The effect of organic amendments on sugarcane (*Saccharum spp.*) root health and function and associated nematode populations

The University of Queensland
Australia

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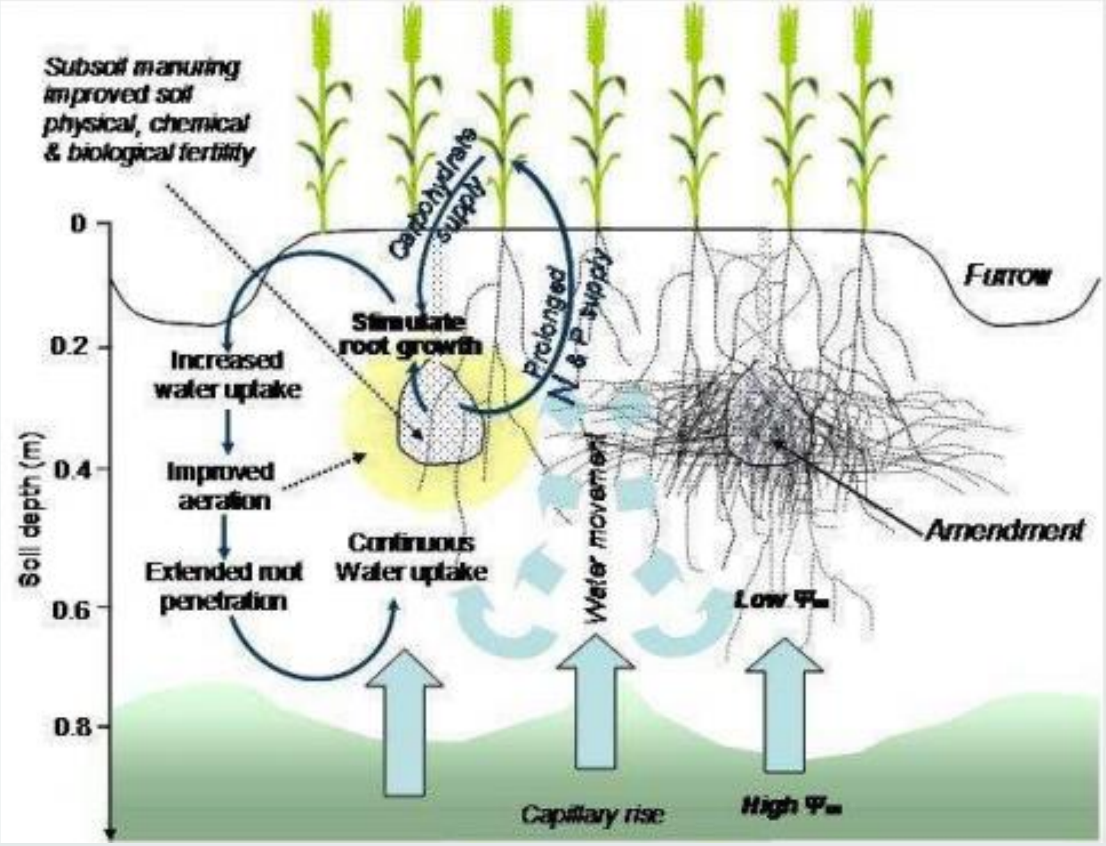
Background

- Sugar from **SUGARCANE** adds $1.75 billion to the Australian economy
- Production constrained by **poor** root **health** and function
- **Chemical** Constraints: sodicity
- **Physical** Constraints: sodic duplex soils
- Grain crops grown on hostile subsoils benefit from sub soil slotting of manure or other organic materials
- Can this same strategy be applied to sugarcane?
  - Yield from sugarcane is constrained by numerous factors my research focused on an important plant pathogen- **nematodes**

Peries Model of Sub-soil manuring



Peries *et al. 2016*

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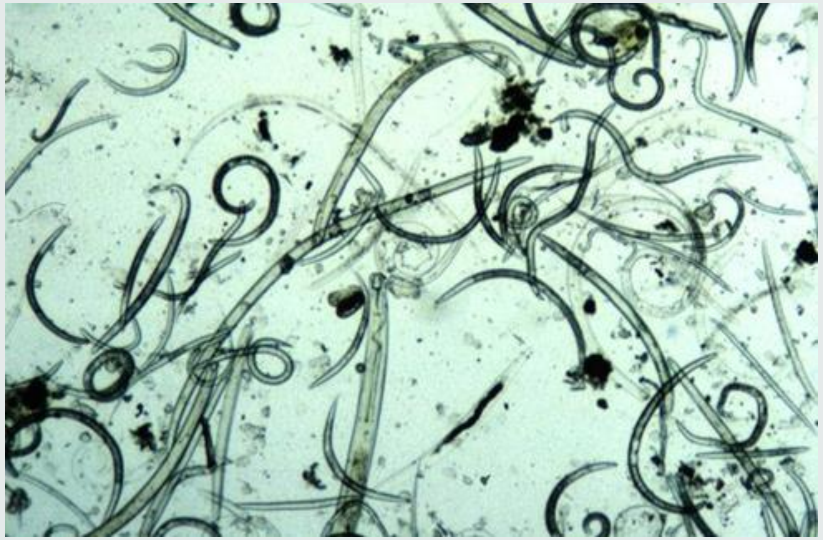
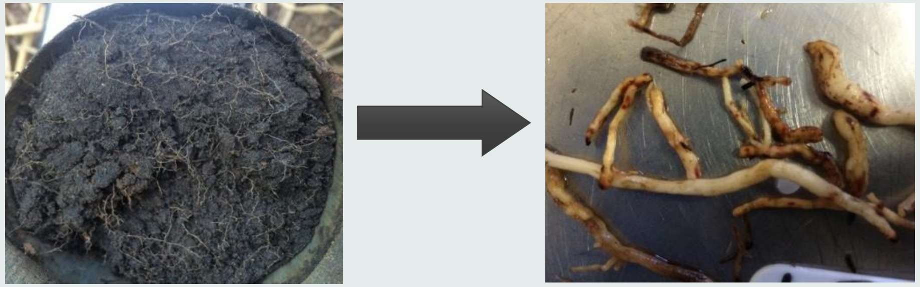
Nematodes are an important factor constraining cane growth



Linsell *et al.* 2014

- **Plant parasitic nematodes** (PPN) **HARMFUL**
  - Key species: **Lesion, Stunt, Stubby, Spiral**
  - **Damage roots**



- **Free living** nematodes (FLN) **BENEFICIAL**
  - Indicator of the broader microbial food web that can moderate damage from PPN
- As an alternative to chemical control, **organic amendments** of mill mud and sugarcane trash can change the FLN:PPN balance and **suppress PPN** when applied to the surface

This research

- Aim: to apply organic **amendment**s in the **sub soil** to overcome **constraints** to root development
  - → deliver **improvements** in root system **health and function** through moderation of **nematode** populations

Organic amendment	How is it produced	Benefits to root and nematodes
Sugarcane Trash	The remaining tops and leaves after harvesting	Increase FLN, reduce PPN, increase root biomass and fine roots
Mill Mud (MM)	Fiber and soil leftover from the raw juice during milling, mixed with boiler ash (burnt cane fiber and wood waste)	Provides nutrients and some suppression of major plant pathogens

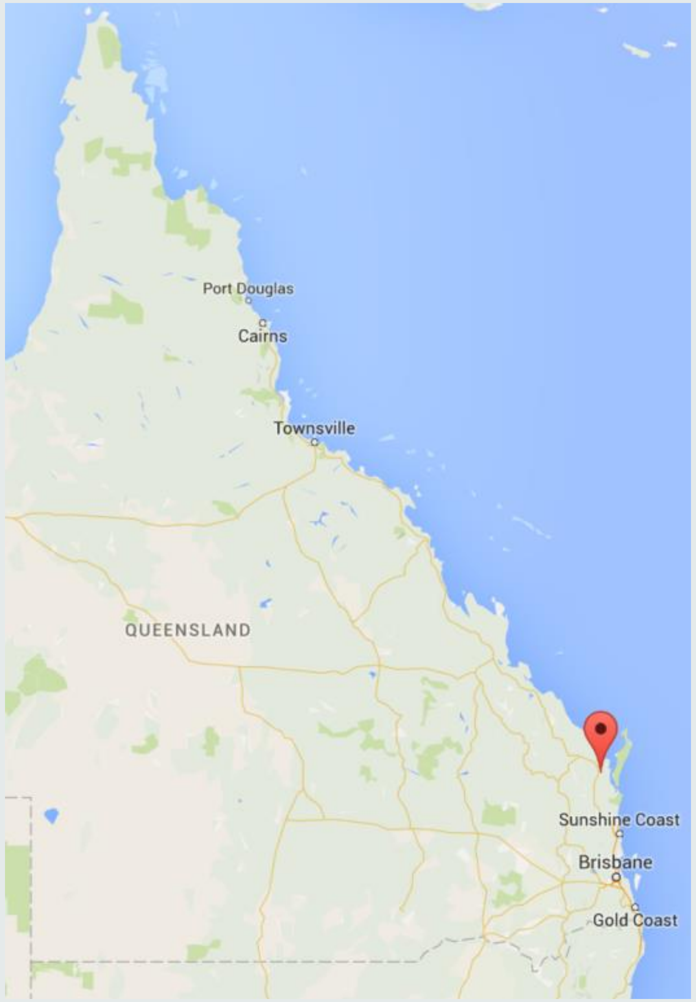
Two parts to the project:

Part 1: Field trial

- Collaborate with **staff from QDAF** in a **long term sugarcane field** study established in Maryborough, Qld in 2015 (funded by **SRA**)
- **Aim**: to investigate the **effects of banded, sub-soil** applications of combinations of **sugarcane trash** and **mill mud** on root health, nematode populations and crop growth on a sodic duplex soil
- **My role**, with support from **Dr Graham Stirling** (nematode specialist), was to collect soil cores from surface and sub surface depths for root analysis, scanning and nematode analysis

Part 2: Glasshouse trial

- Soil collected from the **Maryborough** site used in a glasshouse pot experiment in Brisbane
- **Aim**: explore the impacts of **similar treatments** investigated in the field on root **growth** and **function** in more detail



Google Maps 2016

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Conclusions from the field trial

- **Sodic subsoil severely restricts root growth** (length, surface area & dry mass)
  - Visually, **mill mud increased fine roots**
  - Nematode numbers increased with the amount of root, but there were no effects of treatment
- No significant improvements to root health or nematode populations = no responses in above ground biomass.
- Assessment only conducted half way through year 1 of the trial. A limited period for amelioration of abiotic and biotic constraints

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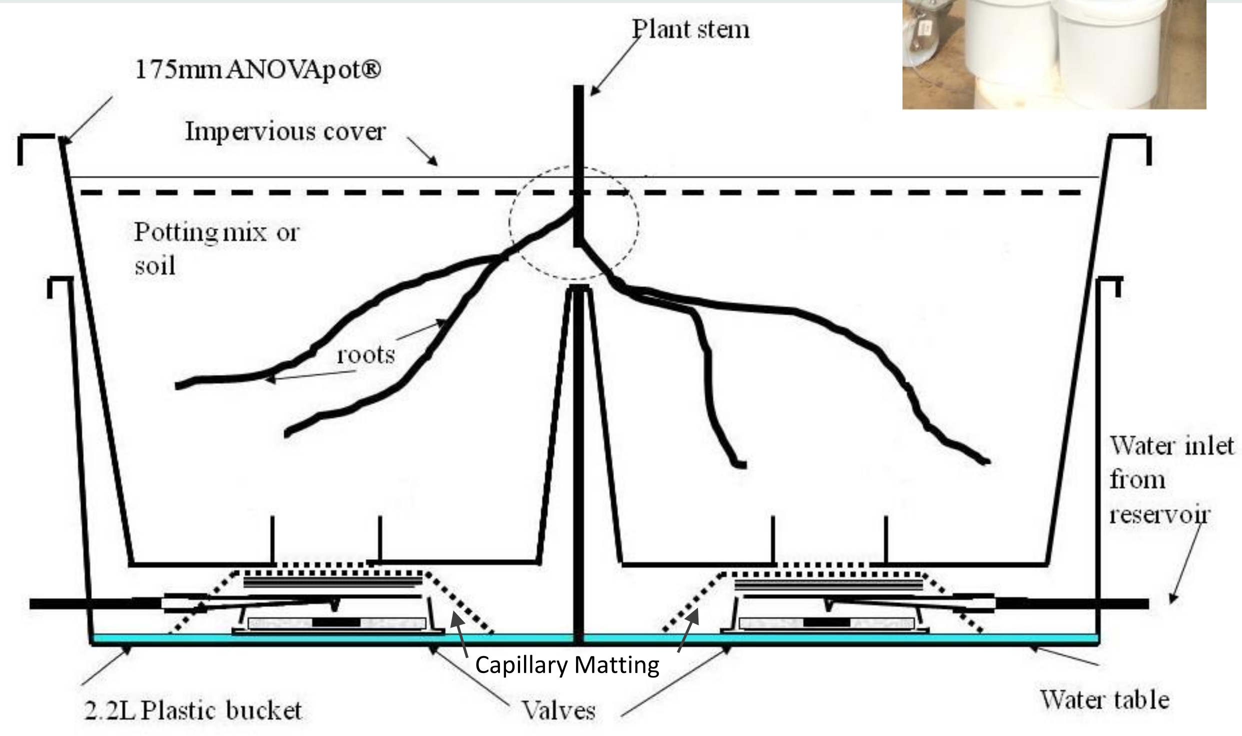
Glasshouse experiment

- Provide a more **comprehensive look** at the **root function** and **nematode** dynamics under a more controlled set of conditions

- Utilise the **Split root system** and the semi automated **Pot-in-Bucket** system

- **Pot in bucket** (Hunter et al 2012)
  - Provides a c**onstant water table** to ensure a **stable** soil **moisture** environment
- **Split pot** (Hunter and Scattini, 2014)
  - Every **plant** has **access** to '**ideal**' soil conditions
  - ***Note that this is the first time this system has been used with sugarcane- so learning was the name of the game!!***



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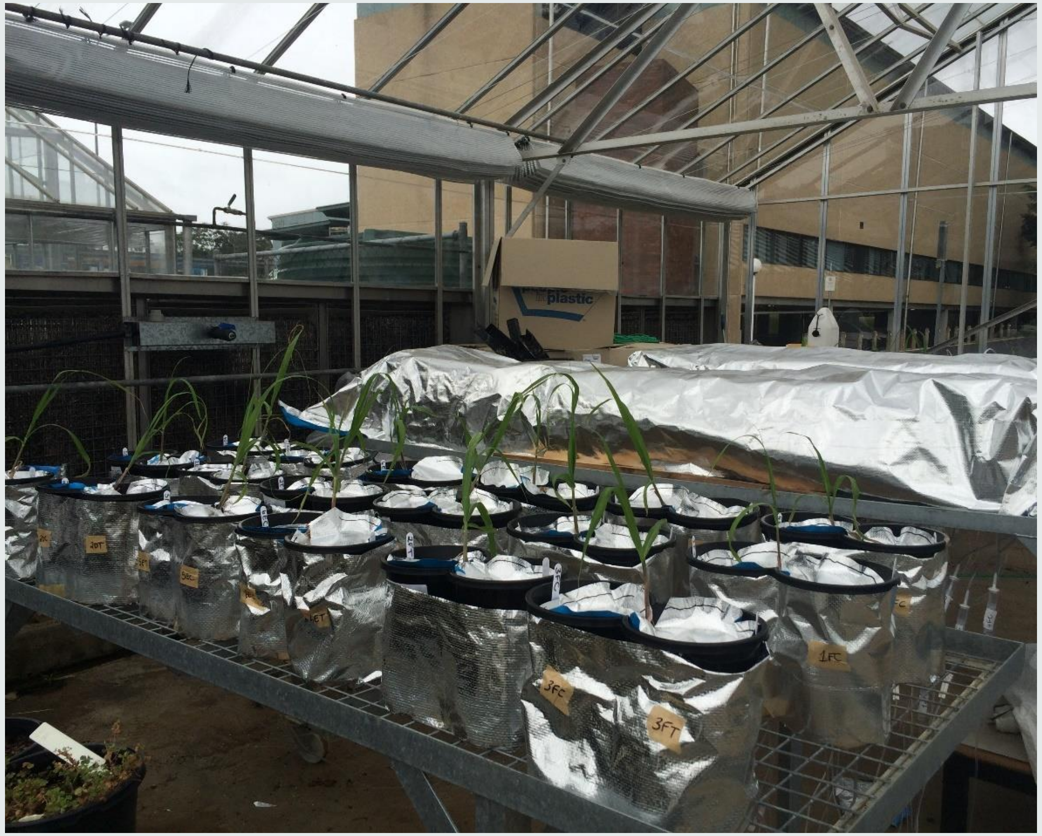
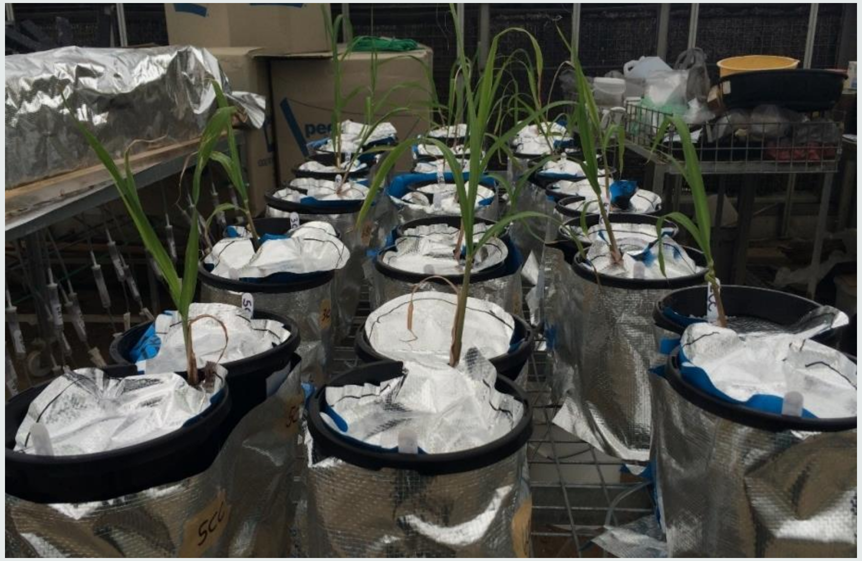
Glasshouse set up

- 6 **treatments** based on the **field study** (randomised in six complete blocks)
  1. **Mill mud** in a **band** (6 kg/m^2)
  2. **Mineral fertiliser** in a **band** with additional field soil
  3. **Mill mud** (6 kg/m^2) + **cane trash** (0.3 kg/m^2) in a **band**
  4. **Mill mud** (6 kg/m^2) + **cane trash** (0.3 kg/m^2) **incorporated**
  5. **Cane trash** (0.3 kg/m^2) applied in a **band**
  6. **Field** soil with **no organic amendments**
- Both **split pots** were **fertilised**
- **A single sprouted sugarcane** sett was placed on the divide



Glasshouse data

- Monitoring aspects known to be related to yield in agricultural crops
  - **Water use**
  - **Nutrient extraction** (Rubidium-Rb). Uptake similar to potassium but not essential to biomass growth
- Plants grown for 8 weeks after transplanting, with shoot and root growth and nematode populations monitored



Glasshouse results

Root Morphology

- No effects of amendment observed for dried root mass, length, surface area (Winrhizo® scanner)
- For all but one treatment (mineral fertiliser) **the pasteurised split pot generated more root mass** than the unpasteurized equivalent.
- **Mineral fertiliser** (MF) resulted in significantly **more roots** but no significant increase to root length and surface area compared to other treatments.
- More roots = significantly more Rb accumulation

Root efficiency: Rb uptake/g of root & water uptake/g of root

- **No statistical** differences between treatments for root efficiency

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Glasshouse results: root function

- Strong, **positive linear relationships**
  - →**Validates** the use of **both factors** as a **good** indicator of **root health**
- Suggestion of **more efficient water accumulation in pasteurised** soil
  - → benefit of controlling pathogens?

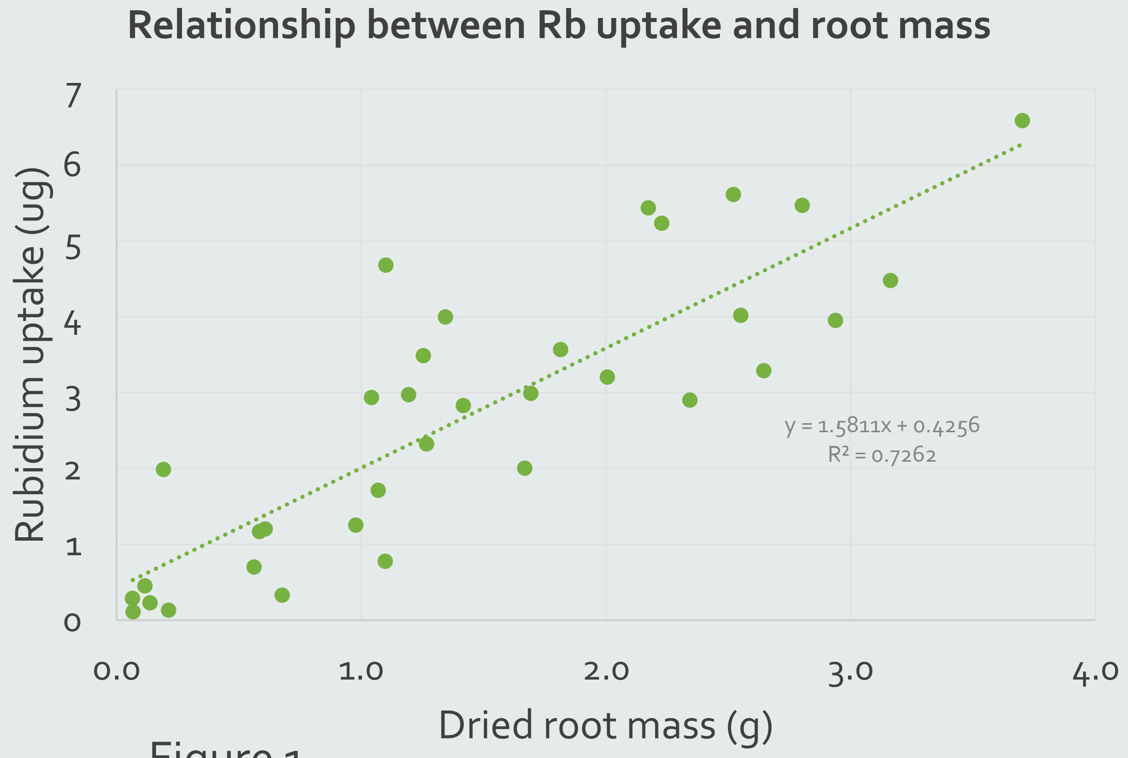

Figure 1.

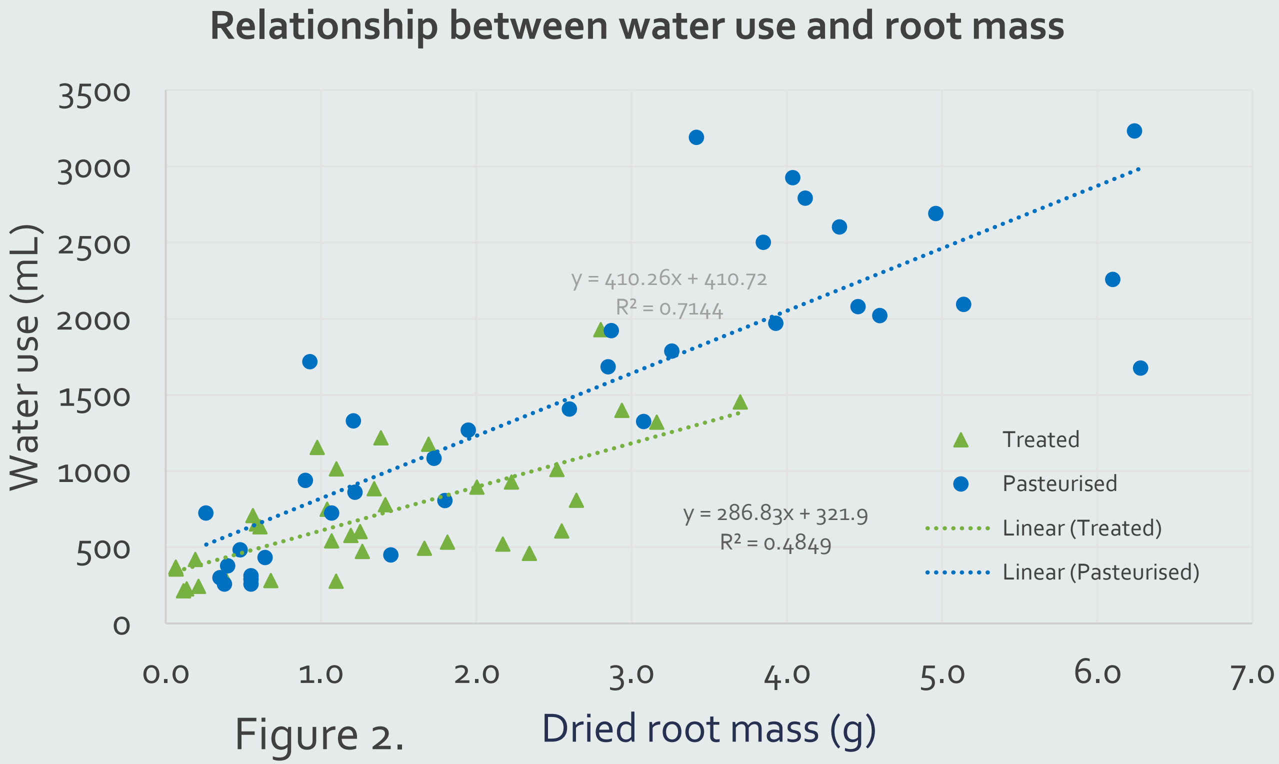

Figure 2.

Glasshouse results: Nematodes

- **Field** = Lesion
- **Start** of **glasshouse** experiment = **Stubby**
- **End** of **glasshouse** experiment = **Stunt**
    - **Pot conditions** influenced the **nematode community**
        - Lesion = endoparasite =**more damaging**
        - Stubby, Stunt = ectoparasite = **less damaging**

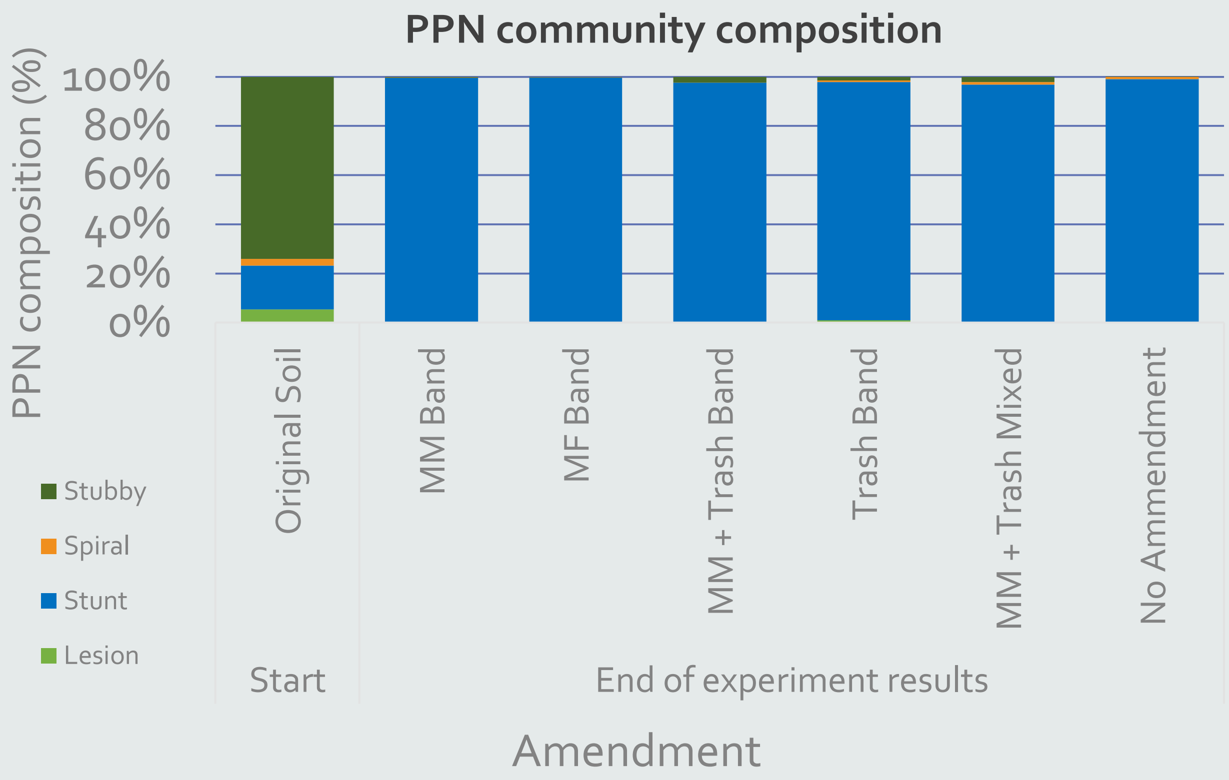

Figure 3.

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Glasshouse results: Nematodes

- **High number of PPN in the MF treatment**
  - → **Greater root mass** which **did not convert** into **increased length** & **surface area**
- **High C:N ratio** (cane trash) amendments increase **microbial populations** and the **FLN community that live on them**

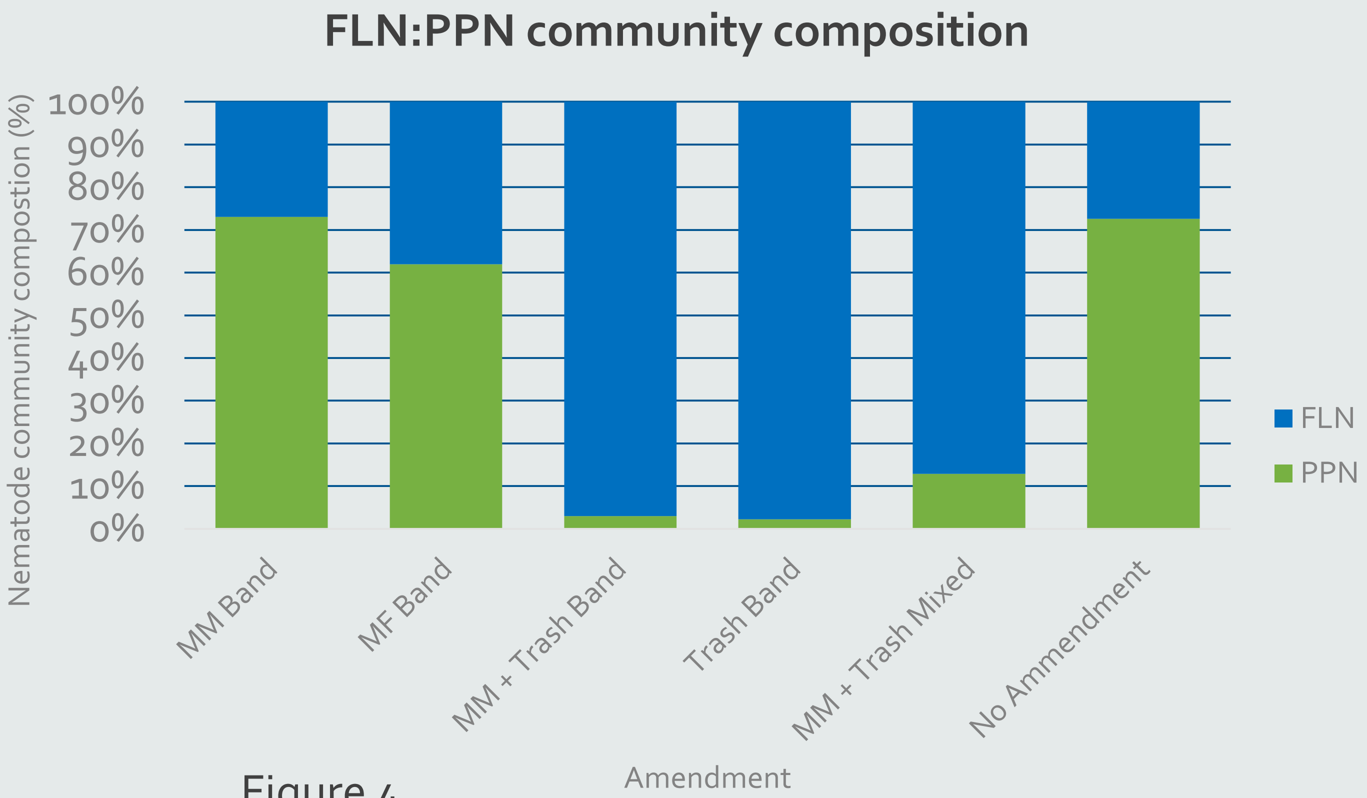

Figure 4.

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Conclusions

Results

- **Both water use and Rb uptake were good indicators of root health**
- **Cane trash** produced **positive** effects in reducing **PPN** populations

What was learnt?

- **Problems** of **excessive variability** in vegetative growth within treatments
- **Lack of experience** with the **watering system** on this **soil type**
- Focusing on one **constraint** is difficult when there are **many**
- **Root recovery** by hand in the field and glasshouse situations is **difficult**!!

Future Research

Glasshouse

- Further development of **glasshouse techniques** to ensure **uniform sugarcane root development** and a more **reliable** soil moisture supply
- The split root and "pot-in-bucket" technique provides a useful system for root experimentation on less constrained soils

Field

- Long term trial will continue for 4 more years
- Will **cane trash** produce significant **positive** effects in the field?

Acknowledgements

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Andrew Dougall	Field trial contact	Maryborough Sugar Factory
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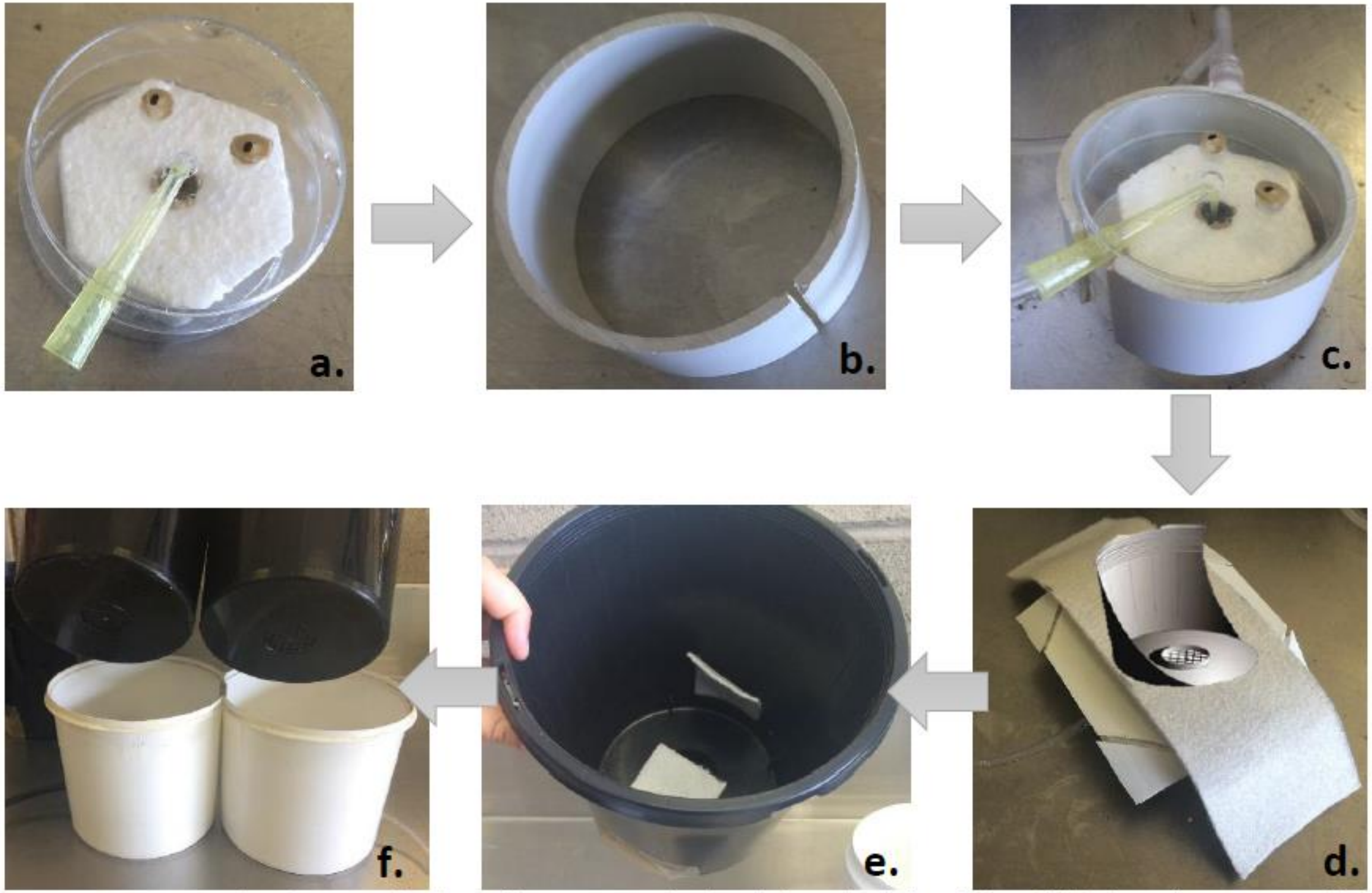

Figure 2 Putting together the pot in bucket self-watering method with the valve (a.) and the cuff (b.) that allows water table height to be set depending on its location around the valve (c.). The valve and cuff is then assembled at the bottom of the white buckets (f.) with matting placed on top to ensure a large and stable surface to put the capillary matting and the ANOVA pot (e.) on top of the self-watering system (d.). A medical infusion kit (not shown) is then attached to the valve at the bottom of the bucket and attaches to large container of water (not shown) to complete the PIB self-watering system. As a split root experiment will be conducted two pots have been plastic welded together (f.) and will form the experimental set up that will be used in the glasshouse trial