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Nutritional requirements of coffee trees in northern New South Wales

A report for the Rural Industries Research and Development Corporation

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Foreword

The coffee industry in Northern New South Wales is a relatively new industry. The Northern Rivers area, in Northern New South Wales, has traditionally been an avocado and macadamia nut growing region. Coffee growing began in the early 1990s, as farmers sought to diversity or redirect their crop base. Due to the relatively young age of the coffee industry within the area, little is known about the nutritional requirements of coffee trees.

Scientific research into the establishment of a nutritional recipe within the Northern Rivers region aimed to assist existing coffee farmers in maximising crop yields and hence annual profit margins. Research into the nutritional requirements of coffee trees can also encourage new entrants into the market, possibly creating a growth within the industry so that coffee exports may become plausible.

This report outlines research conducted on coffee trees through their early growth period in response to differing nutritional treatment regimes.

This project was funded from RIRDC Core Funds which are provided by the Federal Government.

This report, a new addition to RIRDC's diverse range of over 800 research publications, forms part of the New Plant Products R&D program, which aims to facilitate the development of new industries based on plants or plant products that have commercial potential for Australia.

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Simon Hearn
Managing Director
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CAPE also acknowledges the input provided by Mr. Stephen Morris from the Department of Agriculture. His advice on statistical layout as well as his assistance with data analysis has added favourably to this project.

In addition, CAPE would like to acknowledge the role that Mr. Mark Haeselsberger, of Soil-Tec Laboratories, had throughout the duration of this project. His input with regards to the nutrient regime used throughout the trial added significantly to the research undertaken.

And finally, CAPE offers its thanks to its staff, namely Peter Morrissey and Graham Colpus, for their ongoing dedication to this research.

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Executive Summary

This project, an examination into the "Nutritional Requirements of Coffee Trees in Northern New South Wales" was funded through the RIRDC and commenced in July 1997.

The coffee industry in Northern New South Wales is a relatively new industry. The Northern New South Wales area, commonly referred to as the Northern Rivers area, has traditionally been an avocado and macadamia nut growing region.

As farmers sought to diversify or redirect their crop base in the early 1990s, the growing of coffee commenced. Due to the relatively young age of the coffee industry within the area, little is known about the nutritional requirements of coffee trees.

The aim of this research was to determine if phosphorus, which is an essential element for cell division, was a limiting nutrient in above ground coffee tree growth on the far North Coast of NSW. Additionally, this project aimed at finding an optimum fertiliser regime for the growth and production of Arabica coffee grown under sub-tropical conditions. It was felt that such research in this area would assist existing and potential coffee farmers in maximising crop yields and/or maximising profits through determining the optimum times and rates at which to apply fertilisers.

In essence, four different fertiliser combinations (consisting of different combinations of phosphorus, nitrogen and potassium) were applied to newly planted coffee trees. The height of these trees were measured throughout the study period to provide an indication of tree growth in response to the differing fertiliser combinations. Above and below ground plant biomass measurements were not taken due to the destructive nature of such measurements (i.e. coffee trees would need to be uprooted and destroyed).

Each 'measurement tree' was measured four times over the duration of the trial in reference to their individual height. An initial measurement was taken in May 2000, with measurements following in February 2001, September 2001 and March 2002.

Through analysing the trees during this period, it was found that there was little to no difference in tree height between the four different treatments irrespective of the differing nutrient treatments. Although the figures do seem to highlight that the plants involved in 'Treatment 3' were consistently, although not significantly, shorter than the others.

It is also possible that the application of phosphorus by hand in a solid particulate form throughout the Trial Block may have reduced actual uptake rates by the coffee trees themselves in dry weather. Had phosphorus been applied through the fertigation unit (like that of the other nutrients), results obtained may have been somewhat different.

Coffee tree growth increased dramatically between the months of September 2001 and March 2002. This closely coincides with the introduction of fertigation equipment on the farm, whereby nutrients applied to the trial (excluding phosphorus) were done so via fertigation. As such, the application of nutrients via fertigation (i.e. in a liquid form) may have assisted the growth of coffee trees. However, as only one growth measurement of the coffee trees was taken following the introduction of the fertigation equipment, and all of the trees were fertigated rather then selected specimens, there is no direct evidence for such a relationship. Therefore such a conclusion that fertigation increases the growth of coffee trees is purely speculative. As such, more research needs to be undertaken in this area to determine if a relationship exists.

The research into the nutritional requirements of coffee trees in Northern NSW has raised a number of questions and identified the need for further research in this area.

1. Introduction

Phosphorus is an essential element for cell division. It is required for photosynthesis, sugar and starch formation, in energy transfer, and movement of carbohydrates through the plant. As such, the aim of this study was to determine if phosphorus was a limiting nutrient in above ground coffee tree growth on the far North Coast of NSW. Additionally, this study aimed at determining an optimum fertiliser strategy for the growth and production of Arabica coffee grown under sub-tropical conditions.

Specific objectives of the trial were;

- to apply four different fertiliser combinations (consisting of different combinations of phosphorus, nitrogen and potassium) to newly planted coffee trees, and
- to measure coffee tree height throughout the study period as an indication of tree growth in response to the differing fertiliser combinations.

1.1 Industry Background

The coffee industry in Northern New South Wales is a relatively new industry. The Northern new South Wales area, commonly referred to as the Northern Rivers area, has been a traditional avocado and macadamia nut growing region. As farmers sought to diversity or redirect their crop base in the early 1990s, growing of coffee commenced.

Due to the failure of avocado's from poor weather conditions in the late 1980s, there was a strong need for a replacement crop. Historic and market Research led to the discovery that coffee had been successfully grown in the region in the late 1800s, only disintegrating at the turn of the Century due to falling profit margins caused by an increase in the cost of labour.

The development of a mechanical harvester ensured that the industry could be viable once again, and as such, coffee varieties were selected for mechanical harvesting purposes and growing started in 1990. CAPE Australia was the first commercial coffee grower within the Northern Rivers region.

1.2 Project Background

The "Nutritional Requirements of Coffee Trees in Northern New South Wales" project commenced in July 1997 after a successful funding application to the RIRDC. The coffee nutrition trial commenced with the marking out of the 'Trial Block' and preparation of coffee rows. According to a prearranged schedule, the Trial Block was due to be planted in the spring/summer of 1997/8. This 'planting date' was postponed for two reasons. The first being an iron deficiency in the young coffee plants earmarked for planting, and the second being the extreme dry weather conditions during the spring/summer of 1997/8. Throughout the North Coast, the spring/summer of 1997/8 was coined 'the hottest and driest summer on history' with all irrigation from creeks prohibited east of Lismore. As such, the planting of the Trial Block was postponed to the spring of 1998 to ensure a productive early growth period. In spring 1998 the Trial Block was planted.

Torrential rain in February 1999, as chance would have it, created severe surface water run off throughout the Trial Block. This resulted in erosion channels throughout the coffee rows washing away many of the planted trees. After consultation with both Mr. David Peasley (of David Peasley Horticultural Services) and Mark Haselberger (of Soil-Tec Laboratories) regarding the project at this time, the decision to re-establish an entire new trial block was made. Such a decision was based upon the fact that a significant amount of 'inter-plot' contamination had occurred through the erosion and subsequent transportation of topsoil. According to both Mr. Peasley and Mr. Haselberger's reports, to try to reassess an individual plots phosphorus status would require extensive analysis and a recalculation of their phosphorus requirements. Had the trial continued on this block, derived data would render meaningless information as a result tree and phosphorus variation within individual treatment plots.

In November 1999 a new trial block was establish and planted. What was the original trial block became known as the ex Trial Block and is now producing coffee for the plantation. To avoid the mishaps of the previous trial block, rows were graded into a mound to encourage the channelling of water away from the coffee trees.

2. Methodology

2.1 Study Site

CAPE's coffee plantation is located at Newrybar, on the far north coast of New South Wales (Figure 1 and 2). The plantation is situated on a north facing hill, approximately 10 minutes inland from Byron Bay. Total plantation area is 17 hectares with coffee trees ranging from 12 years of age to less than a year.

Figure 1: Location of CAPE's coffee plantation. Scale unknown.

Figure 2: 'Trial Block' located at CAPE Australia coffee plantation.

A trial block consisting of 12 rows (170 plants per row) was established in November 1999 (Figure 2). Coffee trees were planted in a south to north, down slope orientation. The experimental design 'Latin Square' was applied to the Trial Block for statistical purposes. This resulted in the Trial Block area being divided into a 4 by 4 array of equally sized plots, with 4 treatments replicated 4 times (Figure 3).

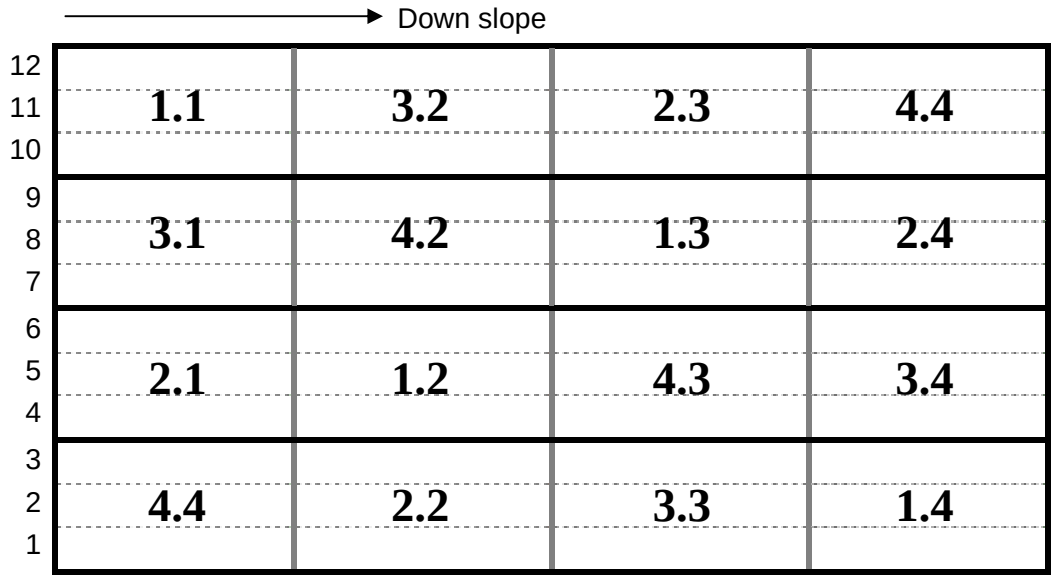

Figure 3: Trial Block configuration.

Note: Numbers 1-12 on left hand side of figure refer to row number. Large bold numbers refer to experimental treatment number, with number following decimal point referring to replication number.

Each trial plot contains approximately 120 coffee plants in three rows. Each trail plot was divided into a 'split-plot' (Figure 4). This mapped out specific measurement and buffer trees for the project.

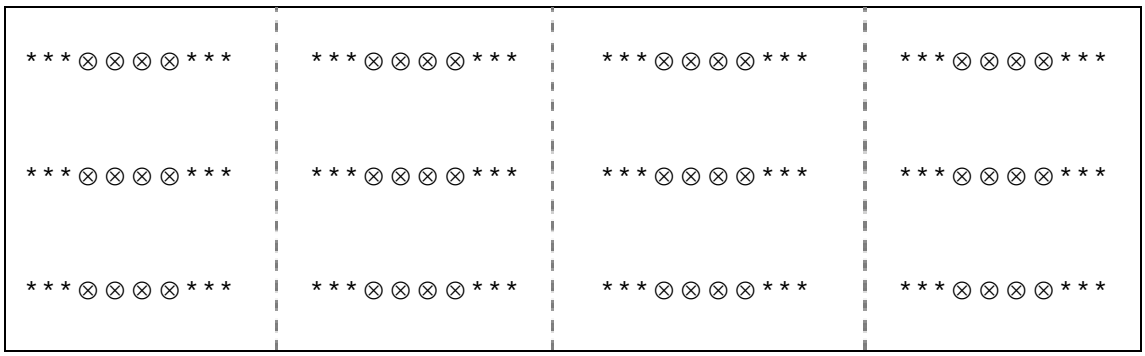

Figure 4: Configuration of 'split plot' within each trial plot.

Note: '⊗' represents measurement trees, and '*' represents buffer trees

2.2 Fertiliser Regime

As shown in Figure 2, the Trial Block is divided into 16 sections or plots in a 4 x 4 array. Four treatments were applied to the trial block, each replicated 4 times to investigate to influence of phosphorus of coffee tree growth. The details of the four treatments undertaken is outlined in Table 1.

Table 1: Treatments undertaken within Trial Block. Note: Treatment number directly refers to plot numbers in Trial Block. Treatment 1 is the 'control', thus receiving 0kg/ha of phosphorus. Units in kg/ha.

Application year		Nitrogen	Phosphorus	Potassium
2000	Treatment 1	650	0	225
	Treatment 2	650	120	225
	Treatment 3	650	220	225
	Treatment 4	650	320	225
2001	Treatment 1	725	0	275
	Treatment 2	725	200	275
	Treatment 3	725	300	275
	Treatment 4	725	420	275
2002	Treatment 1	880	0	325
	Treatment 2	880	220	325
	Treatment 3	880	360	325
	Treatment 4	880	504	325

Nitrogen, as Urea, was applied to the Trial Block, in February, late April, early August and late September during year 1 of the investigation. This was then replaced with Nitram in years 2 and 3 of the trial. Potassium, as Sulphate of potash, was applied in January, late April and early August.

Borax was applied at 10kg/ha throughout the Trial Block in December and June in 2000 and 2001, and once only in 2002. Zinc mono was applied at 20kg/ha in December for the initial year of the trial only.

Phosphorus, applied as triple super, was applied once a year in February 2000, May 2001, and March 2002. Calcium Nitrate was applied in one 56kg/ha dose to the entire Trial Block in December 2001, a 30kg/ha dose in early April 2002 and one 30kg/ha dose in late April 2002.

Fertigation equipment was introduced to the farm in early October, 2001. Thus the application of all nutrients other than phosphorus was done so via the irrigation drip lines. The hand application of phosphorus (sulphate of potash) was continued by hand.

2.3 Measurement of Trees

Each 'measurement tree' (refer to Figure 4) was measured four times over the duration of the trial in reference to their individual height. An initial measurement was taken in May 2000, with measurements following in February 2001, September 2001 and March 2002.

3. Results and Discussion

Mean coffee tree height in each treatment and each replication within treatments are shown in Table 2. As shown in Table 2, there is little variance between treatment replications and the treatments themselves.

Table 2: Mean coffee tree height within each treatment and treatment replications. Note: All values are shown in millimetres (mm).

	30-Feb-2001	17-May-01	20-Sep-01	18-Mar-02
Treatment 1				
Replication 1	522.9	637.2	752.3	1204.4
Replication 2	495.6	637.1	759.8	1168.0
Replication 3	522.1	641.1	795.8	1168.2
Replication 4	489.6	606.4	756.9	1129.6
Mean	**507.6**	**630.5**	**766.2**	**1167.6**
Treatment 2				
Replication 1	532.9	634.2	776.5	1242.6
Replication 2	471.1	585.5	748.2	1140.5
Replication 3	536.5	674.1	809.7	1040.2
Replication 4	481.3	588.1	719.4	1200.3
Mean	**505.5**	**620.5**	**763.5**	**1155.9**
Treatment 3				
Replication 1	468.1	590.4	698.5	1041.2
Replication 2	493.8	588.5	719.7	1228.9
Replication 3	511.8	647.2	771.7	1118.6
Replication 4	495.7	586.7	751.6	1151.6
Mean	**492.3**	**603.2**	**735.4**	**1107.2**
Treatment 4				
Replication 1	516.6	660.8	848.3	1265.4
Replication 2	506.4	600.8	763.3	1140.6
Replication 3	476.1	624.3	751.2	1166.2
Replication 4	497.1	624.6	726.3	1119.3
Mean	**499.1**	**627.6**	**772.3**	**1172.9**

Due to little variance among treatment replications, overall tree height means for each treatment were averaged (refer to Table 2). Figure 5 displays mean coffee tree height for each treatment throughout the trial period.

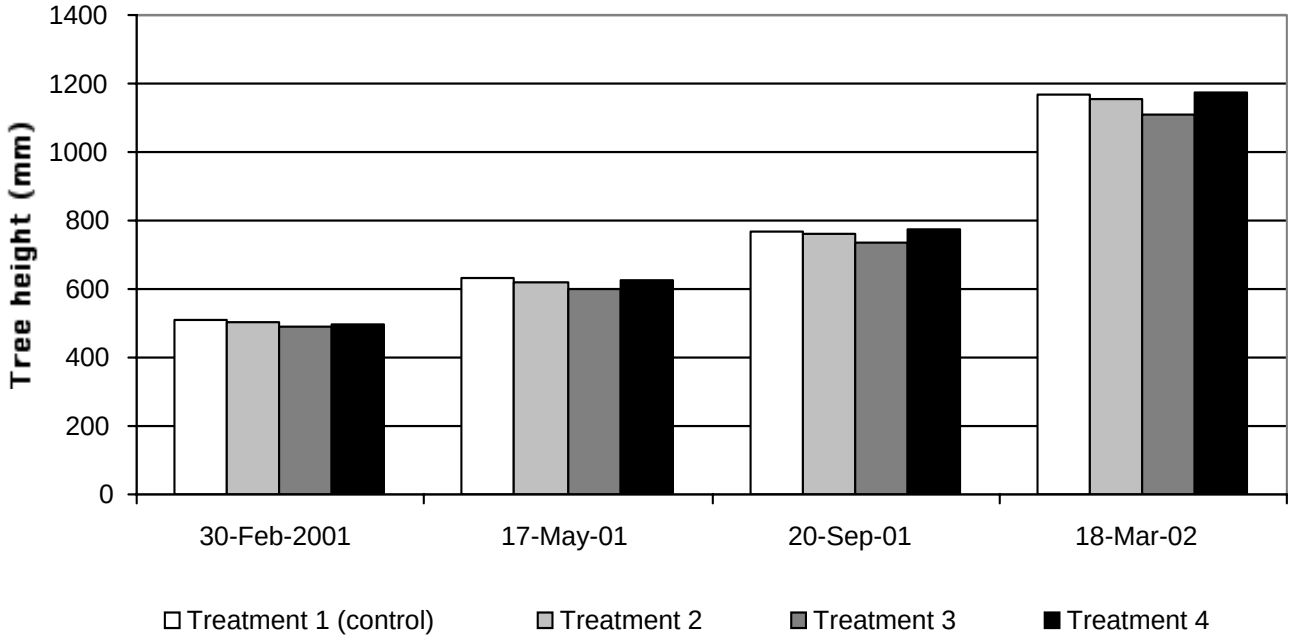

Figure 5: Mean tree height between treatments throughout the trial period.

As can be seen from Figure 5, there is little to no difference in tree height between the four different treatments irrespective of the differing nutrient treatments. However, it should be noted that Treatment 3 consistently, although not statistically, produced the smallest coffee trees throughout the trial. Table 3 displays a single factor ANOVA (analysis of variance) between each treatment at the four measurement dates.

Table 3: ANOVA (single factor analysis of variance) between the four Treatments at each sample date Note: If p is greater than 0.05, there is a statistically significant difference between treatments.

Measurement Date	Single factor Anova between Treatments
30-Feb-01	p = 0.78
17-May-01	p = 0.58
28-Sept-01	p = 0.55
18-Mar-02	p = 0.87

As can be seen from Table 3, there is little variance between each Treatment at all four sampling times (indicated by a p value greater than 0.05). Thus, the influence of an increasing phosphorus fertilising regime, to the application rates displayed in Table 1, was not found to significantly increase coffee tree growth. From this, the assumption that phosphorus, in the rates tested, is not a limiting nutrient in coffee tree growth within the Northern Rivers region can be made. The application of phosphorus by hand in a solid particulate form throughout the Trial Block may have reduced actual uptake rates by the coffee trees themselves in dry weather. Therefore, had

phosphorus been applied in a soluble liquid form (like that of the other nutrients), results obtained may have been somewhat different.

Figure 6 displays mean coffee tree growth of each treatment throughout the study period. This graph represents the growth of the coffee trees between each of the four measurement times, not the actual height of the coffee trees.

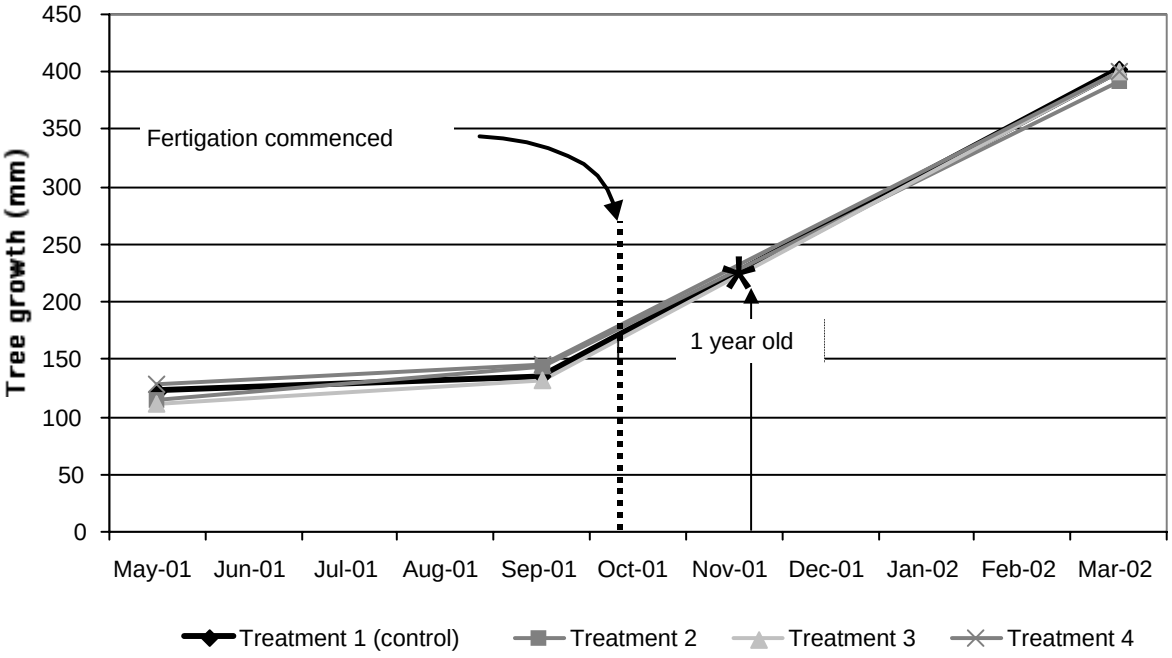

Figure 6: Mean coffee tree growth for each Treatment throughout study period.

Note dotted line where fertigation commenced.

Analysing Figure 6, coffee tree growth appears to increase dramatically between the months of September 2001 and March 2002. This closely coincides with the introduction of fertigation equipment on the farm whereby nutrients applied to the trial (excluding phosphorus) were done so via fertigation. As such, the application of nutrients via fertigation (i.e. in a liquid form) can be assumed to increase the growth of coffee trees. As only one growth measurement of the coffee trees was taken following the introduction of the fertigation equipment such a conclusion is somewhat speculative. Increased growth of the coffee trees between October 2001 and March 2002 may have corresponded to a natural growth flux of the coffee trees themselves.

4. Conclusions and Recommendations

Two main conclusions can be drawn from this study. The first being that phosphorus is not a limiting nutrient in coffee tree growth on the far North Coast of NSW at the rates tested during this study. Due to the relatively young age of the coffee trees in the trial (1.5 years old at conclusion of trial), phosphorus may become limiting in plant growth as the natural phosphorus soil reserves become limited and trees increase their demand with an increasing biomass production (above and below ground). To determine this, CAPE Australia is continuing data collection and analysis for the next 12 months (at its own costs) to coincide with the first substantial fruiting of the trees.

Following this 12 month period, it is recommended that the trial continue for an additional three years. This should provide a more extensive data base by which accurate recommendations can be made on the growth and yield of coffee trees in relation to differing nutrient inputs.

The second conclusion of this study relates to the use of fertigation on coffee plantations. Individual coffee tree growth appears to increase with the introduction of fertiliser application via fertigation. It must be noted, however, that such a conclusion is based on observations throughout the sample period and that the investigation was not designed to or aimed at determining the effectiveness of fertigation on coffee tree growth. Further specific investigation on the use of fertigation on coffee farms would determine the worthiness of fertigation units within the Northern Rivers region of NSW.