2016

Quantifying the effects of microbial additions to sugarcane soils on crop productivity; final report 2013/069
SRA Research Project Final Report

Quantifying the effects of microbial additions to sugarcane soils on crop productivity: final report 2013/069

SRA Grower Group Innovation Project

<table>
<thead>
<tr>
<th>SRA project number:</th>
<th>GGP – 060, 2013/069</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group name:</td>
<td>Biologically Active Grower Group</td>
</tr>
<tr>
<td>Contact person:</td>
<td>Jayson Dowie</td>
</tr>
<tr>
<td>Project title:</td>
<td>Quantifying the effects of microbial additions to sugarcane soils on crop productivity.</td>
</tr>
</tbody>
</table>
| Project objectives: | • Quantify crop productivity benefits from inoculation of cane-field soils with microbes.  
  • Measure the effects of microbial additions on soil health under different production systems.  
  • Quantify any changes to physical, chemical and biological soil properties from introduced microbial products.  
  • Assessing whether nutrient applications can be reduced using microbial additions, while still maintaining yield.  
  • Examining two different feedstock’s (mill mud and trash) to determine whether carbon from feedstock influences microbial populations and soil effects.  
  • Compare impact of microbes under different climatic conditions, soil types and farming systems. |

Milestone number: 8
Milestone title: Final Report
Due date for milestone: May, 2016
Achievement criteria: Final Report
Success in achieving the milestone: ☒ Completely achieved
☐ Partially achieved
☐ Not achieved
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Abstract

Replicated field trials were implemented in four major districts within the Australian sugarcane industry to identify and objectively measure the effects of microbial additions under different sugarcane systems, climatic conditions and soil types that may lead to the positive impacts of sugarcane growth, soil health, and economic benefits.

Soil physical characteristics such as Bulk Density and soil moisture percentages were conducted in Mackay and Proserpine sites. There was no data to suggest that the application of these surface applied microbial products had any effect on improving soil compaction nor moisture retention in the soil.

There was no consistent data in any of the four regions to suggest that the application of the VRM based products increased the percentage of organic carbon over the trial period. The current data did not suggest a relationship between increase availability of phosphorous (as indicated by BSES-P levels) and the application of a biology product.

Biological populations seemed to spike in trials where a carbon source was available. Without this carbon source, biological population changes were not so prominent. In Proserpine where two of the treatments had mill mud applied, bacterial and fungal populations were greater at specific sampling times compared to treatments which did not supply a food source. The Burdekin replicated this observation in the GCTB treatment where the biological addition was applied.

Though bacterial and fungal populations seemed to spike at certain sampling times throughout the trials in some regions, this did not lead to any significant increases in yield. There were no significant differences in cane yield in Mackay, Burdekin, or Tully. Interestingly, the standalone biological applied treatment in Proserpine showed significantly lower yield in 2014, however, this was not replicated in 2015.

The VRM based microbial addition had no measurable effect on pachymetra populations or nematodes in these trials using this product.
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Introduction

Growers from Plane Creek, Proserpine, the Burdekin and further North in the Herbert and Tully were well aware of the decline in sugar yields experienced over the last decade. There was a general feeling that maybe the biological balance of the soil may have changed due the increase in chemical use, tillage operations and compaction. The biological aspect of the soil, in contrast to the physical and chemical processes, is relatively unknown and the potential of the biological world on cane productivity was perceived to not be realised to its full potential. This led the growers to take a journey to try and understand the potential effect it had on their farms in their respected district and thereby created the “Biologically Active” grower group involved in this Grower Group Innovation Project (GGIP).

Claims made from Biological products available commercially can promise a multitude of positive effects. Such claims include, but are not limited to, the ability of the bacteria and fungi in solution to reduce the amount of inorganic nutrients required to be applied for a crop by fixing atmospheric nitrogen and having the ability to release phosphorous sorbed to the soil colloids. Other claims state that because of the high respiration rates of the biology applied, this respiration can increase the moisture contained within the soil. Some say that the biological populations can reverse the impact of compaction and free your soil up. Others state that the microbial additions improve soil carbon levels and have the ability to reduce parasitic nematode populations.

The main focus of this project was to objectively measure proclaimed effects of microbial additions. Soil physical measurements such as bulk density and the amount of moisture in soil was collected to determine any changes occurring to the soil during the project in regards to structure and moisture retention. Soil chemical samples were taken from different trials to measure any potential increases to organic carbon as well as exploring any potential changes to N and P in treatments applied with the microbial products. Soil samples were also collected and sent to a microbiology lab in Adelaide (Microbiology Laboratories Australia) to measure changes in bacterial and fungal populations. Nematode samples from specific trials were send to the SRA Tully Lab to measure changes in nematode species over time between treatments. And finally, replicated trials were harvested and treatments statistically analysed to determine if applied treatments produced more or less cane in comparison to the standards or non-applied treatments.

The microbial product chosen by the group to use as part of this investigation was V R M BioLogik (www.vrm.com.au ). The group realized that the product used needed to be reproducible and commercially available to growers. VRM has been supplying ‘Microbial Balancing’ formulation products to Queensland sugarcane growers for more than decade. The company promotes four key components of the liquid formulations of beneficial microorganisms:

- Photosynthetic organisms (anaerobic and aerobic)
- Lactobacillus
- Yeasts
- Specialised organisms with specific functions

The inoculant products claim to target and foster nutrient management and nutrient capture in soil.
The objective of trials were to identify and objectively measure the effects of V R M BioLogik (www.vrm.com.au) microbial inoculant/ biofertiliser additions under different sugarcane systems, climatic conditions and soil types that may lead to the positive impacts of sugarcane growth, soil health, and economic benefits, across four major sugarcane production regions within the Australian Sugarcane Industry.

Methodology

Physical Soil Characteristics
Soil cores of a known volume were taken from treatments to determine if there was any influence from the microbes on soil physical properties such as Bulk Density and percent moisture. Three subsamples were taken from georeferenced soil positions in the trials based on soil type. Zones were based on EC data maps to reduce infield soil variation. This was conducted to avoid data variations, caused by different soil zones. Soil cores were weighed post collection, dried at 55°C in an oven for 5 days, and then reweighed to determine dry weight. All sample data was interpolated using an Analysis of Variance with a P value set at 5%.

Bulk Density (BD) \( (\text{Bulk density} \ (g/cm^3) = \frac{\text{Dry soil weight} (g)}{\text{Soil volume} \ (cm^3)}) \) can be used as an indicator of compaction and the soil moisture measurements give us an indication of the moisture available in the profile at a particular time of sampling.

Chemical Soil Characteristics
Periodic soil samples were taken in each of the treatments, for all of the regions (Mackay, Proserpine, the Burdekin and Tully) in georeferenced zones. Samples were taken on the shoulder of the hill away from the placement fertiliser band. Sample depth was 0-20cm. The results were graphed to see if there was any scientific data to substantiate these anecdotal claims. The soil chemical status was analysed via Incitec Pivot Laboratory using a complete sugar analysis (A43).

Biological Soil Characteristics
Soil biological analyses were conducted in all regions, to monitor and determine any changes in bacterial and fungal groups over time at predetermined geospatial positions infield. Soil samples from each region were periodically sent to Microbiological laboratories in Adelaide (http://www.ciaaf.com.au/about-2/). The test code used was a MWSE (Microbe Wise – large suit of bacteria and fungi). Samples were collected to 0-10cm in the stool zone close to the base of the plant as part of the sampling protocol supplied by the laboratory. Samples were collected in sterile specimen jars and immediately refrigerated at -10 Degree Celsius before dispatch to laboratory.

Nematode samples (Burdekin)
Soil cores from 0-20cm were taken from the root zone close to the stool for nematode analysis at a consistent georeferenced position within treatments for the life of the project. These samples were then sent to SRA Tully for analysis.
Pachymetra soil assay (Tully and Herbert)
Samples of soil from 0-25cm within the cane row and sent to the SRA lab in Tully for spore counts. Five cores were collected from each georeferenced position within the treatments, consolidated and a composite sample was used.

Harvest Data

Mackay
All treatments were replicated three times and each plot consisted of seven full rows that ran the entire length of the field and had an average area of 0.4ha. The harvest of the individual plots were supervised and consigned correctly by Farmacist staff. Commercial mill data was subsequently retrieved from Plane Creek Mill.

Proserpine
All treatments were replicated three times and each plot consisted of 6 full rows that ran the entire length of the field and had an average area of 0.36 ha. The harvest of the individual plots were supervised and consigned correctly by Farmacist staff. Commercial mill data was subsequently retrieved from Proserpine Mill and harvest results are as follows. Although the mill was able to provide individual rake weights, the mill was not able to collect juice samples from these individual rakes, and as such, CCS data differences between treatments was limited.

Burdekin
All treatments were replicated three times and each plot consisted of 6 full rows that ran the entire length of the field and had an average area of 0.56 ha. Trial was designed and statistically analysed as a split plot trial. The harvest of the individual plots were supervised and consigned correctly by Farmacist staff. Commercial mill data was subsequently retrieved from Kalamia Mill in the Burdekin and harvest results are as follows.

Great Lands trial, Burdekin
For these trials, an aerobic bacterial blend was used. The product was Great Lands Plant Growth Promoting Bacteria (PGPB). All treatments were replicated four times and each plot consisted of 6 full rows that ran the entire length of the field and had an average area of 0.33 ha. The harvest of the individual plots was supervised by Farmacist staff. Commercial mill data was subsequently retrieved from Wilmar Sugar and harvest results are as follows.

Tully
All treatments were replicated three times and each plot consisted of 6 full rows that ran the entire length of the field and had an average area of 0.43 ha. The harvest of the individual plots was supervised by Farmacist staff. Commercial mill data was subsequently retrieved by Mr Greg Shannon from Tully Sugar and harvest results are as follows.
Results

Physical Soil Characteristics
The following results depict the changes to soil moisture and bulk density over time, as a result of having a biology product and/or mill mud applied.

Mackay

**Table 1 Summary of Trial Treatments for Mackay**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100% BSES 6 Easy Steps (160N, 16P, 114K, 27S)</td>
</tr>
<tr>
<td>2</td>
<td>100% BSES 6 Easy Steps + Biology applied at 200 l/ha</td>
</tr>
<tr>
<td>3</td>
<td>70% BSES 6 Easy Steps (130N, 13P, 92K, 22S)</td>
</tr>
<tr>
<td>4</td>
<td>70% BSES 6 Easy Steps + Biology applied at 200 l/ha</td>
</tr>
</tbody>
</table>

**Table 2 Soil Core Moisture Content for Mackay 2013-2015**

<table>
<thead>
<tr>
<th></th>
<th>29-06-13</th>
<th>21-10-13</th>
<th>30-05-14</th>
<th>17-12-14</th>
<th>16-06-15</th>
<th>19-11-15</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>14.38 a</td>
<td>9.56 a</td>
<td>15.50 ab</td>
<td>13.64 a</td>
<td>9.30 a</td>
<td>16.95 a</td>
</tr>
<tr>
<td>T2</td>
<td>14.61 a</td>
<td>10.29 a</td>
<td>16.30 a</td>
<td>13.93 a</td>
<td>8.33 a</td>
<td>17.67 a</td>
</tr>
<tr>
<td>T3</td>
<td>13.72 a</td>
<td>8.23 a</td>
<td>14.52 b</td>
<td>10.64 b</td>
<td>9.91 a</td>
<td>18.10 a</td>
</tr>
<tr>
<td>T4</td>
<td>14.16 a</td>
<td>11.41 a</td>
<td>15.24 ab</td>
<td>12.97 a</td>
<td>10.44 a</td>
<td>20.34 a</td>
</tr>
</tbody>
</table>

Means followed by the same letter do not significantly differ (P=0.05, LSD)

**Table 3 Bulk Density for the Mackay Treatments, 2013-2015**

<table>
<thead>
<tr>
<th></th>
<th>29-06-13</th>
<th>21-10-13</th>
<th>30-05-14</th>
<th>17-12-14</th>
<th>16-06-15</th>
<th>19-11-15</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>1.72 a</td>
<td>1.47 a</td>
<td>1.66 a</td>
<td>1.36 a</td>
<td>1.61 b</td>
<td>1.96 a</td>
</tr>
<tr>
<td>T2</td>
<td>1.65 a</td>
<td>1.43 a</td>
<td>1.76 a</td>
<td>1.51 a</td>
<td>1.86 a</td>
<td>1.78 ab</td>
</tr>
<tr>
<td>T3</td>
<td>1.67 a</td>
<td>1.48 a</td>
<td>1.76 a</td>
<td>1.47 a</td>
<td>1.91 a</td>
<td>1.50 b</td>
</tr>
<tr>
<td>T4</td>
<td>1.65 a</td>
<td>1.41 a</td>
<td>1.74 a</td>
<td>1.51 a</td>
<td>1.66 b</td>
<td>1.49 b</td>
</tr>
</tbody>
</table>

Means followed by the same letter do not significantly differ (P=0.05, LSD)

Proserpine

**Table 4 Summary of Trial Treatments for Proserpine**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100% BSES 6 Easy Steps (160N, 114K, 18S) (Control)</td>
</tr>
<tr>
<td>2</td>
<td>100% BSES 6 Easy Steps + Mill Mud applied at 100t/ha</td>
</tr>
</tbody>
</table>
## Table 5 Soil moisture content for Proserpine, 2014-2015

<table>
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<th>11-12-14</th>
<th>27-02-15</th>
<th>26-08-15</th>
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<tbody>
<tr>
<td>T1</td>
<td>11.54 a</td>
<td>14.21 a</td>
<td>13.52 a</td>
</tr>
<tr>
<td>T2</td>
<td>10.83 a</td>
<td>14.82 a</td>
<td>13.54 a</td>
</tr>
<tr>
<td>T3</td>
<td>11.62 a</td>
<td>13.95 a</td>
<td>13.62 a</td>
</tr>
<tr>
<td>T4</td>
<td>11.64 a</td>
<td>15.00 a</td>
<td>13.38 a</td>
</tr>
</tbody>
</table>

Means followed by the same letter do not significantly differ (P=0.05, LSD)

## Table 6 Bulk density for the Proserpine treatments, 2014-2015

<table>
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<th>11-12-14</th>
<th>27-02-15</th>
<th>26-08-15</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>1.91 a</td>
<td>1.98 a</td>
<td>1.92 a</td>
</tr>
<tr>
<td>T2</td>
<td>1.87 a</td>
<td>1.96 a</td>
<td>2.02 a</td>
</tr>
<tr>
<td>T3</td>
<td>1.92 a</td>
<td>2.01 a</td>
<td>1.97 a</td>
</tr>
<tr>
<td>T4</td>
<td>1.90 a</td>
<td>1.93 a</td>
<td>1.96 a</td>
</tr>
</tbody>
</table>

Means followed by the same letter do not significantly differ (P=0.05, LSD)
Chemical Soil Characteristics

Organic Carbon

**Figure 1** Organic Carbon (mg/kg) Measurements for all regions, 2013-2015

BSES P

**Figure 2** BSES P (mg/kg) Measurements for all regions, 2013-2015
**Nitrate-N**

![Nitrate-N graphs for Burdekin and Proserpine, 2013-2015](image)

**Figure 3 Nitrate-N (mg/kg) Measurements for the Burdekin and Proserpine, 2013-2015**

**Biological Soil Characteristics**

Soil Biological analyses were conducted in all regions, to monitor and determine any changes in bacterial and fungal groups over time. Soil samples from each region were periodically sent to Microbiological laboratories in Adelaide ([http://www.ciaaf.com.au/about-2/](http://www.ciaaf.com.au/about-2/))

**Bacterial and Fungal populations**

![Bacterial and Fungal population graphs for Mackay, Proserpine, Burdekin, and Tully, 2013-2015](image)

**Figure 4 Changes to the Total Bacterial Population of All Regions, 2013-2015**
FIGURE 5 CHANGES TO THE TOTAL FUNGAL POPULATION OF ALL REGIONS, 2013-2015
Nematodes

**Figure 6** Changes to the parasitic nematode populations, Burdekin 2014-2015

**Figure 7** Pachymetera counts for the Tully trial, 2014
Harvest Data

Mackay

**Table 7 Summary of the trial treatments in Mackay, 2014-2015**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100% BSES 6 Easy Steps (160N, 16P, 114K, 27S)</td>
</tr>
<tr>
<td>2</td>
<td>100% BSES 6 Easy Steps + Biology applied at 200 l/ha</td>
</tr>
<tr>
<td>3</td>
<td>70% BSES 6 Easy Steps (130N, 13P, 92K, 22S)</td>
</tr>
<tr>
<td>4</td>
<td>70% BSES 6 Easy Steps + Biology applied at 200 l/ha</td>
</tr>
</tbody>
</table>

**Table 8 Yield data, Mackay 2014-2015**

<table>
<thead>
<tr>
<th>Treatment (2014)</th>
<th>tCane/ha</th>
<th>CCS</th>
<th>tSugar/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 100% Nutrition (Control)</td>
<td>87.12</td>
<td>a</td>
<td>16.31</td>
</tr>
<tr>
<td>2 100% Nutrition plus Biology</td>
<td>91.43</td>
<td>a</td>
<td>16.48</td>
</tr>
<tr>
<td>3 70% Nutrition</td>
<td>90.26</td>
<td>a</td>
<td>16.37</td>
</tr>
<tr>
<td>4 70% Nutrition plus Biology</td>
<td>91.35</td>
<td>a</td>
<td>16.49</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment (2015)</th>
<th>tC/ha</th>
<th>CCS</th>
<th>tS/ha</th>
</tr>
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<tbody>
<tr>
<td>1 100% Nutrition (Control)</td>
<td>65.82</td>
<td>a</td>
<td>17.35</td>
</tr>
<tr>
<td>2 100% Nutrition plus Biology</td>
<td>65.82</td>
<td>a</td>
<td>17.29</td>
</tr>
<tr>
<td>3 70% Nutrition</td>
<td>63.44</td>
<td>a</td>
<td>17.42</td>
</tr>
<tr>
<td>4 70% Nutrition plus Biology</td>
<td>63.17</td>
<td>a</td>
<td>17.18</td>
</tr>
</tbody>
</table>

**Prob F**

<table>
<thead>
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<th>Prob F</th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
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<td>0.79</td>
<td>0.99</td>
<td>0.9</td>
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</table>

Means followed by the same letter do not significantly differ (P=.05, LSD)
**Figure 8** Tonnes of cane per hectare harvest data, Mackay 2014-2015

**Figure 9** CCS harvest data, Mackay 2014-2015
Figure 10 Tonnes of Sugar per Hectare harvest data, MacKay 2014-2015

Proserpine

Table 9 Summary of trial treatments in Proserpine, 2014-2015

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>100% BSES 6 Easy Steps (160N, 114K, 18S)  (Control)</td>
</tr>
<tr>
<td>2</td>
<td>100% BSES 6 Easy Steps + Mill Mud applied at 100t/ha</td>
</tr>
<tr>
<td>3</td>
<td>100% BSES 6 Easy Steps + Biology applied at 130L/ha</td>
</tr>
<tr>
<td>4</td>
<td>100% BSES 6 Easy Steps + Mill Mud applied at 100t/ha plus Biology (130L/ha)</td>
</tr>
</tbody>
</table>

Figure 11 Tonnes of Cane per Hectare harvest data, Proserpine 2014-2015
**Figure 12 CCS Harvest Data, Proserpine 2014-2015**

**Figure 13 Tonnes of Sugar per Hectare Harvest Data, Proserpine 2014-2015**

**Table 10 Yield Data, Proserpine 2014 and 2015**

<table>
<thead>
<tr>
<th>Treatment (2014)</th>
<th>tCane/ha</th>
<th>CCS</th>
<th>tSugar/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 100% Nutrition - Control (C)</td>
<td>86.58 a</td>
<td>14.88 a</td>
<td>12.88 a</td>
</tr>
<tr>
<td>2 C + Mill Mud @ 100 t/ha (MM)</td>
<td>87.65 a</td>
<td>14.88 a</td>
<td>13.04 a</td>
</tr>
<tr>
<td>3 C + Biology @ 130 L/ha (B)</td>
<td>76.65 b</td>
<td>14.88 a</td>
<td>11.41 b</td>
</tr>
<tr>
<td>4 C + MM + B</td>
<td>93.38 a</td>
<td>14.88 a</td>
<td>13.90 a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment (2015)</th>
<th>tCane/ha</th>
<th>CCS</th>
<th>tSugar/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 100% Nutrition - Control (C)</td>
<td>85.53 ab</td>
<td>15.93 a</td>
<td>13.6 a</td>
</tr>
<tr>
<td>2 C + Mill Mud @ 100 t/ha (MM)</td>
<td>84.81 ab</td>
<td>16.24 a</td>
<td>13.73 a</td>
</tr>
<tr>
<td>3 C + Biology @ 130 L/ha (B)</td>
<td>78.09 b</td>
<td>15.93 a</td>
<td>12.45 a</td>
</tr>
<tr>
<td>4 C + MM + B</td>
<td>91.99 a</td>
<td>16.21 a</td>
<td>14.81 a</td>
</tr>
</tbody>
</table>

LSD P=.10
Burdekin

**Table 11 Summary of trial treatments in the Burdekin, 2014-2015**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Burnt trash (control) 100% Nutrition</td>
</tr>
<tr>
<td>2</td>
<td>Burnt trash plus Biology (150 L/ha) 100% Nutrition</td>
</tr>
<tr>
<td>3</td>
<td>GCTB (control) 100% Nutrition</td>
</tr>
<tr>
<td>4</td>
<td>GCTB plus Biology (150 L/ha) 100% Nutrition</td>
</tr>
</tbody>
</table>

**Figure 14 Tonnes of cane per hectare harvest data, Burdekin 2014-2015**

**Figure 15 CCS harvest data, Burdekin 2014-2015**
**Figure 16** Tonnes of sugar per hectare, Burdekin 2014-2015

**Table 12 Yield Data, Burdekin 2014 and 2015**

<table>
<thead>
<tr>
<th>Treatment (2014)</th>
<th>tCane/ha</th>
<th>CCS</th>
<th>tSugar/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Burnt/ No Biology</td>
<td>116.13 a</td>
<td>14.00 a</td>
<td>16.46 a</td>
</tr>
<tr>
<td>2 Burnt/ Biology (150 L/ha)</td>
<td>104.86 a</td>
<td>14.18 a</td>
<td>14.87 a</td>
</tr>
<tr>
<td>3 GCTB/ No Biology</td>
<td>121.65 a</td>
<td>13.60 b</td>
<td>16.55 a</td>
</tr>
<tr>
<td>4 GCTB/ Biology (150 L/ha)</td>
<td>114.60 a</td>
<td>13.37 c</td>
<td>15.33 a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment (2015)</th>
<th>tCane/ha</th>
<th>CCS</th>
<th>tSugar/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Burnt/ No Biology</td>
<td>75.81 a</td>
<td>15.77 a</td>
<td>11.95 a</td>
</tr>
<tr>
<td>2 Burnt/ Biology (150 L/ha)</td>
<td>79.81 a</td>
<td>15.7 a</td>
<td>12.53 a</td>
</tr>
<tr>
<td>3 GCTB/ No Biology</td>
<td>76.63 a</td>
<td>15.43 a</td>
<td>11.85 a</td>
</tr>
<tr>
<td>4 GCTB/ Biology (150 L/ha)</td>
<td>81.15 a</td>
<td>15.5 a</td>
<td>12.85 a</td>
</tr>
</tbody>
</table>

LSD P=.10

Greatlands Trial, Burdekin

**Table 13 Summary of the Greatlands trial treatments, Burdekin 2015**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Control</td>
</tr>
<tr>
<td>2</td>
<td>100 L/ha applied at planting</td>
</tr>
<tr>
<td>3</td>
<td>100 L/ha at planting, 100 L/ha applied at OOH</td>
</tr>
</tbody>
</table>
**Figure 17** Tonnes of cane per hectare harvest data, Burdekin 2015

**Figure 18** CCS harvest data, Burdekin 2015
There was no significant difference the treatments for tonnes of cane per hectare or CCS. The tonnes of sugar per hectare for the control (treatment 1) was significantly higher than the two biology treatments (treatments 2 and 3).

**Figure 19** Tonnes of sugar per hectare harvest data, Burdekin 2015

**Table 14 Yield Data, Greatlands Trial Burdekin 2015**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>tC/ha</th>
<th>CCS</th>
<th>tS/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Control</td>
<td>182.44</td>
<td>a</td>
<td>13.84</td>
</tr>
<tr>
<td>2 100 L/ha applied at planting</td>
<td>179.02</td>
<td>a</td>
<td>13.83</td>
</tr>
<tr>
<td>3 100 L/ha at planting, 100 L/ha applied at OOH</td>
<td>180.32</td>
<td>a</td>
<td>13.7</td>
</tr>
</tbody>
</table>

**Means followed by the same letter do not significantly differ (P=.10, LSD)**

Prob F 0.23 0.69 0.019

**Figure 19** Tonnes of sugar per hectare harvest data, Burdekin 2015

**Table 15 Summary of trial treatments, Tully 2014**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No Biology (Control) 100% Nutrition</td>
</tr>
<tr>
<td>2</td>
<td>Biology applied at 127 L/ha 100% Nutrition</td>
</tr>
<tr>
<td>3</td>
<td>Biology applied at 244 L/ha 100% Nutrition</td>
</tr>
</tbody>
</table>
**Figure 20** Tonnes of cane per hectare harvest data, Tully 2014

**Figure 21** CCS harvest data, Tully 2014
In the 2014 Tully trial, there was no significant difference between the treatments for tonnes of cane per hectare, CCS or tonnes of sugar per hectare.

### Discussion

#### Soil Physical Characteristics

There are claims that the applied microbes enable positive physical changes to soils such as improving moisture percentages due to respiration of these microbes and the ability to increase soil organic matter faster thereby improving moisture retention. Other claims suggest that the microbes have a positive effect on soil compaction which affect the porosity of the soil and hydraulic conductivity.

In order to attempt to quantify these changes, periodic measurements such as Bulk Density (BD) and Water Holding Capacity (WHC) were conducted to monitor changes in the physical sphere (Tables 2 and 3).

In four of the six sampling events in Mackay, there was no statistical evidence that the addition of the product has any impact on the ability of the soil to retain higher moisture concentrations when compared to the no-VRM treatments (Table 2). Samples taken on the 30th of May, 2014, indicated that treatment 2 (100% nutrition plus Biology) contained a higher moisture content that treatment 3 which did not have applied biology. Treatment 3 was also shown to hold the least amount of moisture on the 17th December, 2014.
In all cases, treatment 1, which also did not have external biology applied, performed the same as both treatments 2 and 4 which did have the biological addition. Therefore, it would hard to surmise that the exclusion of applied biology was the reasoning for the differences. It is highly possible that the soil characteristics in treatment 3 is inherently limited in its ability to maintain moisture, in comparison to the soil in the other treatments.

In four of the six sampling regimes of Bulk Density (BD) measurements in Mackay, there was no significant difference; however, there was a significant difference on the 16th of June, 2015 and the 19th of November 2015 (Table 3). Treatments 2 and 4 had biology applied, whereas treatments 1 and 3 did not. Nonetheless, there is no pattern to suggest that these differences in BD could be wholly contributed to the biological addition. On the 16th of June, 2015, treatments 2 (biology) and 3 (no biology) showed higher compaction levels than treatments 4 (biology) and 1 (no biology). Even though treatment 1 showed lower compaction on this date, this was reversed according to the data set collected on the 19th of November where treatment 1 has higher compaction than treatments 3 and 4. No clear-cut determination can be made to support the theory that the applied biology had any impact on reducing soil compaction.

In Proserpine, results showed that there were no differences in moisture holding capacity (Table 5), or bulk density values (Table 6) between any of the treatments (Table 4). One might have expected that treatments 2 and treatment 4 may have showed some differences due to the mill mud addition, but it seemed that the 100 t/ha application had no impact on measured physical characteristics of the soil. Mill mud applied at this rate is used more for nutritional benefits, rather than soil amelioration. It is also important to note that mud was not reapplied in the second year of the trial.

Soil Chemical Characteristics

Organic Carbon (Figure 1)

There was no evidence to suggest that Organic Carbon (OC) levels increased after applications of the VRM product. The Mackay levels remained relatively unchanged between all treatments, regardless of biological addition (Fig 1).

In Proserpine, the control (T1) remained constant however the other treatments dropped lower than their original baseline value at the December 14 sampling event. This was unexpected as the addition of mill mud was expected to raise organic carbon. OC levels then climbed in the second year of the trial above the control treatment.

At the time of the baseline samples, in the burnt treatments in the Burdekin (Table 11), the OC levels were unusually high. Samples were taken after the treatment plots had been laid out; therefore, there is the potential that the windrowing and burning of extraneous matter, had an impact on OC. That being said, the high OC for treatments 1 and 2 values persisted throughout the trial compared to the GCTB treatments (3 and 4).

In Tully, the OC levels in treatment 2 (Table 15) did increase over time; however, treatment 3, which had a higher rate of the VRM product applied did not show any increase. With this in mind, the suggestion that the addition of the product was responsible for the increase of OC in treatment 2, would be inconsistent with the results found in treatment 3.
BSES-P (Fig 2)
Though treatment 4 (70% nutrition + biology) in Mackay saw a large increase in BSES-P between August 2013 and December 2014 (Fig 2), this was not reflected by the other biology treatment (treatment 2). Similar to the non-biology treatments, treatment 2 (100% nutrition + biology) saw a steady decrease in BSES-P.

All four treatments preformed similarly in Proserpine. Treatments 2, 3, and 4 started off with higher BSES-P values than treatment 1, by September 2015 the BSES-P levels for all of the treatment were lower and at a similar level (55-25mg/kg).

In the Burdekin, treatment 1 (Burnt, control) maintained higher levels of BSES-P between October 2013 and April 2014, compared to the remaining treatments. Biology did not appear to have an impact on BSES-P in Burdekin soils. The trial in Tully was the only one to see an overall increase in BSES-P between August 2013 and November 2014. Treatment 1 maintained higher BSES-P values than the two biology treatments (treatments 2 and 3) therefore the increase in OC% cannot be attributed to the product application.

Nitrate-N
The soil Nitrate-N was measured in the Burdekin and Proserpine; in general, both regions saw an increase over time (Fig 3). In the Burdekin, though treatments 1 and 2 saw decreases in Nitrate-N in December of 2013, both treatments increased substantially by April 2014. A similar pattern occurred in treatment 4; however, the changes were less obvious than treatments 1 and 2. Treatment 3 (GCTB + Biology) was the only treatment that did not see an overall increase in Nitrate-N. In the Proserpine trial, there were large differences between the initial Nitrate-N values (September 2013); however, by September 2015 all of the treatments were at a similar level (4.5-6.2mg/kg). Where treatments 1, 2, and 3 saw Nitrate-N increase, treatment 4 was the only treatment to slightly decrease.

Soil Biological Characteristics
Bacterial Populations (Figure 4)
The bacterial population performed differently across the difference regions and trial treatments. Bacteria in the soil can have many roles in the function of the soil/plant relationship. They can be responsible for nutrient solubilisation, disease suppressions, nitrogen fixation and nitrogen cycling. They help break down proteins, amino acids and sugars quite quickly for plant uptake.

In Mackay, the control treatment and the Biology treatment performed similarly between September 2013 and November 2015. There was a slight spike in the bacterial biomass of the control treatment between November and 2015 and January 2015; however, there was little difference between the treatments at the other sampling times. Applying a biological product does not appear to have an impact on the bacterial population of the trial in the Mackay region.
In Proserpine, the treatments performed similarly; however, the population variation over time was not as pronounced between the treatments. The control treatment saw the bacterial population rise between July 2014 and January 2015, then remain steady until September 2015. Treatments 2, 3 and 4 followed a similar pattern, but the spike in population was more prominent than in treatment 1. The two treatments with mill mud applied (treatment 2 and 4) produced higher bacterial populations than the control and biology-only treatment. It appears that the addition of mill mud has a greater effect on increasing the bacterial population than applying the biology product.

In the Burdekin, the bacterial population of the burnt cane treatments rose steadily between October 2013 and December 2014. Under the burnt cane system, there was little to no difference between the control and biology treatments. Comparatively, there was a large difference between the bacterial populations of the green cane trash blanket populations to that in the burnt section (Fig.4 and Fig.5). Where the population of the control GCTB treatment performed similarly to the burnt cane systems, the biology treatment with a GCTB saw a large spike in bacterial population at approximately January 2014. Though there was a spike in population the GCTB and biology treatment, by December 2014, all of the treatments had very similar final bacterial populations. It may be that burning the trash blanket removed the food source of the bacteria, leaving no food source for the applied biological product. This is reflected by the difference in population of treatments 1, 2, and 3, compared to treatment 4.

In the Tully trial, there was a large difference between the two biology treatments and the control treatment. Where the population of the control treatment remained steady between December 2013 and February 2015, there were two population spikes in the bacterial population of the two biology treatments. The treatments performed similarly, indicating that the higher application rate of treatment 3 did not have a greater impact on increasing the bacterial population, than the standard application rate of treatment 2.

**Fungal Populations (Figure 5)**
Fungi play a more important role by breaking down organic matter in the system. The breakdown of residue can release important nutrients, which can in turn be used by the plant. Some strains of fungi, such as mycorrhizas, can help plant growth by enabling nutrient uptake; some Trichoderma species are responsible for disease suppression. The fungal populations between the regions performed similarly to the bacterial populations.

In Mackay, there was variation between the fungal populations of the control treatment and the biology treatment; however, they followed a similar trend throughout the sampling period. At the final sampling event, the biology treatment had a slightly higher fungal population. When combined with the bacterial data from Figure 4, this data indicates that applying the VRM biological product had little effect on the microbial population of the trial in Mackay.
In Proserpine, the two treatments that had Mill mud applied produced the highest fungal populations during the sampling time. The two treatments without mill mud (treatments 1 and 3) saw very little change occur to the fungal population. This data suggests that it is the application of mill mud, rather than the VRM product, had an impact on the fungal populations of the Proserpine trial.

The fungal population of The Burdekin trial followed a similar pattern to the Burdekin bacterial populations (Figure 4). The two burnt treatments and the control GCTB treatment performed very similarly over the sampling period. The fungal population of treatment 4 was much higher than the other treatments, at every sampling event. It seems that the presence of the biological product and a GCTB resulted in a consistently higher fungal population compared to treatments 1, 2, and 3.

In Tully, the fungal population of the control treatment remained steady between December 2013 and February 2015. There was a spike in the fungal population of both the biology treatments around December 2014; however, by February 2015, the fungal populations of all three treatments were very similar. The application rate of the VRM product seems to have had a greater impact on the fungal population than the bacterial population; the spike in population of treatment 3 (2x the application rate of treatment 2) was greater than treatment 2. That being said, by February 2015, the fungal populations of all three treatments were very close.

Nematodes (Figure 6)
Almost all parasitic nematode numbers decreased after the application of the VRM product; however, the results show that it was not treatment dependent. It appears that an unknown factor may have resulted in the drop in nematode populations. This is evident as not only did almost all of the populations drop post-application, the same populations also increased between October 2014 and July 2015. There were no treatment-specific trends that occurred during the trial; this suggests that applying the Greatlands product at either 100L/ha at planting (treatment 2) and 100L/ha at planting and another 100L/ha at top dress (treatment 3) had little effect on any of the parasitic nematode populations.

Pachymetera (Figure 7)
It seems that the application of the VRM product did not have a consistent effect on the population of the Pachymetera in the Tully trial. The population of all of the treatments declined over time and the treatments did not appear to have had an effect on this population reduction.

Harvest results by Region
Mackay
In the Mackay region, the application of the VRM product did not cause a significant difference between the treatment yields in 2014 and 2015. There was a yield decline
between 2014 and 2015; however, the yields of each respective year reflected the same pattern. This pattern was the same for the tC/ha, CCS and tS/ha yield of both years. This was an interesting result, as treatments 3 and 4 provided 70% of the nutrition that was applied to treatments 1 and 2. This would indicate that the higher rate of fertilizer was not required by the crop to produce the same yield, either with or without the application of biology. Furthermore, the application of the VRM product did not appear to have an impact on either of the aspects of sugarcane yield; as evidenced by treatments 2 and 4 (biology applied) performing similarly to treatments 1 and 3 (no biology).

**Proserpine**

There was some significant difference in the yields of the Proserpine trial. It appears that applying the VRM product in 2014 resulted in a significantly lower yield of cane per hectare and tonnes of sugar per hectare in the biology treatment (3), when compared to the remaining treatments. In 2014, there was a laboratory issue that resulted in individual treatment CCS values not being collected. As a result, the trial treatment was used as an overall value for 2014. It appears that applying biological product to the Proserpine trial had a detrimental effect on yield. The application of mill mud to treatments 2 and 4 did not have a significant effect on yield. Due to this error in the CCS values, it is unknown whether the application of the VRM product or CCS had an effect on the sugarcane in 2014.

In 2015, the tonnes of cane per hectare yields of the biology treatment (3) were significantly lower than that of treatment 4 (mill mud and VRM applied). Though the cane yield of treatments 3 and 4 were significantly different, the corresponding CCS values and tonnes of sugar yields were not significantly different. From the 2015 data, it appears that the application of the biological product may have a somewhat detrimental effect on cane yields, that is not reflected in tonnes of sugar yields. The application of both mill mud and the VRM product had a positive effect on cane yield of treatment 4; this may be due to the mill mud providing an additional food source to the microbes in the VRM product.

**The Burdekin**

In the VRM biology trial, there was no significant difference between the treatments yields in 2014 or 2015. It appears that there was no yield effect due to applying the biological product or retaining a Green Cane Trash Blanket. In 2014, there was no significant difference between the cane and sugar yields of the treatments; however, there was some significant difference between the CCS values. The CCS of treatment 4 (GCTB + Biology) was significantly lower than treatments 1, 2 and 3. The treatment 3 CCS was significantly lower than treatments 1 and 2. It appears that, in 2015, retaining the GCTB had a negative effect on the CCS of those treatments.

In 2015, another trial using the Greatlands biological product was implemented in the Burdekin. This was another microbial product that contained aerobic bacteria and marketed as a plant growth promotion bacteria. There was no significant difference between the cane yield and CCS results between the treatments; however, the tonnes of sugar yield of the
control treatment was significantly higher than the two biology treatments. There was no significant difference between the sS/ha yield of the two biology treatment’s: 100L/ha applied at planting and 100L/ha applied at planting and another 100L/ha applied as a top-dress. It appears that, in the 2015 trial, the application of the biological product has a detrimental effect on the yield of tonnes of sugar per hectare when compared to the control treatment.

**Tully**
The trial in Tully was only conducted in 2014. There was no significant difference between the cane yields, CCS and sugar yields of the treatments. It appears that the application of the VRM product did not have an effect on the treatment yields. Doubling the application rate of the biology product did not have an effect on yield.

**Conclusion**
Overall, applying the VRM biological product to trials across the project had little effect on the physical, chemical and biological soil characteristics. The soil physical characteristics pre and post biological product application were measured in Mackay and Proserpine between 2013 and 2015. There were no major significantly different values in this data, and it can be inferred that the application of the VRM product had no effect on bulk density or soil moisture retention. When the soil samples were analysed for Organic Carbon, BSES-P and Nitrate-N, there were no treatment specific trends present over the sampling period. Often the control treatment in the 4 regions had the highest values over time, or performed similarly to the other treatments in that region. This pattern was reflected in the three areas of soil biology that were analysed. No treatment specific trends occurred in the bacterial or fungal populations post application of the VRM product. In the Burdekin Greatlands trial, the effect of the Greatlands product on nematodes was investigated. It was found that the applied biology did not affect the nematode population, outside of the environmental factors. Similarly, the VRM and Greatlands products did not consistently have a significant effect on the yield of each regions trial. When a significant difference did occur, it tended to be an increase as a result of either mill mud application or, a decrease in yield as a result of the application of the biology product. The application of a biological product does not appear to have a consistent effect, either positive or negative, on the soil environment or final yield of sugarcane.

It is important to note that the project results cannot be used to discount all other microbial products, nor the advanced formulations created by the supplier used in these trials. Knowledge in this field is limited and ever evolving and progress is continually being made every day to explore the effect of microorganisms in the soil. Continued research into this biosphere is very important.

**Environmental Impact**
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? Any new publications since the last milestone?

All key messages are included in the report within. Final results have been presented to a group of 60 growers in the Burdekin in April 2016. It yielded interesting discussion and although results have not shown any major increases in production, some growers believe that exploring ways to improve soil health and therefore sustainability is very important to them and they realise that it is a long term goal and not something that can only be explored for a three year period as detailed in the report.

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

Adoption for most growers will be purely based on the ability of these products to provide a positive economic return to growers. Based on the current data, there is no evidence to suggest a financial reward for applying these products without understanding the complexities of the system we are dealing with. To sustain populations, conditions need to be accommodating to these living organisms. There is still a lot we do not know about the biological world present under our crops; however, more and more progress is being made every day. Although these trials have not really shown an incredible differences in production to date, benefits could still be seen over a longer time frame.

(c) Has there been any communication with the SRA Professional Extension and Communication (PEC) unit. If yes, please provide the name of the contact person.

Belinda Billing.
Andres Jaramillo