March 2017
- Gordonvale: 1 November 2017
- Tully: 2 November 2017
- Childers: 13, 14 and 15 February, 2018
- Mourilyan: 6, 7 and 8 March 2018
- Ayr: 20, 21 and 22 March, 2018

To cover some of the costs of running the classes, a registration fee of \$150 was charged. Some of the fee was used to purchase the following book, and copies were sent to all those who registered.

Stirling GR, Hayden H, Pattison T & Stirling M (2016) *Soil health, soil biology, soilborne diseases and sustainable agriculture. A guide*. CSIRO Publishing, Melbourne, 275 pp.

The above book was chosen because it provides information on soil microbes and the soil fauna, describes how beneficial and detrimental organisms interact within the soil food web, and discusses the physical, chemical and biological aspects of soil health. It also contains six chapters on the practices which can be used to improve the health of Australia's agricultural soils. A chapter on sugarcane is included.

Classes were limited to a maximum of 15-17 participants. This was done to ensure that attendees had plenty of opportunities to interact with those running the classes. It also ensured that the group was small enough to allow everyone to contribute to discussions on specific points made in the presentations or issues raised by other participants.

### Facilitators

The classes were run by four professionals with many years of experience in sugarcane research and extension. Collectively, they also had expertise in areas such as soil biology, soilborne pests and diseases and integrated pest management.

- Dr Graham Stirling (Biological Crop Protection)
  - A soil biologist with more than 20 years' experience working with nematodes on sugarcane. Author of many research papers, books and book chapters on soil health, soil biology and biological control
- Dr Anthony Young (University of Queensland)
  - A bacteriologist who has worked with bacterial diseases on many crops and contributed to our knowledge of ratoon stunting disease of sugarcane. Four years extension experience with the sugar industry at Harwood, NSW.
- Dr Jay Anderson (University of Queensland)
  - A plant pathologist with expertise in disease problems on a range of horticultural crops, but particularly avocado, banana and passionfruit. Sugarcane experience includes working with *Pasteuria*, a bacterial biocontrol agent of nematodes.
- Mr Sebastien Garcia-Cuenca (Sugar Research Australia)
  - Currently the SRA adoption officer for soil health. Previous experience on a range of different crops, including the use of composts as a soil-health improver in sugarcane and sweet potato.

Three sugar growers (Ashley Petersen from Hervey Bay, Tony Chapman from Bundaberg and Simon Mattsson from Marian) made a major contribution to the classes. Over the last 15-20 years, each of these growers modified their farming system so that it now includes controlled traffic on either 1.83 or 2m row spacing's and minimum tillage and legume rotation crops. Each grower participated in classes in two or more locations and explained the soil health and profitability benefits they have obtained from their new farming system. They also discussed some of the trials they are conducting in the hope of obtaining further improvements.

### Program details

The program consisted of the following components:

- An interactive session to introduce the facilitators, find out why the participants were attending and learn what they hoped to take home from the day.
- An initial presentation to provide a brief overview of the organisms in soil. It covered the microbes, microfauna, mesofauna and macrofauna found in soil, explained how these

organisms interact in the soil food web, and discussed the main ecosystem services they provide (maintenance of soil structure; production, storage and release of nutrients, pest and disease suppression, plant growth promotion, degradation of pollutants).

- A series of 15-30 minute sessions in which bacteria, fungi, nematodes and microarthropods were discussed. Although the key root pests and pathogens of sugarcane were covered, a major focus was explaining the roles of beneficial organisms (e.g. symbionts, antibiotic producers, plant growth enhancers and predators) within the soil biological community.
- A laboratory component was integrated into each of the above sessions. Three compound and three dissecting microscopes were available and they were used to show participants a range of detrimental soil organisms (e.g. *Pachymetra*, *Pythium* and plant-parasitic nematodes) and beneficial organisms (e.g. nematode-trapping fungi, antibiotic-producing bacteria, predatory mites, enchytraeid worms, predatory nematodes and biocontrol agents such as *Trichoderma* and *Pasteuria*).
- Having discussed the organisms that live in the soil and their role in improving its physical, chemical and biological properties, the next step was to outline the management practices that can be used to improve soil health. The key practices were explained and results from field trials were presented to show that benefits would be obtained if these practices were adopted.
- About 30 minutes was spent discussing biological indicators and talking about some of the parameters that could be measured to assess the biological status of a soil. Participants were shown traditional methods of quantifying bacteria, fungi, nematodes and microarthropods in soil and modern DNA methods of assessing these organisms were also discussed.
- Prior to each class, Productivity Services staff collected soil samples from the local area so that samples from soils that were being managed in different ways were available for analysis. Various parameters were assessed (e.g. total C, labile C, microbial activity using the Solvita CO<sub>2</sub> –burst procedure, free-living and plant-parasitic nematodes, arbuscular mycorrhizal fungi and earthworms) and the results were discussed at the class. Data obtained from other regions were also included in the discussion.
- In situations where a sugarcane field was available within close proximity to the venue, some time was spent discussing how root health could be assessed in the field. Blocks of soil were also collected to demonstrate how numbers of earthworms could be determined, and also show participants the macropores produced by earthworms and other ecosystem engineers. The field session concluded with a demonstration of the sampling equipment that could be used to collect representative samples from fields or trial plots, and the penetrometers that could be used to determine whether soil strength was high enough to limit root growth.
- One feature of the program was its relaxed and interactive nature. PowerPoint presentations were always relatively short and participants were continually asked to question the facilitators and interact with them. The primary aim of these discussions was to ensure that the participants went away with some knowledge of the way the soil ecosystem functions and awareness of the key tactics that could be used to improve the biological status of soil.
- A major focus of the day was to demonstrate the effects of practices such as tillage, trafficking, crop rotation, fertilisers, pesticides, mulching and organic inputs on the soil biology, and consider the types of farming system that are needed to improve a soil's biological health. These issues were covered in most of the presentations but were reinforced in a summary session during the afternoon.
- The highlight of each class was the participating grower's presentation. Each grower explained why they had modified their farming system, listed the problems they had faced in doing so, and then went on to show how those problems had been solved. All of them



indicated that within a few years of instigating the new system, soil health benefits such as better tilth, improved soil structure, less compaction and better rainfall infiltration were observed. However, they also indicated that the most rewarding part of the process was the economic benefits they had gained (e.g. reduced fuel costs, lower labour costs, income from rotation crops and reduced fertiliser and pesticide costs).

- The classes concluded with a discussion about how growers could develop an action plan to improve the health of their soils. The process involved; 1) identifying the specific soil constraints that were limiting productivity; 2) developing a plan to rectify the problems; 3) modifying the farming system in some way and; 4) instigating a monitoring program to determine whether the desired improvements were obtained.

A copy of the workbook supplied to each participant can be found in the Appendix. It contains details of the agenda, slides showing some of the key points made in the presentations, copies of the data sheets that were discussed in the classes, and an action plan template.

## 6. RESULTS AND DISCUSSION

### 6.1. Feedback surveys and comments analysis

Excluding the classes sponsored by WTSIP, a total of 231 people attended the Masterclasses, approximately half of the participants were growers (49%), but the sessions were also attended by grower advisors (37%) and other industry representatives (14%). Each participant was encouraged to complete a feedback form and 196 forms were collected. It was not possible to collect feedback forms from participants of the final Masterclass at Mourilyan because incipient flooding from a tropical cyclone meant that participants had to leave as soon as the class finished. The responses received on the feedback forms are summarised below.

#### **Overall delivery of the classes**

The overall delivery of the Masterclasses was seen as useful, informative and engaging by all respondents. Specific comments repeatedly referred to an excellent workshop with highly informative and engaging material and a well-informed delivery team.

Selected quotes:

- Very good workshop with excellent information that was well presented!
- Format with theory followed by hands-on opportunities was excellent!
- Course was well delivered - learned a lot!
- Excellent course - engaging and interesting.
- Course was very well organised, logically set out.
- All presenters very knowledgeable and informative. Great course!
- Super engaging with all the different presenters, the short stints and the microscope parts.

#### **Microscope sessions**

The practical sessions using microscopes were very well received, and perceived as a key to the learning experience. Any future Masterclasses should ensure that this remains a key component and is accordingly planned for and resourced (i.e. microscopes, slides, living material etc.). The development of a library of still specimen slides would assist in consistent material delivery.

**Selected quotes:**

- Use of microscopes/practical application was great.
- Well balanced between theory and visuals (microscopes)
- A good mixture of talk and looking at things.
- Was good to use microscopes and see bacteria etc.
- I really appreciated your efforts in setting up the microscopes and prepping slides etc
- Some sections were a bit rushed due to length of time viewing/waiting for slides and samples. Probably more microscopes, or video linked cameras on microscopes on the big screen would have helped. Really liked the inclusion of the slides to show us the organisms responsible.

**Growers' presentations**

The growers' presentations were particularly well received. Based on responses to suggested improvements (below), attendees would value more emphasis on growers' practical experience in the field.

**Selected quotes:**

- Ashley Petersen's insights were fantastic.
- Ashley Petersen's presentation was really good.
- Grower talk was fantastic

**Suggested Improvements**

Feedback on suggested improvements indicated that there was a strong desire for additional practical, field-based elements to the Masterclasses. Participants wanted to listen to the experiences of local early adopters and have the opportunity to 'show and tell' on the farm. Although such inclusions would certainly be beneficial, such on-farm sessions could only be included if there were significant cuts to what was overwhelmingly seen as a very successful program. Perhaps the best option would be to follow a series of two or three classes at one locality with a one-day field visit in which all local attendees were invited to visit the farms of several 'early-adopters'. A field day of this nature would also provide opportunities for participants to evaluate root health in the field, check for earthworms and other ecosystem engineers, test equipment that could be used to collect samples, and discuss methods that could be used to assess a soil's physical, chemical and biological properties.

**Selected quotes:**

- Perhaps going to a grower's farm to assess the soil health could be beneficial so we can see the process required to get a basic understanding.
- Possibly extended over two days with a property visit and machinery shed 'sticky-beak'.
- Having some local growers who have adopted the new farming system and who could have added their own insights would have been good.
- Include local perspectives, especially the irrigation problems/issues that are always raised as an impediment to making the major changes that are needed re controlled traffic
- Practical session in field would complement the principles discussed.
- Shorten to half day or have field trip in afternoon to see local examples of good soil management
- Info was great but just seemed a bit much. A morning would have been enough
- More examples and discussion of how to implement/their experience in adopting the practice change.
- Less science, more from farmers who are making it work



- Incorporate one converted farm with a visit on site.
- More field visits
- Maybe root-pits to observe roots at depth
- Perhaps more data/experience relating to/from district
- Some things could be related to commercial profit difference.
- Make some links between better soil health and potential crop improvements (t/ha, higher CCS, improved ratoons etc)
- Follow-up course

### **Going forward**

Attendees are looking forward to the Masterclasses being run as an ongoing training opportunity. Based on the positive feedback received, six Soil Health and Biology Masterclasses per year could be offered on an ongoing basis.

This project has allowed for positive relationships to be built with various organisations (e.g. WTSIP, BMRG, Terrain NRM, local productivity services) that support the ongoing delivery of the Masterclasses. These organisations could be approached to assist in providing the necessary funding.

Selected quotes:

- I encourage your team to continue run workshops every year.
- I think this was an excellent course and more should be run
- Run more of these programs aimed at growers.
- Continue this every year with new results.
- More trials to confirm and develop growers know how
- Provide one on one support to growers who are interested in adapting new methods. Was very good.

### **Are there any specific actions you plan to take as a result of this workshop?**

Responses to the above question support some of the comments and feedback previously mentioned and quoted. The greatest scores (circa 20%) support the need/interest in more information, training and advice on soil health and biology, together with on-farm and grower led trials and demonstrations on new management practices.

Summary of responses:

- Make change to my farming practices or equipment - 14%
- Undertake a trial of a new management practice - 20%
- Seek more information or advice about what was covered - 21%
- Do more training or visit other farms/properties - 17%
- Incorporate some of what I learned into my recommendations and advice to growers (if an advisor) - 21%

### **What support/assistance would you require to make these intended changes?**

Responses to this question further highlighted the interest in growers' practical knowledge and the desire for more information and on-ground support. This feedback demonstrates the growing interest in soil health and biology and provides an opportunity to re-engage with growers and demonstrate the cumulative benefits of an Improved Sugarcane Farming System.

It is interesting to note that financial assistance did not rank highly and therefore does not appear to be a major factor in moving to the improved farming system.

Summary of responses:

- Talk to another farmer/s who currently undertakes this practice - 39%
- More information - 24%
- One-on-one professional support - 17%
- Financial assistance - 13%

#### 6.1.1. Next steps/recommendations

The successful delivery of the Soil Health Masterclasses has shown that there is a need for this type of educational program to be offered to growers and industry stakeholders to drive adoption of practices that support soil health. Goodwill has been built around the Masterclasses and both growers and industry stakeholders clearly support the continuation of this program. In order to maintain the momentum already built and to support the efforts of the current Soil Health Project, it is recommended that the Masterclasses continue to be offered across the various cane growing regions into the future. There is definitely a demand for this and ideally the Masterclasses will become one part of a larger soil health campaign.

The feedback received shows that growers are wanting to make changes to their soil management practices and are interested in further practical ways that can assist them to make those changes. This aligns perfectly with the work being carried out within the Soil Health Project (SRA 2017-005). As tools and further information is developed through the Soil Health Project, the Masterclass material that has so far been developed can be enhanced to offer growers and extension staff further support (in the form of practical tools) for making positive changes to their farming systems.

In addition, work that has been carried out by DAF economists for the SRA-funded BMP project and the economics work to be conducted as part of the Soil Health Project can be included within the Masterclasses to provide growers with the necessary economic information that will further encourage adoption of improved farming systems.

## 7. CONCLUSIONS

It is clear that sugarcane industry stakeholders are becoming increasingly aware of issues surrounding soil productivity and sustainability. It is also clear that implementing the Improved Farming System not only improves soil health, but also improves profitability through sustainable yield gain and input cost reduction. The Soil Health Masterclasses were so well-received by participants that conceivably the learnings from the delivery of this project could be adopted within a broader sugar industry context to deliver broad-based returns on investment. Thus, it may be envisioned that, just as the 6-Easy Steps have been widely delivered throughout the Australian industry, the next iteration of the Soil Health Masterclasses could well reach out to a greater cross-section of industry stakeholders and generate long-term, meaningful practice change. The challenge for the sugar industry is to deliver the message and material in an engaging way and ensure that future participants appreciate the dynamic biological communities that underpin the productivity of their soil.

## 8. PUBLICATIONS

The workbook given to participants was the only publication produced during the project (see section 11.2)

## 9. ACKNOWLEDGEMENTS

The team of facilitators and growers that ran the Masterclasses owe a huge debt of gratitude to Ms Andrea Evers, Leader, Marketing at Sugar Research Australia. Andrea was the person who advertised the classes, organised venues, ordered books, took registrations, arranged for the handbook to be printed, found caterers and arranged transport and accommodation. Her reliability, efficiency and attention to detail were one of the main reasons that the classes were successful.

The professionals who organised the classes also wish to thank Ashley Peterson, Tony Chapman and Simon Mattsson for their contributions. Although Ashley, Tony and Simon were busy running their own farm businesses, they always found the time to communicate and were willing to rearrange their schedules so that they could contribute to the classes. They were a major reason why the classes were successful and they deserve a big thank you.

When growers are deciding whether to modify their farming system, the costs of changing the system and the economic benefits obtained are always an important consideration. Although Ashley Peterson, Tony Chapman and Simon Mattsson discussed this in their presentations, we were fortunate to have additional presentations from Mark Poggio and Caleb Connolly (DAF economists) at some of the classes. They provided data from case studies that had been done with several North Queensland growers who had transitioned to an improved farming system. James Ogden Brown (SRA, Bundaberg) provided a similar presentation at the Childers' classes.

Many other people helped organise and run the classes, but the following deserve special mention: Kay Enkelmann (BMLG); Caroline Coppo and Alex Lindsay (WTSIP); Juliette Greenway and Angela Williams (Isis Productivity Services) and Angela Marshal (DAF).

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## 11. APPENDIX

### 11.1. Appendix 1 METADATA DISCLOSURE

Not applicable to this project

### 11.2. Appendix 2

The following material is attached:

- A copy of the presentations that formed the basis of the classes, together with the presentations given by the three growers
- A copy of the workbook used for the classes, which includes the agenda, data sheets and action plan
- Action Plan template
- List of materials provided for the practical sessions
- Photographs of placemats and some of the material displayed in the practical sessions
- Master Class attendees by role and locality