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Investigating the role of microbes & carbon in soil/plant interactions in Burdekin soils; final report 2013/068

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Sugar Research Australia

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## SRA Research Project Final Report

**Investigating the role of microbes & carbon in soil/plant interactions in Burdekin soils: final report 2013/068**

<table>
<thead>
<tr>
<th>SRA Project Code</th>
<th>2013/068 (GGP068)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Title</strong></td>
<td>Investigating the Role of Microbes &amp; Carbon in Soil/Plant Interactions in Burdekin Soils</td>
</tr>
<tr>
<td><strong>Key Focus Area in SRA Strategic Plan</strong></td>
<td>Key Focus Area No 2: Soil Health and Nutrient Management</td>
</tr>
<tr>
<td><strong>Research Organisation(s)</strong></td>
<td>BBIFMAC Inc.</td>
</tr>
<tr>
<td><strong>Chief Investigator(s)</strong></td>
<td>Tom McShane</td>
</tr>
</tbody>
</table>
| **Project Objectives** | ▪ Strengthen linkages between researcher groups and sugarcane farmers  
▪ Increased knowledge and a clearer understanding of the potential benefits of the various microbe additives  
▪ Gain a better understanding on the potential to increase soil carbon in our sugarcane soils  
▪ Better discernment between truly beneficial soil microbial additives and “snake oil” commercial products  
▪ Increased skills in preparation and application of microbial solutions/compounds and in getting them to flourish in the soil  
▪ Improved farming practices to foster improvement in soil health  
▪ A plan for future involvement and investment in the soil health/soil microbes/soil carbon activities |
| **Milestone Number** | 6 |
| **Milestone Due Date** | 1/12/2015 | **Date submitted** | 1/2/2016 |
| **Milestone Title** | Final Report |
| **Success in achieving the objectives** | ☒ Completely Achieved  
☐ Partially Achieved |
This project addresses SRA Strategic Plan Key Focus Area #2: Soil Health and Nutrient Management

Key deliverables that this project contributes to:
- Identification of the most important factors affecting soil health within the sugarcane production system.
- Development of practices that reduce chemical inputs and nutrient losses.
- Improved nutrient-use efficiency (reduced inputs per tonne of sugar produced).
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Section 1: Executive Summary

a) Issue
There has been a growing interest in the Burdekin sugarcane industry in the potential to utilise soil microbes and other ameliorants to improve soil health, increase soil carbon, and improve soil productivity. Farmers have claimed to produce significant agronomic gains after adding various microbial brews to their soil. As these claims are largely not verified by soil tests or crop yields, this project aimed to complement and add value to the laboratory-based studies conducted by researchers at UQ and BSES. The pot trials and field trials conducted as part of this project aimed to investigate the impact of the use of microbes on soil health and cane production, and provide growers with the opportunity to evaluate the crop response to some of the most promising microbial/carbon options available.

b) R&D Methodology
Firstly, the project involved pot trials (over two seasons) which involved testing the two major soil types in the Burdekin (Delta Loam Soil and Barratta Clay Soil) using four microbial treatments, three carbon treatments and two fertiliser rates. Secondly, the project engaged and collaborated with two growers to establish two field trials (one on Delta soil and the other on Barratta soil), in order to monitor the key parameters that can influence microbial activity. Each field trial consisted of 5 treatments including a selection of popular microbial/carbon options available to growers. Regular monitoring at the pot and field trials throughout the crop cycles involved measuring soil respiration (to track microbial activity), soil temperature, and soil moisture. Upon harvest, cane yields and sugar yields were calculated to investigate the treatment effects on cane production. In order to ensure the successful delivery of trials, the project team collaborated closely with Dr Allan Garside (TropAg) and Dr Susanne Schmidt (UQ) for their expertise in project design; in addition to collaborating with the NQ Dry Tropics (NQDT) Soil Health team to deliver extension activities and monitor key parameters in field trials.

c) The project deliverables (outputs) were predominately knowledge-based, including:

- Strengthened linkages between researcher groups and sugarcane farmers through the following workshops and field days:
  - ABC Grower Group Presentation October 2013
  - GIVE (Grower Innovation Virtual Expo) 18th – 19th March 2014
d) **The project outcomes**

The project addresses SRA Strategic Plan Key Focus Area #2: Soil Health and Nutrient Management. Key deliverables that this project contributed to were:

- Identification of the most important factors affecting soil health within the sugarcane production system.
- Development of practices that reduce chemical inputs and nutrient losses.
- Improved nutrient-use efficiency (reduced inputs per tonne of sugar produced).

The Key Success measures that this project contributed to include:

- Soil health indicators developed for sustainable sugarcane production.
- Guidelines, mechanisms and/or varieties identified for increasing nutrient use-efficiency within plant and ratoon crops.
- Guidelines and mechanisms developed for minimising chemical and nutrient losses and understanding water quality.

The results of the trial reinforce the view held by many scientists that there is no magic elixir for soil health, and that an increase in microbial activity and an improvement in soil health does not happen over a short time period. Soil health is achieved by addressing all factors which limit it and every soil type and location has its own limiting factors. The project team has communicated these results through field days, workshops, case studies, newsletter articles and conversations with field trial participants, to ensure growers understand that the benefits of increasing microbial activity in the soil will not result in positive results immediately but instead requires a long term approach. As a result of the project these farmers are more convinced than ever that the key is to increase the carbon levels in the soil to enable the microbes to flourish. Soil moisture and aeration are also key factors for microbial success that these farmers found through the study.
Section 2: Background

There has been a growing interest in the Burdekin sugarcane industry in the potential to utilise soil microbes and other ameliorants to improve soil health, increase soil carbon and generally improve soil productivity and enable better utilisation of natural and applied nutrients. This interest has been stimulated by the increasing cost of fertiliser inputs, and the apparent under-utilisation of applied nutrients. In addition, increasing interest in the use of microbes has been triggered by concerns surrounding the adverse impact of nutrient and pesticide runoff from coastal farmlands on the Great Barrier Reef, and an increasing awareness of soil health generally.

Several farmers are already adding various microbial brews to their soil and some claim to be getting significant agronomic gains. These claims are largely not verified by soil tests or crop yield, so therefore they cannot be promoted with confidence. This project aimed to complement and add value to the laboratory-based studies conducted by researchers at UQ and BSES (Schmidt, Lakshmanan). The pot and field trials conducted as part of this project aimed to allow growers to evaluate the crop response to some of the most promising microbial/carbon options available.

The aim of this project was to test the theory that by increasing soil microbial activity there can be agronomic gains through the suppression of 'bad pathogens', increasing soil carbon and increasing the availability of 'soil pool' nutrients. The project involved replicated, multi-factorial pot trials as well as field trials to test the two major soil types in the Burdekin using four microbe treatments, three different carbon treatments and two rates of applied fertilisers. The trials were conducted to investigate the impact of the use of microbes on soil health and cane production. Soil CO₂ emissions were regularly monitored in order to track the microbial activity of all treatments.
Section 3: Outputs and Achievement of Project Objectives

3.1 Project objectives

- Strengthen linkages between researcher groups and sugarcane farmers
- Increase knowledge and understanding of the potential benefits of various microbe additives
- Gain a better understanding of the potential to increase soil carbon in sugarcane soils
- Enable a better discernment between truly beneficial soil microbial additives and “snake oil” commercial products
- Increase skills in the preparation and application of microbial solutions/compounds and in getting them to flourish in the soil
- Improve farming practices to foster improvement in soil health
- Assist in planning for future involvement and investment in soil health/soil microbes/soil carbon activities in the district

3.2 Project activities

The following activities were proposed as part of the project. All of the activities with the exception of one (Activity 11) were completed.

1. Establish a project steering committee comprising farmers, industry reps, and agronomic consultants.
2. Work closely with farmers who have agreed to collaborate and supply soil for pot trials and operate trials on their farm.
3. Develop and implement an experimental design for the pot trial and statistically valid field trials to test the effect of increased microbial activity and carbon sources.
4. In the first year establish a scientifically valid, large capacity pot trial (50 litres) that will include the following treatments: Fertilizer rates X 2; Microbial additions X 3 (incl. zero control); Carbon sources X 4; X two of the major Burdekin soil types.
5. In the second year establish the replicated on farm trial sites and manage them in such a manner that they can be directly compared with each other and against a control site.
6. Regularly monitor soil microbial activity throughout the crop cycle (in both pot and field trials) by measuring the rate of CO$_2$ respiration with a gas monitoring system.
7. Monitor crop agronomy, biomass production and final yields to evaluate treatments.
8. Measure soil carbon to establish a C baseline using DERM’s sampling protocol and again seasonally to track changes over time.
9. Collaborate with University of Queensland scientists to value add to both projects results.
10. Host field days and information sessions, which will include topical guest speakers and experts.
11. Produce a video of the demonstration trials featuring farmers involved, techniques used, crop growth measurements at various stages and final results and conclusions.
12. Disseminate results to wider local industry and throughout the industry generally.
Activity number 11 was not completed as it became evident once the project results were obtained that it would be extremely difficult to convey the findings via a video given there were no 'tangible' or visible results. Instead more effort was put into the field day where the range of variables and complex outcomes could be communicated directly to the audience.
3.3 Methodology
The following describes the methods and processes used to conduct the trials for the project.

3.3.1 Develop a detailed work-plan after consultation with the Project Steering Committee, including design of trials and methods of data collection
The Project Steering Committee consisted of 4 Burdekin Sugarcane growers, representatives from selected key stakeholders and members of the scientific community bringing expertise in agronomy and R&D. Below is the list of Committee members and their organisations.

- Tom McShane (BBIFMAC Inc.)
- Joe Linton (ABC Grower Group)
- Alan Garside (Senior Agronomist – TropAg)
- John Deambrosis (Burdekin Productivity Services)
- Rob Ahern (Sugarcane Grower)
- Ian Shepherdson (Sugarcane Grower)
- Stewart McCubben (Sugarcane Grower)
- Mindi McNiven (Canegrowers Burdekin)
- Susanne Schmidt (UQ)

The project team also liaised closely with the NQDT Soil Health team with regards to the project field trials and extension activities (e.g. field days).

3.3.2 Collect soil for analysis for baseline soil nutrient, microbes & carbon levels in pot trial soils
Determine laboratory and parameters to be measured and reported
Prior to treatment application, soils from the Barratta flood plain and the Delta area (representing the major soils of the Burdekin) were collected, dried, homogenised and sub-sampled for analysis (refer to Figure 1). The samples were submitted to the Department of Environment and Resource Management Chemistry Centre for a full soil analysis on the 16th April 2013 with results obtained on the 13th June 2013 (results included in Appendix 1). The purpose of this ‘pre-analysis’ was to obtain baseline data on the soils prior to the trial commencing. Key parameters tested included:

- Organic carbon
- Potassium
- Phosphorus
- Nitrate nitrogen
- pH
- EC
- Chloride
3.3.3 Seek expert advice & acquired treatment materials for trial

Earlier in the conceptualization of the project the project team consulted with Dr Allan Garside and Dr Susanne Schmidt with regard to agronomy, project design, treatments applied and data to be collected.

Identify and acquire microbe & carbon sources and types

The Project Steering Committee collaborated to identify carbon sources (soybean and sugarcane mulch) and different microbial treatments, as indicated in Figures 2 & 3 (VRM, Living Soil, Black Earth and Zero Microbes). Within these treatments, each pot had either Low or High Nitrogen Fertiliser rates (rates explained in Figure 7) to gauge the impact of these treatments on nutrient uptake and efficiencies; and one of Cane Mulch, Soybean Mulch and No Mulch, which provided a source of Carbon.
A randomised design and layout was established after consultation with Dr Allan Garside and Dr Susanne Schmidt. The site was designed so that each specific treatment was repeated three times, and each replicated block contained 24 pots, as indicated in Figure 4.
3.3.4 Apply treatments, plant cane sets and initiate pot trial

Established randomized block design on site

Between November 2012 and April 2013 the trial site was carefully designed and established to ensure complete randomization and success of the trial. Both Delta and Barratta soils were placed into 50L pots that had a layer of gravel and geotextile in the bottom of the pot to provide unimpeded drainage. To avoid contamination between treatments, each of the microbial treatments were kept in three adjacent blocks (refer to final layout of the site in Figure 4). Below are photos of the site establishment (Figures 5 - 6).
Applied treatments to all pots, planted single sets and installed irrigation system

Once the block design was established, unique treatments were applied to each pot (Figures 7 & 8). The table below (Figure 9) outlines the specific application rates applied.

<table>
<thead>
<tr>
<th>MICROBES</th>
<th>APPLICATION RATE</th>
<th>COLOUR</th>
<th>NITROGEN</th>
<th>APPLICATION RATE</th>
<th>CARBON</th>
<th>RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRM</td>
<td>To apply 10 L/ha. Add 179 mls to 20 L apply 40 mls/pot</td>
<td>Purple</td>
<td>Low N</td>
<td>Basal + 132 g urea in 5 L apply 50 mls</td>
<td>Zero C</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Black</td>
<td>Low N</td>
<td>Basal + 132 g urea in 5 L apply 50 mls</td>
<td>Cane C</td>
<td>159 g/pot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Green</td>
<td>Low N</td>
<td>Basal + 132 g urea in 5 L apply 25 mls</td>
<td>Soy C</td>
<td>159 g/pot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blue</td>
<td>High N</td>
<td>Basal + 580 g urea in 5 L apply 50 mls</td>
<td>Zero C</td>
<td>None</td>
</tr>
<tr>
<td>Treatment</td>
<td>NPKS applied</td>
<td>Carbon</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------------------------</td>
<td>--------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low N / Zero C</td>
<td>50:26:60:26</td>
<td>Nil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low N / Cane C</td>
<td>50:26:60:26</td>
<td>10t/ha or 159gms/pot</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low N / Soybean C</td>
<td>31:26:60:26 includes half basal MAP + half urea</td>
<td>10t/ha or 159gms/pot</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hi N / Zero C</td>
<td>180:26:60:26</td>
<td>Nil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hi N / Cane C</td>
<td>180:26:60:26</td>
<td>10t/ha or 159gms/pot</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hi N / Soybean C</td>
<td>180:26:60:26</td>
<td>10t/ha or 159gms/pot</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Basal = 464 SOP in 10L apply 50mls/pot + 318 MAP in 10L apply 50 mls/pot.

*** All Barratta pots received 10t/ha gypsum.

Table continued on next page
Following on from treatment application, three single sugarcane sets were propagated in each pot (Figure 10) to ensure plant growth success. Once plant growth was visible, two sets were removed to avoid overcrowding.

The pot trial was located suitably for watering and regular maintenance and a trickle irrigation system was established to supply water to meet crop requirements (Figure 11). This guaranteed equal moisture content across all pots in the trial.

### 3.3.5 Service, monitor and sample pot trial

Project staff serviced the trial site as per the project work plan developed for the Project (refer to Appendix 2), which details the weekly and fortnightly tasks undertaken.

On a fortnightly basis, the Project Team monitored the pot trial’s crop growth, noted any issues on-site and measured CO₂ soil respiration due to its direct relationship with microbiological activity. Soil respiration was measured using a closed dynamic chamber method, namely a Soil CO₂ Flux System, which included an EGM-4 Environmental Gas Monitor, a Soil Respiration Chamber, and a Soil Temperature Probe (Figure 12). This method involved placing a closed chamber over the soil surface. Tubes running from the top of the chamber passed the air in the chamber through an infrared gas analyser (IRGA), which continuously measured CO₂ concentration. The air was then pumped back into the chamber. An initial CO₂ measurement was taken and subsequent measurements were
taken at regular intervals over the next few minutes until a final CO₂ concentration was recorded at a predetermined end time (Figure 13).

On the 16th January 2014, soil cores were taken from each pot and sent to Microbiology Laboratories Australia for a microbial activity analysis (results summary included in Appendix 3). This analysis involved measuring the activity of soil microbes by measuring the amount carbon dioxide (CO₂) emitted by microbes, Soil Basal Respiration (SBR) and Soil Microbial Biomass Carbon (SMBC).

3.3.6 Convene a project planning/progress meeting

A Project Steering Committee meeting was held at the trial site on Thursday 21st November 2013 (Figure 14). Committee members inspected the response to the various treatments and reviewed the gas analysis results to date. Plans to extend the trial into field scale blocks were also discussed. This would involve two field trials located in the Burdekin, one site on Delta soil and one on Barratta soil.
3.3.7 Ratoon, reapply treatments, service and monitor pot trial

The first season pot trial was harvested at 20 weeks (February 2014) where the BBIFMAC project team collected data on: stem numbers, total wet weight, and total dry weight to determine final biomass yields (Figure 15). The second season pot trial was then established on 28th February 2014, where each of the pots were ratooned, re-randomised, irrigated and had treatments reapplied.
3.3.8 Convene a project planning/progress meeting
A steering committee meeting was convened to discuss results (biomass yield results and CO$_2$ respiration results) to date. In addition, members discussed which treatments would be applied to the field trials and the key parameters that would be monitored during the one-year timeframe. The steering committee decided that it was unlikely the field trials would show crop yield differences over a one-year timeframe, thus more effort would be placed on monitoring parameters such as CO$_2$ from microbial activity, soil temperature, soil moisture, microbe counts and nematode population. In order to do so, the project team collaborated with Diana O’Donnell (NQ Dry Tropics) who assisted with resources from her soil health program.

3.3.9 Select field trial sites and establish field trials
The project team selected and established two field trial sites in order to allow the project team to monitor the key parameters that can influence microbial activity, and to develop a better understanding how to manipulate condition to increase soil carbon and soil health generally. One field trial was located in Airville on Delta Loam Soil, and the second field trial was located in Clare on Barratta Clay Soil.
1. *Airville Field Trial (Delta Loam Soil)*

The Airville field trial was planted in April 2014 (crop variety KQ228) and the following treatments were applied.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Treatment 1</strong>&lt;br&gt;(control)</td>
<td>Mill mud (~200t/ha wet) applied end of July 2013</td>
</tr>
<tr>
<td><strong>Treatment 2</strong></td>
<td>Mill mud (~200t/ha wet) applied end of July 2013&lt;br&gt;VRM (5L/ha at planting)&lt;br&gt;Fish Oil (2L/ha)&lt;br&gt;Kelp (4L/ha)</td>
</tr>
<tr>
<td><strong>Treatment 3</strong></td>
<td>Mill mud (~200t/ha wet) applied end of July 2013&lt;br&gt;VRM (5L/ha at planting)&lt;br&gt;Molasses (5L/ha)</td>
</tr>
<tr>
<td><strong>Treatment 4</strong></td>
<td>Mill mud (~200t/ha wet) applied end of July 2013&lt;br&gt;VRM (5L/ha at planting)&lt;br&gt;Humic Acid (7-10L/ha)</td>
</tr>
<tr>
<td><strong>Treatment 5</strong></td>
<td>Mill mud (~200t/ha wet) applied end of July 2013&lt;br&gt;VRM (5L/ha at planting)</td>
</tr>
</tbody>
</table>

*Figure 17 - Treatments applied to Airville Field Trial*

Each treatment area consisted of 6 rows with 1.524m spacing and 425m row length, with a total area of 0.389 hectares per treatment (map of trial site included in Appendix 4). The layout of the trial is provided in Figure 18.
2. Clare Field Trial (Barratta Clay Soil)

The Clare field trial was planted in mid May 2014 (crop variety Q252) and consisted of 5 different treatments as outlined below. The following treatments were applied mid July 2014, except for the Mill Mud, which was applied early September 2014. Fertiliser was applied to all of the five treatments.
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment 1</td>
<td>Soybean</td>
</tr>
<tr>
<td>(control)</td>
<td></td>
</tr>
<tr>
<td>Treatment 2</td>
<td>Soybean</td>
</tr>
<tr>
<td>VRM (5L/ha)</td>
<td>Fish Oil</td>
</tr>
<tr>
<td>VRM (5L/ha)</td>
<td>Kelp (4L/ha)</td>
</tr>
<tr>
<td>Treatment 3</td>
<td>Soybean</td>
</tr>
<tr>
<td>VRM (5L/ha)</td>
<td>Molasses</td>
</tr>
<tr>
<td></td>
<td>(5L/ha)</td>
</tr>
<tr>
<td>Treatment 4</td>
<td>Soybean</td>
</tr>
<tr>
<td>VRM (5L/ha)</td>
<td>Humic Acid</td>
</tr>
<tr>
<td></td>
<td>(7-10L/ha)</td>
</tr>
<tr>
<td>Treatment 5</td>
<td>Soybean</td>
</tr>
<tr>
<td>VRM (5L/ha)</td>
<td>Mill Mud</td>
</tr>
<tr>
<td></td>
<td>(125t/ha)</td>
</tr>
</tbody>
</table>

*Figure 20 - Treatments applied to Claire Field Trial*

Each treatment area consisted of 10 rows with 1.524m spacing and 400m row length, with a total area of 0.6 hectares per treatment (map of trial site included in Appendix 5). The layout of the trial is provided in Figure 21.

*Figure 21 - Layout of Clare Field Trial*
3.3.10  Monitor and sample soil and plants for analysis

**Second Season Pot Trials**

From 31st March 2014 to 19th August 2015, Project Officers monitored the second season pot trial’s crop growth, soil water requirements and soil carbon dioxide respiration.

**Field Trials**

The project team monitored the crop growth, soil temperature, soil moisture and soil carbon dioxide respiration of each field trial. Soil moisture was measured using an MP306 Moisture Sensor which measured Volumetric Soil Water Content (%). Both soil moisture and temperature were measured at 0-20cm of the soil profile.

In addition, Diana O’Donnell (NQ Dry Tropics) assisted by providing resources from her Soil Health Program, enabling the project team to also monitor microbe and nematode populations (at both sites).

The BBIFMAC project team monitored the Airville Field trial from 30th April 2014 to 5th November 2014; and monitored the Clare Field trial was conducted from 1st July 2014 to 19th November 2014. Soil sampling for analysis of microbial and nematode populations was conducted on the following dates:

<table>
<thead>
<tr>
<th>Trial Site</th>
<th>1st Sampling</th>
<th>2nd Sampling</th>
<th>3rd Sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airville</td>
<td>9/7/2014</td>
<td>6/8/2014</td>
<td>22/10/2014</td>
</tr>
<tr>
<td>Clare</td>
<td>15/7/2014</td>
<td>1/10/2014</td>
<td>19/11/2014</td>
</tr>
</tbody>
</table>

*Note: all samples taken from 0-15cm of soil profile and sent to Microbiology Laboratories Australia for analysis.

3.3.11  Host Industry Field Day

BBIFMAC co-hosted (with NQ Dry Tropics) a Field day on 21st May 2015 which involved presenting results from our field trials. The Industry Field day involved presenters from Department of Agriculture and Fisheries, Central Queensland University and Microbiology Laboratories Australia. Topics of discussion included:
• How healthy soils can reduce costs and improve productivity;
• How soil microbial populations are impacted by cropping management;
• Ways to increase soil carbon; and
• How to monitor soil health.

3.3.12 Harvest Trials

*Pot Trial*

The second season pot trial was harvested on 11\textsuperscript{th}-12\textsuperscript{th} May 2015 (Figures 23 – 26) with the following data being collected – stem numbers, total wet weights and total dry weights.
Field Trials

The Airville field trial was harvested on 7th July (approximately 58 weeks after treatment application) and the Clare field trial was harvested on 27th July (approximately 45 weeks after treatment application). The net weights and CCS values were recorded at harvest. Cane yields and sugar yields were calculated using the total area of each treatment site.
3.4 Results & Discussion

3.4.1 Pot Trial – First Season (Plant Cane, 2013/2014)

- Results from full soil analysis prior to treatment application are included in Appendix 1.

- After soil cores were taken from each pot for microbial activity analysis (16/1/14), there were no significant differences found between treatments, however activity in the Barratta Clay soil appeared to be much higher than activity in the Delta soil (see Appendix 3 for results).

- Upon site inspection, there were no visual differences evident between the microbial treatments over the trial period; however there were visual differences between the soil types and the nitrogen rates. There were several reasons why the microbe treatments may not have significantly affected plant growth in the pot trial:
  - Elevated temperature in pots may inhibit microbial activity
  - Microbes may take more time to positively influence growth
  - Other environmental factors may suppress microbial activity

- Carbon dioxide gas measurements showed treatment differences at various times (see Figure 27), however overall there were no significant differences between treatments.
  - Generally the zero microbes had lower CO₂ respiration rates
  - Spikes in CO₂ occurred with application of nitrogen fertilizer and re-application of microbes
  - Results for CO₂ exchange rates within each individual microbial treatment are included in Appendix 6.
• Findings from the biomass harvest:
  o Stalk numbers were lower in the Delta soil and the wet stalk weights were higher than in the Barratta soil. There were no statistical differences between the microbe treatments (see Figure 28).
  o While the only statistical difference in dry matter yields was between soil types (Figure 29) and fertiliser rates, (Figure 30) there was a clear trend that showed sugarcane mulched pots had lower yields, and this is likely because of tie up of nitrogen in the crop cycle (see Figure 31 and Total Dry Weights in Appendix 7).
Figure 28 - Pot Trial Harvest (2014): Cane Stalk Numbers and Weights

Figure 29 - Average plant dry weights (kgs): Microbial treatments vs. Soil type
3.4.2 Pot Trial – Second Season (First Ratoon, 2014/2015)

- Similar to the findings in the First Season Pot Trial, there were no significant differences between treatments in CO$_2$ soil respiration rates (see Figure 32). Results for CO$_2$ exchange rates within each individual microbial treatment are included in Appendix 8.

- Findings from the biomass harvest results:
  - On average, stalk numbers were similar in the Delta soil and Barratta soil, and the wet stalk weights were slightly higher in the Delta soil (see Figure 33).
  - While there were no significant differences in dry matter yields between soil types, there was a trend that showed dry matter yields were higher on average for High Nitrogen pots (Figure 34) and those pots with soybean mulch (Figure 35). Results for Total Dry Matter yields are included in Appendix 9.
Field Trial - Established July 2014

---

**Figure 32** – Pot Trial (Second Season): Average carbon dioxide exchange rates over time in all treatments

**Figure 33** - Pot Trial Harvest (2015): Cane Stalk Numbers and Weights
There were no clear differences in CO$_2$ soil respiration rates between treatments at the Airville trial site (see Figure 36).

- Soil temperature and Volumetric Soil Water Content (%) results are included in Appendix 10. The project team planned to measure soil moisture at both field trial sites, however due to equipment failure the team were unable to collect a complete set of data over the timeframe.
- Over three sampling periods (July, August and October 2014), soil analysis indicates an increase in microbial diversity, however there was no clear difference between treatments (see Figure 37). The full results from this soil analysis (courtesy of NQ Dry Tropics) are...
included in Appendix 12. It should be noted that at the time of preparing this Final Report, NQ Dry Tropics had not completed their full data analysis of the microbe and nematode soil sampling collected in conjunction with the BBIFMAC project team (for both trial sites).

- Biomass yield results indicated there were no treatment effects, as Treatment 2 (Mill mud+VRM+Fish oil+Kelp) produced the lowest cane yield at 168.13 tonnes/ha, while the highest cane yield was recorded where no treatments were applied (Buffer B) at 200.30 tonnes/ha. Treatment 2 also produced the lowest sugar yield at 22.90 tonnes/ha, while the highest sugar yield was produced in the control treatment (Treatment 1) at 25.30 tonnes/ha (see Figure 38 and full results in Appendix 14).

Figure 36 - Average CO₂ exchange rates across treatments
Figure 37 – Airville Field Trial: Microbial Diversity

Figure 38 – Airville Field Trial: Cane yield and Sugar yield

3.4.4 Clare Field Trial (Barratta Clay Soil)
Over time, the average carbon dioxide respiration rate for Treatment 5 (Soybean + VRM + Mill mud) was higher than in other treatments. This could be explained by the addition of Mill mud (see Figure 39).

Soil temperature and Volumetric Soil Water Content (%) results are included in Appendix 11.

Over three sampling periods (July, August and October 2014), soil analysis indicates an increase in Total bacteria, Total fungi and Total microorganisms across all treatments (see Appendix 13). Microbial diversity increased across all treatments, except for Treatment 5 (see Figure 40) which was inconsistent with results from CO₂ soil respiration where Treatment 5 indicated the highest microbial activity during October and November (2014).

Similar to the findings at the Airville trial site, biomass yield results indicated there were no significant differences in yields across treatments. Treatment 2 (Soybean+VRM+Fish oil+Kelp) produced the highest cane yield at 185.79 tonnes/ha, while the highest sugar yield was recorded where no treatments were applied (Buffer A) at 22.49 tonnes/ha. (see Figure 41 and full results in Appendix 15).
Microbial Diversity

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<th>0-15cm October</th>
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<td>Soybean + VRM + Mill mud</td>
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<td>82.8</td>
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Figure 40 – Clare Field Trial: Microbial Diversity

Clare Field Trial - Cane Yield and Sugar Yield

Figure 41 – Clare Field Trial: Cane Yield and Sugar Yield
Section 4: Outputs and Outcomes

Outputs derived from the project include:

- **Workshops & Field Days**
  - ABC Grower Group Presentation October 2013
  - GIVE (Grower Innovation Virtual Expo) 18th – 19th March 2014
    - BBIFMAC Project team presented to members of the sugarcane industry to explain the importance of soil microbes; the project’s overview, trial design and progress.
  - Soil Health Symposium 21st May 2015
    - Results from field trial communicated with industry and Burdekin sugarcane growers
  - Soil Health Technical Advisory Committee meeting December 2015
    - Update group members on project progress and results

- **Communication Material**
  - Throughout the project, activities and results have been communicated to local and broader industry groups via grower group meetings, field days, workshops, NQ Dry Tropics Case Studies and a Cane Connection article (Spring 2015 edition).

Knowledge-based Outputs derived from the project include:

- Strengthened linkages between researcher groups and sugarcane farmers
- Increased knowledge and a clearer understanding of the potential benefits of the various microbe additives
- Improved understanding of the potential to increase soil carbon in sugarcane soils
- Increased skills in preparation and application of microbial solutions/compounds.
- Information to assist in improving farming practices to foster improvements in soil health.
- All data collected from the trials were stored on a database. This information includes:
  - Maps and trial site locations
  - Trial design and methodology
  - Soil profile data
  - Soil chemical analysis data
  - Soil microbe population analysis
  - Plant analysis
  - Biomass yields at all sampling intervals
Section 5: Intellectual Property (IP) and Confidentiality

Since we used several commercially available products in the trials, we do request that the publication of the data in this report is limited and/or taken in context, so as not to detract from the value of these products should they be used in other situations soils and sites. These trials tested these products in the limited circumstances pertaining to the local trials, and it is not our intention to discredit the use of these products in different circumstances or situations.

Section 6: Industry Communication and Adoption of Outputs

a) **What key messages have come from the project to date, when and how they have been communicated and to whom? Has there been any communication with the relevant SRA Professional Extension and Communication (PEC) officer or unit?**

The results of the trial reinforce the view held by many scientists that there is no magic elixir for soil health, and that it does not happen over a short time period. Soil health is achieved by addressing all factors which limit it and every soil type and location has its own limiting factors. The project and its findings have been presented at a number of industry events over the course of the project:

- Soil Health Symposium - Ayr, 21 May 2015
- Grower Innovation Virtual Expo - Innisfail, 18-19 March 2014
- Australian Cane Farmers Association - Ayr, 4 December 2013
- Presentation to ABC (Advance Burdekin Collective) growers - Ayr, 10th October 2013

b) **What new information, if any, is available on the adoption of project outputs?**

The farmers who participated in the field trials understand that the benefits of increasing microbial activity in the soil will not result in positive results immediately but requires a long term approach. As a result of the project these farmers are more convinced than ever that the key is to increase the carbon levels in the soil to enable the microbes to flourish. Soil moisture and aeration are also key factors for microbial success that these farmers found through the study.

c) **List any newsletters, fact sheets or any other media coverage.**

Tom McShane was featured in the Spring 2015 SRA Cane Connection discussing the results of the project. In the article he explained that microbial brews applied to the project’s pot and field trials had shown little positive impact on yield; and advised that when applying microbes to increase organic soil carbon, the entire soil environment (eg. Soil moisture and soil mineralogy) must be considered. A copy of the article is included in Appendix 16.
d) Identify any further opportunities to disseminate and promote project outputs at seminars, field days etc.

The project team has collaborated closely with the NQ Dry Tropics Soil Health team throughout the project and the NQ Dry Tropics team has included the findings from this project in a number of their soil health related events, including field days, symposiums and presentations.

Section 7: Environmental Impact

While there were no particular environmental benefits demonstrated by the trial, the use of the sugarcane milling byproduct mill mud is widespread throughout the industry and thoughtful use of this produce is advised so that the risk of offsite water quality issues is minimized.

Section 8: Recommendations and Future Industry Needs

N/A

Section 9: Publications

N/A
Section 10: Budget Report

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Justification
## Appendices

### Appendix 1: Soil Sample Analysis (prior to treatment application)

**Pot Trial Soil Analysis Results**

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### Appendix 2: Pot Trial Workplan
INVESTIGATING THE ROLE OF MICROBES & CARBON IN SOIL/PLANT INTERACTIONS IN BURDEKIN SOILS

WORK PLAN

One-time Tasks:
- Send untreated soil for analysis
- Group planning meeting - Milestone due September 2013
- Sample plant biomass strategically for analysis
- Harvest biomass from pot trials for yields and nutrient analysis
- Soil sampling?

Weekly Tasks:
- Site inspections
- Remove weeds and tidy pots
- Water pots as required

Fortnightly Tasks:
- Measure soil respiration
- Monitor crop growth and take photographs
- Note any issues with pots
- Manage database and enter results

Appendix 3: Summary of Microbial Analysis (16 Jan 2014) – overleaf.
* Note – Microbial Activity Indicator “80” is used as a guideline and considered a “good level of activity”
Appendix 4: Airville Field Trial Site

Appendix 5: Clare Field Trial Site
Field Site

Sampling site
Appendix 6: Pot Trial (First Season) - CO₂ Exchange Rates for Individual Treatments

Figure 6.1 - Carbon dioxide exchange over time with VRM treatment
Figure 6.2 - Carbon dioxide exchange over time with Living Soil treatment
Figure 6.3 - Carbon dioxide exchange over time with Black Earth treatment
Figure 6.4 - Carbon dioxide exchange over time with Zero Microbes treatment

Appendix 7: Pot Trial (First Season) – Dry Weight Analysis
Appendix 8: Pot Trial (Second Season) - CO₂ Exchange Rates for Individual Treatments

Figure 8.1 - Carbon dioxide exchange over time with VRM treatment
Figure 8.2 - Carbon dioxide exchange over time with Living Soil treatment
Figure 8.3 - Carbon dioxide exchange over time with Black Earth treatment
Figure 8.4 - Carbon dioxide exchange over time with Zero Microbes treatment
Appendix 9: Pot Trial (Second Season) – Dry Weight Analysis

![Plant Analysis - Dry Weight (Kg)](image_url)

- **Black Earth Living Soil VRM Zero Microbes**
  - **BARRATTA CLAY**
  - **DELTA SOIL**

**Kg**
- 0.0
- 0.5
- 1.0
- 1.5
- 2.0
- 2.5
- 3.0
- 3.5
- 4.0
- 4.5
- 5.0

**TOTAL DRY WEIGHT (KG)**
Average Plant Dry Weights - Microbial treatments vs. soil type

- Black Earth
- Living Soil
- VRM
- Zero Microbes

Kg

- Barratta Clay
- Delta Soil
Appendix 10: Airville Field Trial Results – Soil Temperature and Volumetric Soil Water Content
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<th>T2 (MM+VRM+Fish Oil+Kelp)</th>
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Figure 10.1 – Airville Field Trial: Soil Temperature across treatments
Appendix 11: Clare Field Trial Results – Soil Temperature and Moisture (overleaf)

![Graph showing soil temperature and moisture results for various treatments over a period from 20/06/14 to 19/11/14. The treatments include T1 (Soybean) Temp, T2 (Soybean+VRM+Fish Oil+Kelp) Temp, T3 (Soybean+VRM+Molasses) Temp, T4 (Soybean+VRM+Humic Acid) Temp, and T5 (Soybean+VRM+Mill mud) Temp for temperature, and T1 (Soybean) Moisture, T2 (Soybean+VRM+Fish Oil+Kelp) Moisture, T3 (Soybean+VRM+Molasses) Moisture, T4 (Soybean+VRM+Humic Acid) Moisture, and T5 (Soybean+VRM+Mill mud) Moisture for moisture.]
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Appendix 12 – Airville Field Trial: Microbe and Nematode populations

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<td>8.3</td>
<td>12.0</td>
<td>27.3</td>
</tr>
<tr>
<td>Mill mud+VRM</td>
<td>6.8</td>
<td>13.4</td>
<td>22.8</td>
</tr>
</tbody>
</table>
Appendix 13 – Clare Field Trial: Microbe and Nematode populations
### Appendix 14 – Airville Field Trial: Yield Results

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Net Weight</th>
<th>CCS</th>
<th>Cane Yield (tonnes/ha)</th>
<th>Sugar Yield (tonnes/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 - Mill Mud (Control)</td>
<td>71.28</td>
<td>13.8</td>
<td>183.42</td>
<td>25.30</td>
</tr>
<tr>
<td>T2 - MM + Biology (VRM) + Fish Oil + Kelp</td>
<td>65.34</td>
<td>13.6</td>
<td>168.13</td>
<td>22.90</td>
</tr>
<tr>
<td>T3 - MM + VRM + Molasses</td>
<td>74.44</td>
<td>12.8</td>
<td>191.55</td>
<td>24.50</td>
</tr>
<tr>
<td>T4 - MM + VRM + Humic acid</td>
<td>71.28</td>
<td>13</td>
<td>183.42</td>
<td>23.80</td>
</tr>
<tr>
<td>T5 - MM + VRM</td>
<td>70.44</td>
<td>13.2</td>
<td>181.26</td>
<td>23.90</td>
</tr>
<tr>
<td>Buffer A (control)</td>
<td>69.44</td>
<td>13.2</td>
<td>178.68</td>
<td>23.60</td>
</tr>
<tr>
<td>Buffer B (control)</td>
<td>77.84</td>
<td>12.4</td>
<td>200.30</td>
<td>24.80</td>
</tr>
<tr>
<td>Average</td>
<td>71.44</td>
<td>13.14</td>
<td>183.82</td>
<td>24.11</td>
</tr>
</tbody>
</table>

- Lowest value
- Highest value

### Appendix 15 – Clare Field Trial: Yield Results
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Net Weight</th>
<th>CCS</th>
<th>Cane Yield (tonnes/ha)</th>
<th>Sugar Yield (tonnes/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 – Soybean (Control)</td>
<td>119.2</td>
<td>12</td>
<td>179.38</td>
<td>21.53</td>
</tr>
<tr>
<td>T2 – S + Biology (VRM) + Fish Oil + Kelp</td>
<td>123.46</td>
<td>11.4</td>
<td>185.79</td>
<td>21.18</td>
</tr>
<tr>
<td>T3 - VRM + Molasses</td>
<td>119.44</td>
<td>12.2</td>
<td>179.74</td>
<td>21.93</td>
</tr>
<tr>
<td>T4 - VRM + Humic acid</td>
<td>119.72</td>
<td>12</td>
<td>180.17</td>
<td>21.62</td>
</tr>
<tr>
<td>T5 - VRM + Mill mud</td>
<td>119.36</td>
<td>11.9</td>
<td>179.62</td>
<td>21.38</td>
</tr>
<tr>
<td>Buffer A (control)</td>
<td>115.04</td>
<td>12.99</td>
<td>173.12</td>
<td>22.49</td>
</tr>
<tr>
<td>Buffer B (control)</td>
<td>118.18</td>
<td>11.8</td>
<td>177.85</td>
<td>20.99</td>
</tr>
<tr>
<td>Average</td>
<td>119.2</td>
<td>12.04</td>
<td>179.38</td>
<td>21.59</td>
</tr>
</tbody>
</table>
Grower project yields lessons for soil health improvements

A Burdekin grower group project is finding that applying microbes to soils is not enough by itself to improve soil health, and that when applying microbes you need to consider the entire soil environment.

By Brad Pfeffer

Tass McShane with the community NRM agency BRIMAC says that applying microbes to improve soil health needs to be considered in relation to the overall soil environment.

“Growers are saying everything is fine,” he said. “If you put microbes on and you have not got your soil structure, soil moisture and other parameters right then you end up achieving very little. The ultimate aim is to increase the organic carbon content in your soils.”

He said that there were many steps that farmers could take to improve their soil’s health over time.

The project has conducted both large and small scale trials on Burdekin Delta soils on Burdekin clay with (Cay) over the last two years.

Treatments included a wide range of microbial strains and amendments in different combinations, and these treatments included red mud, lime, humic acid, humate derivatives, and others.

Mr McShane said the various microbial strains that were applied had led to obvious little positive impact on yield, although he identified that building soil health was a process that could take many years.

“This is not a grower-driven project and it has delivered some important information for the industry relating to the enhancement of soil health for growers.”