SRA Grower Group Innovation Project Final Report

(Please note: The report must be submitted as a Word document)

<table>
<thead>
<tr>
<th>SRA Project Code</th>
<th>Project #- GGP053</th>
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<tr>
<td>Project Title</td>
<td>Improvement of internal soil drainage and yield on heavy clay soils in the Herbert.</td>
</tr>
<tr>
<td>Group Name</td>
<td>LUMPS Farming</td>
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<tr>
<td>Chief Investigator(s)</td>
<td>Vince Russo</td>
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**Project Objectives**

Project Objectives: Assess and evaluate practices which could potentially improve internal soil drainage and cane yield. The trials will provide growers with opportunity to access different practices and their cost effectiveness to improve crop establishment, cane yield, ratoonability and internal soil drainage.

<table>
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<th>Final report</th>
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<tr>
<td>Reason for delay (if relevant)</td>
<td>Lawrence Di Bella was unable to submit the final report on 1 December, 2014 because he was carrying for ill family members and then became ill himself.</td>
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**Success in achieving the objectives**

☒ Completely Achieved  ☐ Partially Achieved  ☐ Not Achieved

**SRA measures of success for key focus area**
Section 1: Executive Summary
The Herbert consists of large areas of clay soils being approximately 60% of soils being sugarcane farmed within the region. These soils are usually nutritionally fertile; however yield potential is limited due to waterlogging. Surface drainage has been improved through laser levelling throughout the district, however yield potential is not fully realised due to limitations associated with internal soil drainage. The soils are prone to significant nitrogen losses associated with denitrification and anaerobic conditions which limit crop growth when waterlogging does occur.

The project investigated biological, mechanical and cultural practices which may increase the productivity of these soils. The project has clearly shown that yields can be increased on heavy clay soils in the Herbert through the use of mill ash as a soil amendment. The use of mill ash has also clearly shown that the product will enhance germination, crop establishment and increase stalk density leading to increases in cane yield on heavy clay soils in the Herbert.

Qureshi et.al (2000) highlighted that there was significant environmental benefits for transporting and applying mill by-products further from the mill site, to manage environmental hazards. This project has highlighted both the economic and environmental benefits of using mill by-products more effectively in a farming system. During the duration of the project SnE Plant Hire constructed a GPS zonal mill mud and ash applicator and has modified its fleet of trucks to allow for zonal application of mill by-products; this has been a very positive step in the handling and distribution of mill by-products in the Herbert.

Section 2: Background
The Herbert consists of large areas of clay soils being sugarcane farmed within the region. These soils are usually nutritionally fertile; however yield potential is limited due to waterlogging. Surface drainage has been improved through laser levelling throughout the district, however yield potential is not fully realised due to limitations associated with internal soil drainage.

This project investigated 5 methods to potentially increase internal soil drainage and cane yields. Methods assessed were:

1. Conventional land preparation (including deep ripping)
2. Mill ash filled slot on a preformed mound on GPS
3. Mill ash broadcast
4. Mound pre wet season and zonal tillage on GPS
5. Bioactivate®, with conventional land preparation

In the initial project proposal mole draining was proposed as a method for assessment, however it was decided that this method was not feasibly possible. Mole draining of most clay soil blocks in the Herbert is not feasible because the landscape is extremely flat and there is nowhere to effectively drain the water to.
Section 3: Outputs and Achievement of Project Objectives

Activities undertaken at the trial.

The trial site was planted between the 4th and 5th of August with KQ228.

Prior to planting the following activities occurred to prepare the block for planting, refer to figure 1. Figure 2 highlights the practices undertaken in the first ratoon crop.

Figure 1. Practices undertaken on the trial between November, 2011-August, 2013.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Practices undertaken (November, 2011- August, 2013)</th>
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| Conventional land preparation   | • 2 discing to plough out old crop  
• Spray with Roundup Power Max @ 4L/ha in April  
• Spray with Roundup Power max @ 3L/ha in June  
• Lime application @ 2.5t/ha  
• 2- tillage using coil tyred implement 1 week prior to planting  
• 2- ripping and hoeing 1 week prior to planting  
• Planting with a stick planter  
• GF351@ 348kg/ha of fertiliser  
• Sprayed with Sprayseed @ 1.6L/ha and Duirex @ 1kg/ha after 3 weeks after planting  
• 1 grubbing prior to hilling up  
• Side dress plant cane with CK50/50 @ 343kg fertiliser /ha  
• 1 hilling up  
• Sprayed with Stomp CR @3L/ha, Soccer @ 1.5kg/ha and Gramoxone @ 1.5L/ha  |
| Mill ash filled slot on a preformed mound | • 2 discing to plough out old crop  
• Zonally apply mill ash @~100t/ha wet weight and mound  
• Spray with Roundup Power Max @ 4L/ha in April  
• Spray with Roundup Power max @ 3L/ha in June  
• Lime application @ 2.5t/ha  
• 2- zonal ripping and hoeing 1 week prior to planting  
• Planting with a stick planter  
• GF351@ 348kg/ha of fertiliser  
• Sprayed with Sprayseed @ 1.6L/ha and Duirex @ 1kg/ha after 3 weeks after planting  
• 1 grubbing prior to hilling up  
• Side dress plant cane with CK50/50 @ 343kg fertiliser /ha  
• 1 hilling up  
• Sprayed with Stomp CR @3L/ha, Soccer @ 1.5kg/ha and Gramoxone @ 1.5L/ha  |
| Mound pre wet season and zonal tillage on GPS | • 2 discing to plough out old crop  
• Mound  
• Spray with Roundup Power Max @ 4L/ha in April  
• Spray with Roundup Power max @ 3L/ha in June  |
<table>
<thead>
<tr>
<th>Mill ash broadcast</th>
<th>Bioactivate®, with conventional land preparation</th>
</tr>
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| • Lime application @ 2.5t/ha  
• 2- zonal ripping and hoeing 1 week prior to planting  
• Planting with a stick planter  
• GF351@ 348kg/ha of fertiliser  
• Spray with Sprayseed @ 1.6L/ha and Duirex @ 1kg/ha after 3 weeks after planting  
• 1 grubbing prior to hilling up  
• Side dress plant cane with CK50/50 @ 343kg fertiliser /ha  
• 1 hilling up  
• Sprayed with Stomp CR @3L/ha, Soccer @ 1.5kg/ha and Gramoxone @ 1.5L/ha  |
| • 2 discing to plough out old crop  
• Broadcast application of mill ash @ 200t/ha wet weight  
• Spray with Roundup Power Max @ 4L/ha in April  
• Spray with Roundup Power max @ 3L/ha in June  
• Lime application @ 2.5t/ha  
• 2- tillage using coil tynded implement 1 week prior to planting  
• 2- ripping and hoeing 1 week prior to planting  
• Planting with a stick planter  
• GF351@ 348kg/ha of fertiliser  
• Sprayed with Sprayseed @ 1.6L/ha and Duirex @ 1kg/ha after 3 weeks after planting  
• 1 grubbing prior to hilling up  
• Side dress plant cane with CK50/50 @ 343kg fertiliser /ha  
• 1 hilling up  
• Sprayed with Stomp CR @3L/ha, Soccer @ 1.5kg/ha and Gramoxone @ 1.5L/ha  |
| • 2 discing to plough out old crop  
• Spray with Roundup Power Max @ 4L/ha in April  
• Spray with Roundup Power max @ 3L/ha in June  
• Lime application @ 2.5t/ha  
• 2- tillage using coil tynded implement 1 week prior to planting  
• 2- ripping and hoeing 1 week prior to planting  
• Planting with a stick planter  
• GF351@ 348kg/ha of fertiliser  
• Sprayed with Sprayseed @ 1.6L/ha and Duirex @ 1kg/ha after 3 weeks after planting  
• 1 grubbing prior to hilling up  
• Side dress plant cane with CK50/50 @ 258kg fertiliser /ha and Bioactivate® @125kg/ha  
• 1 hilling up  
• Spray BioBoost® 2L/ha  
• Sprayed with Stomp CR @3L/ha, Soccer @ 1.5kg/ha and Gramoxone @ 1.5L/ha  |
Figure 2. Practices undertaken on the trial between August, 2013- September, 2014.

All treatments received the same practices during this period. The treatments are as follows:
- Fertiliser application in mid-November 2013 (the potassium and sulphur rates were not varied where mill ash was applied).
- Sprayed with 2,4-D @ 0.8L/ha, Starane @ 0.8 L/ha and Tordon @ 0.75 L/ha in January 2014.

**Soil tilth, land preparation and tiller counts**
Figures 3, 4, 5 and 6 are photographs of activities undertaken prior to planting.

Figure 3. Zonal ripping and rotary Hoeing before planting on the pre-formed bed treatments- late July, 2012.

Figure 4. Treatment on the right is zonal applied mill ash and treatment on the left is conventional tillage before planting- late July, 2012.
The soil condition at planting was noticeably different between treatments. The conventional prepared treatments had considerably larger clods present at planting, while both mill ash treatments and the mound pre wet season and zonal tillage on GPS treatments had less larger clods and more finer particles at planting. Figure 7 are the tiller counts for the trial in plant cane.

Figure 7. Tiller counts throughout the plant crop till harvest. Germination (tiller counts) and establishment was noticeably better on the mill ash treatments compared to the conventional land preparation treatments (refer to figure 7). Refer to figures 8 and 9 for photographs of different germinations between treatments. Figure 9 highlights the differences in soil colour between the mill ash application and conventional land preparation treatments after planting.
Figure 7 indicates that the crop did not sustain the higher tiller numbers in the ash treatments by harvest time and there was no significant difference (lsd 5%) between any treatments for the number of tiller.
There was a significant difference between some treatments for stalk weight and height between some treatments (mill ash treatments were significantly better than the conventional treatment). Figure 10 highlights the differences in stalk weights between treatments at harvest. Figures 11 and 12 highlight the crop height differences between the conventional treatment and the mill ash treatments.

Figure 10. Difference in stalk weights (kg) between treatments.
Figure 11 (left) - Broadcast mill ash treatment on the right, compared to the conventional treatment, in plant cane.
Figure 12 (right) - Zonal applied ash filled slot on the left, compared to the conventional treatment, in plant cane.
Figure 13 (below) Number of stalks over 20m in the first ratoon crop.

Figure 13. Highlights that there was no significant difference in the number of stalks for each treatment at harvest.

Note: Letters on the graph indicate treatments that are significantly different from each other.
The mill ash treatments had statistically the highest stalk weights at harvest for a first ratoon crop; when compared to the other treatments assessed. Refer to figure 14.

**Harvest results**

The trial was harvested on the 15/8/2013 (as plant cane) and the 11/9/2014 (as first ratoon).

The harvest results are as follows:

**CCS:**

**Plant cane** - Figure 15. CCS levels at harvest- plant cane. The ash fill slot had the highest CCS at 14.48, with the conventional and mound prior to the wet season treatments having the same CCS of 14.3. The Bioactivate® treatment had a CCS of 14.06. The lowest average CCS was experienced in the broadcast ash treatment, with a CCS of 13.9. There was no significant difference for CCS between all treatments (lsd 5%).
**Figure 15. CCS at the plant cane harvest.**  
Note: Letters on the graph indicate treatments that are significantly different from each other.

**First ratoon cane**- Figure 16. CCS levels at harvest- 1st ratoon crop. The Bioactivate treatment had the highest CCS at 11.35. The lowest average CCS was experienced in the conventional treatment, with a CCS of 11.16. There was no significant difference for CCS between all treatments (LSD 5%).

**Figure 16. CCS at the first ratoon harvest.**  
Note: Letters on the graph indicate treatments that are significantly different from each other.
TCPH:

**Plant cane-**
The broadcast ash treatment had the highest cane yield at 102 tcph, followed by the ash filled slot at 87.05 tcph. The conventional and mound prior to the wet season treatments had the lowest cane yields at 73.19 tcph and 72.64 tcph, respectively. The Bioactivate® treatment had a cane yield of 78.51 tcph. The broadcast ash treatment was significantly better than all treatments and the ash filled slot was significantly better than all other treatments, except the broadcast ash treatment (lsd 5%). Refer to figure 17.

![TCPH-plant](image)

**Figure 17. TCPH at the plant cane harvest.**

Note: Letters on the graph indicate treatments that are significantly different from each other.

**First ratoon cane-**
The broadcast ash treatment had the highest cane yield at 77.28 tcph, followed by the ash filled slot at 75.47 tcph. The conventional and mound prior to the wet season treatments had the lowest cane yields at 64.68 tcph and 64.45 tcph, respectively. The Bioactivate® treatment had a cane yield of 68.81 tcph. The broadcast ash and ash filled slot treatment were significantly better than all other treatments (lsd 5%). Refer to figure 18.
Figure 18. TCPH for the first ratoon harvest.
Note: Letters on the graph indicate treatments that are significantly different from each other.

TSPH:
**Plant cane** - Both mill ash treatments had the highest sugar yield (tsp) of 14.41 for the broadcast ash treatment (A) and 12.6 for the ash filled slot (B). There was no significant difference (LSD 5%) between the conventional (C), mound prior to the wet season (C) and Bioactivate® (C) treatments. Refer to figure 19.

Figure 19. TSPH for the plant harvest.
Note: Letters on the graph indicate treatments that are significantly different from each other.
**First ratoon cane:** Both mill ash treatments had the highest sugar yield (tsph) of 8.66 for the broadcast ash treatment and 8.45 for the ash filled slot. There was no significant difference (LSD 5%) between the conventional, mound prior to the wet season and Bioactivate® treatments. Refer to figure 20.

![Figure 20. TSPH for the first ratoon harvest.](image)

*Note: Letters on the graph indicate treatments that are significantly different from each other.*

**Water sampling results:**

Full Stop™ Wetting Front Detectors were installed in 2 of the 3 replicates (only enough equipment for 2 replicates could be purchased from the supplier at the time of installation) to assess differences in sub-surface water quality at 1 metre depth in the soil profile. The Full Stop™ Wetting Front Detectors are not a scientific robust piece of equipment and should only be used as indicators of change within a field, refer to [www.fullstop.com.au](http://www.fullstop.com.au). The Full Stop™ Wetting Front Detectors were used instead of piezometers because the project budget did not allow for the installation of piezometers and there maintenance. Figure 21 is a photograph taken when filtering of water from the Full Stop™ Wetting Front Detectors. Figure 22 highlights the design of the Full Stop™ Wetting Front Detectors.

There was no significant difference in water quality for nitrogen measured between treatments, however there appears to be natural field variation in nitrogen across the field and some variation between sampling times at the same sample point. Refer to figure 23 for the water quality results taken from the Full Stop™ Detectors.
Figure 21(right). Filtering water samples collected from the Full Stop™ Wetting Front Detectors.
Figure 22 (left). A diagram of a Full Stop™ Wetting Front Detector.
Figure 23 (below). The water quality results taken from the Full Stop™ mini piezometers.

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<th>NOₓ (µg N/L) 13/03/2013</th>
<th>Urea-N (µg N/L) 9/03/2013</th>
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**Leaf testing results:**
The trial was leaf sampled on the 15th of April, 2013; 8 months and 10 days after planting and on the 31st of March, 2014 in the first ratoon crop. The industry accepted leaf sampling method was the practice used (refer to [www.hcpsl.com/factsheets/leafsamplingfactsheet](http://www.hcpsl.com/factsheets/leafsamplingfactsheet)) to collect samples from the trial. There was no significant differences between treatments for: total N, phosphorus %, potassium %, sulphur %, calcium %, magnesium %, sodium %, iron %, manganese %, copper %, zinc %, boron %, nitrate nitrogen % and chloride % in either the plant or first ratoon crops.
Economic analysis:
DAFF staff undertook an economic analysis as a part of this project. Refer to appendix 1.

Changes to the original project proposal and design.
After undertaking survey levels and a field inspection by the grower group members, HCPSL and Drain Tech staff, it was decided not to install a sub-surface drain coil in the headland drain area. The reasoning why the sub-surface drain coil was not installed was due to an insufficient drainage outlet.

It is anticipated that the use of sub-drainage coil and mole draining on much of the flat clay soils farmed in the Herbert will be of very limited opportunities when there is not significant outlets to drain water to. It was resolved that in this case, a well-drained surface drainage systems would be more cost effective and efficient long term. The trial block was laser levelled before the establishment of the trial.

Because of the change in project design concerning the mole drain treatment, the group has decided to apply Bioactivate® prior to filling in and hilling up to this treatment. The group sort to investigate if Bioactivate® as a biological soil amendment to see it would be beneficial to manage internal soil drainage over the crop cycle by improving soil structure.

HCPSL secured funding from the Woolworths Fresh Food Future Program which was used to fund part of the extension component of this project. HCPSL staff conducted a field day south of Ingham (on the 2nd of September, 2013) to showcase the zonal mill mud/ash applicator owned and operated by SnE Plant Hire (the contractor employed by Wilmar to distribute mill mud and ash from Victoria Mill). A report was submitted to the Woolworths Fresh Food Future Program which can be found in Appendix 2.

Discussion:
The mound prior to the wet season was not significantly different to the conventional farming treatment in this trial. Observations in the Herbert region where mounding prior to the wet season has occurred and slower germinating varieties have been planted, there has been noted improvements in germination and crop establishment. The reason why this effect was probably noticed in this trial was due to the rapid germination and establishment of KQ228. Blocks that are mounded during the fallow generally have a better soil tilth prior to planting; as was the case in this trial.

The Bioactivate™ and BioBoost™ showed no significant difference in CCS, cane and sugar yield, when compared to the conventional treatment. This treatment had a 25% lower nitrogen and potassium fertiliser input than other treatments accessed, however input costs to purchase the products needs to be considered and are reflected in the economic assessment component of the report. The manufacturer of the two products suggest the benefits of the products will not be fully realised until into a ratoon crops. Up until the first ratoon crop there has not been a significant benefit from the Bioactivate™ and BioBoost™ when compared to the conventionally grown crop. Further research is required to investigate the benefits of Bioactivate™ and BioBoost™ in older ratoon crops.

The trial indicated that there is significant opportunities to improve cane and sugar yields on heavy clay soils in the Herbert region through the use of mill ash as a soil
amendment. The use of mill ash was found to enhance germination and establishment of plant cane on difficult to manage clay soils. Even through the stalk numbers were not significantly different between both mill ash treatments and the conventional farming treatment, stalk weight and height was significantly different in both the plant and first ratoon crops.

The use of zonal application of mill ash to the cane row will reduce the costs when compared to broadcast applications of the product. The cost of transport from the mill will have a significant effect on the cost of the product; hence zonal application compared to broadcast application would be more viable as you move away from the sugar mill. The economic analysis clearly highlights the average gross margin was the highest with both the mill ash treatments. The analysis shows a clear financial benefit in plant cane and first ratoon cane for applying mill ash, in this trial. The average gross margin difference between the conventional tillage treatment and the mill ash treatments was significant and in this case the application of mill ash was cost effective.

Section 4: Intellectual Property (IP) and Confidentiality
The IP of Bioactivate® and Bio BioBoost® remain the property of BactiGro™ Australia.

Section 5: Industry Communication and Adoption of Outputs
During the duration of the trial, the following groups have visited the site:

- 36 growers and industry representatives visited the site through the Herbert Sustainable Farming Systems Group in May, 2014.
- 4 representatives from the Bioactivate® company visited the site in August, 2013.
- 124 school children and teachers visited the site in August, 2013 from schools with the Herbert and Burdekin region.
- 4 Wilmar Sugar representatives visited the site in December, 2012 to investigate options for better utilisation of mill ash and management of problematic clay soils.
- 1 representative from the USDA visited the site on the 11th of September, 2012.
- 12- Brazilian industry delegates on the 13th of September, 2012.
- 7- Herbert district agricultural school based trainees on the 19th of September, 2012.

There was considerable discussion about the use of reduced rates of mill ash and the use of mill ash in the farming system during the ISSCT and Brazilian industry visits. The approach undertaken in this project was seen as a novel approach to improve soil fertility and soil structure by those attending the ISSCT workshop. Refer to figure 24.
Figure 24. Vince Russo discussing the trial with a delegate from the ISSCT Agronomy and Engineering workshop, 2012.

The activities of the project have been reported to the Woolworths Fresh Food Future Program (refer to Appendix 2), which funded the extension component of this project.

The project has also been reported in the Herbert Sugar Industry Report in the 2013 edition. A copy of this report can be obtained from HCPSL.

The project outcomes and progress were also reported at GIVE 2014, which was held in Innisfail, May 2014.

The greatest achievement of this project has been the commercial scale adoption of zonally applied mill ash and mill mud throughout the Herbert cane growing region. SnE Plant Hire have constructed a zonal applicator for mill mud and ash which is now commercially available to growers throughout the district. Refer to figure 25.

Figure 25 (left) - Demonstration of SnE Plant Hire zonal mill mud and ash applicator. (Right) - Stephen Gileppa (owner of SnE Plant Hire) inspecting a plant cane block treated with mill ash.
Section 6: Environmental Impact

The more efficient use of mill by-products (like mill mud and ash) and application away from ‘traditionally’ treated areas adjacent to a sugar mill could be a significant environmental benefit long term.

Section 7: Recommendations and Future Industry Needs

Zonal mill ash applications appears to be a viable option on heavy clay soils. Zonal applications of mill ash allows the grower to treat a larger area more cost effectively when compared to broadcast applications. The economics will determine if a grower should consider to apply mill ash and what type of method of application should be considered. The trial indicated that there is the opportunity to improve germination and crop establishment, while increasing stalk weight and cane yield from this practice when using mill ash. This trial has proven that mill ash is a very useful soil amendment.

Further research is required to validate what nutrient availability does occur following the application of mill ash. In this trial there was no nutrient response to the application of the mill ash, as indicated by the leaf sampling results. Currently Six Easy Steps recommendations indicate that potassium and sulphur applications should be reduced following an application of mill ash, however in this case leaf test results show no significant difference between treatments.

Further research is required to investigate if mill ash has the potential to improve nutrient use efficiency, especially for nitrogen. Korndorfer and Anderson (1993) highlighted that the use of vinasse increased yields in sugarcane, white pigeon pea and maize as well as N,P,K,S and Ca uptake; however the predominant effect was mainly due to K and S; is this the case for mill ash which predominately consists of K and S?

Further research is required to investigate the benefits of Bioactivate™ and BioBoost™ in older ratoon crops. Based upon the trial data to date, there is no significant benefit from applying these 2 products in a cane farming system. This trial did not access the long term benefits associated with these two products in older and subsequent ratoon crops.

As indicated in section 6, the more efficient use of mill by-products (like mill mud and ash) and application away from ‘traditionally’ treated areas adjacent to a sugar mill could be a significant environmental benefit long term.

Section 8: Publications

List of publications during the project duration:

- Appendix 2- Report to the Woolworths Fresh Food Future Program.
- An article in the 2013 Herbert Sugar Industry Report. A copy could be obtained by contacting HCPSL.
- Appendix 3- December, 2013 HCPSL newsletter.
References


www.hcpsl.com/factsheets/leafsamplingfactsheet
PART B

Program Manager’s Recommendation
(To be completed by the SRA-RFU Program Manager)

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<th>Date Received</th>
<th>Date Reviewed</th>
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1. Program Manager’s Comments

2. Recommendation
PART C

Milestone and Payment Approval
*(To be completed by the SRA-RFU Program Manager)*

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