Project Title	*Cordyline* and *Phormium*: Investigation of causes of tip burn and yellow leaf spot syndrome
Project number:	HNS 171a
Project leader:	Jill England, ADAS Boxworth
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AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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GROWER SUMMARY

Headlines

Application of calcium nitrate (foliar feed) at up to 1520 mg/L calcium and potassium nitrate (liquid feed) at 200 – 300 mg/L potassium were found to reduce both tip burn and yellow leaf spot symptoms in *Cordyline* in some years.

Background

Cordyline yellow leaf spot syndrome and tip burn in both *Cordyline* and *Phormium* have been identified as major problems to the horticulture industry, affecting production with no clearly established causes, leaving growers unable to take reliable practical courses of action to address them (England 2009). An estimated 1 million and 1.24 million *Cordyline* and *Phormium* plants are grown each year respectively.

Tip burn

No clear cause has previously been established for tip burn in *Cordyline* and *Phormium*. Study HNS 171 estimated the value of *Cordyline* and *Phormium* crops affected by tip burn in excess of £1 million (England 2009). Leaf margin and tip browning symptoms in plants can be caused by nutrient imbalance including calcium, potassium and boron deficiency, and boron and fluoride toxicity, of which fluoride toxicity has been reported in *Cordyline* (Conover and Poole 1971), but not in *Phormium*. Typical macroscopic symptoms of fluoride toxicity are tip and margin necrosis (tip burn) with a distinct reddish-brown line separating it from healthy tissue in both monocotyledons and broad leaved plants (Fornasiero 2001).

Cordyline yellow leaf spot syndrome

Cordyline yellow leaf spot syndrome is a condition of unknown cause that reduces the quality and profitability of these plants. The symptoms are unsightly yellow leaf spots, initially small raised pustules, apparently water soaked, that sometimes turn necrotic (Figure 1). Sales losses have been reported by nurseries throughout the UK, and HNS 171 estimated the loss across those *Cordyline* producers who responded to the survey, at £119,437 each year. Additional losses are likely to be incurred once plants are distributed to

retail nurseries and garden centres as larger plants appear to be affected more than plugs and liners (England, 2009).

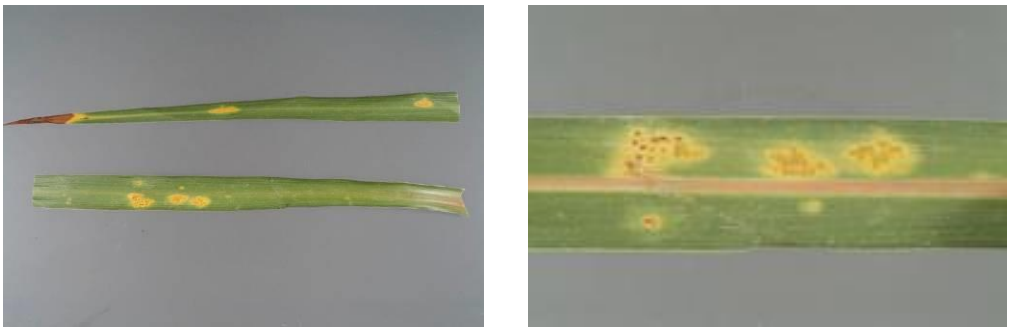

Figure 1. *Cordyline* leaf spot symptoms: raised pustules, initially chlorotic but becoming necrotic (Charles Lane, Fera).

Summary of the project and main conclusions

A single trial was carried out in the final year of this project which combined investigation of the involvement of nutrient imbalance on incidence of tip burn and yellow leaf spot syndrome in *Cordyline australis.*

Cordyline yellow leaf spot syndrome

In year 1, 33 *Cordyline* samples were screened for the presence of three viral pathogens (Cucumber mosaic virus, CMV; Tomato spotted wilt virus, TSWV; and *Impatiens* necrotic spot virus, INSV), all commonly found in a wide range of ornamental species and potentially linked to leaf spotting, and virus particles (Transmission Electron Microscope followed by inoculation onto a standard range of bio-indicator plants to assess whether any 'transmissible' pathogens were present). None of the viruses screened for, nor virus particles were detected in any of the samples tested, with or without symptoms. It was concluded that there was no commonly identified viral cause for leaf spotting in *Cordyline*.

A controlled environment study of *Cordyline* in year 1 aimed to reproduce oedema symptoms in leaf segments. A range of environmental conditions were investigated, but none of the combinations of light, temperature and humidity used reproduced the symptoms.

In years 2-3, monitoring of environmental conditions during production of *Cordyline australis* crops at Stoneyfield Nursery and Palmstead Nurseries indicated that temperature and humidity fluctuated more, and over a greater range, at Stoneyfield Nursery than Palmstead Nurseries. However, the higher light levels at Stoneyfield Nursery may be implicated in the reduced level of leaf spot recorded, as they were above 200 μM/m^2/s for approximately 75%

of period that data was collected, whilst they only reached this level on one occasion at Palmstead Nurseries.

Tip burn

Nutrient feeding trials carried out in year 1 of this project proved inconclusive. A large proportion of the *Cordyline* and *Phormium* plants were damaged during severe cold weather experienced during the winter, before the final results could be recorded. In year 2-3 (year 2 treatments were continued into year 3), less tip burn developed in the calcium nitrate (liquid and foliar) and potassium nitrate (high dose rate) treatments, with the results generally following the same trend at all assessments. Fluoride toxicity did not appear to be implicated in causing tip burn under the conditions of this trial, therefore this aspect was not followed up in the final year of this project.

The impact of calcium, potassium and nitrogen (applied as urea) on tip burn and yellow leaf spot syndrome were further investigated via a nutrition trial in year 4. The trial was set up within an unheated polytunnel at East Malling Research, with treatments applied from 7 June 2013. Plugs of *Cordyline australis* were potted into 3 L pots; the variety was selected for its susceptibility to tip burn and *Cordyline* yellow leaf spot syndrome. Pots were placed on the ground and irrigated via drip irrigation, and by hand watering as necessary during the winter. Twelve treatments were applied, based on the results from this project, previous research and best commercial practice (Table 1).

Table 1. Nutrient feeding trial treatments

Treatments			Application method	Dose Rate (mg/L)
1	Ca low	$Ca(NO_3)_2$	Foliar feed	1520
2	Ca high	$Ca(NO_3)_2$	Foliar feed	3040
3	Ca low	$Ca(NO_3)_2$	Liquid feed	75
4	Ca high	$Ca(NO_3)_2$	Liquid feed	150
5	K low	KNO_3	Liquid feed	150
6	K high	KNO_3	Liquid feed	300
7	Ca high + K low	$Ca(NO_3)_2$+ KNO_3	Liquid feed	150 + 150
8	Ca high + K high	$Ca(NO_3)_2$ + KNO_3	Liquid feed	150 + 300
9	Ca low + K low	$Ca(NO_3)_2$+ KNO_3	Liquid feed	75 + 150
10	Ca low + K high	$Ca(NO_3)_2$ + KNO_3	Liquid feed	75 + 300
11	U	Urea	Liquid feed	107
12	C	Untreated control	Liquid feed	Water only

Treatments were applied weekly, with the calcium foliar feed applied under dull conditions. The liquid feed treatments were applied via Dosatron D3 Greenline injectors governed by Galcon DC-4S controllers.

Some tip burn had begun to develop after two weeks of treatment and continued to develop consistently across all treatments and plots through the season. However, the warm, dry summer and autumn delayed development of serious leaf spot and tip burn symptoms until early spring 2014 and the interim inspection was delayed until February 2014, by which time yellow leaf spot symptoms had developed further. There was no difference in incidence of tip burn between treatments or plots by either the interim or final assessments, therefore only yellow leaf spots were assessed.

Number of plants affected

The number of plants in each plot with yellow leaf spots was assessed after 35 and 42 weeks of treatment. After 42 weeks of treatment 1 (calcium nitrate, low rate, foliar feed) and treatment 6 (potassium nitrate high rate, liquid feed) had significantly fewer plants per plot with yellow leaf spots than the untreated control (Figure 2). All untreated plants had some degree of leaf spots.

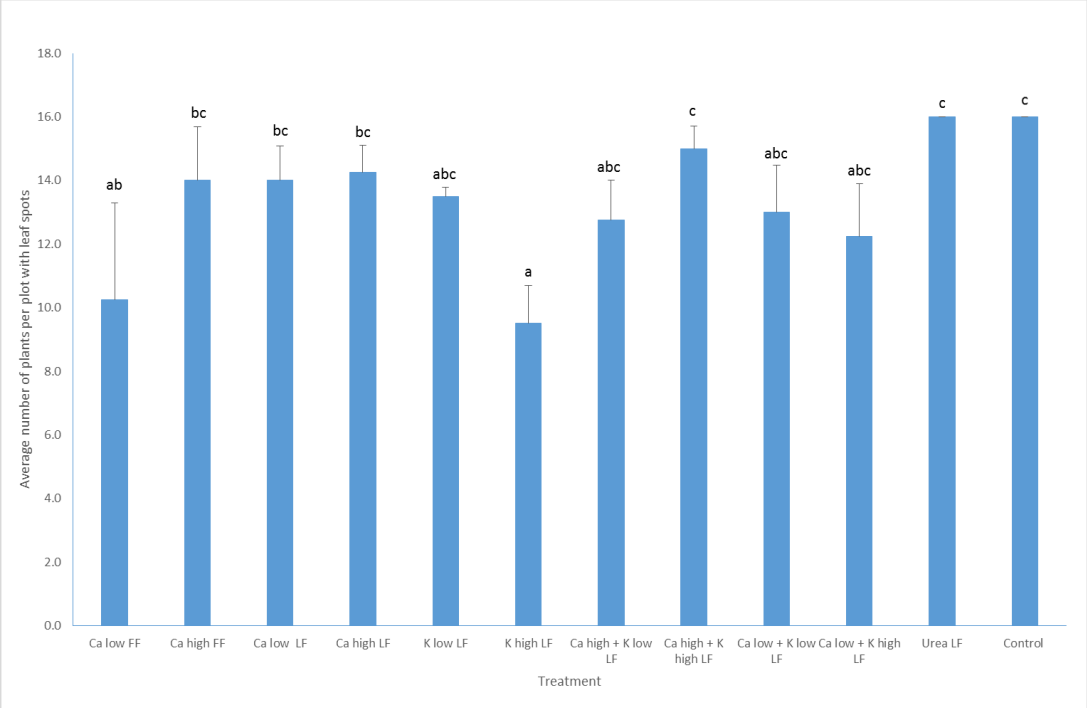

Figure 2. Average number of plants per plot with yellow leaf spots, 42 weeks after treatment: FF = foliar feed, LF = liquid feed Treatments identified by different letters (a, b, c) are significantly different.

Yellow leaf spot: whole plot scores

After 35 weeks of treatment the differences between treatments were not significant, primarily due to high within-plot variation. By 42 weeks after treatments, incidence of leaf spot had increased in all plots, and all treatments had significantly fewer leaf spots than the control, although where within-plot scores for treatments were high, the results were generally more variable. In some treatments the yellow leaf spots were often small and sparse, leading to low scores compared to the control in the whole plot assessment.

Plant quality

Plants were scored on a scale of 1-5, where 1 was a dead plant and those scoring 5 showed no tip burn or leaf spots, and plant size and leaf colour were unaffected. After 35 weeks of treatment, all plants were marketable. After 42 weeks, no plants scored either 1 or 5 for quality, plants in most treatments were generally marketable, although it may have been necessary to remove the tip burn prior to marketing. The exception was the untreated control where all plots were graded as mostly unsaleable, scoring 2, as they had more leaf spots, and tip burn and were generally paler. Leaf colour had a major influence on quality scores and the highest quality plants were found in treatment 10 (calcium nitrate, low rate, liquid feed + potassium nitrate, high rate), which had the best leaf colour. Treatment 4

(calcium nitrate, high rate, liquid feed), treatment 6 (potassium nitrate, high rate, liquid feed) and treatment 7 (calcium nitrate, high rate, liquid feed + potassium nitrate, low rate, liquid feed) generally had good leaf colour. Plant quality in the calcium nitrate (low rate, foliar feed) treatment was average mainly due to leaf colour even though leaf spot incidence was lower than other treatments. Treatment 11 (urea) produced smaller, slightly pale plants, and treatment 5 (potassium nitrate low rate, liquid feed) also produced slightly pale plants. Most plants were saleable, albeit with some tip burn and a degree of leaf spot.

Tissue analysis

Various leaf tissue analyses carried out at the start of the final year's trial (16 May 2013), at the start of year 2 (pre-trial, 12 October 2011) and at the end of the final year showed that plant tissue with both tip burn and yellow leaf spot symptoms had less leaf potassium and calcium, compared with tissue without symptoms.

Growing media analyses

Growing media samples from each treatment were analysed at the start of the trial and at the mid-trial and final assessments. At the mid-trial and final assessments the conductivity was generally high to excessive (>600 uS/cm), including the untreated control. This was due to high sulphate and chloride levels, particularly at the final assessment (after 42 weeks of treatment) where the highest level was found in treatment 11 (urea, 1504 uS/cm). This could have been affecting root health, thereby reducing nutrient uptake. As in year 2, salts appear to have built up over time; plants were irrigated via drip irrigation and the salts were not adequately flushed through the growing media.

Summary

Treatment 1 (calcium nitrate, low rate, foliar feed) and treatment 6 (potassium nitrate, high rate, liquid feed,) produced the best overall scores, with fewer plants affected and lower whole plot scores. Of these two treatments, plant quality was higher in treatment 6 (potassium nitrate, high rate, liquid feed), although plants submitted to treatment 1 (calcium nitrate, low rate, foliar feed) were not of poor quality. For treatment 11 (urea), although the whole plot scores indicated significantly less leaf spots than the control, plants were generally smaller and tended to be pale and of lower quality.

Financial benefits

- Control of tip burn in *Cordyline and Phormium* could save the horticulture industry an estimated £1 million annually.
- Control of *Cordyline* yellow leaf spot syndrome could result in savings estimated at £120,000.

Action points for growers

To reduce incidence of tip burn and yellow leaf spot:

- Apply calcium nitrate as a foliar feed. A dose rate of 1520 mg/L calcium was the upper effective limit in this trial.
- Apply potassium nitrate as a liquid feed, with a dose rate of 300 mg/L potassium.
- The best commercial option may be application of a combination of calcium nitrate (liquid feed, 75 mg/L calcium) + potassium nitrate (liquid feed, 300 mg/L potassium), as this treatment resulted in the best quality plants.

SCIENCE SECTION

Introduction

The resurgence of interest in growing tropical plants including *Cordyline* and *Phormium* in recent years has resulted in an estimated 1 million and 1.24 million plants being grown each year respectively. Project HNS 171 identified *Cordyline* yellow leaf spot syndrome and tip burn in both *Cordyline* and *Phormium* as major problems to the horticulture industry, affecting production with no clearly established causes, leaving growers unable to take reliable practical courses of action to address them (England 2009).

Tip burn

Tip burn affects both *Cordyline* and *Phormium* and no clear cause has been established. In HNS 171 the value of *Cordyline* and *Phormium* crops affected by tip burn was estimated to be in excess of £1 million (England 2009)

Leaf margin and tip browning symptoms in plants can be caused by nutrient imbalance including calcium, potassium and boron deficiency, and boron and fluoride toxicity. Of these, only fluoride toxicity has been reported in *Cordyline* (Conover and Poole 1971), but not *Phormium*. Typical macroscopic symptoms of fluoride toxicity are tip and margin necrosis (tip burn) with a distinct reddish-brown line separating it from healthy tissue in both monocotyledons and broad leaved plants (Fornasiero 2001).

Conover and Poole (1971) recorded leaf necrosis due to fluoride toxicity in *Cordyline terminalis* 'Baby Doll' during propagation where fluoride levels exceeded 0.25 mg/L in the soil or water. Symptom severity increased with lower substrate pH and reduced light levels. Necrosis also occurred in misted cuttings in vermiculite, perlite and Terragreen, but not at significant levels in various barks and peats tested (Poole and Conover 1975).

The addition of superphosphate (3.80 kg m^3, 1.5% fluoride) has been found to increase necrosis and tissue fluoride content of cuttings of *Cordyline terminalis* 'Baby Doll' grown in German peat and Turface. Toxicity symptoms were reduced by increasing doses of calcium sulphate and magnesium sulphate (Poole & Conover 1975). Controlled release fertilisers are predominately used by growers today, and the consensus is that phosphate levels are higher than necessary for the production of hardy nursery stock in some formulations (Holmes, personal communication). It has also been suggested that tip burn in very young

leaves may be attributable to the application of fertilisers over the growing point of young leaves (Moorman 2009). Various sources recommend a growing media pH of 6.0 to 6.5 and irrigation water with fluoride levels below 0.25 mg/L (Bunt 1988) and 1.0 mg/L (Holmes and Adlam 2006) for ornamental crops. Fluoride levels are not generally included in standard irrigation water and growing media analyses and their concentration is rarely monitored.

Nutrient feeding trials carried out in year 1 of this project proved inconclusive. A large proportion of the *Cordyline* and *Phormium* plants were damaged during severe cold weather experienced during the winter. Plant tissue analysis revealed that fluoride accumulation in leaves increased with fluoride dose rate. Results also suggested that tip burn was associated with higher calcium levels, possibly through a reduction in potassium uptake, however no firm conclusions could be drawn.

In year 2-3, a further nutrient feeding trial designed to assess the impact of calcium nitrate, potassium nitrate, potassium sulphate and sodium fluoride on tip burn in *Cordyline* and *Phormium*, less tip burn developed in the calcium nitrate (liquid and foliar) and potassium nitrate (high dose rate) treatments. The results generally followed the same trend at all three assessments.

Cordyline leaf spot syndrome

Cordyline yellow leaf spot syndrome is a condition of unknown aetiology that reduces the quality and profitability of these plants. The symptoms are unsightly yellow leaf spots. Initial small raised pustules are chlorotic, apparently water soaked and sometimes turn necrotic (Figure 11). Consultation with growers, consultants and plant pathologists across UK and Europe has revealed this to be an industry-wide problem, with no consistent cause as yet identified. Sales losses have been reported by nurseries throughout the UK, and a recent survey (HNS 171) estimated the loss across those *Cordyline* producers who responded to the survey at £119,437 each year. Additional losses are likely to be incurred once plants are distributed to retail nurseries and garden centres as larger plants appear to be affected more than plugs and liners (England, 2009).

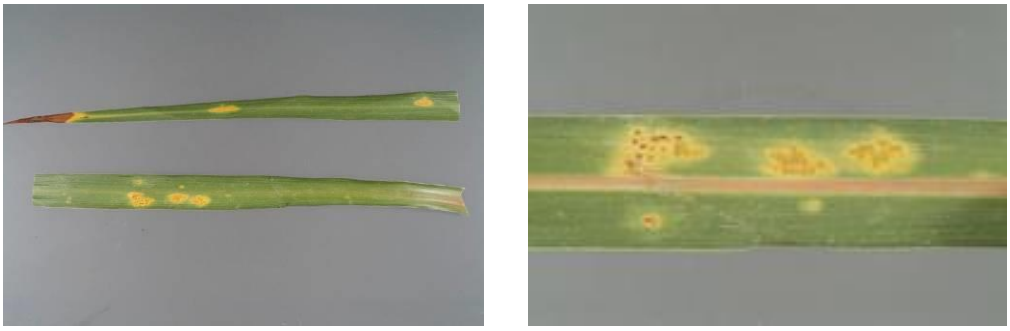

Figure 1. *Cordyline* leaf spot symptoms: raised pustules, initially chlorotic but becoming necrotic (Charles Lane, FERA).

Samples provided to FERA as part of HNS 171 were tested for a range of pests and diseases. Few pests (caterpillar and red spider mite, each on one sample) and no primary pathogenic bacteria or fungal species were associated with the samples. However, ultrastructure analysis identified swollen cells below the leaf epidermis of a number of leaf samples, typical of oedema. Oedema is a physiological condition attributed to an imbalance in water relations which commonly occurs during periods when high water availability coincides with high humidity. Roots then take up water faster than it is used or transpired through the leaves and the resultant build-up of water pressure in leaf mesophyll cells causes them to enlarge and form swollen blister-like areas. Investigative work on oedema in other plant species susceptible to this condition (e.g. Eucalyptus, tomato, geranium) has previously enabled symptoms to be produced within a controlled environment (Morrow and Tibbetts, 1987).

A controlled environment study of *Cordyline* in year 1 aimed to reproduce oedema symptoms in leaf segments. A range of environmental conditions were investigated, but none of the combinations of light, temperature and humidity used reproduced the symptoms.

In year 1, 33 *Cordyline* samples were screened for the presence of three viral pathogens (Cucumber mosaic virus, CMV; Tomato spotted wilt virus, TSWV; and Impatiens necrotic spot virus, INSV), all commonly found in a wide range of ornamental species and potentially linked to leaf spotting, and virus particles (Transmission Electron Microscope followed by inoculation onto a standard range of bio-indicator plants to assess whether any 'transmissible' pathogens were present). None of the viruses screened for, nor virus particles were detected in any of the samples tested, with or without symptoms. It was concluded that there was no commonly identified viral cause for leaf spotting in *Cordyline*.

In years 2-3, monitoring of environmental conditions during production of *Cordyline australis* crops at Stoneyfield Nursery and Palmstead Nurseries indicated that temperature and

humidity fluctuated more, and over a greater range, at Stoneyfield Nursery than Palmstead Nurseries. However, the greatest differences were seen in light level readings; at Palmstead Nurseries the light level exceeded 200 µM/m^2/s on one day only, while at Stoneyfield Nursery it was above this level for approximately 75% of period that data was collected. Incidence of leaf spot was lower at Stoneyfield Nursery than at Palmstead Nursery, however would be premature to conclude that this can be entirely attributed to the environmental conditions without comparing the incidence of symptoms on similar plant material under different controlled environmental conditions. It may also be significant that the plant material at Stoneyfield Nursery was younger than that at Palmstead Nursery.

As *Cordyline* plants developed symptoms of both tip burn and *Cordyline* yellow leaf spot syndrome, both of which followed the same trends in the nutrient feeding trial in year 2-3, a single nutrient feeding trial was planned for year 4 (the final year) to investigate both tip burn and *Cordyline* yellow leaf spot syndrome.

Objectives

Objective 1. Tip burn: investigate the involvement of nutrient imbalance, and irrigation water and growing media fluoride levels, on incidence of tip burn in *Cordyline* and *Phormium*.

Objective 2. *Cordyline* yellow leaf spot syndrome: investigate the involvement of rod-like virus particles (previously found in *Cordyline* samples analysed by Fera) and phytoplasma in *Cordyline* yellow leaf spot syndrome.

Objective 3. *Cordyline* yellow leaf spot syndrome (controlled environment): investigate the involvement of environmental conditions in the development of *Cordyline* yellow leaf spot syndrome.

Materials and methods

Materials and methods for previous years of this project are included in the reports for year 1 and year 2-3.

Objective 1: Tip burn

The trial set up within an unheated polytunnel at East Malling Research, with treatments applied from 7 June 2013. Plugs of *Cordyline australis* (Supplier: Kernock Park Plants) were potted into 3 L pots; the variety was selected for its susceptibility to tip burn and *Cordyline* yellow leaf spot syndrome (England, 2009). Pots were placed on the ground and irrigated via drip irrigation, and by hand watering as necessary during the winter when automatic irrigation was not used. The trial was covered with fleece when the temperature was forecast to drop below 5°C. The potting mix used was Sinclair SHL Peat-Bark Growing Medium (pH 5.0, N 120 g/m^3, P_2O_5 140 g/m^3, K_2O 240 mg/L; peat: 0-10mm 40%, peat 3-15mm 45%, bark: 5-10mm 15%) with Osmocote Pro (12-14M, 3 kg/m^3) controlled release fertiliser. Growing media and irrigation water analyses were carried out prior to the trial to establish a baseline for comparison with later analyses (Appendix).

Treatments

Treatments (
Table 11) based on the results from year 1, previous research and best commercial practice, were applied from 7 June 2013.

Trial treatments were foliar and liquid feeds of calcium nitrate, and liquid feeds of potassium nitrate and urea. Water only was applied as a control treatment throughout. Treatments were applied weekly, with the calcium foliar feed applied under dull conditions.

Table 1. Nutrient feeding trial treatments

Treatments			Application method	Dose Rate (mg/L)
1	Ca low	$Ca(NO_3)_2$	Foliar feed	1520
2	Ca high	$Ca(NO_3)_2$	Foliar feed	3040
3	Ca low	$Ca(NO_3)_2$	Liquid feed	75
4	Ca high	$Ca(NO_3)_2$	Liquid feed	150
5	K low	KNO_3	Liquid feed	150
6	K high	KNO_3	Liquid feed	300
7	Ca high + K low	$Ca(NO_3)_2$+ KNO_3	Liquid feed	150 + 150
8	Ca high + K high	$Ca(NO_3)_2$ + KNO_3	Liquid feed	150 + 300
9	Ca low + K low	$Ca(NO_3)_2$+ KNO_3	Liquid feed	75 + 150
10	Ca low + K high	$Ca(NO_3)_2$ + KNO_3	Liquid feed	75 + 300
11	U	Urea	Liquid feed	107
12	C	Untreated control	Liquid feed	Water only

Experimental design

Treatments were evaluated in a randomised block experiment with 4-fold replication (Appendix 1), each plot containing 16 plants. Treatments were applied via Dosatron D3 Greenline injectors, fed from 20 L tanks of stock solution, and governed by Galcon DC-4S controllers.

Assessments

Inspections and assessments are summarised below (

Table). Samples for leaf tissue analysis (newest fully expanded leaf from each pot) were collected from each plot for nutrient analysis (

Table); tissue samples from plots that received the same treatment were pooled.

Table 2. Nutrient feeding trial inspections and assessments

Date	WOT*	Action	Data collection
16.05.13		Lay out trial	Leaf tissue analysis Growing media analysis Irrigation water analysis
07.06.13		First treatment applied	
21.06.13	2	Inspection	
16.08.13	10	Inspection	
20.09.14	15	Inspection	
23.10.13	20	Inspection	
14.11.13	23	Inspection	
03.01.14	30	Inspection	
03.02.14	35	Interim assessment	Leaf tissue analysis Growing media analysis
27.03.14	42	Final assessment	Leaf tissue analysis Growing media analysis

*WOT = weeks of treatment

Tip burn and yellow leaf spot were assessed as follows:

1. The length of tip burn was measured from the tip of the leaf (mm), sampling 10 randomly selected, affected leaves per plot. Data was calculated and is presented in this report as a percentage of the control.

2. Yellow leaf spot was assessed as follows:

- Number of plants per plot affected by leaf spot.
- Whole plot assessment of leaf spot, based on the NIAB method for recording plant disease (Table 3) (Anon, 2013).

Table 3. Score grades for NIAB method of recording plant disease (Anon, 2013)

Score	Leaf appearance
0	No leaf spot observable
0.1	Trace of leaf spot
1	Leaves with one small lesion; plants with a few scattered lesions
5	Leaves appear 1/10 affected; affected leaves with a few lesions
10	Leaves appear 1/4 affected/ affected leaves with a few large or many small lesions
25	Area appears half affected, half green (or normal colour for variety)
50	Leaf area appears more affected than green
75	Very little green tissue left
100	No green tissue left

3. Plant quality per plot, which combined tip burn, yellow leaf spot and plant vigour and leaf colour (Table).

Table 4. Plant quality score grades

Score	Leaf appearance
5	No tip burn / leaf spots, good leaf colour, vigorous plants
4	All plants saleable (slight tip burn/leaf spots)
3	Plants mostly saleable (>50%)
2	Plants mostly unsaleable (>50%), leaves pale pale, plants less vigorous
1	Plants all unsaleable, leaves pale / chlorotic, lack of vigour
0	Dead plants

Statistical analysis was carried out where appropriate using GenStat Release 12.1 (PC/Windows XP) and GenStat Release 12.2 (PC/Windows 7).

Results

For the final year of this study, *Cordyline* plants were potted earlier and treatments were applied from 7 June 2013 (Figure 2). Some tip burn had begun to develop after two weeks of treatment and continued to develop consistently across all treatments and plots through the season. However, the warm, dry summer and autumn delayed development of serious leaf spot and tip burn symptoms until early spring 2014. Yellow leaf spots had started to

develop after 20 weeks of treatment, with one plant affected in three plots: treatments 2 (calcium nitrate foliar feed, high rate), 9 (calcium nitrate, low rate + potassium nitrate, low rate) and 12 (untreated control). The interim inspection was delayed from September 2013 until February 2014. By this time severe leaf spots had developed, however there was no clear difference in incidence of tip burn between treatments or plots at either the interim or final assessments and therefore data was not collected.

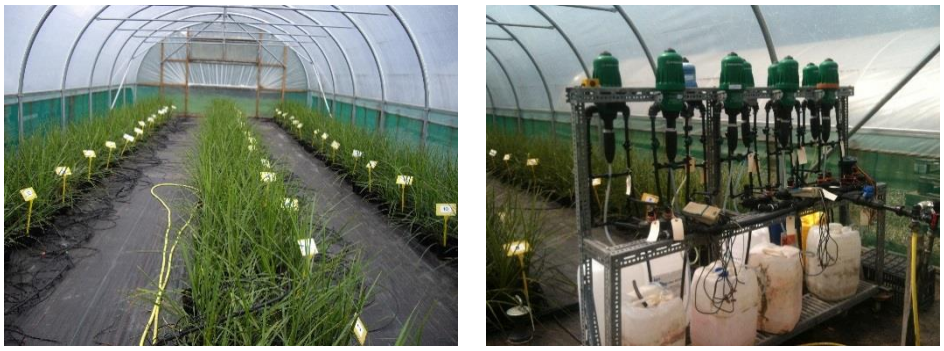

Figure 2. Nutrient trial at set up (left) and Dosatrons (right)

Number of plants affected

The number of plants in each plot with yellow leaf spots was assessed after 35 and 42 weeks of treatment. At the assessment following 35 weeks of treatment, there were significantly fewer plants with yellow leaf spots in all treatments compared to the untreated control (Figure 3, Table). However, incidence of yellow leaf spot in all treatments increased and after 42 weeks only treatment 1 (calcium nitrate, low rate, foliar feed) and treatment 6 (potassium nitrate, high rate, liquid feed) had significantly fewer plants per plot than the untreated control (Figure 4. Table 6). Interestingly, treatment 10, (calcium nitrate, low rate, liquid feed + potassium nitrate, high rate, liquid feed) was not significantly different to the control. All untreated plants had leaf spot to some degree.

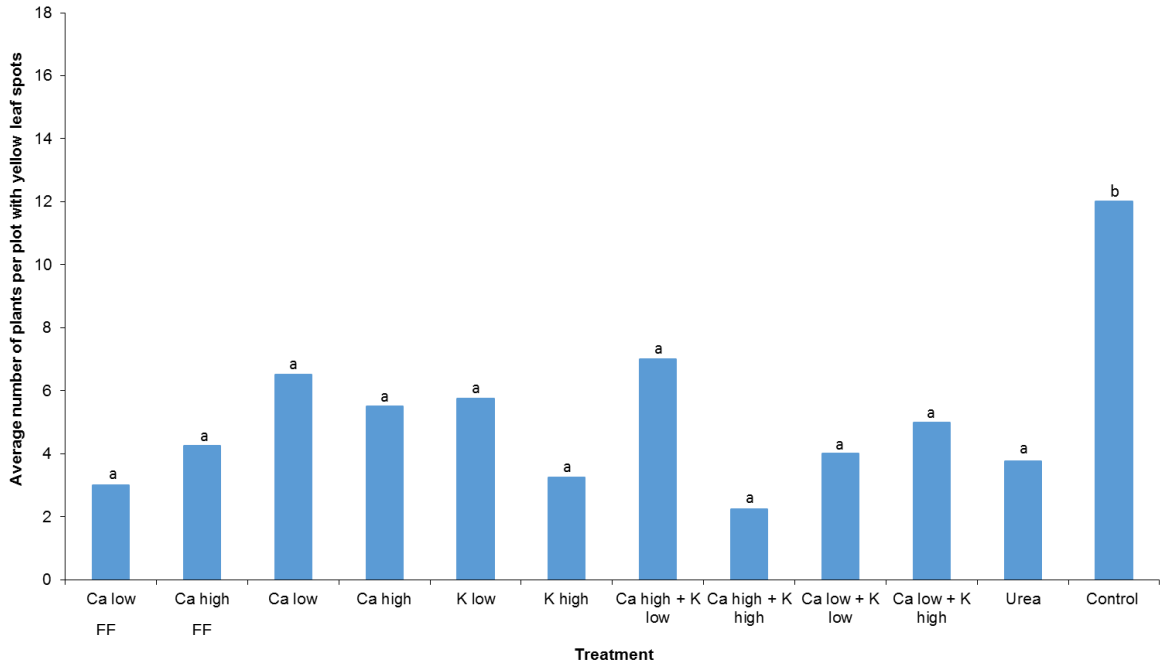

Figure 3. Average number of plants per plot with yellow leaf spots after 35 weeks of treatment: FF = foliar feed, all other treatments liquid feed. Treatments identified by different letters (a, b) are significantly different.

Table 5. Analysis of Variance (ANOVA) table. Average number of plants per plot with yellow leaf spots after 35 weeks of treatment.

Source of variation	d.f.	s.s.	m.s	v.r.	F pr.	
Block	3	63.40	21.13	1.90	0.148	
Treatment	11	293.56	26.69	2.40	0.025	* Significant
Residual	33	366.35	11.10			
Total	47	723.31				

Table 6. Analysis of Variance (ANOVA) table. Average number of plants per plot with yellow leaf spots after 42 weeks of treatment.

Source of variation	d.f.	s.s.	m.s	v.r.	F pr.	
Block	3	38.750	12.917	1.85	0.157	
Treatment	11	178.250	16.205	2.32	0.030	* Significant
Residual	33	230.250	6.977			
Total	47	447.250				

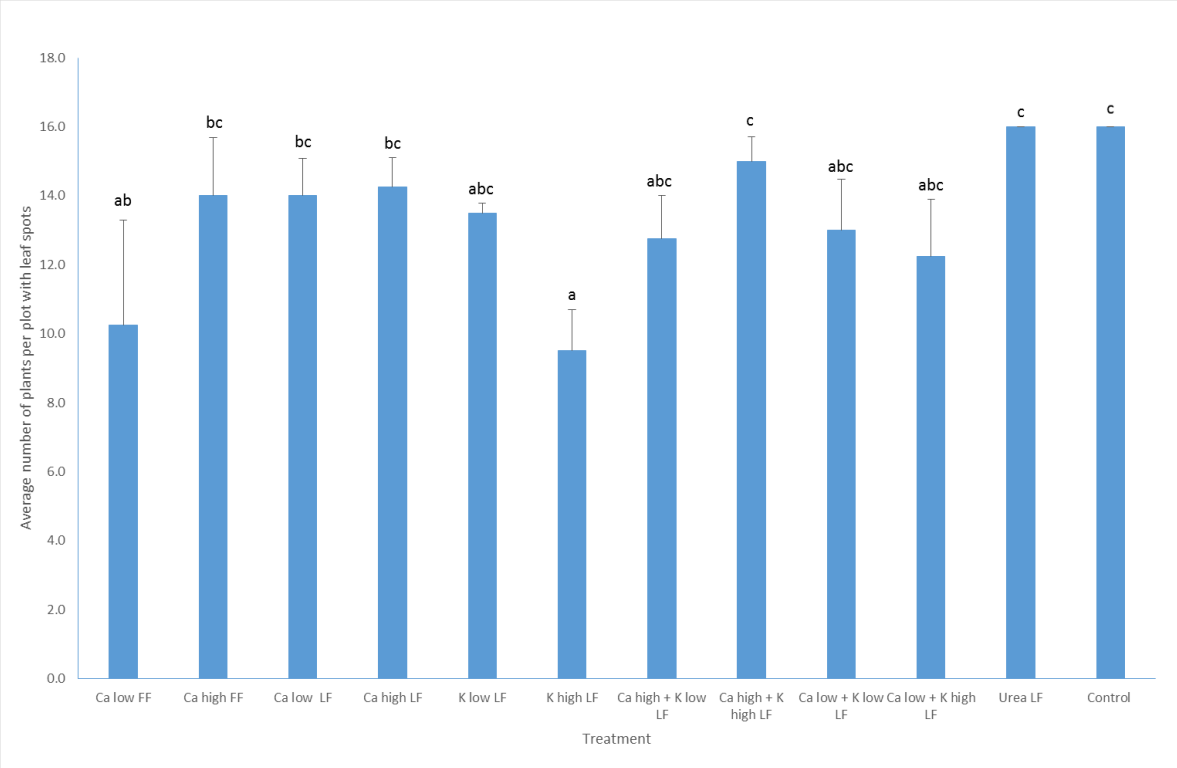

Figure 4. Average number of plants per plot with yellow leaf spots, 42 weeks after treatment: FF = foliar feed, LF = liquid feed Treatments identified by different letters (a, b, c) are significantly different.

Yellow leaf spot: whole plot scores

After 35 weeks of treatment although treatment 3 (calcium nitrate, low dose, liquid feed) and the untreated control both had high whole plot scores (Figure), due to high within-plot variation, the differences between treatments were not significant. By 42 weeks after treatments, incidence of leaf spot had increased in all plots, and all treatments had significantly fewer leaf spots than the control (Figure , Table 7). Again, within-plot scores for treatments where more symptoms were recorded were generally more variable.

Scores for treatment 2 (calcium nitrate, high dose, foliar feed) ranged between 0.1 and 5.0, but there was less variability within the treatment 11 (urea), where three of the plots scored 1.0. All of the untreated control plots scored 1.0 or greater; the five treatments with the lowest scores consistently scored 0.1.

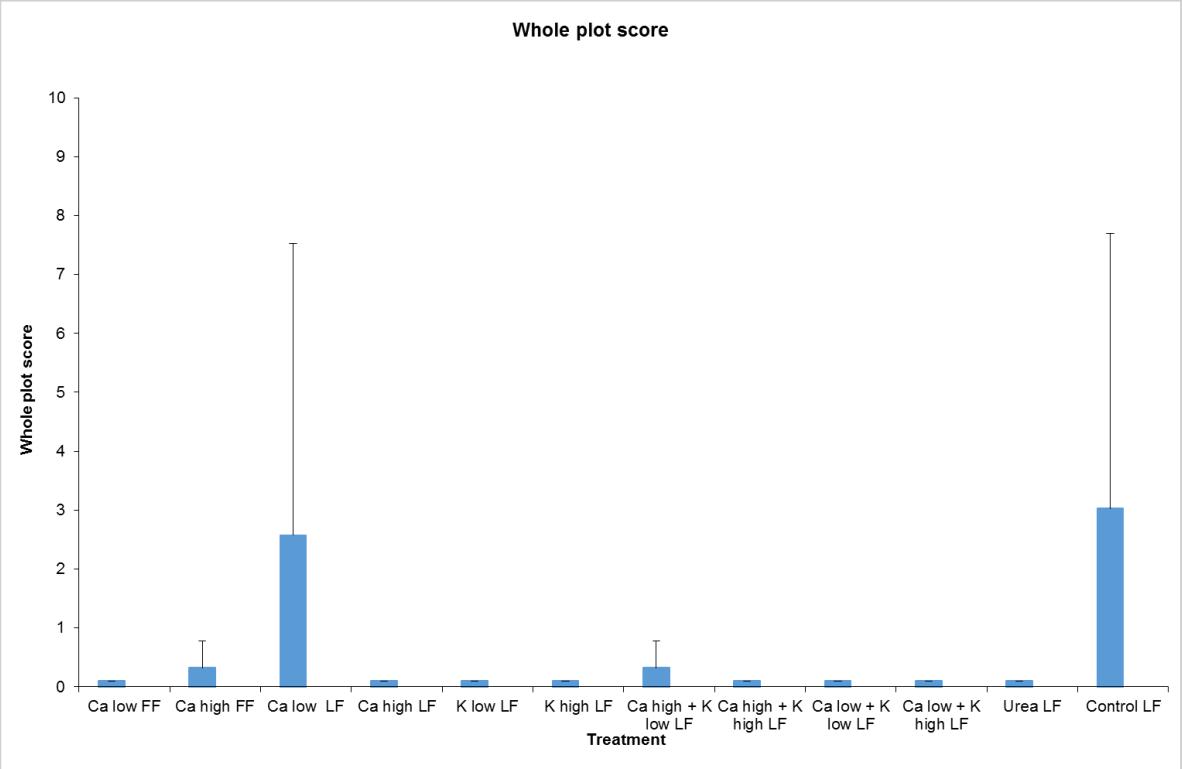

Figure 5. Whole plot score after 35 weeks of treatment: FF = foliar feed, LF = liquid feed. Treatments are not significantly different.

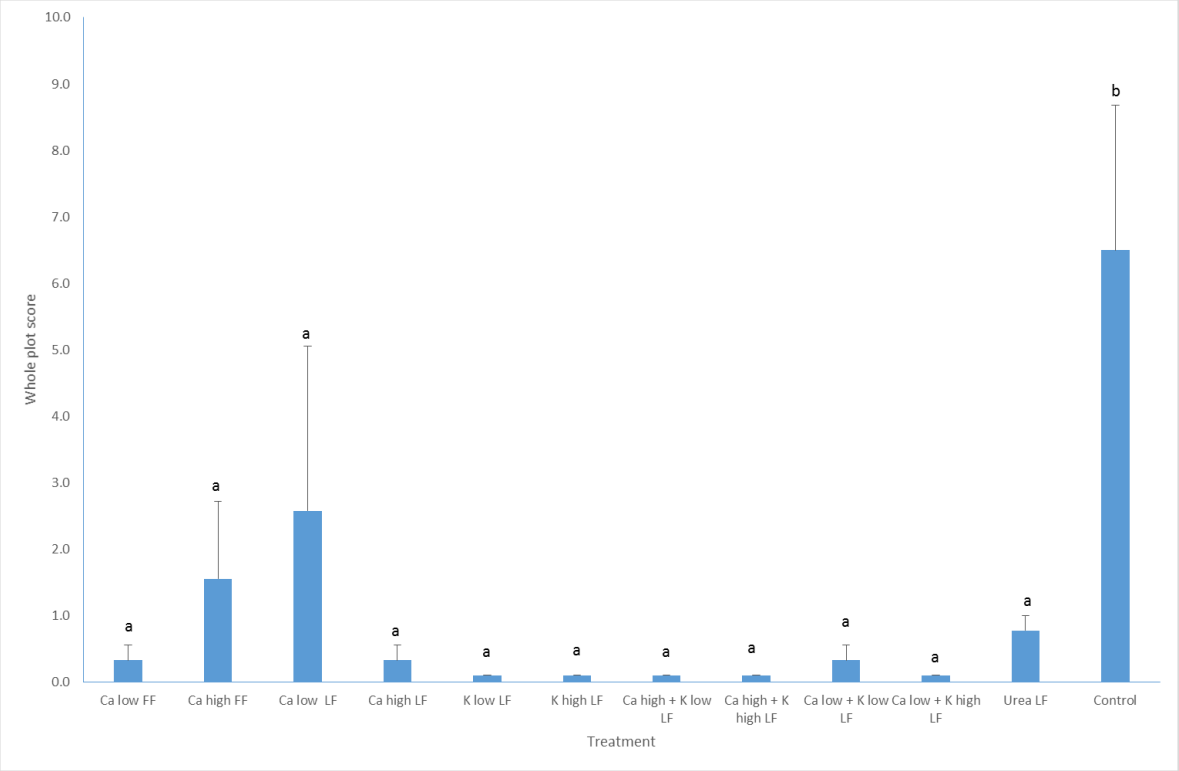

Figure 6. Whole plot score after 42 weeks of treatment: FF = foliar feed, LF = liquid feed. Treatments identified by different letters (a, b) are significantly different.

Table 7. Analysis of Variance (ANOVA) table. Whole plot score 42 weeks after treatment.

Source of variation	d.f.	s.s.	m.s	v.r.	F pr.	
Block	3	22.779	7.593	1.90	0.150	
Treatment	11	151.445	13.768	3.44	0.003	** Highly significant
Residual	32	128.083	4.003			
Total	46	302.128				

Plant quality

Plants were scored on a scale of 1-5, where 1 was a dead plant and those scoring 5 showed no tip burn or leaf spots, and plant size and leaf colour were unaffected (Table). After 35 weeks of treatment, all plants were marketable.

By 42 weeks after treatment, no plants scored either 1 or 5 for quality, plants in most treatments were generally marketable, although it may have been necessary to remove the tip burn prior to marketing. The exception was the untreated control where all plots were graded as mostly unsaleable, scoring 2, as they had more leaf spots, and tip burn and were

generally paler. Treatment 11 (urea) produced smaller, slightly pale plants, and treatment 5 (potassium nitrate, low rate, liquid feed) also produced slightly pale plants.

Leaf colour had a major influence on quality scores and the highest quality plants were found in treatment 10 (calcium nitrate, low rate, liquid feed + potassium nitrate, high rate, liquid feed), which had the best leaf colour. Treatment 4 (calcium nitrate, high rate, liquid feed), treatment 6 (potassium nitrate, high rate, liquid feed) and treatment 7 (calcium nitrate, high rate, liquid feed + potassium nitrate, low rate, liquid feed) generally had good leaf colour.

Plant quality in treatment 1 (calcium nitrate, low rate, foliar feed) was average, mainly due to leaf colour even though leaf spot incidence was lower than other treatments. Most plants were saleable, albeit with some tip burn and a degree of leaf spot, but they were generally paler than the other treatments with higher levels of nutrition.

Tissue analysis

Leaf tissue analysis (Appendix) carried out at the start of the trial (16 May 2013) indicated that less potassium and calcium were present in *Cordyline* tissue with tip burn than without, in accordance with the findings of year 2 (pre-trial, 12 October 2011). Similar analyses were carried out at the end of the final year, comparing tissue with and without yellow leaf spot symptoms, using tissue collected from plants treated with potassium nitrate (high rate, liquid feed) and the untreated control. These analyses again showed that plant tissue with yellow leaf spot symptoms had less leaf potassium and calcium than tissue without leaf spots; this trend was consistent in tissue from both treated plants and the untreated control.

Two further sets of leaf tissue analyses were carried out during the final year of the trial, after 35 and 42 weeks of treatment, using tissue taken from the youngest fully expanded leaves. The analyses indicated increased leaf calcium in treatments 1 to 4 (calcium nitrate foliar and liquid feed treatments), with the calcium taken up more effectively in the foliar feed than the liquid feed after 42 weeks of treatment. Foliar application of calcium (treatments 1 and 2) appears to have reduced leaf spot severity, although more effectively at the lower rate (treatment 1) than the high rate (treatment 2).

Application of extra potassium generally appears to have reduced leaf calcium, which may be expected as the ions are of similar size and are antagonistic in uptake. Leaf potassium was generally higher in treatments 1 and 3 (calcium nitrate, low rate, foliar and liquid feeds) after 42 weeks of treatment. Treatments 6 to 10 (potassium nitrate, high rate and the four

combination treatments of calcium nitrate and potassium nitrate) appear to have reduced leaf magnesium after 35 and 42 weeks of treatment. Leaf magnesium was higher in treatment 1 (calcium nitrate, low rate, foliar feed) than any other treatment, and lower in treatment 2 (calcium nitrate, high rate, foliar feed) than treatment 1 (calcium nitrate, low rate, foliar feed). The majority of the treatments show higher leaf NPK than the control.

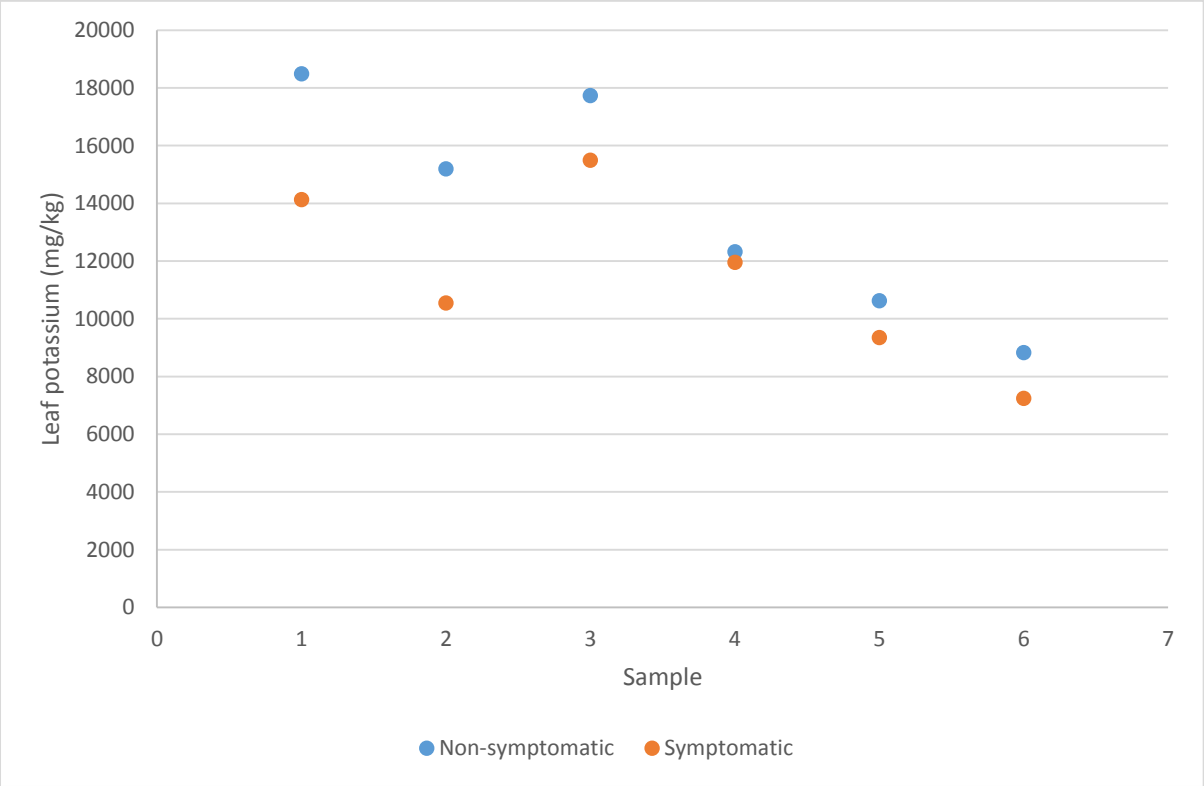

Figure 7. Leaf potassium in symptomatic and non-symptomatic *Cordyline* samples taken: 1) 12.10.11 pre-trial, year 2, 2) 16.05.13 pre-trial, final year, 3) 22.03.13, end of year 2, KNO_3 high rate, 200 mg/L, 4) 22.03.13 untreated control, end of year 2, 5) 10.04.14 KNO_3 high rate, 300 mg/L, 6) 10.04.14 untreated control.

Analysis of symptomatic and non-symptomatic tissue, taken from plants treated with potassium (high dose) and the untreated control, was carried out during year 2 and the final year of this study. Samples were tested prior to treatment (pre-trial) and at the end of the trial. Data cannot be directly compared as environmental conditions differed from year to year, and either leaf spot or tip burn were assessed in each year, however it is possible to follow trends.

On each occasion there was higher leaf potassium (Figure 7) and lower leaf magnesium (Figure) in non-symptomatic tissue, when assessing both tip burn and yellow leaf spot symptoms. Leaf calcium levels were not consistent, fluctuating throughout (Figure); these analyses were limited, and plants treated with additional calcium were not subjected to this tissue analysis.

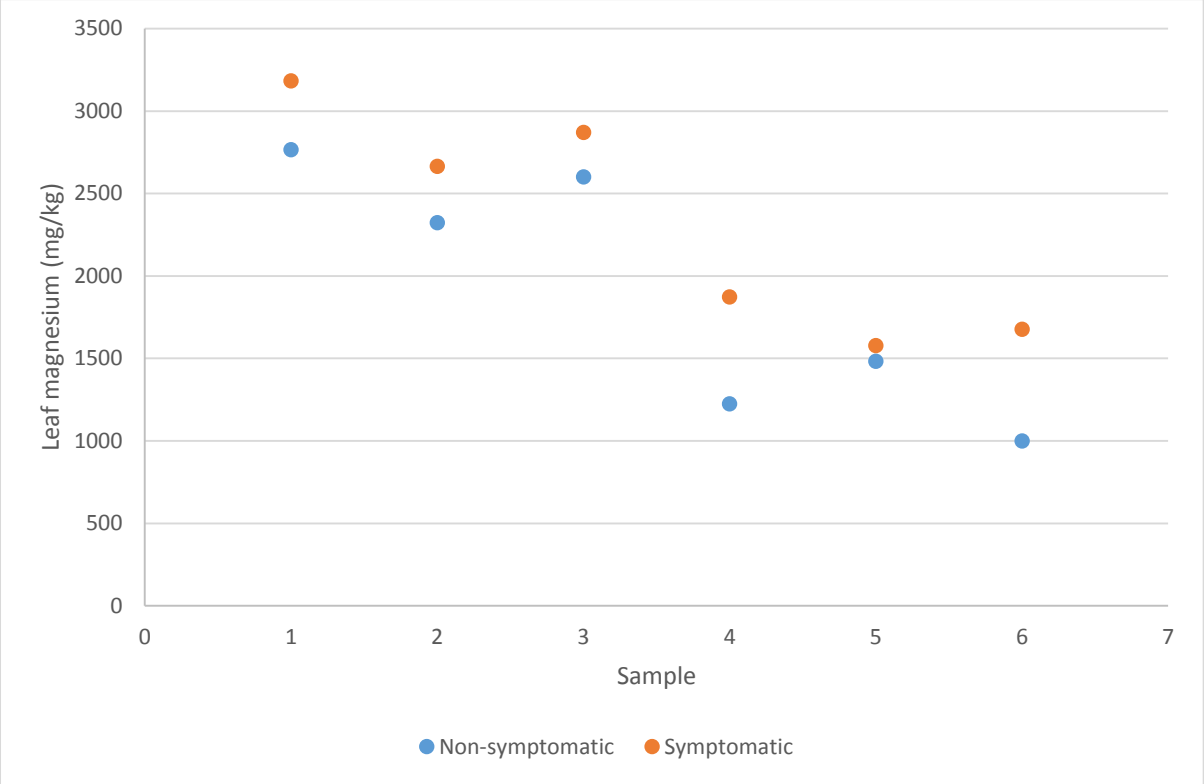

Figure 8. Leaf magnesium in symptomatic and non-symptomatic *Cordyline* samples taken: 1) 12.10.11 pre-trial, year 2, 2) 16.05.13 pre-trial, final year, 3) 22.03.13 KNO_3 high rate, 200 mg/L, 4) 22.03.13 untreated control, 5) 10.04.14 KNO_3 high rate, 300 mg/L, 6) 10.04.14 untreated control.

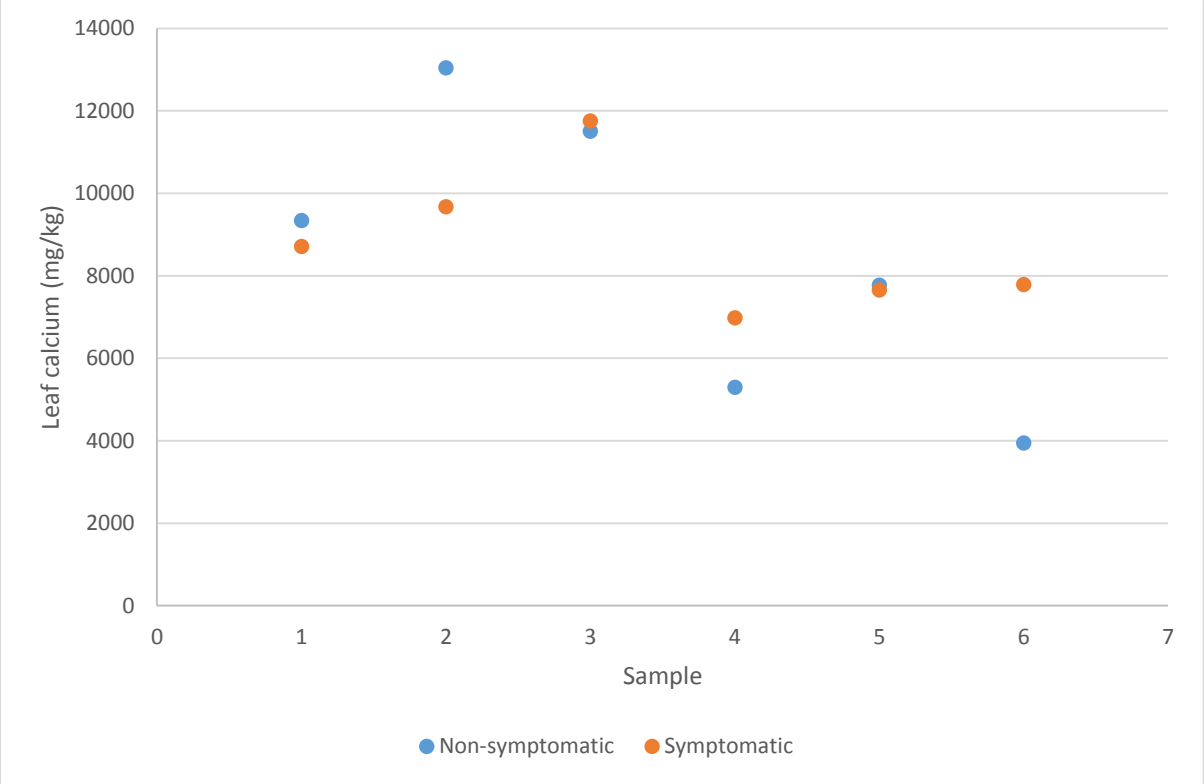

Figure 9. Leaf calcium in symptomatic and non-symptomatic *Cordyline* samples taken: 1) 12.10.11 pre-trial, year 2, 2)16.05.13 pre-trial, final year, 3) 22.03.13 KNO_3 high rate, 200 mg/L, 4) 22.03.13 untreated control, 5) 10.04.14 KNO_3 high rate, 300 mg/L, 6)10.04.14 untreated control.

Examination of the ratios of leaf potassium, calcium and magnesium in symptomatic and non-symptomatic tissue on each sampling date indicates that the ratio of potassium to magnesium is higher in non-symptomatic tissue, and the ratios of calcium to magnesium, and potassium to calcium are generally higher in non-symptomatic plants (Table , Appendix). Data for tissue sampled on different dates cannot be compared.

Table 8. Leaf tissue analyses: comparison of ratios in pre- and post-treatment *Cordyline australis*. * Untreated control. ** HR = 300 mg/L. * HR = 200 mg/L. KNO_3 = potassium nitrate HR = high rate. S = symptomatic. NS = non-symptomatic.**

Date	Symptom assessed	Treatment	K:Mg		K:Ca		Ca:Mg	
			S	NS	S	NS	S	NS
10.04.14	Leaf spot	KNO_3, HR**	5.58	10.61	1.20	2.70	**4.64**	**3.94**
10.04.14	Leaf spot	UC*	3.86	7.20	1.04	1.67	3.72	4.32
16.05.13	Tip burn	Pre-trial	6.68	10.24	1.38	1.96	4.85	5.24
22.03.13	Tip burn	KNO_3, HR***	5.80	7.60	**1.60**	**1.40**	3.60	5.60
22.03.13	Tip burn	UC*	4.20	4.70	1.00	1.10	4.10	4.40
12.10.11	Tip burn	Pre-trial	4.44	6.68	1.62	1.98	2.73	3.38

Growing media analyses

Growing media samples from each treatment were analysed at the start of the trial (final year) and at the mid-trial and final assessments (Appendix , Appendix). At the mid-trial and final assessments the conductivity was generally high to excessive (>600 uS/cm), including the untreated control. This was due to high sulphate and chloride levels, particularly at the final assessment (after 42 weeks of treatment) where the highest level was found in the urea treatment (1504 uS/cm). This could have been affecting root health, thereby reducing nutrient uptake. As in year 2, salts appear to have built up over time; plants were irrigated via drip irrigation and the salts were not adequately flushed through the growing media.

Conclusions

The warm, dry summer and autumn delayed development of leaf spot and tip burn symptoms until the spring; the treatments were perhaps not adequately challenged to separate out some of the benefits of one treatment over another as in year 2. The treatments selected for this experiment were those that gave the best results in previous years, and treatments were combined to determine any synergistic effect. In some treatments the yellow leaf spots were often small and sparse, leading to low scores in the whole plot assessment, in comparison to the control. Tip burn did develop, but it occurred in all treatments, with no clear differences apparent between treatments, therefore data was not collected.

Treatments 1 (low calcium, foliar feed) and 6 (high potassium, liquid feed) produced the best overall scores, with fewer plants affected and lower whole plot scores for leaf spot. Of these two treatments, plant quality was higher in treatment 6 (high potassium, liquid feed), although plants submitted to treatment 1 (low calcium, foliar feed) were not of poor quality. The best commercial option may be application of a combination of calcium nitrate (liquid feed, 75 mg/L calcium) + potassium nitrate (liquid feed, 300 mg/L potassium), as this treatment resulted in the best quality plants. For treatment 11 (urea), although the whole plot scores indicated significantly less leaf spots than the control, plants were generally smaller and tended to be pale, reducing plant quality scores.

The comparison of leaf tissue nutrient levels along with analysis of symptomatic and non-symptomatic tissue with and without symptoms clarify specific trends, namely that high leaf potassium and low magnesium appear to be correlated with reduced symptoms.

The results from this trial suggest that application of calcium (foliar feed) and potassium nitrate (high dose, liquid feed) do appear to reduce incidence of yellow leaf spot syndrome in *Cordyline australis*, although there may be an upper level of calcium nitrate application (1520 mg/L calcium) above which the benefit is reduced. As with this trial, growers are reporting low incidence of tip burn and leaf spot during the 2013-14 season. Having followed the results from years 1-3 of the project, a number of growers have started applying calcium as a foliar feed to Cordylines. This has been successful in reducing the problems with leaf spots but it does not eliminate them.

Technology transfer

- AHDB Horticulture News article October 2013

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Appendix 1. Trial layout

Plot	Treatment	Plot	Treatment	Plot	Treatment
1	3	17	4	33	5
2	12	18	11	34	9
3	1	19	6	35	8
4	7	20	10	36	2
5	6	21	7	37	1
6	2	22	10	38	9
7	5	23	12	39	8
8	4	24	3	40	11
9	2	25	1	41	12
10	3	26	7	42	4
11	5	27	6	43	10
12	9	28	8	44	11
13	12	29	11	45	10
14	4	30	2	46	7
15	1	31	3	47	5
16	9	32	8	48	6

Key

	Block 1
	Block 2
	Block 3
	Block 4

Treatment	
1	Ca low (foliar feed)
2	Ca high (foliar feed)
3	Ca low (liquid feed)
4	Ca high (liquid feed)
5	K low
6	K high
7	Ca high + K low
8	Ca high + K high
9	Ca low + K low
10	Ca low + K high
11	Urea
12	Untreated control

Appendix 2. Pre-trial water and growing media analyses. Final year.

East Malling Research Water Analysis 16 May 2013

pH	7.35	Conductivity	499 uS/cm
	mg/l		mg/l
Nitrate-N	1.5	Chloride	49.1
Sulphate	79.8	Phosphorus	1.0
Boron	0.06	Potassium	4.9
Copper	0.04	Magnesium	6.1
Manganese	<0.01	Calcium	64.4
Zinc	0.02	Sodium	45.8
Iron	<0.01		

Sinclair DHL Peat-Bark growing media 16 May 2013

pH	5.6	Conductivity	470 uS/cm
Density	502 kg/m3	Ammonia-N	55.7 mg/l
Dry Matter	54.2%	Nitrate-N	165.4 mg/l
Dry Density	272.1 g/m^3	Total Soluble N	221.1 mg/l
Chloride	123.9 mg/l	Sulphate	309.4 mg/l
Phosphorus	86.8 mg/l	Boron	0.18 mg/l
Potassium	443.1 mg/l	Copper	0.09 mg/l
Magnesium	68.9 mg/l	Manganese	0.88 mg/l
Calcium	71.5 mg/l	Zinc	0.34 mg/l
Sodium	70.2 mg/l	Iron	1.27 mg/l

pH and conductivity measurements are made at 20˚C

Appendix 3. Leaf tissue analyses

Leaf tissue analysis 10.04.14. Samples with and without leaf spots.

		Nitrogen DUMAS	Phosphorus	Potassium	Calcium	Magnesium	Sulphur	Manganese	Copper	Zinc	Iron	Boron
Treatment		% w/w	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
KNO_3, HR	Symptomatic	1.362	1143	9352	7788	1677	1002	210	2.8	9.6	51.9	20.8
KNO_3, HR	Non-symptomatic	1.052	1041	10622	3941	1001	888	73.2	1.6	9.1	33.2	12.5
Untreated control	Symptomatic	1.338	1228	7241	6979	1874	1083	304	2.5	14.9	47.5	28.9
Untreated control	Non-symptomatic	0.998	1193	8829	5295	1226	868	115	2	15.2	38.4	10.6

HR = high rate

Leaf tissue analysis 31.03.14

Treatment		Nitrogen DUMAS	Total P	Total K	Total Ca	Total Mg	Total S	Total Mn	Total Cu	Total Zn	Total Fe	Total B	K:Mg	K:Ca	Ca:Mg
		% w/w	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg			
$Ca(NO_3)_2$ (LR)	FF	1.785	2299	14293	9168	1539	865	131.0	6.9	31.9	352	14.2	9.29	1.56	5.96
$Ca(NO_3)_2$ (HR)	FF	1.366	1659	12998	8327	1358	780	168.0	2.5	23.0	56.3	13.8	9.57	1.56	6.13
$Ca(NO_3)_2$ (LR)	LF	1.571	2006	14168	7771	1171	1493	105.0	1.8	25.00	81.8	13.6	12.10	1.82	6.64
$Ca(NO_3)_2$ (HR)	LF	1.508	1478	10836	7082	1146	1542	112.0	1.8	22.7	52.6	13.00	9.46	1.53	6.18
KNO_3 (LR)	LF	1.266	1668	13928	5250	1201	1989	135.0	1.9	18.4	49.1	10.4	11.60	2.65	4.37
KNO_3 (HR)	LF	1.609	1811	15271	5908	1133	2651	94.2	2.1	21.5	40.8	9.6	13.48	2.58	5.21
$Ca(NO_3)_2$ (HR) + KNO_3 (LR)	LF	1.294	1499	13557	5075	989	3064	82.1	1.5	15.8	30.8	8.7	13.71	2.67	5.13
$Ca(NO_3)_2$ (HR) + KNO_3 (HR)	LF	1.426	1515	13772	5398	1131	1553	77.0	1.7	19.5	45.7	9.2	12.18	2.55	4.77
$Ca(NO_3)_2$ (LR) + KNO_3 (LR)	LF	1.487	1577	13932	6005	1132	1565	88.4	1.8	18.7	43.2	10.5	12.31	2.32	5.30
$Ca(NO_3)_2$ (LR) + KNO_3 (HR)	LF	1.521	1683	15859	5202	1085	1329	68.7	1.8	19.3	41.2	10.0	14.62	3.05	4.79
Urea	LF	1.236	1409	11043	5712	1070	2093	107.0	1.5	22.7	33.2	9.8	10.32	1.93	5.34
UC	LF	1.195	1498	11906	6461	1293	3118	160.0	2.3	21.7	44.3	11.4	9.21	1.84	5.00

HR = high rate, LR = low rate FF = foliar feed. LF = liquid feed. $Ca(NO_3)_2$ = calcium nitrate. KNO_3 = potassium nitrate

Leaf tissue analysis 10.02.14

Treatment		Nitrogen DUMAS	Total P	Total K	Total Ca	Total Mg	Total S	Total Mn	Total Cu	Total Zn	Total Fe	Total B	K:Mg	K:Ca	Ca:Mg
		% w/w	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg			
$Ca(NO_3)_2$ (LR)	FF	1.234	1414	9618	7408	1417	1191	120	6.9	15.2	135	10	6.79	1.30	5.23
$Ca(NO_3)_2$ (HR)	FF	0.885	1273	8761	7825	1306	909	123	2.8	11.7	70.3	9.4	6.71	1.12	5.99
$Ca(NO_3)_2$ (LR)	LF	1.178	1332	8580	7958	1305	1079	136	2.9	14.5	80.8	11.1	6.57	1.08	6.10
$Ca(NO_3)_2$ (HR)	LF	1.025	1310	9239	7075	1407	906	110	2.4	13.9	67.5	11.4	6.57	1.31	5.03
KNO_3 (LR)	LF	0.946	1344	11467	5659	1384	813	107	2.2	13	50.9	8	8.29	2.03	4.09
KNO_3 (HR)	LF	0.932	1316	13402	3118	878	864	71.8	2.1	13	35.7	5.5	15.26	4.30	3.55
$Ca(NO_3)_2$ (HR) + KNO_3 (LR)	LF	0.953	1352	13168	3268	845	874	76.8	1.8	14.3	37.4	5.5	15.58	4.03	3.87
$Ca(NO_3)_2$ (HR) + KNO_3 (HR)	LF	0.917	1178	12576	3240	883	939	59.8	1.5	11.1	28.7	5.2	14.24	3.88	3.67
$Ca(NO_3)_2$ (LR) + KNO_3 (LR)	LF	0.807	1145	11666	3426	897	767	61.3	1.7	11.5	32.8	6.1	13.01	3.41	3.82
$Ca(NO_3)_2$ (LR) + KNO_3 (HR)	LF	1.039	1354	13114	3616	969	949	72.8	2.5	13.9	38.8	6.4	13.53	3.63	3.73
Urea	LF	1.180	1269	11004	4585	1117	1067	89.3	1.9	13.7	35	7.7	9.85	2.40	4.10
UC	LF	0.840	1191	10237	4754	1319	827	105	2.2	15	32.4	7.5	7.76	2.15	3.60

HR = high rate, LR = low rate FF = foliar feed. LF = liquid feed. $Ca(NO_3)_2$ = calcium nitrate. KNO_3 = potassium nitrate

Leaf tissue analysis 16.05.13 (pre-trial, final year)

	Total N DUMAS	Total P	Total K	Total Ca	Total Mg	Total S	Total Mn	Total Cu	Total Zn	Total Fe	Total B	K:Mg	K:Ca	Ca:Mg
	% w/w	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg			
No tip burn	1.224	2495	15193	7771	1483	1260	42.3	4.7	32.0	71.2	10.6	10.2	2.0	5.2
With tip burn	1.135	1655	10548	7654	1578	1880	79.0	3.2	26.4	143.0	12.9	6.7	1.4	4.9

Results are reported on a 100% Dry Matter Basis. pH and conductivity measurements are made at 20˚C

Leaf tissue analysis 22.03.13

Cordyline	Total N DUMAS	Total P	Total K	Total Ca	Total Mg	Total S	Total Mn	Total Cu	Total Zn	Total Fe	Total B	K:Mg	K:Ca	Ca:Mg
	% w/w	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg			
KNO_3 (HR, LF) with leaf spots	1.44	1546	15496	9676	2666	1134	182	2.8	27.5	172	17.0	5.8	1.6	3.6
KNO_3 (HR. LF) with no leaf spots	1.66	1896	17736	13042	2323	1192	109	3.0	25.1	149	20.0	7.6	1.4	5.6
UC* with leaf spots	1.21	1749	11953	11754	2871	1111	162	2.4	25.2	115	20.8	4.2	1.0	4.1
UC* with no leaf spots	1.10	1939	12319	11509	2601	1027	133	2.6	24.3	79	17.3	4.7	1.1	4.4

Untreated control. Results are reported on a 100% Dry Matter Basis. pH and conductivity measurements are made at 20˚C. KNO_3 = potassium nitrate. HR = high rate, LR = low rate, LF = liquid feed, FF = foliar feed. UC = untreated control

Leaf tissue analysis 28.02.13

Cordyline	Total N DUMAS	Total P	Total K	Total Ca	Total Mg	Total S	Total Mn	Total Cu	Total Zn	Total Fe	Total B	Fl	K:Mg	K:Ca	Ca:Mg
	% w/w	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg			
$Ca(NO_3)_2$ (FF)	1.61	2471	15068	12371	2061	1375	106.0	3.5	22.4	181.0	24.2	1.3	7.3	1.2	6.0
$Ca(NO_3)_2$ (LF)	1.99	2449	14729	11222	1670	1409	79.1	3.8	21.3	93.6	24.3	0.7	8.8	1.3	6.7
KNO_3 (HR)	1.80	2377	18470	9657	1851	1265	64.7	2.6	19.9	74.8	21.8	<0.5	10.0	1.9	5.2
KNO_3 (LR)	1.52	2168	16099	9563	2012	1487	91.8	3.0	20.2	54.8	22.8	<0.5	8.0	1.7	4.8
K_2SO_4	1.34	2072	17321	8815	1975	1048	96.9	2.5	19.6	71.2	18.7	<0.5	8.8	2.0	4.5
Fluoride	1.43	2240	15028	8968	1726	1151	79.1	2.7	19.6	51.6	19.5	1.8	8.7	1.7	5.2
UC*	1.31	2128	13831	8913	1847	1192	87.8	2.6	19.6	57.0	20.2	1.0	7.5	1.6	4.8

* Untreated control. Results are reported on a 100% Dry Matter Basis. pH and conductivity measurements are made at 20˚C. HR = high rate, LR = low rate, LF = liquid feed, FF = foliar feed

Leaf tissue analysis 31.01.13

Cordyline	Total N DUMAS	Total P	Total K	Total Ca	Total Mg	Total S	Total Mn	Total Cu	Total Zn	Total Fe	Total B	Fl	K:Mg	K:Ca	Ca:Mg
	% w/w	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg			
$Ca(NO_3)_2$ (FF)	1.75	2601	15420	21268	2636	1556	167	16.0	56.3	4374	15.9	13.2	5.8	0.7	8.1
$Ca(NO_3)_2$ (LF)	2.28	2946	18025	13546	1710	1446	87.9	5.1	29	748	15.8	2.9	10.5	1.3	7.9
KNO_3 (HR)	2.07	2780	22756	8863	1770	1370	62.5	3.3	24.1	239	12.8	1.4	12.9	2.6	5.0
KNO_3 (LR)	2.12	2776	21082	9432	1794	1464	75.9	4.2	25.6	322	12.0	1.5	11.8	2.2	5.3
K_2SO_4	1.66	2551	20971	8025	1694	1278	73.6	3.4	23	154	11.1	0.8	12.4	2.6	4.7
Fluoride	1.71	2747	18305	10815	1771	1182	82.1	4.0	24.9	152	12.4	0.9	10.3	1.7	6.1
UC*	1.61	2466	17261	8781	1723	1167	73.9	3.3	21.3	122	10.7	0.7	10.0	2.0	5.1

* Untreated control. Results are reported on a 100% Dry Matter Basis. pH and conductivity measurements are made at 20˚C. HR = high rate, LR = low rate, LF = liquid feed, FF = foliar feed

Leaf tissue analysis 29.11.12

Cordyline	Total N DUMAS	Total P	Total K	Total Ca	Total Mg	Total S	Total Mn	Total Cu	Total Zn	Total Fe	Total B	Fl	K:Mg	K:Ca	Ca:Mg
	% w/w	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg			
$Ca(NO_3)_2$ (FF)	1.73	2502	18443	13365	2681	1025	122	6.7	33.1	918	19.3	4.1	6.9	1.4	5.0
$Ca(NO_3)_2$ (LF)	2.37	2505	17531	13594	2199	971	92	4.4	28.0	364	20.8	1.4	8.0	1.3	6.2
KNO_3 (HR)	2.45	2702	24822	12501	2439	887	98.5	7.8	30.4	300	18.9	1.1	10.2	2.0	5.1
KNO_3 (LR)	2.20	2337	20430	13751	2459	705	103	4.6	27.4	271	18.7	1.3	8.3	1.5	5.6
K_2SO_4	1.84	2400	23814	11016	2527	952	109	4.4	28.4	118	16.2	0.7	9.4	2.2	4.4
Fluoride	1.58	2354	18244	11746	2585	744	115	3.9	28.7	121	17.4	2.6	7.1	1.6	4.5
UC*	1.78	2603	17741	13141	2848	685	124	4.3	29.0	151	19.4	0.9	6.2	1.4	4.6

* Untreated control. Results are reported on a 100% Dry Matter Basis. pH and conductivity measurements are made at 20°C. HR = high rate, LR = low rate, LF = liquid feed, FF = foliar feed.

Leaf tissue analysis 12.09.12

Cordyline	**Total N DUMAS**	**Total P**	**Total K**	**Total Ca**	**Total Mg**	**Total S**	**Total Mn**	**Total Cu**	**Total Zn**	**Total Fe**	**Total B**	**Fl**	**K:Mg**	**K:Ca**	**Ca:Mg**
	% w/w	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**			
$Ca(NO_3)_2$ (FF)	1.5	1970	13315	9631	2812	1358	136.0	3.5	21.6	104.0	37.6	2.0	4.7	1.4	3.4
$Ca(NO_3)_2$ (LF)	1.5	1766	11883	8410	2367	1383	94.2	2.5	15.5	1121.0	20.5	4.4	5.0	1.4	3.6
KNO_3 (HR)	1.9	1861	17480	8215	2606	1712	107.0	2.9	17.3	299.0	23.2	2.2	6.7	2.1	3.2
KNO_3 (LR)	1.3	1845	14835	6993	2530	1361	94.7	2.5	15.3	189.0	18.5	1.7	5.9	2.1	2.8
K_2SO_4	1.3	1888	18405	7235	2535	1415	115.0	2.3	17.7	80.4	18.0	0.9	7.3	2.5	2.9
Fluoride	1.5	1975	13897	9246	2988	1605	142.0	2.8	20.9	94.5	27.2	4.2	4.7	1.5	3.1
UC*	1.3	1865	13219	8194	2726	1360	123.0	2.5	17.8	62.5	25.0	0.8	4.8	1.6	3.0
Phormium	**Total N DUMAS**	**Total P**	**Total K**	**Total Ca**	**Total Mg**	**Total S**	**Total Mn**	**Total Cu**	**Total Zn**	**Total Fe**	**Total B**	**Fl**	**K:Mg**	**K:Ca**	**Ca:Mg**
	% w/w	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**			
$Ca(NO_3)_2$ (foliar feed)	2.3	2484	17113	5525	1660	1584	104.0	1.9	18.3	168.0	26.8	1.9	10.3	3.1	3.3
$Ca(NO_3)_2$	2.1	2627	17976	4077	1556	1535	90.4	1.5	18.1	56.8	28.0	<0.5	11.6	4.4	2.6
KNO_3 (HR)	2.6	2507	20047	3983	1633	1802	101.0	1.5	16.7	52.2	25.9	<0.5	12.3	5.0	2.4
KNO_3 (LR)	2.1	2779	19337	5396	1868	1531	112.0	1.9	19.8	88.4	30.6	<0.5	10.4	3.6	2.9
K_2SO_4	2.0	2505	21564	4974	1768	1447	143.0	1.7	19.8	65.7	27.1	<0.5	12.2	4.3	2.8
Fluoride	1.9	2377	16548	4050	1642	1430	99.1	1.5	18.9	56.6	25.6	0.6	10.1	4.1	2.5
UC*	2.2	2794	18362	4341	1765	1478	110.0	1.6	19.2	85.0	27.8	<0.5	10.4	4.2	2.5

* Untreated control. Results are reported on a 100% Dry Matter Basis. pH and conductivity measurements are made at 20˚C. HR = high rate, LR = low rate, LF = liquid feed, FF = foliar feed

Leaf tissue analyses 4.07.12

Cordyline	Total N DUMAS	Total P	Total K	Total Ca	Total Mg	Total S	Total Mn	Total Cu	Total Zn	Total Fe	Total B	Fl	K:Mg	K:Ca	Ca:Mg
	% w/w	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg			
$Ca(NO_3)_2$ (FF)	2.04	3555	22615	5124	2461	986	191	6.0	26.7	115	14.7	<0.5	9.2	4.4	2.1
$Ca(NO_3)_2$ (LF)	2.48	3433	21800	4683	2269	927	149	4.6	25.7	58.1	13.4	<0.5	9.6	4.7	2.1
KNO_3 (HR)	2.19	3384	23946	4017	2138	903	128	4.2	26.9	53.6	12.2	<0.5	11.2	6.0	1.9
KNO_3 (LR)	2.13	3413	22762	4963	2346	992	172	4.1	26.2	58.4	13.1	<0.5	9.7	4.6	2.1
K_2SO_4	2.19	3393	25503	4198	2307	911	168	4.0	27.5	68.3	13.5	<0.5	11.1	6.1	1.8
Fluoride	2.18	3475	22585	4846	2478	940	165	4.0	27.2	45.1	13.4	<0.5	9.1	4.7	2.0
UC*	2.20	3016	20528	5386	2164	848	151	4.6	26.3	221	14.9	<0.5	9.5	3.8	2.5
Phormium	Total N DUMAS	Total P	Total K	Total Ca	Total Mg	Total S	Total Mn	Total Cu	Total Zn	Total Fe	Total B	Fl	K:Mg	K:Ca	Ca:Mg
	% w/w	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg			
$Ca(NO_3)_2$ (FF)	2.22	2884	21384	4243	1658	526	169	2.3	16.8	94.9	22.7	<0.5	12.9	5.0	2.6
$Ca(NO_3)_2$ (LF)	2.27	2894	22068	3476	1636	428	136	1.8	16.6	66.2	22.7	<0.5	13.5	6.3	2.1
KNO_3 (HR)	2.29	2958	23893	3005	1649	466	136	2.0	15.6	46.9	21.3	<0.5	14.5	8.0	1.8
KNO_3 (LR)	2.37	2985	21564	3154	1607	446	143	2.2	18.1	110	23.9	<0.5	13.4	6.8	2.0
K_2SO_4	2.21	3036	23385	3374	1644	452	152	2.0	18.1	52.9	23.3	<0.5	14.2	6.9	2.1
Fluoride	2.24	2966	21904	3272	1674	431	153	1.9	17.2	45.8	21.6	<0.5	13.1	6.7	2.0
UC*	2.23	2997	21821	3019	1676	430	127	1.9	16.8	37.5	20.9	<0.5	13.0	7.2	1.8

* Untreated control. Results are reported on a 100% Dry Matter Basis. pH and conductivity measurements are made at 20˚C. HR = high rate, LR = low rate, LF = liquid feed, FF = foliar feed

Leaf tissue analysis 12.10.11 Pre-trial.

Cordyline	**Total N DUMAS**	**Total P**	**Total K**	**Total Ca**	**Total Mg**	**Total S**	**Total Mn**	**Total Cu**	**Total Zn**	**Total Fe**	**Total B**	**Fl**	**K:Mg**	**K:Ca**	**Ca:Mg**
	% w/w	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**			
No tip burn	1.732	2442	18489	9342	2767	1894	162.0	3.9	36.6	413	24.2	<0.5	6.7	2.0	3.4
With tip burn	1.593	1655	14128	8708	3184	1522	379.0	2.0	47.2	150	16.5	1.1	4.4	1.6	2.7
Phormium	**Total N DUMAS**	**Total P**	**Total K**	**Total Ca**	**Total Mg**	**Total S**	**Total Mn**	**Total Cu**	**Total Zn**	**Total Fe**	**Total B**	**Fl**	**K:Mg**	**K:Ca**	**Ca:Mg**
	% w/w	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**			
No tip burn	2.200	2459	20142	6390	2777	159	56.5	2.0	21.9	159	15.2	<0.5	7.3	3.2	2.3
With tip burn	1.646	1626	16342	10481	3819	1512	158.0	2.0	24.7	444	13.7	I.S.	4.3	1.6	2.7

I.S. = Insufficient Sample. Results are reported on a 100% Dry Matter Basis. pH and conductivity measurements are made at 20˚C

Appendix 4. Growing media analyses

Growing media analysis: 31.03.14

		$Ca(NO_3)_2$ (LR)	$Ca(NO_3)_2$ (HR)	$Ca(NO_3)_2$ (LR)	$Ca(NO_3)_2$ (HR)	KNO_3 (LR)	KNO_3 (HR)	$Ca(NO_3)_2$ (HR) + KNO3(LR)	$Ca(NO_3)_2$ (HR) + KNO3 (HR)	$Ca(NO_3)_2$ (LR) + KNO3 (LR)	$Ca(NO_3)_2$ (LR) + KNO3 (HR)	Urea	UC
		FF	FF	LF	LF	LF	LF	LF	LF	LF	LF	LF	
EC @ 20°C	uS/cm	1068	1017	1063	1061	1108	1111	714	613	1048	1025	1504	1040
pH		5.71	5.63	5.59	5.50	5.57	5.60	5.48	5.79	5.29	5.62	5.41	5.57
Density	kg/m^3	694	598	578	706	657	671	621	636	575	598	753	628
Dry matter	%	48.9	51.5	51.5	62	58.7	45.8	50.4	44.8	53.9	59.3	64.1	59.7
Dry density	kg/m^3	339.40	308.00	297.70	437.70	385.70	307.30	313.00	284.90	309.90	354.60	482.70	374.90
Cl	mg/l	194.20	187.40	142.90	147.70	175.50	146.30	161.10	95.90	210.80	131.80	246.70	218.00
P	mg/l	194.50	180.40	163.10	189.50	207.40	211.00	131.60	105.20	180.20	173.10	249.60	211.90
K	mg/l	212.30	286.20	285.70	376.80	442.30	406.30	261.80	139.70	384.20	407.00	515.60	336.20
Mg	mg/l	276.10	240.00	284.90	240.30	261.50	282.10	135.60	116.40	238.60	244.20	352.50	293.50
Ca	mg/l	470.90	379.90	455.00	379.90	362.40	440.20	225.40	279.10	370.10	361.60	545.90	418.90
Na	mg/l	445.20	378.60	437.00	337.90	414.40	428.60	341.70	316.60	406.80	445.20	578.70	349.60
Ammonia-N	mg/l	79.10	101.00	68.10	119.20	108.40	64.70	51.60	28.10	88.50	61.10	160.40	66.30
Nitrate-N	mg/l	81.90	157.00	121.40	195.90	153.00	148.40	116.50	83.10	168.60	134.30	254.60	135.40
Total soluble N	mg/l	161.00	258.00	189.50	315.10	261.40	213.10	168.10	111.20	257.10	195.40	415.00	201.70
Sulphate	mg/l	2459.40	1990.60	2494.60	1876.40	2219.80	2308.60	1252.30	1243.70	1994.60	2225.40	3058.50	2057.70
B	mg/l	0.18	0.17	0.15	0.19	0.16	0.18	0.18	0.17	0.16	0.17	0.20	0.20
Cu	mg/l	0.22	0.21	0.23	0.24	0.27	0.23	0.13	0.13	0.20	0.24	0.29	0.23
Mn	mg/l	1.55	1.45	1.68	1.71	2.09	2.02	0.83	0.47	1.90	1.66	2.99	2.10
Zn	mg/l	1.13	0.94	0.96	1.02	1.29	1.23	0.47	0.66	0.73	0.91	1.26	1.12
Fe	mg/l	2.44	2.80	3.16	4.00	3.82	3.63	2.36	1.28	3.09	3.52	5.68	3.88
K:Mg		0.77	1.19	1.00	1.57	1.69	1.44	1.93	1.20	1.61	1.67	1.46	1.15
K:Ca		0.45	0.75	0.63	0.99	1.22	0.92	1.16	0.50	1.04	1.13	0.94	0.80
Ca:Mg		1.71	1.58	1.60	1.58	1.39	1.56	1.66	2.40	1.55	1.48	1.55	1.43

Growing media analysis: 03.02.14

		$Ca(NO3)_2$ (LR)	$Ca(NO3)_2$ (HR)	$Ca(NO3)_2$ (LR)	$Ca(NO3)_2$ (HR)	KNO3 (LR)	KNO3 (HR)	$Ca(NO3)_2$ (HR) + KNO3(LR)	$Ca(NO3)_2$ (HR) + KNO3 (HR)	$Ca(NO3)_2$ (LR) + KNO3 (LR)	$Ca(NO3)_2$ (LR) + KNO3 (HR)	Urea	UC

		FF	FF	LF	LF	LF	LF	LF	LF	LF	LF	LF	
Conductivity @ 20°C	uS/cm	933	698	639	763	917	564	725	641	867	1018	909	750
pH		5.66	5.70	5.64	5.58	5.59	6.18	5.65	5.75	5.70	5.42	5.52	5.61
Density	kg/m3	599	640	604	601	596	588	582	596	584	607	625	647
Dry matter	%	53.0	55.9	58.9	52.5	63.0	40.7	59.8	51.5	44.9	49.1	45.4	48.2
Dry density	kg/m3	317.5	357.8	355.8	315.5	375.5	239.3	348.0	306.9	262.2	298.0	283.8	311.9
Cl	mg/l	183.0	78.9	111.0	138.0	150.5	127.2	109.2	116.8	183.1	168.8	208.2	92.8
P	mg/l	165.3	120.3	117.0	139.8	165.1	80.1	140.4	112.8	143.2	184.6	145.2	151.6
K	mg/l	289.7	167.9	229.6	237.6	352.6	261.6	281.8	220.1	305.6	464.9	296.7	218.8
Mg	mg/l	203.6	148.8	122.1	162.8	198.7	87.1	136.5	129.4	191.9	214.9	219.7	180.0
Ca	mg/l	290.9	278.2	192.8	259.7	281.2	206.6	188.8	207.8	292.2	280.4	315.7	318.3
Na	mg/l	362.8	215.9	204.3	299.0	319.9	203.3	271.6	245.8	305.2	347.8	368.5	246.3
Ammonia-N	mg/l	106.4	89.6	86.7	81.7	108.2	51.3	101.7	74.1	83.0	112.9	61.5	75.8
Nitrate-N	mg/l	152.8	118.6	122.1	109.5	155.1	105.1	126.8	101.7	140.7	212.1	114.7	105.6
Total soluble N	mg/l	259.2	208.2	208.8	191.2	263.3	156.4	228.5	175.8	223.7	325.0	176.2	181.4
Sulphate	mg/l	1833.6	1429.1	1130.8	1625.9	1836.8	1009.4	1395.3	1298.4	1730.1	1897.8	1934.1	1651.0
B	mg/l	0.20	0.19	0.18	0.19	0.19	0.19	0.19	0.18	0.18	0.18	0.18	0.19
Cu	mg/l	0.20	0.17	0.14	0.17	0.20	0.12	0.16	0.17	0.19	0.20	0.17	0.20
Mn	mg/l	1.44	1.01	0.93	1.14	1.60	0.47	0.90	0.72	1.55	1.77	1.66	1.05
Zn	mg/l	0.94	0.99	0.60	0.78	0.94	0.85	0.70	0.89	1.11	0.85	0.84	0.89
Fe	mg/l	3.19	2.62	2.47	2.79	3.32	1.51	2.71	2.02	3.05	3.61	3.00	2.57
K:Mg		1.42	1.13	1.88	1.46	1.77	3.00	2.06	1.70	1.59	2.16	1.35	1.22
K:Ca		1.00	0.60	1.19	0.91	1.25	1.27	1.49	1.06	1.05	1.66	0.94	0.69
Ca:Mg		1.43	1.87	1.58	1.60	1.42	2.37	1.38	1.61	1.52	1.30	1.44	1.77

Growing media analysis 28.02.13

Cordyline		**$Ca(NO_3)_2$ (foliar feed)**	**$Ca(NO_3)_2$ (liquid feed)**	**KNO3 (high rate)**	**KNO3 (low rate)**	**K2SO4**	**Fluoride**	**UC***
pH		4.40	4.96	4.38	4.30	4.36	4.44	4.88
Cond. at 20°C	uS/cm	361	183	315	543	484	348	240
Density	kg/m3	477	430	384	400	394	365	410

Ammonia-N	mg/l	31.00	25.70	25.30	24.20	22.80	20.00	21.60
Dry Matter	%	35.0	44.9	46.3	50.3	32.4	37.5	55.1
Nitrate-N	mg/l	2.4	5.9	2.7	1.2	1.3	<0.6	1.9
Dry Density	kg/m3	166.9	193.1	177.8	201.2	127.7	136.9	225.9
Total Soluble N	mg/l	33.4	31.6	28.0	25.4	24.1	20.5	23.5
Cl	mg/l	51.7	12.4	17.6	39.9	58.4	56.6	41.3
Sulphate	mg/l	827.9	429.4	739.8	1387.8	1214.3	815.5	527.1
P	mg/l	30.9	16.8	27.0	51.7	35.9	36.8	20.4
B	mg/l	0.13	0.25	0.10	0.16	0.15	0.12	0.24
K	mg/l	32.40	10.30	22.60	22.70	102.90	14.00	12.80
Cu	mg/l	0.07	<0.06	0.06	0.10	0.08	0.06	<0.06
Mg	mg/l	70.20	24.80	58.90	150.20	103.80	82.90	33.40
Mn	mg/l	0.44	0.10	0.26	1.09	0.79	0.55	0.14
Ca	mg/l	103.50	60.50	64.90	187.50	211.60	97.90	75.20
Zn	mg/l	0.13	0.10	0.08	0.18	0.14	0.11	0.13
Na	mg/l	199.70	100.50	211.90	281.10	178.40	219.20	145.10
Fe	mg/l	2.37	1.99	1.88	2.79	2.06	1.78	1.59
F	mg/l	0.67	<0.60	0.67	0.67	<0.60	6.00	0.90
K:Mg		0.5	0.4	0.4	0.2	1.0	0.2	0.4
K:Ca		0.3	0.2	0.3	0.1	0.5	0.1	0.2
Ca:Mg		1.5	2.4	1.1	1.2	2.0	1.2	2.3

* UC = Untreated control.

Growing media analysis 31.01.13

Cordyline		**$Ca(NO_3)_2$ (foliar feed)**	**$Ca(NO_3)_2$ (liquid feed)**	**KNO3 (high rate)**	**KNO3 (low rate)**	**K2SO4**	**Fluoride**	**UC***
pH		3.94	4.32	4.28	3.93	4.16	4.24	4.35
Cond. at 20°C	uS/cm	313	517	451	584	433	339	498
Density	kg/m3	495	458	442	440	452	516	440
Ammonia-N	mg/l	29.2	37.6	39.9	27.4	31.4	39.4	40.5
Dry Matter	%	40.8	42.2	45.4	46.5	35.9	32.7	41.7
Nitrate-N	mg/l	2.0	7.1	6.1	5.0	<0.6	0.7	7.9
Dry Density	kg/m3	202.0	193.3	200.7	204.6	162.3	168.7	183.5
Total Soluble N	mg/l	31.2	44.7	46.0	32.4	31.9	40.1	48.4
Cl	mg/l	54.9	26.2	29.3	24.4	52.6	46.4	23.6
Sulphate	mg/l	693.9	1500.1	1250.6	1659	1196.2	877.1	1451
P	mg/l	31.2	42.5	41.8	52.9	35.6	19.7	61.6
B	mg/l	0.15	0.16	0.14	0.18	0.16	0.14	0.16
K	mg/l	20.1	23.1	49.4	25.2	23.6	8.8	41.3
Cu	mg/l	0.10	0.15	0.14	0.13	0.12	0.10	0.12
Mg	mg/l	57.7	114.2	97.5	175.1	111.2	60.3	124
Mn	mg/l	0.41	0.75	0.58	1.34	0.54	0.30	0.85
Ca	mg/l	74.8	207.5	151.7	229.7	158.6	115.4	204
Zn	mg/l	0.43	0.48	0.49	1.17	0.50	0.25	0.39
Na	mg/l	203.2	326.7	278.8	291.9	235.9	204.7	257
Fe	mg/l	1.82	2.70	2.75	3.63	1.97	1.02	2.92
F	mg/l	<5.0	<5.0	<5.0	<5.0	<5.0	7.5	<5.0
K:Mg		0.3	0.2	0.5	0.1	0.2	0.1	0.3
K:Ca		0.3	0.1	0.3	0.1	0.1	0.1	0.2
Ca:Mg		1.3	1.8	1.6	1.3	1.4	1.9	1.6

* Untreated control.

Growing media analysis 29.11.12

Cordyline		$Ca(NO_3)_2$ (foliar feed)	$Ca(NO_3)_2$ (liquid feed)	KNO3 (high rate)	KNO3 (low rate)	K2SO4	Fluoride	UC*
pH		4.46	5.02	4.20	4.35	4.21	4.60	4.09
Cond. at 20°C	uS/cm	493	380	742	326	574	222	572
Density	kg/m3	734	729	584	732	663	593	564
Ammonia-N	mg/l	22.8	26.7	31.3	27.3	22.4	17.3	33.9
Dry Matter	%	29.6	28.7	33.4	26.2	31.9	28.2	31.4
Nitrate-N	mg/l	12.5	11.1	30.2	9.2	19.4	<0.6	18.6
Dry Density	kg/m3	217.3	209.2	195.1	191.8	211.5	167.2	177.1
Total Soluble N	mg/l	35.3	37.8	61.5	36.5	41.8	17.3	52.5
Cl	mg/l	34.0	30.5	70.1	34.7	87.3	41.9	55.9
Sulphate	mg/l	1312.2	957.5	2006.6	764.1	1527.2	495.4	1586.8
P	mg/l	44.8	31.8	93.0	29.5	45.1	20.7	67.9
B	mg/l	0.21	0.18	0.20	0.18	0.19	0.18	0.18
K	mg/l	29.2	14.2	98.3	33.3	107.0	11.8	48.9
Cu	mg/l	0.18	0.14	0.21	<0.06	0.11	0.09	0.13
Mg	mg/l	104.4	58.5	163.6	56.7	107.1	33.7	153.6
Mn	mg/l	0.60	0.29	1.58	0.23	0.81	0.24	1.63
Ca	mg/l	222.7	173.4	258.5	89.4	194.1	81.6	189.8
Zn	mg/l	0.30	0.23	0.28	0.17	0.27	0.14	0.33
Na	mg/l	233.8	201.3	430.6	186.0	335.3	131.2	302.2
Fe	mg/l	3.21	1.81	2.63	1.35	1.34	1.79	3.48
F	mg/l	<1.0	<1.0	<1.0	<1.0	<1.0	5.0	<1.0
K:Mg		0.3	0.2	0.6	0.6	1.0	0.4	0.3
K:Ca		0.1	0.1	0.4	0.4	0.6	0.1	0.3
Ca:Mg		2.1	3.0	1.6	1.6	1.8	2.4	1.2

* Untreated control.

Growing media analysis 12.10.12

Cordyline		$Ca(NO_3)_2$ (foliar feed)	$Ca(NO_3)_2$ (liquid feed)	KNO_3 (high rate)	KNO_3 (low rate)	K_2SO_4	Fluoride	UC*
pH		4.45	5.26	4.40	4.97	4.79	5.74	4.66
Cond. at 20°C	uS/cm	1055	229	534	309	175	376	407
Density	kg/m3	545	665	526	611	591	578	594
Ammonia-N	mg/l	115.8	22.1	20.1	19.0	12.9	17.9	15.4
Dry Matter	%	35.1	27.9	32.0	27.3	27.8	34.8	29.3
Nitrate-N	mg/l	311.3	19.3	20.1	21.1	10.2	10.3	7.7
Dry Density	kg/m3	191.3	185.5	168.3	166.8	164.3	201.1	174.0
Total Soluble N	mg/l	427.1	41.4	40.2	40.1	23.1	28.2	23.1
Cl	mg/l	174.9	35.9	46.3	42.9	24.4	96.5	44.6
Sulphate	mg/l	1250.4	407.2	1283.9	599.2	279.7	673.3	890.5
P	mg/l	167.8	23.7	41.4	33.5	18.2	31.2	37.1
B	mg/l	0.21	0.21	0.17	0.15	0.17	0.19	0.22
K	mg/l	467.60	21.10	49.10	31.30	103.80	26.00	23.70
Cu	mg/l	0.15	0.08	0.15	0.14	0.06	0.16	0.10
Mg	mg/l	233.80	15.70	84.00	41.40	11.40	37.50	63.00
Mn	mg/l	3.85	0.10	0.74	0.20	0.09	0.14	0.45
Ca	mg/l	230.30	52.50	131.30	97.10	22.50	145.80	149.70
Zn	mg/l	0.30	0.08	0.15	0.11	<0.06	0.45	0.15
Na	mg/l	216.00	153.00	332.10	153.80	80.40	200.60	201.80
Fe	mg/l	5.76	0.81	1.84	1.29	0.37	1.05	1.41
K:Mg		2.0	1.3	0.6	0.8	9.1	0.7	0.4
K:Ca		2.0	0.4	0.4	0.3	4.6	0.2	0.2
Ca:Mg		1.0	3.3	1.6	2.3	2.0	3.9	2.4

* Untreated control.