EVALUATE CROP MULCHING, FALLOW CROPPING AND COMPOSTING TO REDUCE OR ELIMINATE TRADITIONAL INORGANIC PRE-PLANT FERTILISER.

Research Topic 2: **Ground preparation, fallow management**
and
Research Topic 3: **Pre- and post-plant nutrition management**

Trial numbers: SA02WB-01 and SA03WB-03

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INTRODUCTION

A pineapple crop needs substantial nutritional requirements to effectively grow commercial yields. These nutritional requirements are required both in the pre-plant and post plant stages of crop growth. They consist of large amounts of macro elements such as nitrogen, phosphorus, potassium, calcium and magnesium, as well as small amounts of micro elements such as zinc, iron, copper and boron. Traditionally, the nutritional requirements have been met through inorganic fertilisers for example urea, potash, magnesium sulphate, etc.

Research undertaken by Cyril Ciesiolka from the Department of Natural Resources (DNR) in the 1990s indicated that there is a substantial amount of nutrition in the ratoon crop plants prior to crop destruction, for example 1.2 tonnes per hectare of elemental nitrogen and 1.6 tonnes per hectare of elemental potash. Each ratoon crop consists of approximately 130 tonnes of plant matter per hectare. This is traditionally destroyed by the grower using four to six passes with a rotary hoe which leaves most of the crop residue on the surface of the soil to breakdown. With this practice much of the nutrition and organic matter is not returned to the soil to be utilised by the next crop. By replacing some of the rotary hoe passes with mulching implements for crop destruction, better use can be made of the remnant nutrition in the plant residue by incorporating it back into the soil profile. Furthermore, incorporating organic compost, and growing and incorporating crop residue from fallow crops can further contribute to pre-plant nutritional requirements and supplement inorganic fertilisers.

In Australia the industry is located near the coast, often close to sensitive environmental areas such as the Great Barrier Reef and Moreton Bay Marine Park. It is also often grown on sandy soils that are prone to soil erosion. As well as potential environmental impacts there are also increasing concerns about rising fertiliser costs, so managing nutrient inputs has never been more important. The key issue of concern is off-farm deposition of nutrients, primarily nitrogen. High levels of nutrients in the water can have a negative impact on aquatic environments, for example by causing blue green algae blooms. It is important for pineapple farmers to manage their fertiliser programs efficiently and reduce losses of fertilisers from the farm. Measures include only applying amounts that will be used by the crop, reducing the movement of water across the farm and as far as possible retaining applied nutrients on the farm so they are not contaminating the environment.

This demonstration trial focused on comparing traditional crop destruction practices against the integration of mulchers to better manage crop residue and its nutrient content. It also looked at the effects of adding compost and additional biomass from fallow crops.

HYPOTHESIS

The introduction of a mulcher, in addition to the use of a rotary hoe, to pulverise and incorporate crop residue back into the soil will improve the soil's nutrient content and availability for the next crop. This practice together with the use of a fallow crop prior to pineapple planting and adding compost in the pre-plant phase will start to improve soil health by increasing soil organic matter (OM), cation exchange capacity (CEC) and microbial activity (Hall, 2022).

TRIAL OBJECTIVES

Supplement pre-plant inorganic fertiliser requirements and improve soil health through:

a) Improving release of nutrient back into the soil profile from better incorporation of residue from the previous crop using a mulcher.
b) Planting break crops in the fallow period then incorporating them into the soil.
c) Incorporating compost into the soil profile.

METHOD

Location and grower

The site is Littabella Pines Pty Ltd located on South Littabella Road, Yandaran north of Bundaberg. The farm owners and principal collaborators John and Linda Steemson and their family have been growing sugar cane, pineapples and other small crops for many years in the area and are the first pineapple farm to obtain Reef Certification in the Growcom Hort360 program.

Dates

February 2019	Commence planning, select site, complete harvest of previous crop
April 2019	Soil samples taken for nematode count and nutrient analysis
April 2019	Ratoon crop destroyed; composted chicken manure applied
November 2019	Fallow crops planted
March 2020	Soil samples taken for nutrient analysis
April 2020	Pineapples planted
6 September 2021	Flower initiation in Treatment 1
21 October 2021	Flower initiation in Treatment 2
March / April 2022	Plant crop harvested, yield data collected

Crop details

The trial site followed a previous crop of Smooth Cayenne that was taken to ratoon and harvested in February 2019. The site was replanted with Smooth Cayenne, using industry standard two-row beds on 1.5 metre bed centres. The soil type is a sandy loam topsoil with a depth of 0.3 to 0.4 m overlying a heavy clay subsoil. There were major issues of Phytophthora root rot and extremely high levels of nematode.


Figure 1 and 2. Ratoon from previous crop.

Description

Immediately after harvest of the previous crop, a soil sample was taken for nutrient and nematode analysis. Nematode counts were 2,180 of root knot nematode per 200mL soil, a very high population.

Figure 3. Trial layout

Treatments

The ratoon crop was destroyed in April 2019. Standard industry practice was followed at Site 2 and experimental practices used at Site 1.

Standard industry practice (Site 2)

- Six rotary hoe passes between April and November. This method leaves the crop residue on the surface and upper layers of the soil profile.
- No fallow crops planted i.e. a bare fallow.

Experimental practice (Site 1)

- One pass with a mulcher to pulverise the crop residue into smaller fragments, immediately followed by a pass with a rotary hoe to bury the residue.
- Five tonnes/ha of composted chicken manure applied and incorporated with the crop residue using a rotary hoe.
- This was followed by a deep tillage pass with a plough to incorporate the crop residue and compost deeper into the soil profile.
- In November 2019 after the areas were free of crop residue, three different fallow crops were planted in individual plots, allowed to grow over the subsequent summer months and incorporated into the soil profile in March 2020. The three fallow crops were:
    - Rye grass (site 1A)
    - Oats (site 1B), and
    - Barley (site 1C).

  See Figures 4 to 10 below.

1 month after fallow crop planted

Figure 4. Fallow of rye grass (1A)

Figure 5. Fallow of oats (1B)

Figure 6. Fallow of barley (1C)

3 months after fallow crop planted

Figure 7. Fallow of rye grass

Figure 8. Fallow of oats

Figure 9. Fallow of barley

Variations in the establishment of the fallow crops were the result of dry conditions experienced at planting and throughout the fallow crop cycle. Three months after planting, the dry conditions and heat affected plant growth. The rye grass performed better than the oats or barley.

Figure 10. Treatment 2 (standard practice) - bare fallow

In March 2020 (the month before pineapples were planted) soil samples for nutrient analysis were taken from each of the two treatments.

In April 2020 ground preparation was undertaken including an industry standard pre-plant pesticide program on both standard and experimental treatments.

Pest, disease and growth assessments were undertaken at 3, 6, 12 and 18 months after planting in April 2020 until floral initiation in September 2021.

Treatment 1A, 1B and 1C were induced for flowering on the 6th September 2021. Plants in treatment 2 were not big enough to induce until 21st October 2021.

	
	
Experimental Practices	Standard Treatment

Figures 11 & 12: Experimental treatment and Standard treatment 4 – 6 months after plant crop harvest.

In the vegetative stage of the ratoon crop four to six months after harvest the experimental treatment has greater sucker size and more uniform growth when compared to the standard treatment.

RESULTS

Crop destruction

The mulching treatment pulverised the crop residue into smaller particles and the rotary hoe which followed immediately buried the crop residue into the soil profile. Standard practice with multiple passes of the rotary hoe chopped up the crop and only partially buried the crop residue. See Figures 13 to 18 below.

Experimental Practice (Mulching) – Treatment 1A, 1B and 1C

Figure 13. After mulching

Figure 14. Trash after mulching

Figure 15. Immediate rotary hoe

Standard Practice - Treatment 2

Figure 16. One pass rotary hoe

Figure 17. Trash after rotary hoe

Figure 18. After second rotary hoe

Crop residue breakdown three months after crop destruction

There were differences in the level of crop residue breakdown in both treatments after crop destruction. Observations after three months indicated there was less visible crop residue in the mulched treatment in comparison to the standard practice. The standard practice had visible residue on the surface and was therefore more prone to nutrient loss to the environment (Figures 19 and 22 below).

Experimental Practice (Mulching)

Figure 19. Close up remnant trash

Figure 20. Minimal trash on surface

Standard practice

Figure 21. Close up remnant trash

Figure 22. Remnant trash on surface

Soil analysis

Soil samples from each treatment were taken for nutrient analysis at crop destruction in April 2019 and compared with samples taken just prior to planting the next crop of pineapples in March 2020. An indication of the effect of the different crop destruction methods, addition of composted chicken manure and fallow cropping is presented in figures 23 – 33 below.

Soil pH

At crop destruction the soil pH was 4.5, this had risen slightly in the standard treatment to 4.7 whilst in the experimental treatment it had risen to 5.0.

Soil organic matter

At crop destruction the soil organic matter measured 1.27%. Eleven months later this had dropped to 1.12% in the standard practice and in the experimental treatment had remained close to the starting point at 1.25%.

Solvita respiration levels

This gives an indication of soil health based on the rate of carbon dioxide release from the soil. Carbon dioxide emissions from the soil are primarily due to microbial respiration, therefore the higher the respiration levels the higher the microbial activity. Solvita respiration levels in the standard practice remained at 1% at both testing times however in the experimental treatment it increased from 1% to 2%, indicating twice the amount of microbial activity.

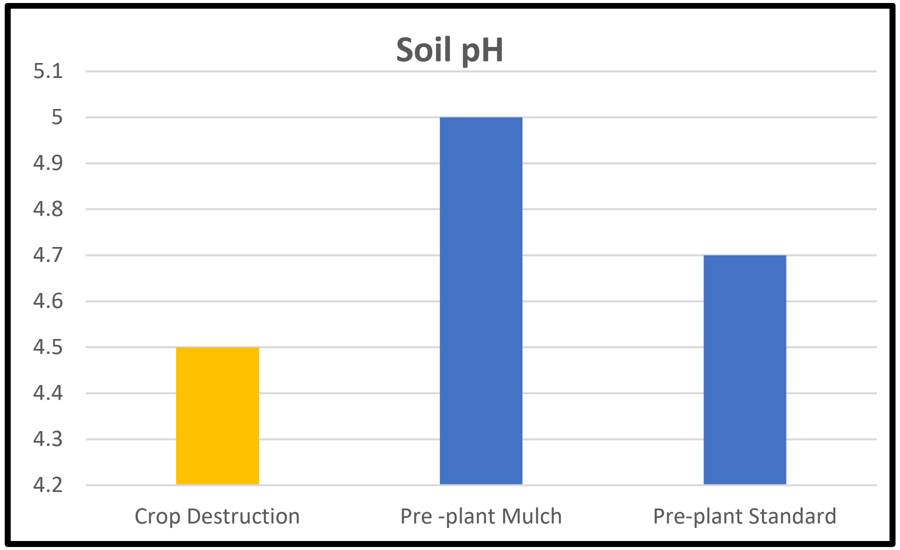
Nutrients

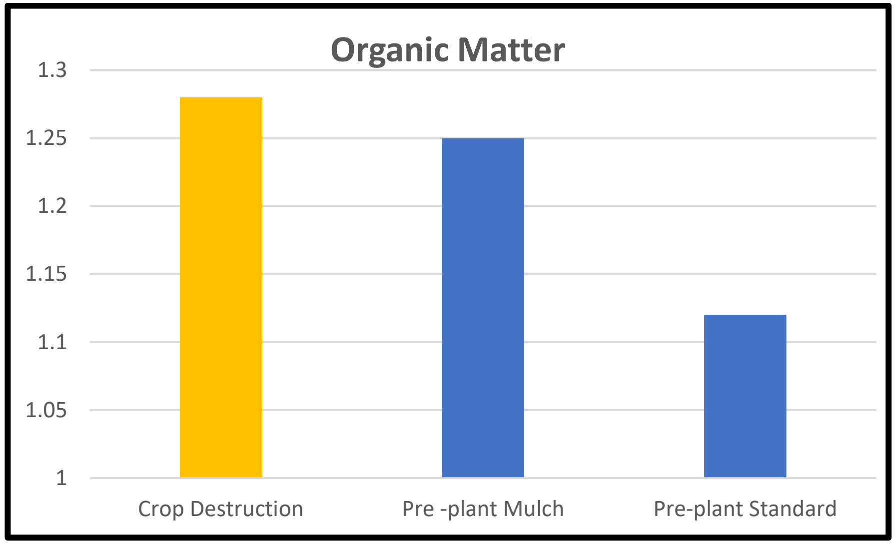
At crop destruction of the previous crop the levels of nitrate, potassium, calcium, magnesium and zinc were very low in the soil.

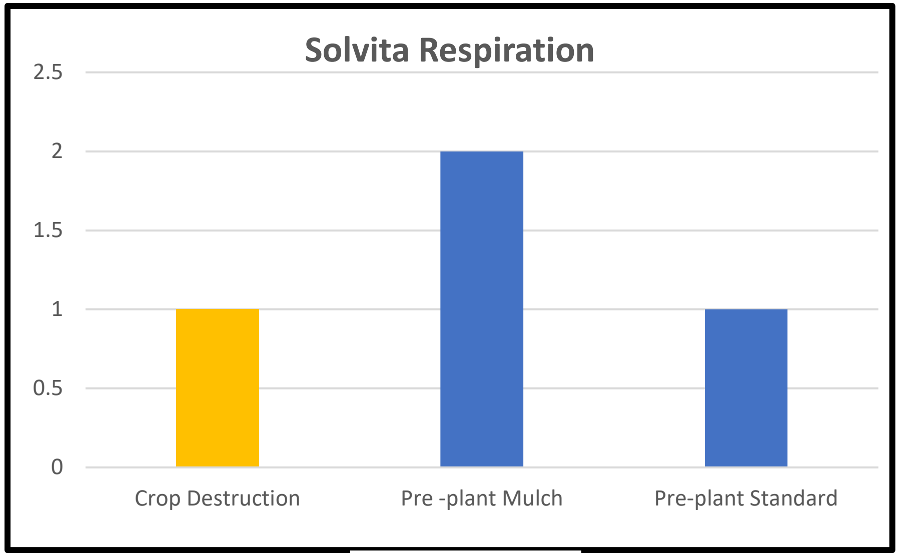
In the experimental treatment prior to planting but after crop destruction, incorporation of the chicken manure and fallow crop, the levels in the soil of nitrate, potassium, zinc and copper were slightly higher than the standard treatment, whilst the levels of phosphorus, calcium, magnesium and iron were substantially higher, especially calcium and magnesium.

The experimental practice required minimal amounts of pre-plant fertiliser and consisted of a moderate rate of calcium, nitrogen and magnesium. Standard industry practices required substantial amounts of pre-plant fertiliser across all elements (see figures 29 – 33).

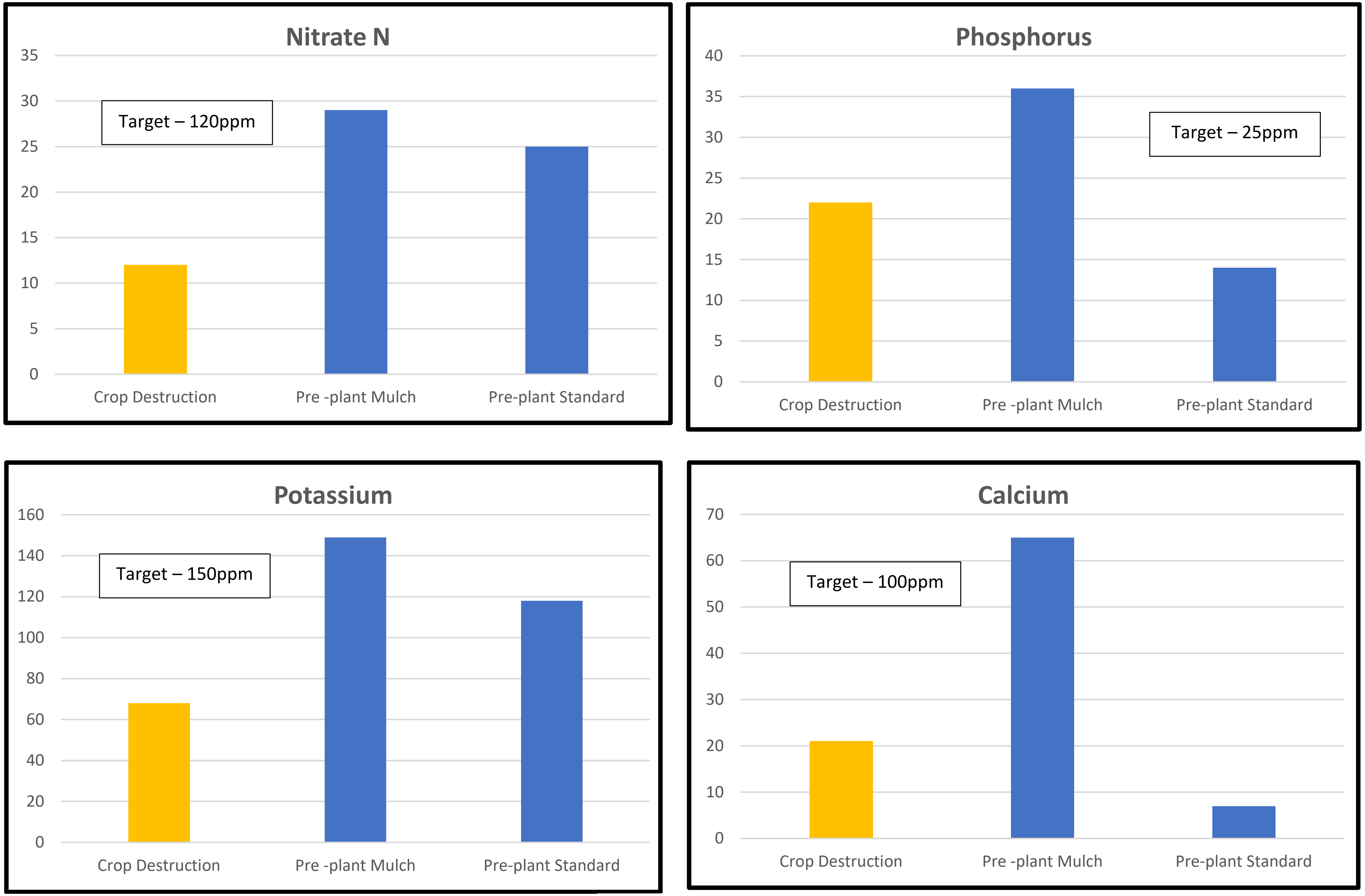
No side dressing was applied within the trial. Foliar fertiliser applications were applied from two months of age with standard industry boom spray equipment.







Figures 23 to 25



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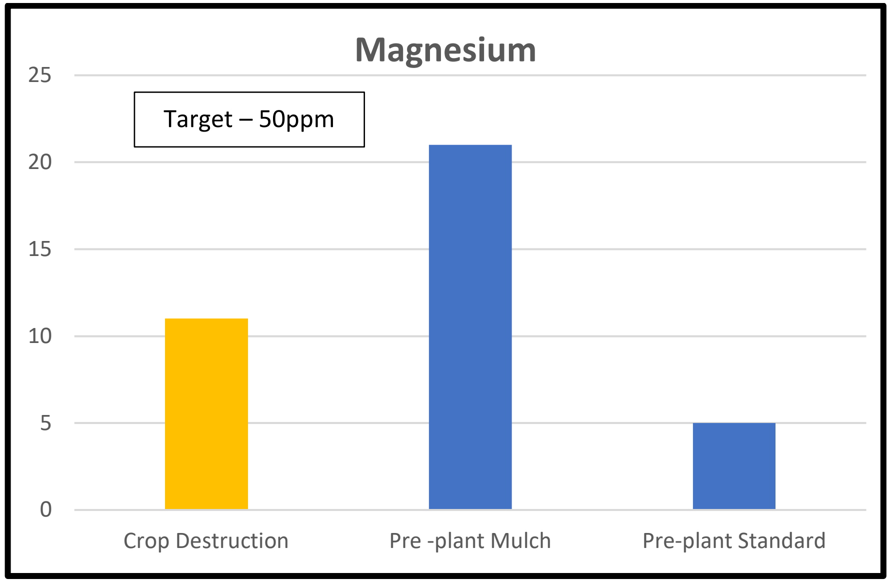

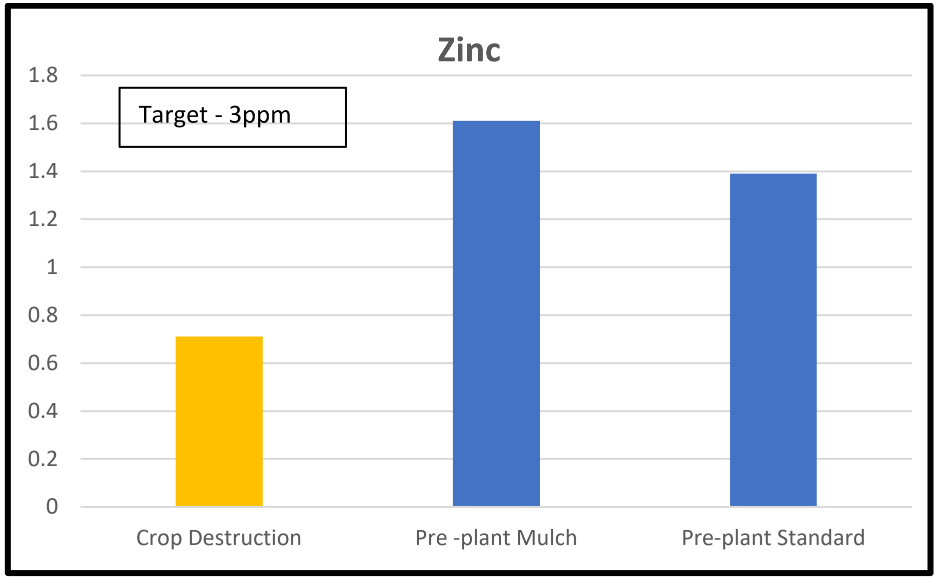

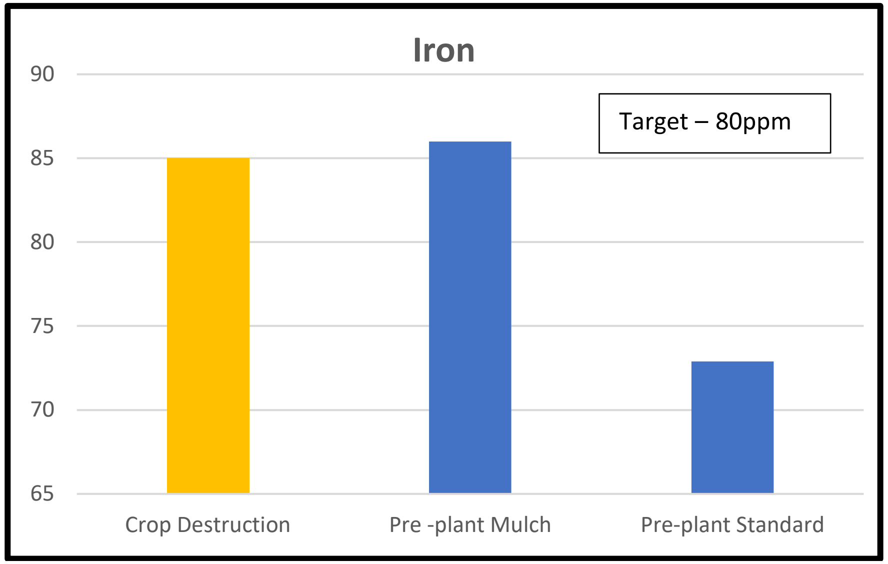

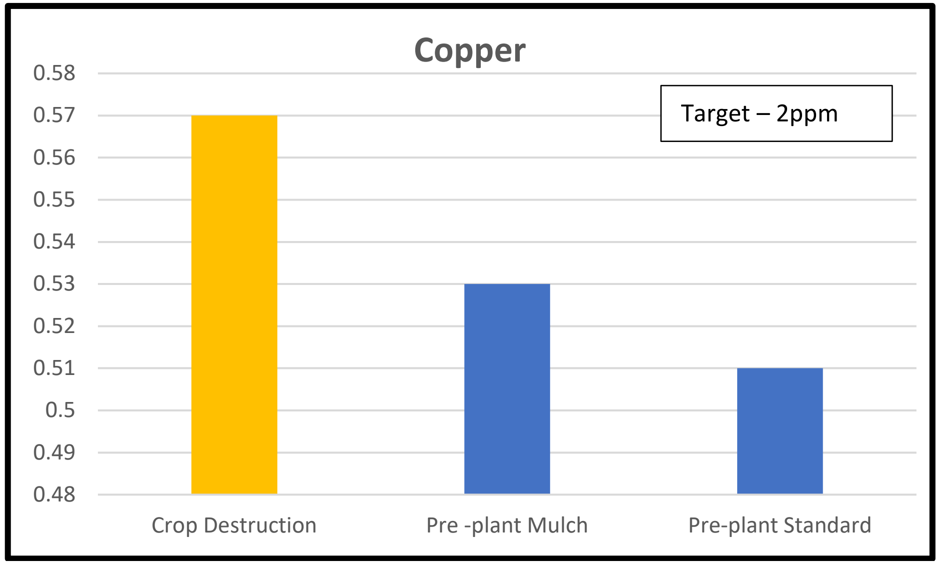

Figures 30 to 33

Growth Assessments

Plant growth was assessed at 3, 6, 12 and 18 months after planting (prior to floral induction). Results show that both plant weight and root growth were higher in the experimental treatment vs the standard practice.

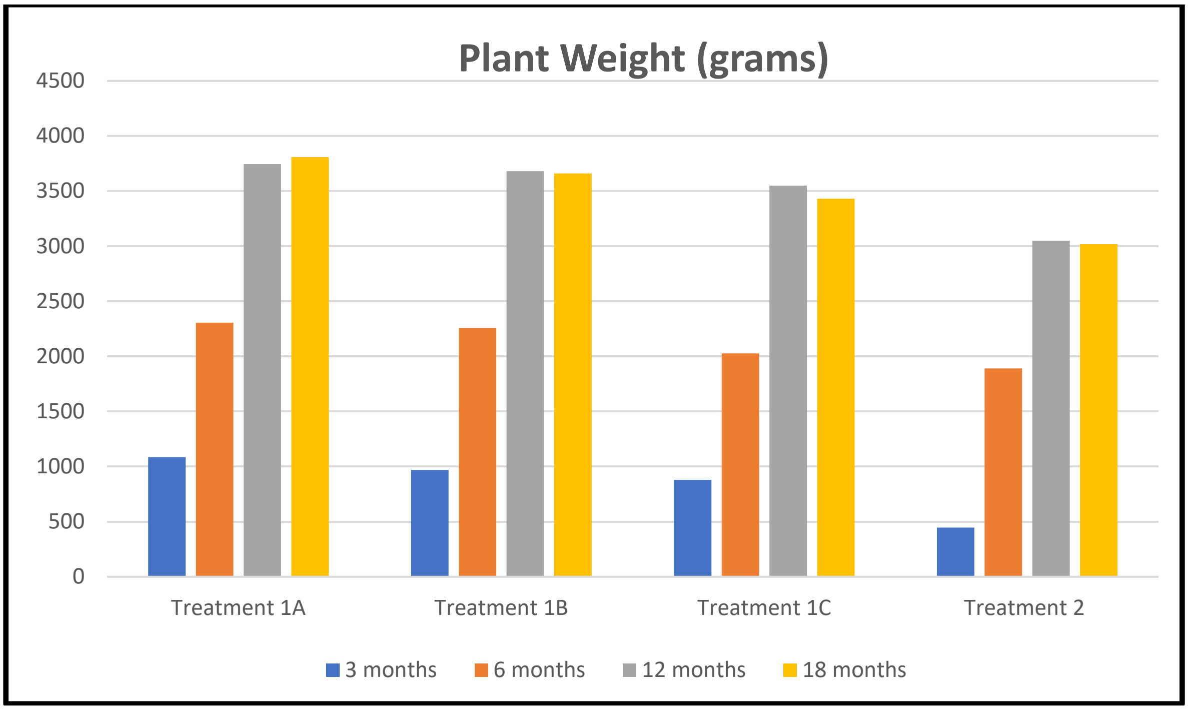

Figure 34

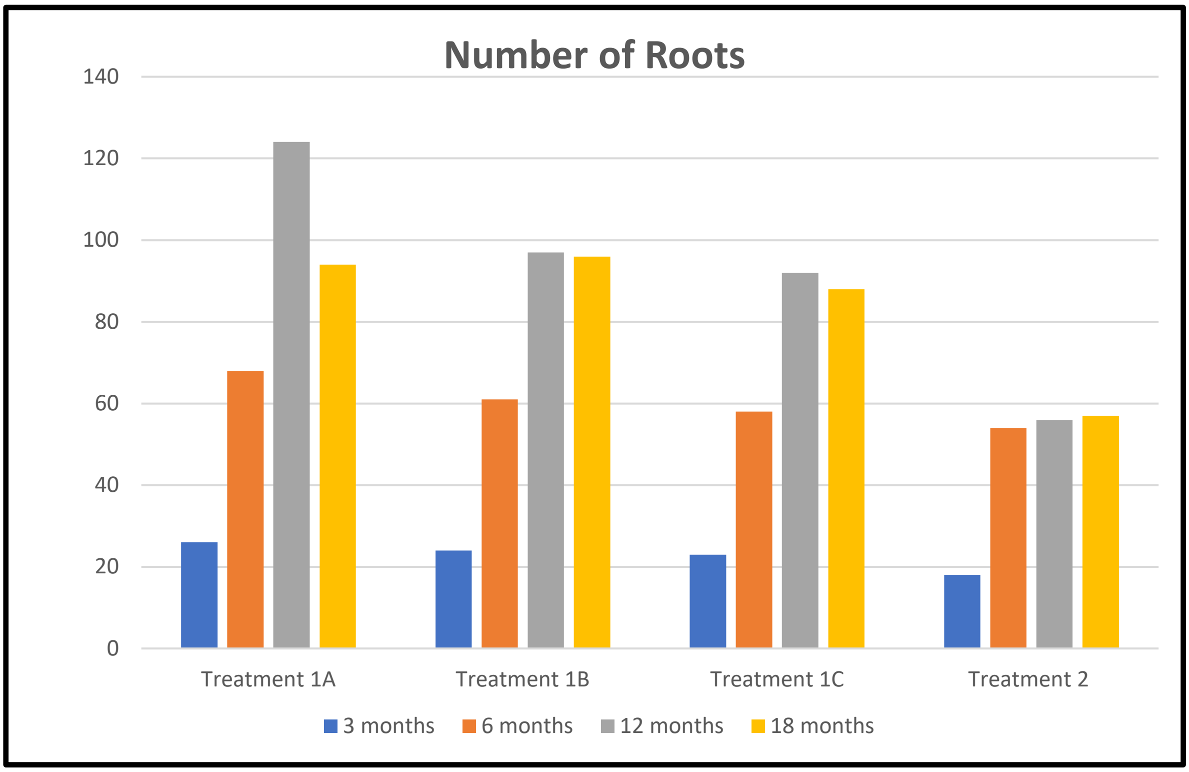

Figure 35

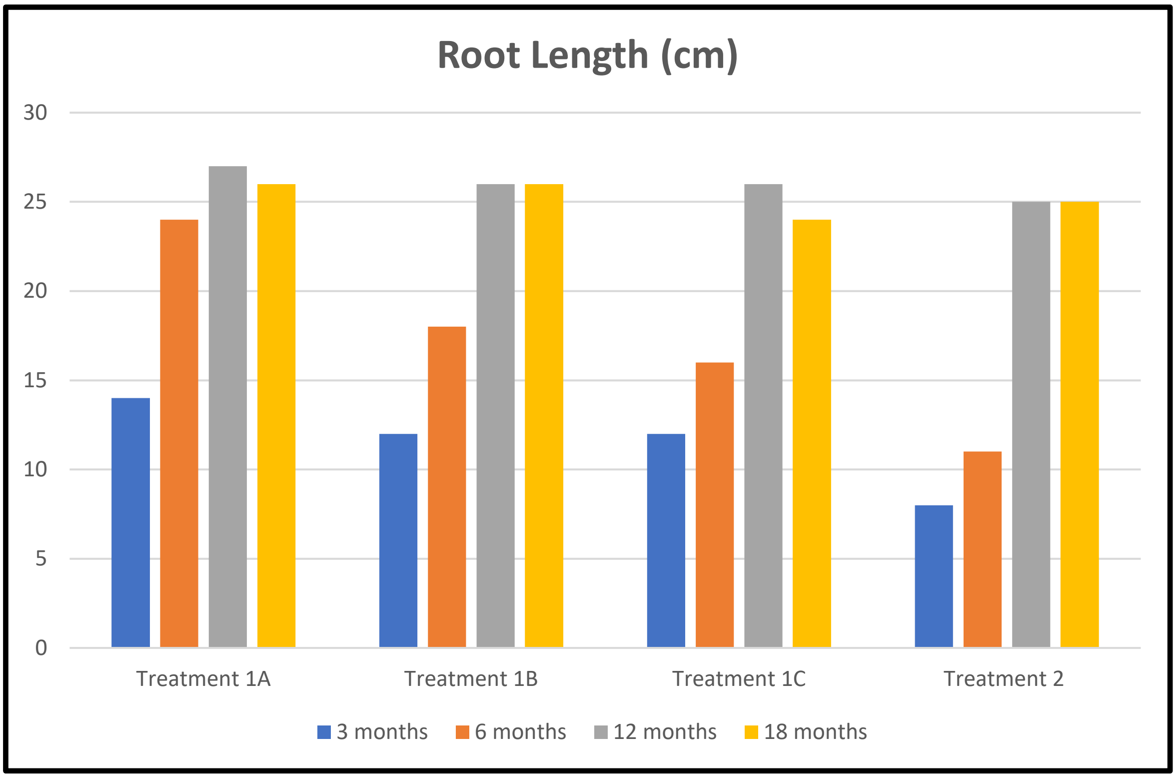

Figure 36

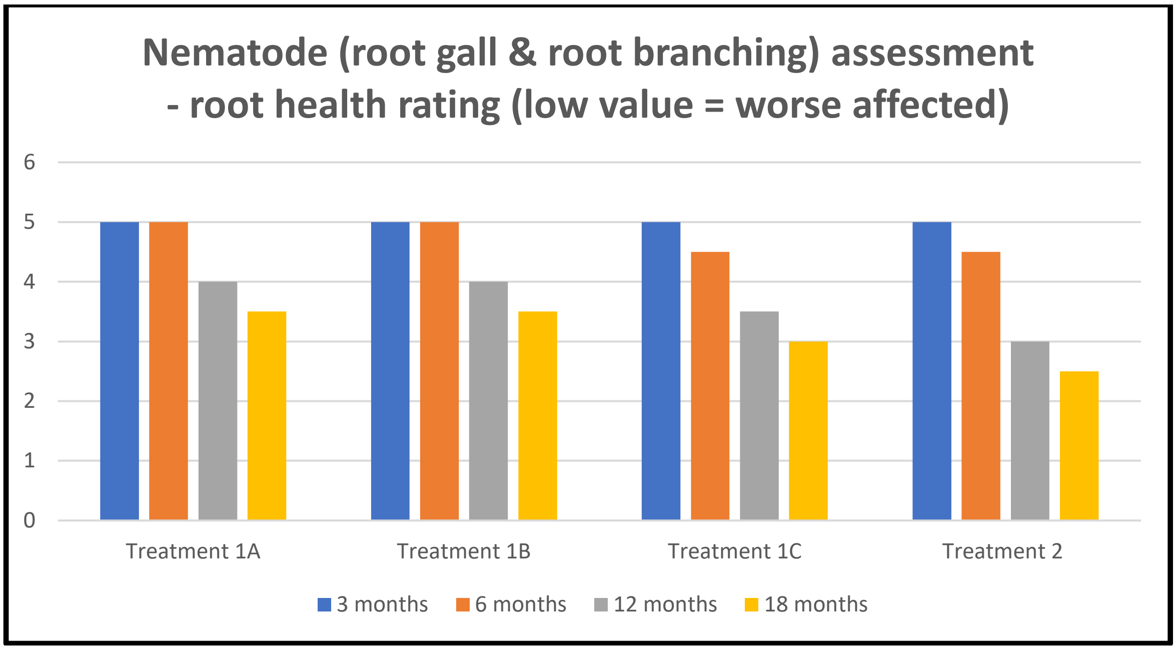

Figure 37

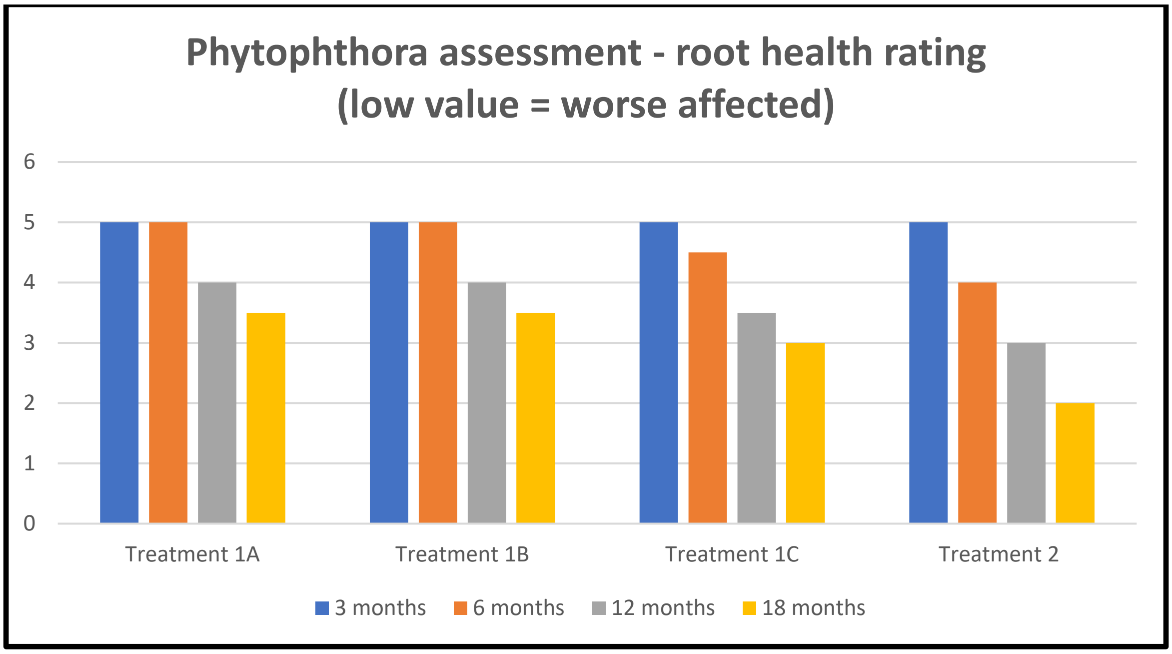

Figure 38

Yield

Yield assessments were taken at the main plant crop harvest for both experimental practices (March 2022) and standard treatment (April 2022). Assessments were collected by the grower consisting records of individual bin numbers harvested from each treatment area. The records did not include natural flowered fruit harvested over a number of months with numerous passes prior to the main harvest, however natural flowering rates appeared similar in all treatments. The approximate sample size of the main harvest was 70% of the total plant crop. All the fruit in this demonstration site was sent to processing where each individual bin was weighed and the weight of fruit in each bin determined. The average bin weight for each treatment was calculated, see below:

Treatment 1A, 1B and 1C were induced for flowering on the 6th September 2021 and harvested in March 2022. Plants in treatment 2 were not big enough to induce until 21st October 2021 and were harvested in April 2022.

Crops harvested in summer and autumn are different in average fruit size and fruit shape - summer harvested fruit is smaller in size and cylindrical in shape, whereas autumn harvested fruit has a large base and narrow shoulders typically conical in shape and is the start of the ‘large fruit’ season from April to September. Fruit harvested in the autumn window will be heavier and weigh substantially more than summer harvested fruit - this needs to be taken into account when comparing the yields in this trial.

For the reasons given above, the yield from the summer harvested Treatment 1 would be expected to be less than fruit harvested in the autumn harvested Treatment 2, however Treatment 1 had a greater average bin weight (31.9 kg or 4.2% higher) indicating the superiority of the practices applied to Treatment 1.

- Standard Treatment – 735.8 kg
- Experimental Practice – 767.7 kg

DISCUSSION

Traditionally the pineapple industry has a long history of unhealthy soils with low organic matter, low organic carbon and poor nutrient availability. The key outcomes of this demonstration highlight the importance of practices required to improve soil health in order to achieve benefits in crop growth, yield and cost.

Crop growth and yield analysis

The practices in this demonstration were to incorporate crop mulching and integrate the use of composts into a pineapple production system. Within this demonstration the experimental practise used mulching as a method to destroy and pulverise the previous standing crop and then incorporate the crop residue into the soil profile. The objective was to observe the potential of 'mulching' to recycle nutrient from the previous crop better and replace some of the requirements for inorganic fertiliser for the new crop cycle, whilst at the same time attempting to maintain or improve soil health. Soil organic matter improves the structure and health of the soil and its capacity to store and supply nutrients and moisture which in turn improve plant growth.

It is not possible to identify how much of the benefit was derived from the different crop destruction practice and how much was from the application of chicken manure because both practices were applied to the same field of pineapples.

Within the experimental practice there was faster crop establishment, more crop growth and greater root numbers through the entire plant crop cycle when compared to the standard treatment (see figures 34 – 36). The improved crop growth and root health in the experimental treatment may be a result of better soil conditions, better soil nutrition, improved microbial activity and lower pest and disease levels (see figure 37 and 38).

Incorporating a finely pulverised crop residue into the soil would allow soil microbes to better penetrate the crop residue, causing more efficient breakdown and subsequent release of nutrient back into the soil profile. The addition of a soil conditioner in the form of composted chicken manure, added additional minerals and supported the microbial populations to release the nutrient from the crop residue in the soil profile. The results of the Solvita Respiration test indicated double the microbial activity in the experimental practice (figure 25).

The breakdown of crop residue in the soil profile and the addition of composted chicken manure were shown in the analyses to improve some soil health characteristics, namely organic matter, soil pH and nutrient levels which are expected to be more suitable for plant establishment, plant growth and root health (see figures 23 – 25). Treatment 1 harvested 86.5 tonnes per hectare and Treatment 2 harvested 82.86 tonnes per hectare. Treatment 1 had a 4.2% increase in yield and a six-week shorter growing cycle. The harvested yield does not include natural flowered fruit. The yield from the natural fruit appeared to be visually the same across both experimental and standard treatments.

Cost benefit analysis

Using a Golden Circle fruit value of $600 per tonne farm gate, Treatment 1 harvested 86.50 tonnes per hectare at a value of $51,900. Treatment 2 harvested 82.86 tonnes per hectare at a value of $49,716. The 4.2% increase in yield for the experimental treatment represents a financial benefit of $2,184 per hectare.

Machinery Operations
This demonstration conducted an experimental practice using one pass with a mulcher and one pass with a rotary hoe compared to standard industry practice of four to six passes with a rotary hoe to destroy and incorporate a ratoon crop. Both machinery operations were compared below:

Cost of a machinery operator - $34 / hr
Cost of fuel to run a 120hp tractor – $51 / hr

Table 1. Cost of rotary hoe and mulcher per pass

Parameters	**Rotary hoe (one pass)**	**Mulcher (one pass)**
Rate (hrs / ha)	2.25	6.5
Labour cost ($/ha)	2.25 hr x $34 = $76.50	6.5 hr x $34 = $221
Fuel cost ($/ha)	2.25 hr x $51 = $114.75	6.5 hr x $51 = $331.50
Total ($/ ha) per pass	$191.25	$552.50

Standard Treatment
The standard treatment to destroy and incorporate a crop consists 4 to 6 passes with the rotary hoe. One pass with the rotary hoe is $191.25 / ha therefore in this trial where 6 passes were done the cost is **$1,147.50 / ha.**

Experimental Practice
The Experimental Practice to destroy and incorporate a crop consists one pass with the rotary hoe and one pass with the mulcher. One pass with the rotary hoe is $191.25 / ha and one pass with the mulcher is $552.50 / ha - a total of **$743.75 / ha**.

Table 2. Total cost of rotary hoe and mulcher passes in each treatment

	Standard treatment	**Experimental treatment**
Mulcher		1 x $552.50 = $552.50
Rotary hoe	6 x $191.25 = $1,147.50	1 x $191.25 = $191.25
Total ($/ ha)	$1,147.50	$743.75

Thus, in this trial the costs of mechanical crop destruction in the experimental treatment was $403.75/ha less compared with the standard treatment.

Fertiliser Inputs
Pre-plant fertiliser requirements were very different between the experimental practice and standard industry treatment in this demonstration.

- The standard treatment required 1,563 kg / ha of pre-plant fertiliser.

- The experimental treatment had the benefit of 5 tonnes per hectare of composted chicken manure and perhaps greater access to nutrients contained in the residue from the previous crop. It also required 935 kg / ha of pre-plant fertiliser.

The cost of the composted chicken manure was $170/t for the material including GST and freight from Southeast Queensland, and the cost of spreading = total cost $850/ha spread.

Recommendations: **Standard treatment**

Table 3. Cost of nutrition inputs in standard treatment

Product	Rate (kg / ha)	Cost of Fertiliser
Sulphate of Ammonia	463 kg / ha	$542.20
MAP	50 kg / ha	$117.53
Sulphate of Potash	78 kg / ha	$153.76
Gypsum	503 kg / ha	$502.70
Magnesium Sulphate	469 kg / ha	$440.63
Total	**1,563 kg / ha**	**$1,756.81**

Table 3

Recommendations: **Experimental treatment**

Table 4. Cost of nutrition inputs in experimental treatment

Product	Rate (kg / ha)	Cost of Fertiliser
Sulphate of Ammonia	444 kg / ha	$519.37
Gypsum	189 kg / ha	$189.19
Magnesium Sulphate	302 kg / ha	$283.96
Sub total	***935 kg / ha***	***$992.51***
Composted chicken manure	5,000 kg / ha	$850
Total		**$1,842.51**

Table 4

The total cost of pre-plant nutrients was $85.70/ha more for the experimental practices.

Note: Recommendations are based on standard industry pre-plant nutrition for Smooth Cayenne.

In spite of similar nutritional costs in both treatments, the impact on the plant growth, timing of the crop and soil characteristics are different. In the standard treatment the nutritional requirements consisted over 1,563 kg / ha of inorganic fertiliser applied 30 days prior to planting. The experimental practices had a nutritional program that focused on the 12 months prior to planting by utilising the nutritional value of the previous crop and application of composted chicken manure to the soil. This was then supported with over 935 kg / ha of inorganic fertiliser prior to planting. In the post plant fertiliser program both experimental and standard treatment had the same nutrition program.

Soil microbes perform fundamental functions such as nutrient cycling, breaking down crop residues, and stimulating plant growth. In the case of the experimental practice the fundamentals of these farming practices were aimed at maintaining and supporting microbial activity within the soil and observing the impact on the crop growth, crop timing and soil characteristics. Using the mulcher to pulverise the crop and incorporating compost chicken manure into the soil, help stimulate and feed microbial populations which release the nutrition from the previous crop. The stronger microbial population created in the experimental practices more effectively generated usable forms of nutrient ready to stimulate plant growth immediately at plant establishment.

In the standard treatment inorganic fertilisers were applied within 30 days prior to planting. There was lower microbial activity in the soil of this treatment at plant establishment.

ADOPTION AND IMPACT

In summary, there is minimal difference in cost to implement the experimental practice and standard treatment. However, the positive impacts on better crop growth, root establishment and a shorter production cycle may be attractive to growers. The positive impact on soil health is a major incentive for long-term productivity and sustainability of farms. However, there remains some doubt in the concepts and theories of soil health and soil biology in the minds of growers.

What is required is a better understanding of soil biology, soil health and the complex interactions within the soil which has been very limited over many years. Traditionally pineapple production has been based on production methods with minimal consideration of soil health and the beneficial impacts of microbial populations. A greater understanding of our soils through further research like this demonstration can raise awareness amongst growers that *'we can grow pineapple and have better soil health'.*

Additionally, with the increased cost of fertiliser growers are looking for alternatives to traditional inorganic fertilisers. With a range of soil conditioners and other composts produced locally, incorporating these products into a pineapple production system can become more viable and a preferred source of pre-plant nutrition. This can be further encouraged by the added effects of improving soil health and long-term productivity of soils.

CONCLUSION

This demonstration has highlighted potential to further investigate the impact of pineapple production systems grown in healthy soils. Growers have the tools and capability required to adopt these practices. With further research and guidance, the industry can achieve a more sustainable production system for the next generation of pineapple farmers.

REFERENCES

- David Hall – Agronomist: specialising in soil health and compost.