EVALUATE THE BENEFITS OF DIFFERENT FUMIGATION PRODUCTS ON PINEAPPLE PLANT CROPS IN SOUTH EAST QUEENSLAND AND NORTH QUEENSLAND

Research Topic 4: Pest Management

Trial numbers: 04-SEQ-02 and 04-NQ-03

CONTENTS

INTRODUCTION

Soil fumigation is often used where high-value agricultural and horticultural crops are grown in long-term monoculture. Soil fumigants provide benefits to growers in managing a wide range of pests and diseases, including nematodes, fungi, bacteria, insects, and weeds.

Soil fumigation is used as a pre-plant chemical treatment of soil, using a pesticide product that converts to a volatile gas. The chemical compounds used in soil fumigation have low boiling points and high vapor pressures enabling them to diffuse through open pore spaces through the soil profile.

Soil fumigation can temporarily increase plant growth and yield. In the case of major pineapple pests such as nematodes, the cysts and juveniles are almost never completely eradicated from a field by fumigation, and a small population left over after fumigation can build up rapidly. Additionally, the cost of fumigation per hectare is very high and identifying crop benefits and pest efficacy is critical in determining economic viability.

HYPOTHESIS

Fumigating pineapple fields before planting will have a positive effect on root establishment and yields in the plant and ratoon crop.

OBJECTIVES

1) To compare the effectiveness of new and existing fumigants for improving yields, especially in the ratoon.
2) To observe the efficacy of fumigation on the full range of soil borne pineapple pests and diseases.
3) To undertake a cost analysis of the different fumigants.

METHOD

LOCATION AND GROWER

Piñata Farms provided two sites, located at opposite ends of the pineapple industry production area:

- Pates Road, Wamuran in South East Queensland
- Carmen Rd, Mareeba in North Queensland.

The sites both had major issues with phytophthora root rot, nematodes and natural flowering.

DATES

- December 2018 - planning commenced.
- April to May 2019 – treatments applied and both sites planted.
- July 2019 – July 2020 - crop health, pest and disease assessments.
- July to August 2020 - floral induction for plant crop harvest.
- January to February 2021 - plant crop harvest at both locations.
- October 2022 - floral induction for ratoon crop harvest (SEQ).
- April 2023 - ratoon crop harvest (SEQ).

CROP DETAILS

The variety used was 73-50 in South East Queensland and MD2 in North Queensland. Crowns were planted at Wamuran and slips were planted at Mareeba on two row beds with 1.1m bed centres and plants 0.3m apart down the row giving a planting density of 60,000/ha.

Prior to fumigation the soil was prepared according to standard industry practices to have good soil tilth and no crop residue. Soil pH was 4.3. The sites had good moisture leading into fumigation and ambient temperatures ranged from 20 – 30°C. Planting took place 21 days after fumigation.

Figure 1: Trial location Wamuran SEQ prior to fumigation. Figure 2: Soil opened up to assist drying out prior to fumigation.

An industry fumigation rig was modified to reflect the fumigant labels requirements. The fumigation rig consisted of a duck foot tine with dual outlets to minimise soil disturbance. The fumigant was injected at 40cm depth, and the surface was immediately compacted using a heavy tyre roller.

Figure 3 Fumigation rig used to apply treatments.

Figure 4. Duck foot tine with dual outlets which can be seen as the two red tubes towards the back of the foot.

DESCRIPTION

Application of treatments were undertaken under the supervision of R & R Fumigation Services. Treatments compared five different fumigants at different rates (low and high rates) with a `Nil` (control) treatment. A complete spectrum of fumigants was applied including mainstream products already used within the pineapple industry i.e. Metham Sodium, Rural Tri-Form and Tri-Form 35. Other fumigants applied were Tri-Form 60 and Pic Plus. Note: The use of Metham sodium is a standard practice for Piñata Farms.

Each fumigant was applied to the soil prior to planting at a low and high rate (except Metham sodium which was applied at one rate) to compare and evaluate pest and disease control efficacy, fumigation cost and return on investment through potential improvements in yield and fruit size.

Table 1. Fumigant treatments, rates applied to the soil and target pest species.

Treatment	Product	Active ingredients	Target pest species	Rate
3	Control			
4	Metham sodium	metham sodium	Controls certain weeds, symphylids and fungal diseases.	600 L/ha
5A	Rural Telone	1,3-dichloropropene	Controls nematodes	160 Kg/ha
5B	Rural Telone	1,3-dichloropropene	Controls nematodes	240 Kg/ha
6A	Tri-Form 35	64% 1,3-dichloropropene 35% chloropicrin	Controls nematodes, symphylids and some diseases including phytophthora.	270 Kg/ha
6B	Tri-Form 35	64% 1,3-dichloropropene 35% chloropicrin	Controls nematodes, symphylids and some diseases including phytophthora.	350 Kg/ha
7A	Tri-Form 60	38% 1,3-dichloropropene 60% chloropicrin	Controls nematodes, symphylids and some diseases including phytophthora.	300 Kg/ha
7B	Tri-Form 60	38% 1,3-dichloropropene 60% chloropicrin	Controls nematodes, symphylids and some diseases including phytophthora.	400 Kg/ha
8A	Pic Plus	80% chloropicrin	Controls nematodes and phytophthora.	270 Kg/ha
8B	Pic Plus	80% chloropicrin	Controls nematodes and phytophthora.	340 Kg/ha

Figure 5. Trial map Pates Road, Wamuran South East Queensland.
Note: Low rates (A) are positioned on the right and high rates (B) are positioned on the left of each treatment.

Figure 6. Trial map Carmen Road, Mareeba North Queensland.
Note: Low rates (A) are positioned on the upper side and high rates (B) are positioned on the lower side of each treatment.

RESULTS

The crop health, pest and disease observations were recorded every three months from July 2019 to July 2020 (3, 6, 9, 12 months after planting). Across both locations six random samples were taken across each treatment area and the root health and overall plant heath characteristics were observed and recorded. The plant root length was measured, and the fresh root mass was recorded. The results from both locations were combined and averaged.

Pineapple assessments at three months of age

General observations of the crop at 3 months of age indicate:

- There were no differences in leaf colour or irregular growth of the crop.
- No visual presence of phytophthora root rot, nematode or insect damage on any root systems.
- Some positive improvements were starting to show up in plant weights and root lengths in fumigated plants compared with the 'Nil' treatment.

Pineapple assessments at six months of age

General observations of the crop at 6 months of age indicate:

- There were no differences in leaf colour across treatments.
- No visual presence of phytophthora root rot, nematode or insect damage on any root systems.
- Plant fresh weights were higher in plants subjected to fumigation especially for Tri-Form 35 (2.7 and 2.3 times greater than the `Nil` Treatment, respectively) and both rates of Tri-Form 60 (2.8 times greater than the `Nil` Treatment).
- Root lengths were 1.5 and 1.7 times longer than the `Nil` Treatment for Tri-Form 35 and Tri-Form 60 respectively.

Pineapple assessments at nine months of age

General observations of the crop at 9 months of age indicate:

- The leaf colour and size of plant are considerably better in the Tri-Form 35 and Tri-Form 60 treatments.
- No visual presence of phytophthora root rot, nematode or insect damage on any root systems.
- Plant weights were 2 to 2.3 times heavier in all the Tri-Form 35 and Tri-Form 60 treatments compared with the 'Nil' treatment.
- Root lengths in the Tri-Form 35 low and high treatments were 3.2 to 3.5 times longer respectively than the 'Nil' treatment.
- Root lengths in the Tri-Form 60 treatments were 2 times longer than the 'Nil' treatment.

Pineapple assessments at twelve months of age

General observations of the crop at 12 months of age indicate:

- No visual presence of phytophthora root rot, nematode or insect damage on any of the Tri-Form 35, Tri-Form 60 treatments and Pic Plus.
- Low levels of phytophthora root rot, nematode or insect damage were observed on the Metham and Telone treatments.
- Plant weights in the Tri-Form 35 and Tri-Form 60 treatments were between 1.6 to 1.7 times greater than the Nil treatments.

- Root lengths in the Tri-Form 35 low and high treatments were between 3 times and 2.3 times longer respectively than the Nil treatments.
- Tri-Form 35, which is a combination of 1,3-dichloropropene and chloropicrin has shown better results than any of the single active constituents.

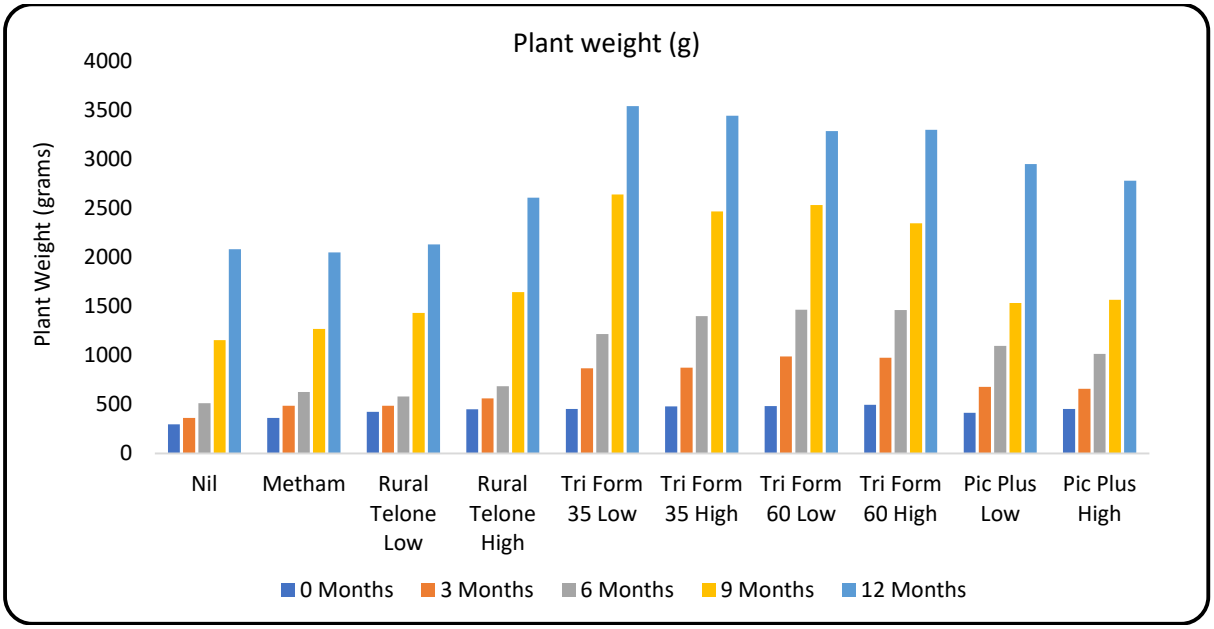

Figure 9. Average fresh mass of pineapple plants from both locations at 3, 6, 9 and 12 months of age

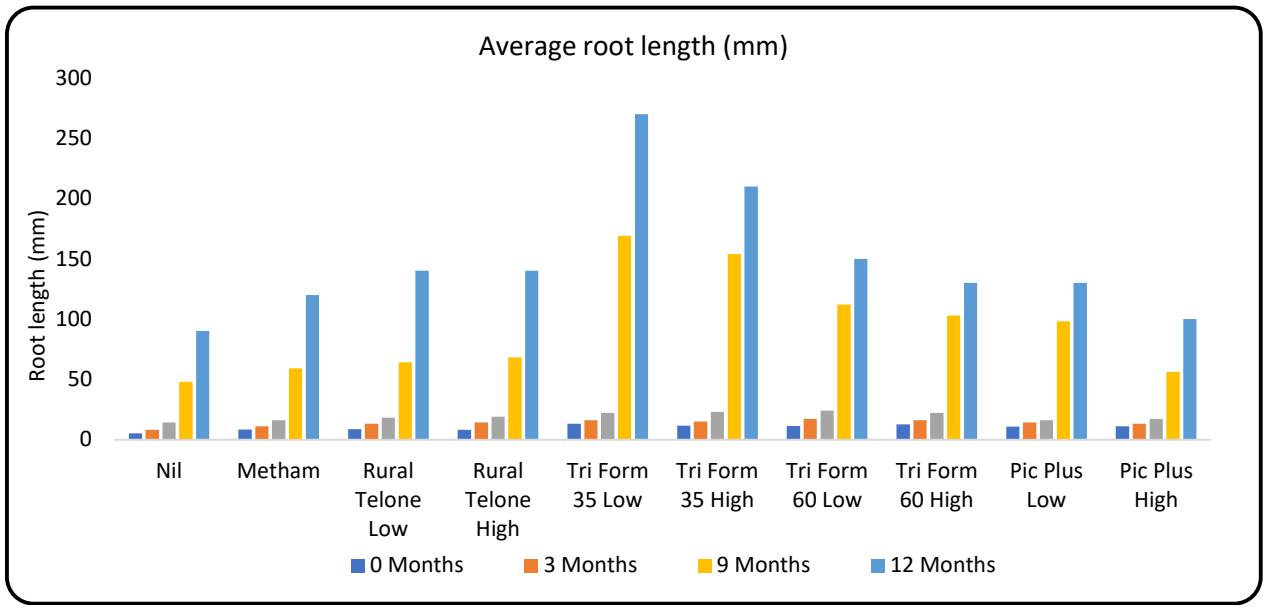

Figure 10. Average root length of pineapple plants from both locations at 3, 6, 9 and 12 months of age.

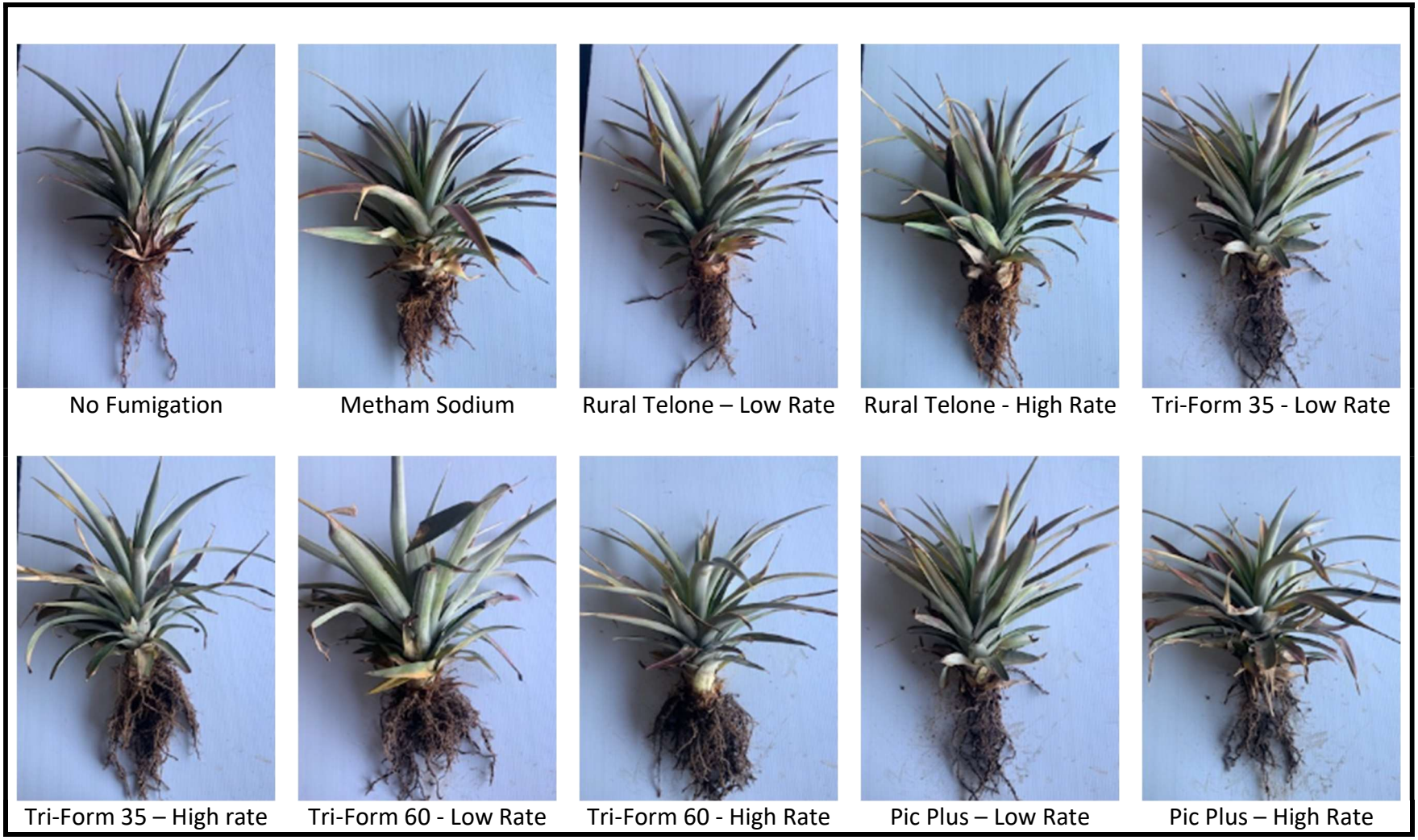

Figure 7. Pineapple plants after 3 months of establishment – Wamuran, South East Queensland

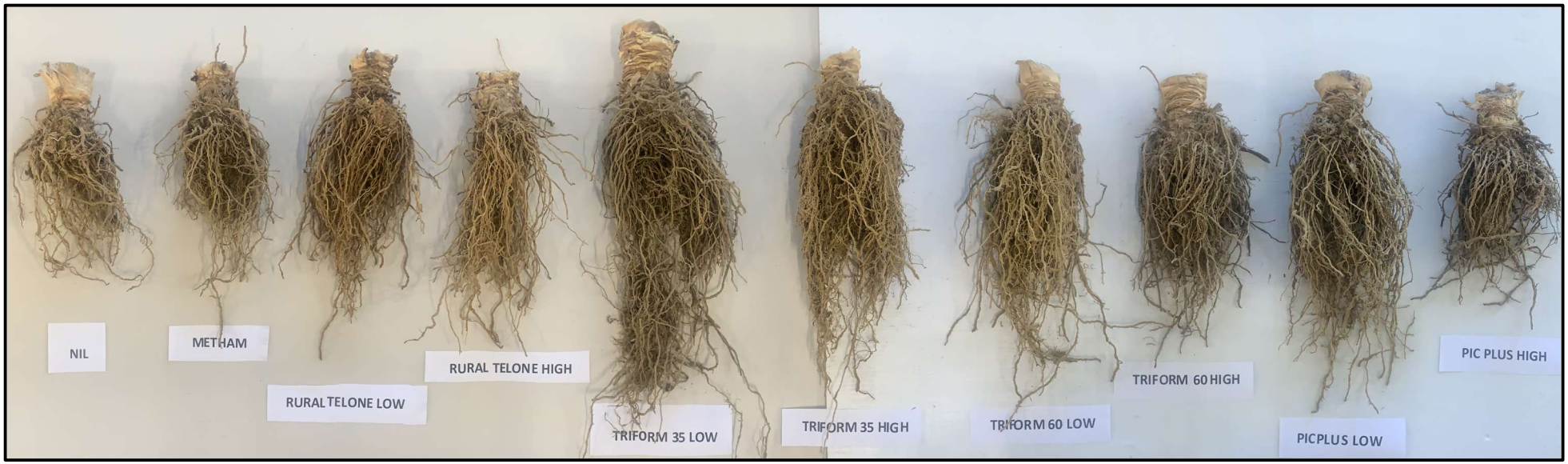

Figure 8. Pineapple roots at 12 months after establishment – Wamuran, South East Queensland

Plant Crop Yield Assessments

Wamuran – South East Queensland

Plant crop harvest using industry standard harvesting practices was undertaken over the summer period in 2021. The trial area had multiple harvest passes due to the large percentage of natural flowering. Multiple deliveries from the farm to the packing shed occurred over several weeks. The number of bins harvested was recorded for each treatment at the packing shed.

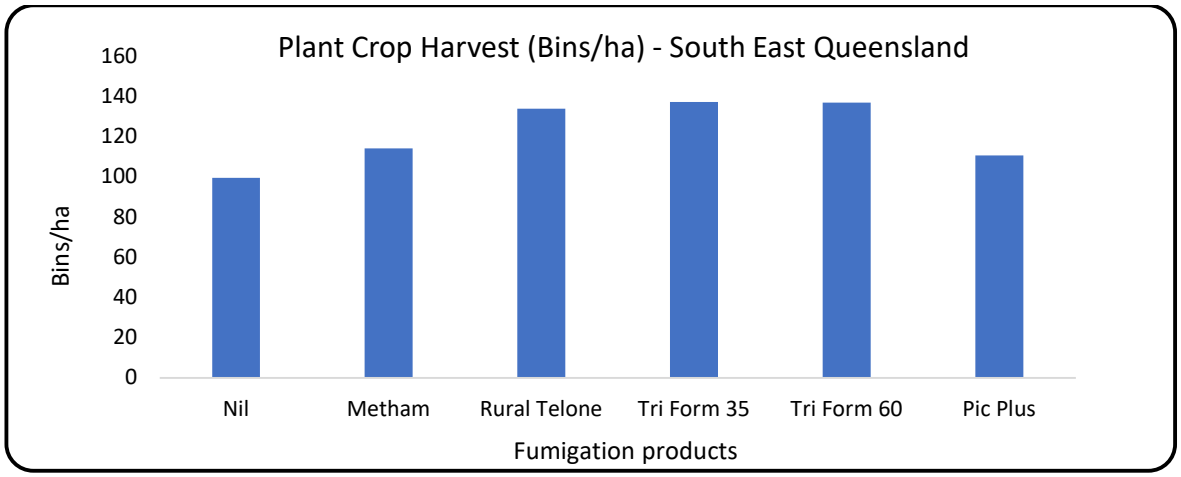

Figure 11. Bins of pineapple per hectare from the plant crop harvest in the South East Queensland trial. Note: The grower had limited capacity to harvest therefore both high and low application rates were harvested together.

From the plant crop harvest data there are several points that can be made:

- Fumigation has a positive impact on yield versus no fumigation.
- Rural Telone, Tri-Form 35 and Tri-Form 60 achieved better yields compared to the `Nil` Treatment (1.3 times more).
- Pic Plus the stronger fumigant with higher concentrations of chloropicrin resulted in a distinct decline in yield when compared to the better performing treatments (1.2 times less).
- Metham Sodium treated soil gave lower yield results than the better performing treatments (1.2 times less).

Fruit packouts were recorded after plant crop harvest in the South East Queensland trial. Quality assurance assessments on receival to the packing shed indicated no fruit quality issues. Some fruit were small in size due to natural flowering and weather adversities. The small fruit were removed during the harvesting process in the field and across the packing line and excluded from the total yield calculation.

Throughout the growing cycle, weather conditions consisted of extended periods of extreme dry, significant fluctuations in cold and hot temperatures and major rainfall events. These conditions have directly impacted yield and caused a major natural flowering event.

It was expected that variations amongst treatments in the plant crop harvest would be minimal. Treatments have now entered the vegetative stage of the ratoon cycle. It is anticipated that significant variations in yield will be distinguishable in the ratoon crop harvest in April 2023.

Mareeba – North Queensland

Plant crop harvest using industry standard harvesting practices was completed in summer 2021. The trial area was completely strip harvested in one day as this area was not affected by natural flowering and no early harvest was required. The number of bins containing the harvested fruit for each treatment were recorded on receival at the packing house.

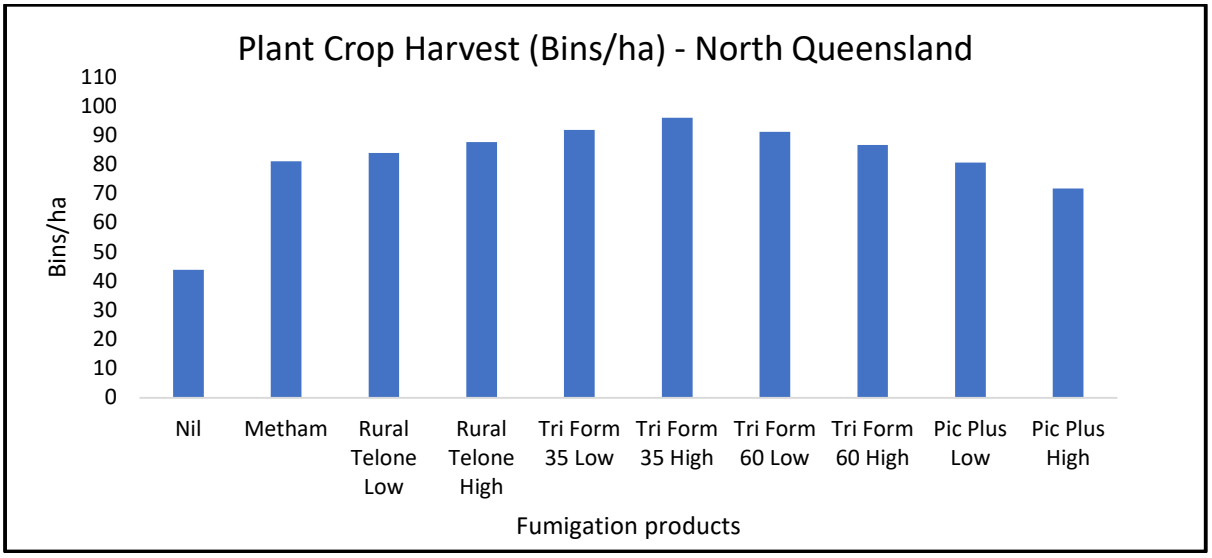

Figure 12. Bins of pineapple per hectare from the plant crop harvest in North Queensland trial

From the plant crop harvest data there are several points that can be made:

- Fumigation has a positive impact on yield versus no fumigation.
- Low and high rates of Tri-Form 35 and a low rate of Tri-Form 60 achieve a better yield result than other treatments and produced 2 times more than the `Nil` Treatment.
- The stronger fumigants with higher concentrations of chloropicrin which include the high rate of Tri-Form 60 and Pic plus had a distinct decline in yield (1.1 and 1.3 times less) when compared to the better performing treatments (Tri-Form 35 low and high rates).

Issues observed at plant crop harvest were primarily small sizes and sunburn. Fruit with these issues were removed both in the field at harvesting and across the packing line therefore excluded from the calculation.

The research site had observable levels of nematode damage in the root systems which is typical of late infestations of nematode populations in the growing cycle. It was observed that treatments with the active constituent 1,3-dichloropropene and chloropicrin (Tri-Form 35 and 60 low rate) performed better than the 1,3-dichloropropene (Telone high and low rates).

No *Dickeya spp* were observed in the trial area. However, other parts of the farm where Metham Sodium and Tri-Form 35 was used have high observable levels of *Dickeya spp*.

Throughout the growing cycle, weather conditions consisted of extended periods of extreme dry, fluctuations in cold and hot temperatures and major rainfall events. These conditions have directly impacted yield across the research site.

It was expected that variations amongst treatments in the plant crop harvest would be minimal. Treatments have now entered the vegetative stage of the ratoon cycle. It is

anticipated that significant variations in yield will be distinguishable in the ratoon crop harvest in July 2022.

ECONOMICS

An economic analysis comparing the types of fumigants and their corresponding yield was undertaken, this is important information due to the high cost of fumigants which can range from $1,800 - $5,000/hectare.

Fumigant Cost

Within this research trial both low and high application rates of fumigants were compared to understand their cost effectiveness.

Table 2. Fumigants products, rates of application and respectively cost per hectare

Products and Rate		Rate (L / kg)	Unit cost ($/kg)	Costs $ / Ha
Control	Nil	NA	NA	Nil
Metham Sodium	600 L/Hectare	600	$ 3.00	$ 1,800.00
Rural Telone.	160 Kg/Hectare	160	$ 12.75	$ 2,040.00
Rural Telone.	240 Kg/Hectare	240	$ 12.75	$ 3,060.00
Tri-Form 35.	270 Kg/Hectare	270	$ 12.75	$ 3,442.50
Tri-Form 35.	350 Kg/Hectare	350	$ 12.75	$ 4,462.50
Tri-Form 60.	300 Kg/Hectare	300	$ 12.50	$ 3,750.00
Tri-Form 60.	400 Kg/Hectare	400	$ 12.50	$ 5,000.00
Pic Plus	270 Kg/ Hectare	270	$ 12.50	$ 3,375.00
Pic Plus	340 Kg/Hectare	340	$ 12.50	$ 4,250.00

Note: This table does not include application costs or varying costs of freight between regions and suppliers (Prices as of January 2019).

Cost benefit for plant crop – South East Queensland

The demonstration results indicated the application of Rural Telone at the low rate showed the highest benefit per hectare. The application of this fumigant resulted in a benefit of $5,877 more per hectare compared with the 'Nil' treatment (Table 3). The lower rate of Tri-Form 35 also performed well in this demonstration.

Table 3. Comparison of cost of fumigant against value of plant crop yield – South East Queensland

Products and Rate		Fumigant cost $ / ha	Bins*/ha	Typical price paid per bin	Gross value of pineapples/ha	Value of crop/ha after deducting cost of fumigant	Net benefit of treatment
Control	Nil	0	99.43	$230.00	$22,868.90	$22,868.90	-
Metham Sodium	600 L/ha	$1,800.00	114.1	$230.00	$26,243.00	$24,443.00	$1,574 more
Rural Telone.	160 Kg/ha	$2,040.00	133.85	$230.00	$30,785.50	$28,745.50	$5,877 more
Rural Telone.	240 Kg/ha	$3,060.00	133.85	$230.00	$30,785.50	$27,725.50	$4,857 more
Tri-Form 35.	270 Kg/ha	$3,442.50	137.2	$230.00	$31,556.00	$28,113.50	$5,245 more
Tri-Form 35.	350 Kg/ha	$4,462.50	137.2	$230.00	$31,556.00	$27,093.50	$4,225 more
Tri-Form 60.	300 Kg/ha	$3,750.00	136.85	$230.00	$31,475.50	$27,725.50	$4,857 more
Tri-Form 60.	400 Kg/ha	$5,000.00	136.85	$230.00	$31,475.50	$26,475.50	$3,607 more
Pic Plus	270 Kg/ ha	$3,375.00	110.48	$230.00	$25,410.40	$22,035.40	$834 less
Pic Plus	340 Kg/ha	$4,250.00	110.48	$230.00	$25,410.40	$21,160.40	$1,709 less

Note: This table does not include application costs or varying costs of freight between regions and suppliers (Prices of fumigants as of January 2019). * *The grower had limited capacity to harvest therefore both high and low application rates were harvested together.*

Cost benefit for plant crop – North Queensland

Similarly, for North Queensland the application of Tri-Form 35 at a low rate showed the higher benefit. The application of this fumigant resulted in a benefit of $7,604 more per hectare compared with the 'Nil' treatment (Table 4). The higher rate of Tri-Form 35 also performed well in this demonstration.

Table 4. Comparison of cost of fumigant against value of plant crop yield – North Queensland

Products and Rate		Fumigant cost $ / ha	Bins/ha	Typical price paid per bin	Gross value of pineapples/ha	Value of crop/ha after deducting cost of fumigant	Net benefit of treatment
Control	Nil	0	43.86	$230.00	$10,087.80	$10,087.80	-
Metham Sodium	600 L/Hectare	$1,800.00	81.12	$230.00	$18,657.60	$16,857.60	$6,770 more
Rural Telone.	160 Kg/Hectare	$2,040.00	84	$230.00	$19,320.00	$17,280.00	$7,192 more
Rural Telone.	240 Kg/Hectare	$3,060.00	87.71	$230.00	$20,173.30	$17,113.30	$7,026 more
Tri-Form 35.	270 Kg/Hectare	$3,442.50	91.89	$230.00	$21,134.70	$17,692.20	$7,604 more
Tri-Form 35.	350 Kg/Hectare	$4,462.50	96.06	$230.00	$22,093.80	$17,631.30	$7,544 more
Tri-Form 60.	300 Kg/Hectare	$3,750.00	91.23	$230.00	$20,982.90	$17,232.90	$7,145 more
Tri-Form 60.	400 Kg/Hectare	$5,000.00	86.67	$230.00	$19,934.10	$14,934.10	$4,846 more
Pic Plus	270 Kg/ Hectare	$3,375.00	80.69	$230.00	$18,558.70	$15,183.70	$5,096 more
Pic Plus	340 Kg/Hectare	$4,250.00	71.72	$230.00	$16,495.60	$12,245.60	$2,158 more

Note: This table does not include application costs or varying costs of freight between regions and suppliers (Prices of fumigants as of January 2019).

DISCUSSION

Traditionally, the Australian pineapple industry grows the crop as a monoculture. Over many successive cropping cycles, the build-up of pest and disease has impacted yield in both the plant and ratoon crop. This has been further exacerbated by increased plantings of hybrid varieties more susceptible to pest and disease. Fumigation has played an important role in addressing pest and disease issues and supported growers maintain yield. Over the past decade, the use of fumigation has declined due to rising costs of production.

This demonstration trial compared different types and rates of fumigants against non-application. The application of fumigant has demonstrated higher yields and profits in the plant crop for both trial sites. Ratoon crops have not yet been harvested.

Key messages from the demonstration:

1. Fumigation had a positive effect on plant mass and root length. Tri-form 35 had the greatest benefit with the low rate giving a better result than the high rate.
2. Tri-form 35 also resulted in the highest yields at both sites. 137 bins/ha vs 99 for the 'Nil' treatment in SEQ. 92 and 96 bins/ha for the low and high rates respectively vs 44 bins/ha for the 'Nil' treatment in NQ.
3. Pic Plus gave a net negative financial benefit in SEQ but a positive benefit in NQ. Historically, NQ has a greater intensities of soil disease and nematode when compared to SEQ.

ADOPTION AND IMPACT

This demonstration has revived the discussion around fumigation across the industry. Over the past two years numerous growers that have never fumigated before have undertaken their own on-farm trials to evaluate different fumigants. Some farmers currently fumigating with more traditional products, such as Metham sodium or Rural Telone, are evaluating the wider range of fumigants available such as Rural Telone 35 and Rural Telone 60.

During this time the pineapple industry has increased the use of fumigation. This demonstration has supported growers make better decisions with their own on farm evaluations. Many growers have moved their fumigation practices beyond on-farm trials to farm wide commercial adoption.

CONCLUSIONS

For growers yields and cost of production are key to ongoing economic sustainability. Fumigation is an important practice for pineapple growers to maintain or increase pineapple yields. However, fumigation is one of the highest 'single' input costs. For growers to get the best return when investing into fumigation there are key considerations:

- Different fumigants are more effective against specific pests and disease.
- Most of farms have different soil types and with each soil type come different pests and disease at varying intensities.
- Traditionally, the 'one fumigant fits all' concept may not be giving growers the most effective use and efficiency from their fumigants.
- Build a history for each block of what fumigant is more effective through simple on farm trials.

ACKNOWLEDGEMENTS

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