Engineering banana cropping systems to suppress soil borne diseases

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Background – Australian Banana Production

2014/15 Fresh Banana Production by State

- QLD: 95%
- WA: 1%
- NT: <1%
- NSW: 4%

Production: 370,989t $565m

Processing: 1,113t

Fresh Export: - $0.0m

Fresh Supply: 369,876t $685m

Consumer metrics:
- 96% 874g
- 16 kg


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Background – Panama disease
Aims

To reduce the impacts of soil borne diseases on banana production through farm management interventions, while maintaining crop productivity.
Crop management

Tillage

Irrigation

Groundcover

Fertiliser
Banana systems

Internal disease rating (1-6)

Dec-14
Banana system treatments

Bare soil

Nitrogen treatments
• 350 kg N/ha/crop
• Low N 220 kgN/ha/crop
• Low N+Entec 220 kgN/ha/crop

Vegetated groundcover

Nitrogen treatments
• 350 kg N/ha/crop
• Low N 220 kgN/ha/crop
• Low N+Entec 220 kgN/ha/crop

2 years, 3 crops cycles, weekly agronomy assessments, 6-monthly soil assessments
Agronomic impacts of management

**Bunch weights**

<table>
<thead>
<tr>
<th>Nutrient Treatments</th>
<th>Plant</th>
<th>1st ratoon</th>
<th>2nd ratoon</th>
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<tbody>
<tr>
<td>Low N</td>
<td>a</td>
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<tr>
<td>Low N Entec</td>
<td>b</td>
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<td>350kgN</td>
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<td>Vegetated</td>
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Banana production

Productivity (15kg ctns/ha/yr)

<table>
<thead>
<tr>
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<th>350kgN</th>
<th>Vegetated</th>
<th>Bare</th>
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<tbody>
<tr>
<td>Nutrient</td>
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<td>Groundcover</td>
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Low N Entec

350kgN

Vegetated

Bare

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Soil Functional Biology - Nematode Communities

Soil Extraction for Nematodes

Nematode Identification

(a) bacterial feeder (b) fungal feeder (c) plant feeder (d) predator (e) omnivore.

Trophic groups
- Fungivores (Fu)
- Bacterivores (Ba)
- Omnivores (Om)
- Carnivores (Ca)

Coloniser – Persister score
Soil Functional Biology - Nematode community

Succession in substrate utilisation profile from; colonisers → persistent nematodes
Soil Functional Biology - Community Level Physiological Profiles

MicroResp™ SETUP

1. soil at 45% MWHC
2. pre-incubated for 7 days
3. soil inoculated with 15 carbon sources
   i. Carboxylic acids (4)
   ii. Carbohydrates (5)
   iii. Amino acids (5)
   iv. Phenols (1)
4. sealed colorimetric CO₂-trap
5. incubated for 6 h
6. CO₂-trap absorbance measured at 590nm
Soil Functional Biology - Community Level Physiological Profiles

Succession in substrate utilisation profile from;
organic acids $\rightarrow$ amino acids
Soil Functional Biology - Next Generation Sequencing

N treatment
- 350 kg urea N ha⁻¹ crop⁻¹
- 220 kg urea N ha⁻¹ crop⁻¹
- 220 kg urea N ha⁻¹ crop⁻¹ + Nitrification inhibitor

Ground cover
- Bare
- Vegetated

 Courtesy of Paul Dennis UQ
Disease suppression

![Graph showing disease suppression vs. B-glucosidase activity](image)

- $R^2 = 0.9754$
- $R^2 = 0.0121$

**B-glucosidase (µg/g/hr)**

**Internal disease rating (1-6)**

- Dec-16
- Dec-14

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Productivity and disease suppression

**Graph A**
- High production (Conducive)
- High production (Suppressive)
- Bare Low N+E
- Bare Low N
- Veg 350 kgN
- Veg Low N+E
- Veg Low N

**Graph B**
- High production (Conducive)
- High production (Suppressive)
- Bare Low N+E
- Bare Low N
- Veg 350 kgN
- Veg Low N+E
- Veg Low N

Relative production vs. Relative suppression (Bioassay) vs. Relative suppression (β-glucosidase)
Next steps

Validation
• Validate field measurements with suppression from commercial banana farms

North Queensland grower survey
• Determine practices fields with high productivity and high β-glucosidase activity.
• Determine farm management practices and/or inherent soil properties that give high β-glucosidase activity and high productivity

Which organisms
• Use of Next Generation Sequencing to identify organisms associated with suppression of Foc.
Conclusions

1. Suppression to Panama disease can be induced through management
   • Increase vegetative groundcover and low N are components of a suppressive cropping system.
   • Improvements to retain crop productivity are required

2. β-glucosidase activity in soil is a good indicator of soil suppression
   • Does not tell the mechanism of suppression

3. Soil suppression is only one component of a suppressive cropping system to manage Panama disease
   • On-farm biosecurity
   • Cultivar resistance is the primary component of a disease suppressive system.
   • Inoculum management through early detection, destruction of infected plants
Acknowledgement