Project title:	Developing Nutrient Management Recommendations for Selected Horticulture Crops
Project number:	HNS 200
Project leader:	Dr Jill England, RSK ADAS
Report:	Annual report, March 2020
Previous report:	First report
Key staff:	Dr Jill England, RSK ADAS David Talbot, RSK ADAS Elysia Bartel, RSK ADAS Chloe Whiteside, RSK ADAS
Location of project:	Field trial: James Coles & Sons Nurseries, 624 Uppingham Rd, Leicester LE7 9QB Container trial: ADAS Boxworth, Battlegate Rd, Boxworth, Cambs CB23 4NN
Industry Representative:	James Moffatt, James Coles & Sons Nurseries
Date project commenced:	1 April 2019

DISCLAIMER

The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

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

Headline

- *Spiraea japonica* ‘Sparkling Champagne’, G*eranium* x *cantabrigiense* ‘Westray’ and *Tradescantia pallida* ‘Purple Sabre’ performance improved at a high feed rate (6 g/L CRF, 2% liquid feed).
- *Prunus lusitanica* ‘Myrtifolia’ performance improved at a low feed rate (2 g/L CRF, 0.5% liquid feed).
- Nitrate-N in run-off water exceeded the Nitrate Vulnerable Zone (NVZ) nitrogen limit in drinking water of 50 mg/L for *Prunus lusitanica* ‘Myrtifolia’ (4 g/L and 6 g/L CRF rates) and *Spiraea japonica* ‘Sparkling Champagne’ (6 g/L CRF rate).

Background

The majority of nursery stock growers currently use a base fertiliser with controlled release fertiliser (CRF), usually added by the growing media manufacturer, to provide sufficient nutrition for the production phase. There is increased interest in using lower CRF rates and supplementing with liquid feed to provide sufficient nutrition during key growth phases, to avoid excess fertiliser at other times and to reduce the potential for nutrient loss in run-off water. The combination of CRF and liquid feed can provide growers with greater control but still meet plant nutrient requirements. Crop safety can be improved by using a lower CRF rate for autumn potting under glass and topping up with liquid feed in the spring as appropriate. Growers could benefit from the associated nutrient cost savings, but with more control over growth, there is an opportunity to optimise productivity and improve quality, while reducing crop waste and minimising point source nutrient pollution from grower holdings.

Year 1 of this work programme focussed on obtaining separate baseline data for CRF and liquid feed uptake in nursery stock liners for a range of nursery stock subjects. Year 2 trials will be based on the data obtained in year 1, and will combine lower CRF rates with a range of liquid feeding regimes to develop ‘feed to need’ strategies. Year 3 trials will be based on the outcomes of year 2, and will be designed to confirm the reproducibility of the results.

This project is comprised of three work packages:

WP1. HNS (field and container) Literature review

WP2. Field tree production. To establish baseline information on nutrition for field-grown HNS trees by categorising the main plant families into vigour groups (e.g. Low; low – medium; medium - high), explore novel methods for applying fertilisers and determine the most suitable analyses (soil EC, tissue and/or leaf chlorophyll) to assess crop nutrient status (submitted as a separate report)

WP3. Container production. Optimisation of combined controlled release fertiliser (CRF) and liquid feed regimes for nursery stock liner production under protection

This is the report for WP3. **The reports for WP1 and WP2 are submitted separately.**

Summary

Two separate trials looked at the effect of CRF and liquid feed dose rate on plant growth and quality to find baseline data for four hardy nursery stock species: *Prunus lusitanica* 'Myrtifolia', *Spiraea japonica* 'Sparkling champagne', G*eranium* x *cantabrigiense* 'Westray' and *Tradescantia pallida* 'Purple Sabre'. Species selection was based on plant vigour, related to nutrient uptake, as more vigorous species require greater nutrient supply, and included both woody and herbaceous species. The trial was located in a polytunnel at ADAS Boxworth. Plug plants were transplanted into 9 cm liners (70% peat, 30% wood fibre, SinclairPro; base fertiliser 0.75 kg/m^3 PG mix 12-14-24) on 20 June 2019. The trials were irrigated by overhead irrigation with additional spot watering as required.

CRF trial treatments. CRF (Osmocote Exact Standard, 12–14 month), an industry standard formulation, was incorporated into the growing media at transplant at three dose rates (**Table 1**). Prills were dibbled into the centre of each pot beneath the plug and the pots were placed into trays with drainage holes, stacked directly above a trough to collect run-off; each tray formed a single plot.

Liquid feed trial treatments. Liquid feed treatments were applied weekly. Two proprietary, industry standard, feed formulations were applied: Peters Professional Plant Starter (ICL, 10:52:10 + TE) to promote root development for the first four weeks (week 26 to week 30), and Peters Professional Grow-Mix (ICL, 3:1:3 + 3 MgO + TE) to promote vegetative growth from week 31 to week 44 (**Table 1**). Each plot received 2 L of feed weekly between week 26 and week 43, reduced to 1 L per week in weeks 43 and 44 when the weather turned cooler; feed volume was linked to uptake, allowing the growing media to dry back between applications. The pots were placed into impermeable trays to ensure that all liquid feed and water applied was taken up by the crop (**Figure 9**).

Table 1. CRF and liquid feed treatment rates. Liquid feed Peters Professional 10:52:10 feed was applied for 4 weeks, followed by Peters Professional Grow-Mix 3:1:3 for the remainder of the trial.

Liquid feed trial			
Treatment	**Dose**	**Volume of stock solution / plot**	**Volume of water / plot**

T1	0.5%	10 ml	1.99 L
T2	1.0%	20 ml	1.98 L
T3	2.0%	40 ml	1.96 L
	CRF trial		
T1	2 g / L		
T2	4 g / L		
T3	6 g / L		

Growing media electrical conductivity (EC) and leaf chlorophyll (using a SPAD meter) were measured weekly. Growing media and leaf tissue samples were submitted for laboratory analysis at the start of the trial, in November 2019 (final assessment) and in January 2020. Plant height, plant quality and root quality were assessed at the interim (September 2019) and final assessments (November 2019). Fresh and dry weights and the run-off water from the CRF trial were measured at the final assessment.

Although the *Spiraea, Geranium* and *Tradescantia* did appear to benefit from the high CRF rate through increased plant height, this may not be the optimum rate and further examination will clarify the effect of reduced nutrient application. The run-off analysis indicated that there may be an opportunity to reduce nutrient rates without impacting on plant quality, and this would also reduce potential leaching of nitrogen and phosphate into the groundwater.

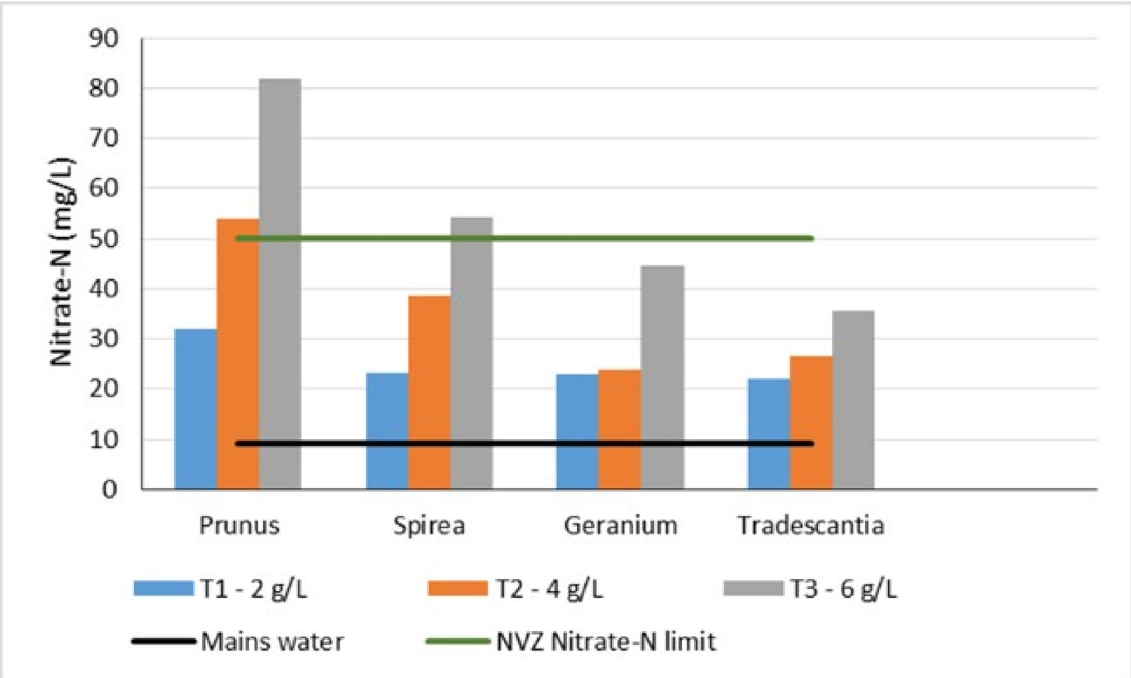

Figure 1. Nitrate-N quantity in run-off water. 14 November 2019. Black horizontal line: nitrate level in the mains water at ADAS Boxworth. Green horizontal line: NVZ drinking water nitrate-N limit (50 mg/L)

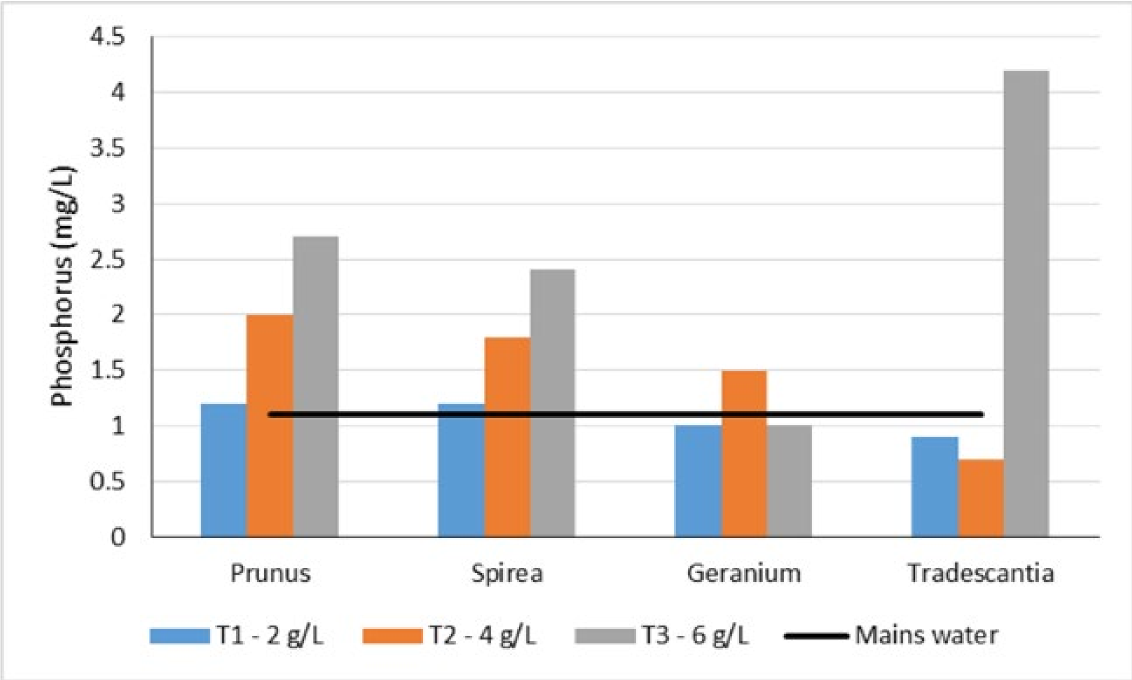

Figure 2. Phosphorus (P) quantity in run-off water. 14 November 2019. Black horizontal line: nitrate level in the mains water at ADAS Boxworth.

Prunus lusitanica is generally considered to be a vigorous species, but in this trial it produced greater growth and acceptable plant quality at the lowest feed rates (2 g/L CRF and 2% liquid feed rates), with increased nitrate in the run-off at the higher dose rates in the CRF trial (**Figure 1**).

Nitrogen (N) and phosphorus (P) levels in the run-off water were generally greatest in the *Prunus*, however the *Tradescantia* appears to have limited P uptake at the 6 g/L rate with high levels in the run-off (4.2 mg/L) compared with the *Prunus* (2.7 mg/L), *Spiraea* (2.4 Mg/L) and *Geranium* (1.0 mg/L) (**Figure 2**). In this trial the *Tradescantia* did not appear to need the amount of P provided in the CRF, as there were low levels in the leaf tissue and high levels in the substrate and in the run-off water, at the high CRF rate. It is worth noting that not all of the P would usually be released by the CRF, and some would become unavailable over time due to forming complexes with calcium, for example. Although the *Tradescantia* performed better at the higher feed rates in both trials, in the liquid feed trial this did not translate into improved plant quality; leaf tissue N levels were low, and this suggests that the liquid feed rate may have provided insufficient nutrients.

Growing media EC was higher in the liquid feed (LF) trial than the CRF trial. For example, in week 34, the EC for *Prunus* was 445 µS/cm in the LF trial, and 157 µS/cm in the CRF trial. This may be because the plants being liquid fed were in non-draining trays that prevented salts from being washed through the growing media, while the CRF trial was set-up in a system designed to allow water and nutrients to drain through for collection of the run-off water for analysis.

The weekly substrate EC measurements were a useful tool to indicate the nutrient status of the growing media and leaf tissue, with – clear differences were seen due to plant response to treatments. EC was generally higher in the higher feed treatments (**Figure 3** and **Figure 4**). For *Tradescantia,* the EC readings reflect that this is a vigorous crop, with few nutrients available in the substrate in the liquid feed trial. Substrate moisture level affects EC measurements, with lower readings in drier substrate. Readings were taken at the same time of day on each occasion, before irrigation was applied to standardise the procedure. However, weather conditions have an impact on EC readings; in this trial, dips in EC coincided with particularly hot weather conditions in week 32, which caused drier growing media moisture.

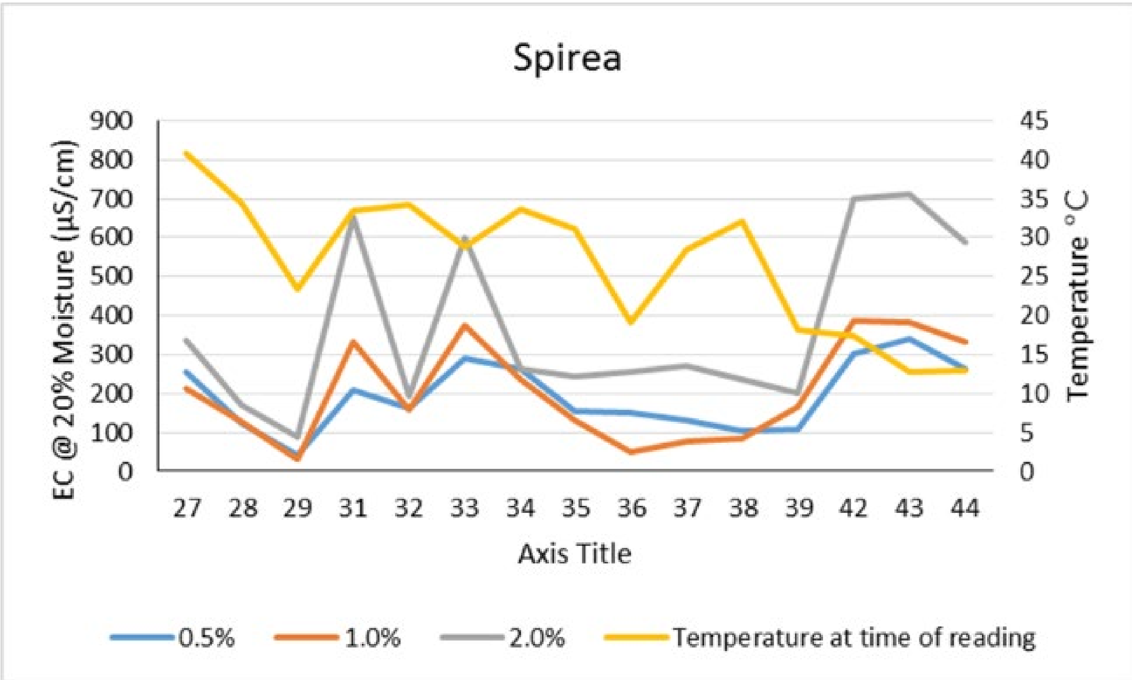

Figure 3. Liquid feed trial. *Spiraea japonica* ‘Sparkling Champagne’ ‘Purple Sabre’ (right). Electrical conductivity (EC) adjusted to 20% moisture content

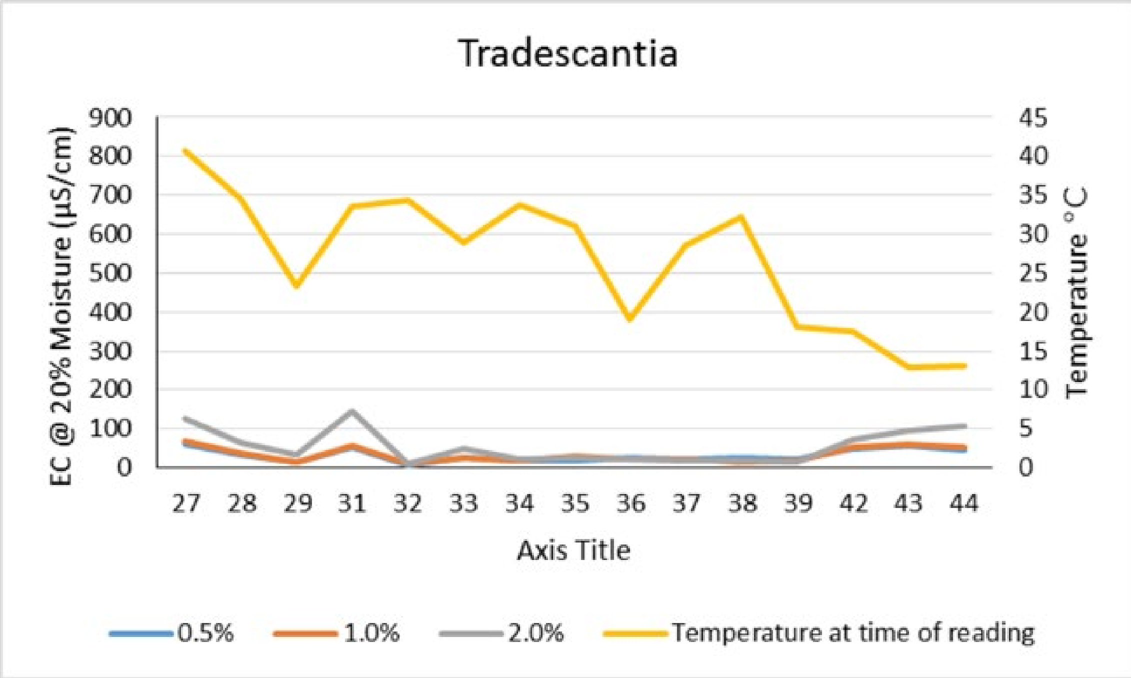

Figure 4. Liquid feed trial. *Tradescantia pallida* 'Purple Sabre' (right). Electrical conductivity (EC) adjusted to 20% moisture content

Leaf chlorophyll (SPAD) readings were similar across all treatments for all species, except for the *Prunus* in this trial, which may be an indication that the treatments were not sufficiently different to affect leaf chlorophyll for the majority of subjects in this trial. Leaf chlorophyll appeared to be within specific ranges for each plant. For example, they were around 30 to 40 for *Spirea* (**Figure 5**), but 35 to 50 for *Tradescantia,* and these findings were common across the LF and CRF trials (**Figure 6**).

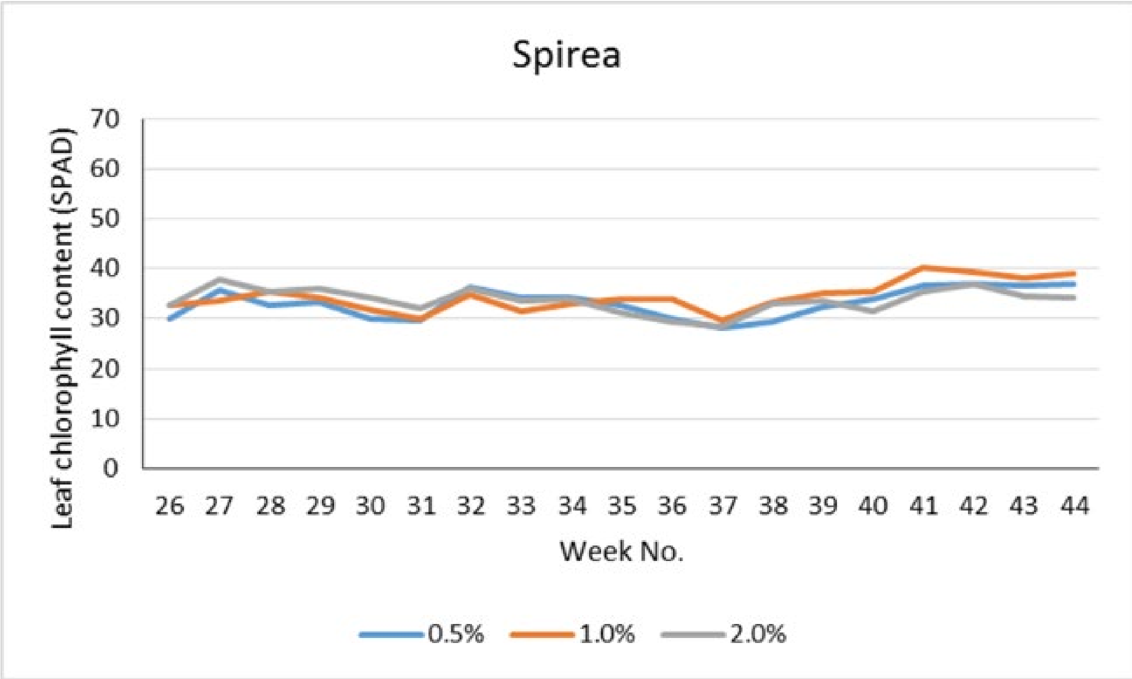

Figure 5. Liquid feed trial. *Spiraea japonica* ‘Sparkling Champagne’. Leaf chlorophyll content

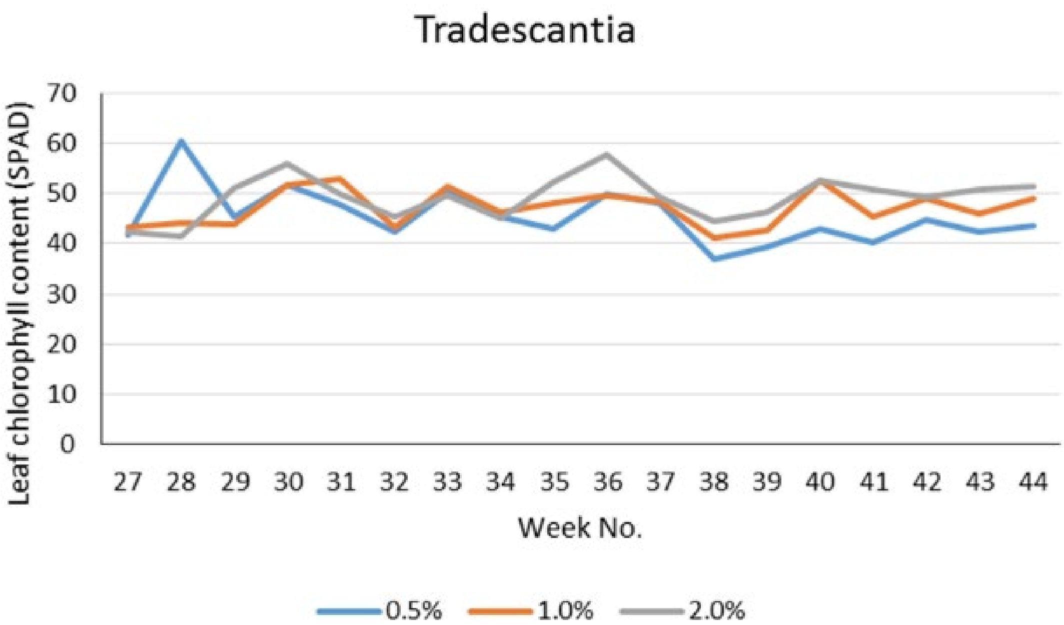

Figure 6. Liquid feed trial. *Tradescantia pallida* ‘Purple Sabre’. Leaf chlorophyll content

Conclusions

A number of tissue N and P measurements obtained within these trials were outside the published standard ranges (**Mills and Jones, 1996**) with no visible deficiency symptoms.

These results show that plant vigour is important; for some species, good quality plants can be grown at low CRF rates, but for others high feed rates are needed to produce marketable crops. *Prunus lusitanica* is generally considered to be a vigorous plant, but in this trial performed better at the lowest dose feeds, with nitrates in the run-off water above the NVZ limit at higher dose rates. The *Spiraea, Geranium* and *Tradescantia* all performed better at the higher dose rates. However, detailed monitoring and analysis revealed different plant requirements for specific plant nutrients, i.e. *Tradescantia* performed better overall at the high feed rates, but appears to need lower levels of P. Greater understanding of plant vigour enables plants to be arranged within vigour groups so that fertilisers can be applied according to plant need, helping growers with better management of input costs and nutrient run-off.

Financial Benefits

Routine monitoring will identify low nutrient levels and allow corrective action to be taken before deficiency symptoms appear. A nutrient management regime could include regular on-site monitoring of EC and perhaps leaf chlorophyll, with laboratory irrigation water, substrate and leaf tissue analysis as appropriate.

While there are costs associated with purchasing monitoring equipment and submitting samples for laboratory analysis, there are some lower cost options, and these costs can be offset through reduced crop losses due nutrition problems. Regular on-site substrate EC measurements in this trial were carried out using a Terros 12 sensor with a ProCheck hand held reader (**Table 2**). Leaf chlorophyll was measured using a SPAD, but the AtLEAF is a useful less expensive alternative that was tested in AHDB project HNS 193 (**Adlam, 2016**).

An example of the cost of laboratory analysis monitoring regime for irrigation water, substrate and leaf tissue samples on a medium sized, single site HNS nursery, extracted from Bragg and Holmes (**2016**), is presented in **Table 3**.

Crop losses due to nutrition problems can approach 1% - 3% of the value of the crop. While crop value will vary depending on the species and market, assuming a farm gate value of 80p per plant for 9 cm liners, an estimated 750,000 plants per hectare, this equates to between £6,000 and £18,000 per hectare per annum.

Table 2. Crop monitoring equipment example costs. The AtLeaf sensor was not used in this trial, but is included as an example. *Costs derived from 2019 quotations.

Device	Purpose	Cost (+VAT)
Decagon ProCheck *	Handheld reader for Terros 12 sensor	£425
Terros 12*	Substrate EC and moisture sensor	£200
Minolta SPAD 502 Plus	Chlorophyll sensor	£2,680
AtLEAF Standard version*		£268
AtLEAF Standard version plus USB connection*		£339
AtLEAF Standard version plus Bluetooth connection*		£372

Table 3. Analysis costs: growing media, water (including run-off), liquid feed and plant tissue, based on a medium sized, single site nursery. Extracted from Bragg and Holmes (**2016**).

Analysis	No of analyses	Cost	Comments
Water	4 analyses per year	£100 - £150	Includes irrigation and run-off water.
Growing media	18 analyses over 18 months	£360	Analysis of three substrate batches or crops; four samples per batch analysed per year.
Leaf tissue	12 analyses over 18 months	£360	Three indicator crops in three substrate mixes, four samples per crop over 18 months.
Total		£820 - £870	

Action Points

- Improve understanding of crop vigour and nutrient requirements through planned monitoring and recording of growing media EC and pH, run-off water and submission of samples for laboratory analysis.
- Build up an on-nursery database of tissue, growing media and irrigation water analyses over seasons, including samples from plants with potential nutrient problems and healthy plants, determining critical thresholds where possible.
- Group plants according to vigour groups, matching nutrient application to vigour group needs.

SCIENCE SECTION

Introduction

The majority of nursery stock growers currently use a base fertiliser with controlled release fertiliser (CRF), usually added by the growing media manufacturer, to provide sufficient nutrition for the production phase. There is increased interest in using lower CRF rates and supplementing with liquid feed to provide sufficient nutrition during key growth phases, but not providing excess fertiliser at other times and increasing the potential for nutrient loss in run-off water, resulting in point source pollution.

Background

The combination of CRF and liquid feed provides growers with the greater control through reduced CRF application and with application of specific liquid or foliar feed formulations to meet plant requirements. Crop safety is improved by using a lower CRF rate for autumn potting under glass and topping up with liquid feed in the spring as appropriate. Growers will benefit from the associated nutrient cost savings, but with more control over growth there is an opportunity to optimise productivity and improve quality, while reducing plant waste and minimising point source nutrient loss from grower holdings.

A recent review of nutrient management in container grown nursery stock (**Pennell et al. 2013**) raised potential environmental and quality issues concerning total reliance on CRF. Firstly, temperature extremes due to changing weather patterns can give rise to nutrient release when plants are unable to utilise it, particularly in plants grown under protection, with autumn potted plants under glass being particularly at risk and this increases the potential for nutrient leaching or plant damage due to the build-up of nutrients in the substrate. In addition to this, increasing attention is being given to environmental pollution and the prevention of the excessive loss of nutrients, particularly nitrates and phosphates into the ground water. High fertiliser rates may contravene regulations such as Nitrate Vulnerable Zones (NVZ), potential Phosphate Vulnerable Zones and drinking water legislation. In future, growers could fall foul of any regulations that are brought in and be subject to regulatory penalties.

Whilst previous work has been carried out that investigated the use of CRFs under protection (**Scott et al., 1993**), formulations and coatings have since been further developed by the manufacturers. Early work to evaluate the use of computer simulation models generally gave good predictions but were not adopted for use in commercial practice to allow for leaching of nutrients (**Scott, 1996**). Recent work has contributed methodologies for sampling and analysis interpretation by growers (**Bragg and Holmes, 2016**) and data on nutrient leaching (**Adlam, 2016**). This study also included a comparative study of optical sensing equipment for monitoring nutrient status (e.g. SPAD readings, AtLeaf and FieldScout GreenIndex Iphone app) and EC probes (e.g. ProCheck).

Independent laboratory analysis is underway to characterise nutrient release patterns of base fertilisers and CRFs, using the EN13266 method (**Terlingen et al., 2016**), which measures nutrient release over time at a set temperature. The analysis is being carried out on a range of products and formulations (coating and longevity) currently marketed by a number of manufacturers (Personal communication, Neil Bragg). CRFs are sensitive to both substrate moisture and temperature; although excess water does not influence nutrient release, it is positively correlated with substrate temperature and therefore sensitive to prevailing environmental conditions. For non-urea containing CRFs, nutrient release in the field can be determined effectively (and non-destructively) by measurement of electrical conductivity (EC) using the ‘pour through’ method (**Hojjatie and Carney, 2014**).

There are currently no independent guidelines on the most appropriate CRF (formulation and rate) / liquid feed rates (individually or in combination) or application timings, to optimise crop quality and reduce production time. Plant nutrient suppliers provide detailed guidance on the use of their products, with application rates categorised by plant groups based on low, medium and high nutrient uptake rates.

This trial programme will provide guidance on upper and lower limits of CRF incorporation and liquid feed management, and the practice of reducing CRF rates, which can then be topped up by liquid feeding as required to maintain plant growth and quality. Combining leaf tissue and growing media analysis with weekly growing media electrical conductivity (EC) measurements will develop a practical methodology whereby growers can have confidence in using lower rates of CRF and liquid feed, with applications made in response to plant need. The trials will be carried out during the summer and autumn, when the CRFs will release more nutrients in the higher temperatures, and the plants are in growth.

Year 1 of this work programme will focus on obtaining separate baseline data for CRF and liquid feed uptake in nursery stock liners for a range of nursery stock subjects. Year 2 trials will be based on the data obtained in year 1, and will combine lower CRF rates with a range of liquid feeding regimes to develop ‘feed to need’ strategies. Year 3 trials will be based on the outcomes of year 2, and will be designed to confirm the reproducibility of the data.

This project is comprised of three work packages:

WP1. HNS (field and container) Literature review

WP2. Field tree production. To establish baseline information on nutrition for field-grown HNS trees by categorising the main plant families into vigour groups (e.g. Low; low – medium;

medium - high), explore novel methods for applying fertilisers and determine the most suitable analyses (soil EC, tissue and/or leaf chlorophyll) to assess crop nutrient status (submitted as a separate report)

WP3. Container production. Optimisation of combined controlled release fertiliser (CRF) and liquid feed regimes for nursery stock liner production under protection

This is the report for WP3. **The reports for WP1 and WP2 are submitted separately.**

WP3. Optimisation of combined controlled release fertiliser (CRF) and liquid feed regimes for nursery stock liner production under protection

Aim

To develop a 'feed to need' methodology with baseline combined low rate CRF and liquid feed recommendations for application to nursery stock liners under protection

Objectives

Objective 1: To measure plant growth and quality of four nursery stock subjects (liners), supplied with standard 12-14 month CRF formulation applied at 3 dose rates.

Objective 2: To measure plant growth and quality of four nursery stock subjects (liners), supplied with industry standard liquid feeds at three dose rates.

Materials and methods

This study was conducted as two separate trials examining the effect of CRF and liquid feed dose rate on plant growth and quality to determine baseline data for four commercially produced hardy nursery stock species (**Table 4**). Plant species selection was based on plant vigour, as related to nutrient uptake, as more vigorous species require greater nutrient supply, and included both woody and herbaceous species. The trial was located within a polytunnel at ADAS Boxworth. Plug plants were transplanted into 9 cm liners (70% peat, 30% wood fibre, SinclairPro; base fertiliser 0.75 kg/m^3 PG mix 12-14-24) on 20 June 2019. The trials were irrigated by overhead irrigation with additional spot watering as required.

Table 4. Hardy nursery stock species

Species number	Species	Vigour	Term
S1	*Prunus lusitanica* 'Myrtifolia'	vigorous	long
S2	*Spiraea japonica* 'Sparkling champagne'	moderate	long
S3	*Geranium x cantabrigiense* 'Westray'	moderate	short
S4	*Tradescantia pallida* 'Purple Sabre'	vigorous	short

Experimental Treatments

Controlled release fertiliser (CRF)

CRF (Osmocote Exact Standard, 12–14 month), an industry standard formulation, was incorporated into the growing media at transplant. A standard CRF formulation was applied at three dose rates (**Table 5**). Prills were dibbled into the centre of each pot beneath the plug during transplant (**Figure 7**); the pots in the CRF trial were placed into trays with drainage holes, stacked directly above a 30.5 cm deep trough to collect run-off water with each tray forming a single plot (**Figure 8**).

Figure 7. CRF prills weighed and dibbled into 9 cm pots immediately prior to transplant.

Liquid feed

Liquid feed treatments were applied weekly, at the same time each week; after the EC and SPAD measurements but prior to irrigation to prevent leaf scorch. The two feed formulations were Peters Professional Plant Starter (ICL, 10:52:10 + TE), to promote root development, which was applied for the first four weeks (from week 26 to week 30), followed by Peters Professional Grow-Mix (ICL, 3:1:3 +3MgO + TE), to promote vegetative growth, from week 31 to week 44. Liquid feed treatments were categorised by dosage (**Table 5**). A 10 L stock solution was prepared and shaken before decanting into 10 L watering cans half filled with the appropriate volume of water to ensure adequate mixing. Treatments were measured with clean, calibrated equipment and applied with a separate watering can for each treatment to prevent treatment contamination. Each plot received two litres of feed weekly between week 26 and week 43, reduced to 1 L per week in weeks 43 and 44 when the weather turned cooler; feed volume was linked to uptake, allowing the growing media to dry back between applications. The pots were placed into impermeable trays to ensure that all liquid feed and water applied was taken up by the crop (**Figure 9**); each tray contained fifteen 9 cm pots and formed a single plot.

Table 5. CRF and liquid feed treatment rates. Liquid feed Peters Professional 10:52:10 feed was applied for 4 weeks, followed by Peters Professional Grow-Mix 3:1:3 for the remainder of the trial.

Treatment	Dose	Volume of stock solution / plot	Volume of water / plot
Liquid feed trial			
T1	0.5%	10 ml	1.99 L
T2	1.0%	20 ml	1.98 L
T3	2.0%	40 ml	1.96 L
CRF trial			
T1	2 g / L		
T2	4 g / L		
T3	6 g / L		

Study design

Treatments were arranged in a randomised block design with three dose rates, four species and four replications for both the CRF and liquid feed trial. There were 48 plots per trial, with 15 x 9 cm pots, arranged in a 5 x 3 pot formation; 720 plants per trial.

Figure 8. CRF feed rate trial layout. Plots are in individual tubs draining into troughs to collect run-off water

Figure 9. Liquid feed rate trial layout. Plots are in individual impermeable trays to ensure that all liquid feed applied is taken up by the plants.

Table 6. Summary of trial inspections and assessments, 2019

Date	Week No.	Action	Assessment
20.06.19	25	Trial set-up	
27.06.19	26	Weekly assessment	EC, leaf chlorophyll
04.07.19	27	Weekly assessment	EC, leaf chlorophyll
11.07.19	28	Weekly assessment	EC, leaf chlorophyll
18.07.19	29	Weekly assessment	EC, leaf chlorophyll
26.07.19	30	Weekly assessment	Leaf chlorophyll
01.08.19	31	Weekly assessment	Leaf chlorophyll
02.08.19	31	Weekly assessment	EC
09.08.19	32	Weekly assessment	EC, leaf chlorophyll
15.08.19	33	Weekly assessment	EC, leaf chlorophyll
22.08.19	34	Weekly assessment	EC, leaf chlorophyll
30.08.19	35	Weekly assessment	EC, leaf chlorophyll
06.09.19	36	Weekly assessment	EC, leaf chlorophyll
13.09.19	37	Weekly assessment	EC, leaf chlorophyll
19.09.19	38	Interim & weekly assessment	Plant height, quality, root quality, EC, leaf chlorophyll
27.09.19	39	Weekly assessment	EC, leaf chlorophyll
03.10.19	40	Weekly assessment	Leaf chlorophyll

10.10.19	41	Weekly assessment	EC, leaf chlorophyll
18.10.19	42	Weekly assessment	EC, leaf chlorophyll
24.10.19	43	Weekly assessment	EC, leaf chlorophyll
31.10.19	44	Weekly assessment	EC, leaf chlorophyll
08.11.19	45	Final assessment	Plant height, quality, root quality, fresh and dry weight. Growing media and foliar analysis. Run-off water analysis for CRF trial

Assessments

Assessments were carried out at three stages: pre-potting (20 June), mid-season (Liquid feed trial 19 September and CRF trial 27 September) and at the end of the trial (CRF trial 7 November and Liquid feed trial 8 November). Additional measurements were taken weekly, on either a Thursday or a Friday before liquid feed was applied and before irrigation events.

In June, 20 plants per species were sampled for height and quality assessment since the plug plants were relatively uniform and treatments had not yet been applied. In September and November the same five plants were assessed in each plot, in a V formation to best represent the spread of the plot, for plant quality, root quality and plant height. These same plants were assessed for fresh and dry weight in November. Other assessments were taken randomly from the remaining plants in the plot, excluding the plants assessed for quality and height.

Plant Specific Assessments

Plant Quality

Plant quality was assessed for each plot in September and November 2019. The same plants were subsequently assessed on both dates. Plants were given a score from a linear scale of 0 - 5 according to the criteria in **Table 7**. Representative specimens from the September assessment are shown in **Figure 10 – Figure 13** and representative specimens from the November assessment are shown in **Figure 14 - Figure 17.**

Table 7. Plant quality scoring guidelines

0	dead
1	very poor quality
2	poor quality
3	good quality, some damage visible
4	very good quality, very little damage
5	excellent quality, no damage visible

Figure 10. *Prunus* plant quality representative, September assessment. Plants scored 2 – 5, from left to right

1) **2)** **3)** **4)** **5)**

Figure 11 *Spiraea* plant quality representative plants, September assessment. Plants scored 1 – 5 as labelled

Figure 12. *Geranium* plant quality representative plants, September assessment. Plants scored 2 – 5 left to right

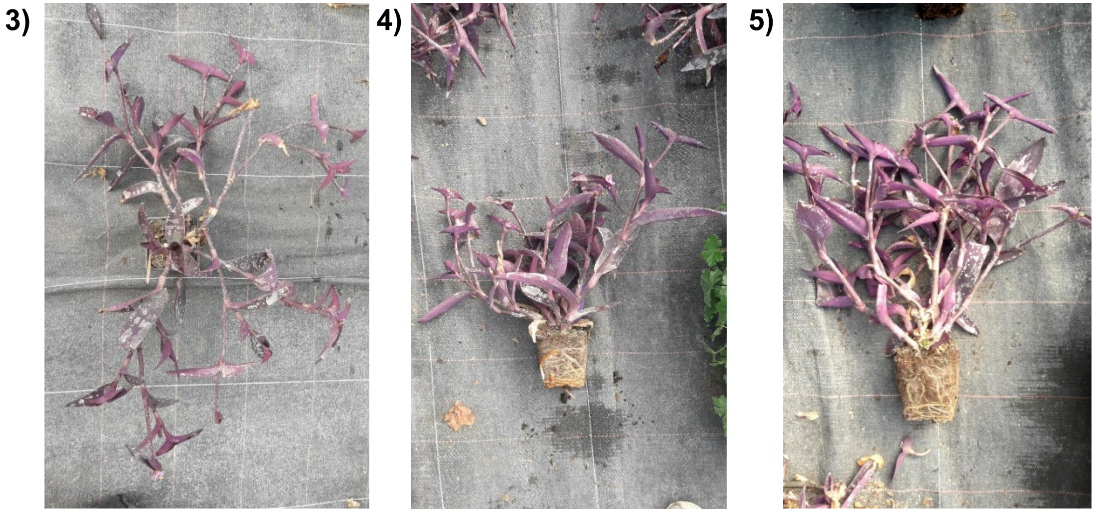

Figure 13. *Tradescantia* plant quality representative plants, September assessment. Plants scored 3 – 5 as labelled

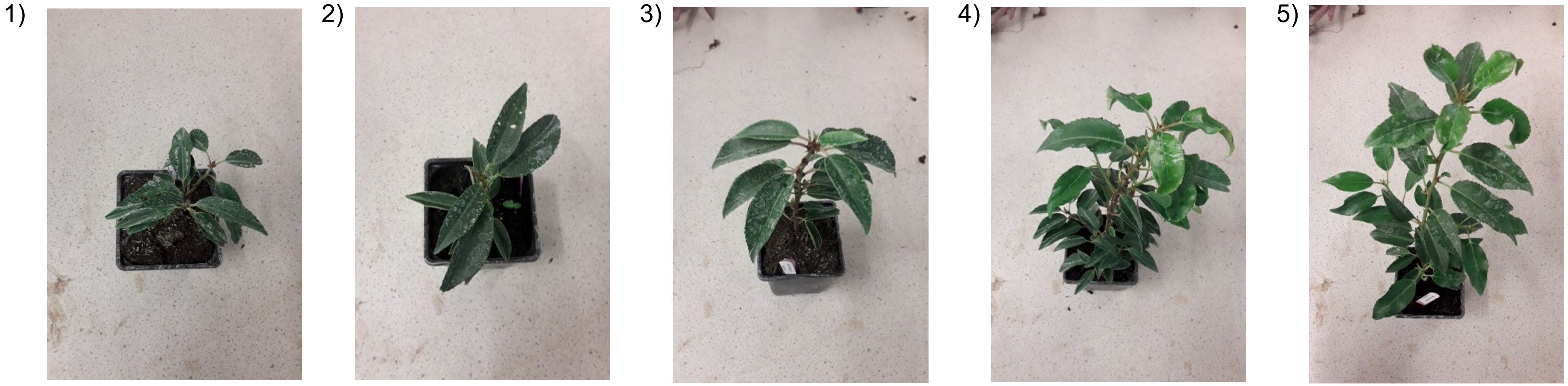

Figure 14. *Prunus* plant quality representative plants, November assessment. Scored 1 – 5, as labelled

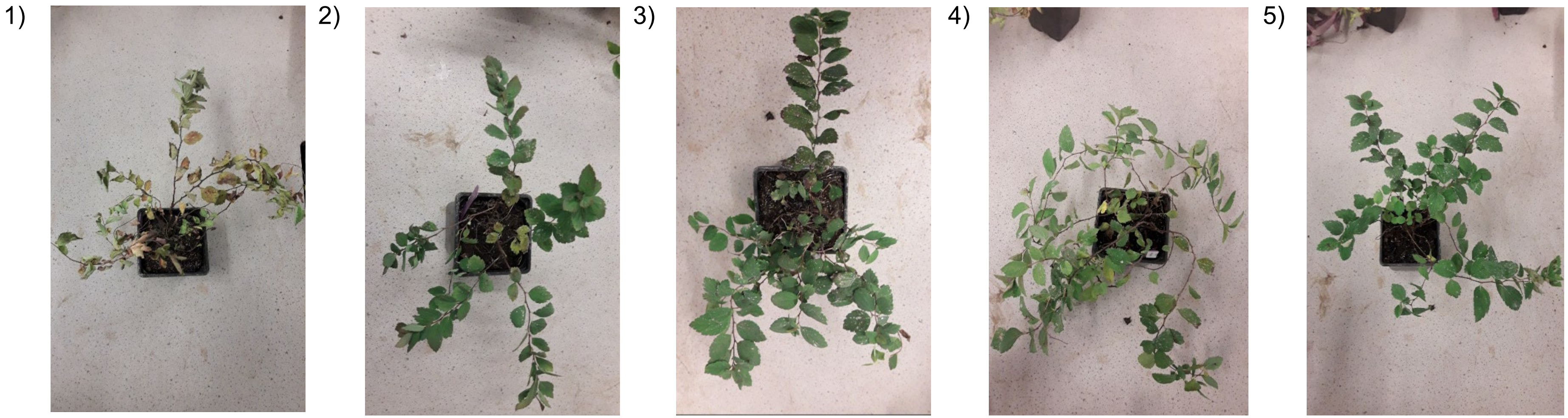

Figure 15. *Spiraea* plant quality representative plants, November assessment. Scored 1 – 5, as labelled

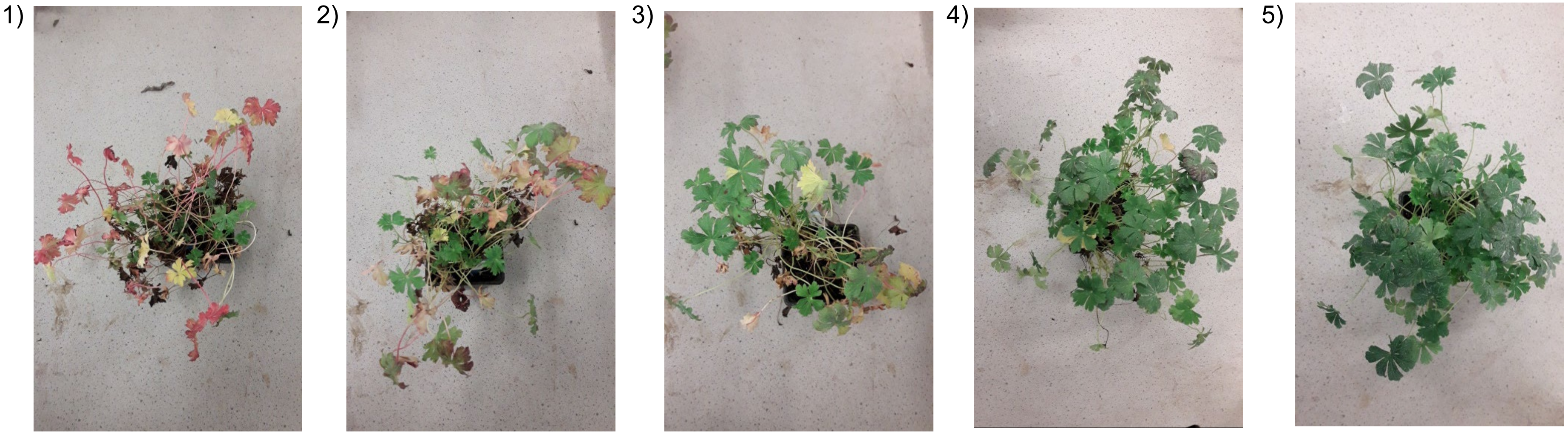

Figure 16. *Geranium* plant quality representative plants, November assessment. Scored 1 – 5, as labelled

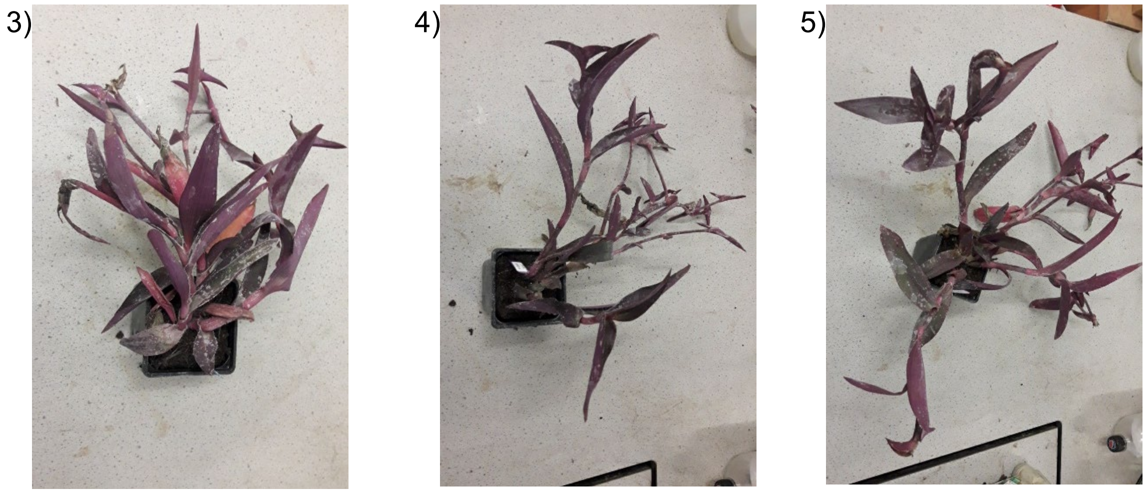

Figure 17. Tradescantia plant quality representative plants, November assessment. Scored 3 – 5, as labelled

Root Quality

Root quality was assessed for each plot in September and November 2019. The same plants which had been assessed for plant quality were assessed for root quality. Root quality was scored on a linear scale of (0 – 4) according to a visual assessment of percentage rooting in the pot (**Table 8**). Representative specimens can be seen in **Figure 18 - Figure 21**.

Table 8. Root quality scores

0	no root development
1	rooting in up to 25% of pot
2	rooting in 26 – 50% of pot
3	rooting in 51 – 75% of pot
4	rooting in 76 – 100% of pot

1) 2) 3) 4)

Figure 18. *Prunus* representative plants with root scores 1 – 4, as labelled

2) 3) 4)

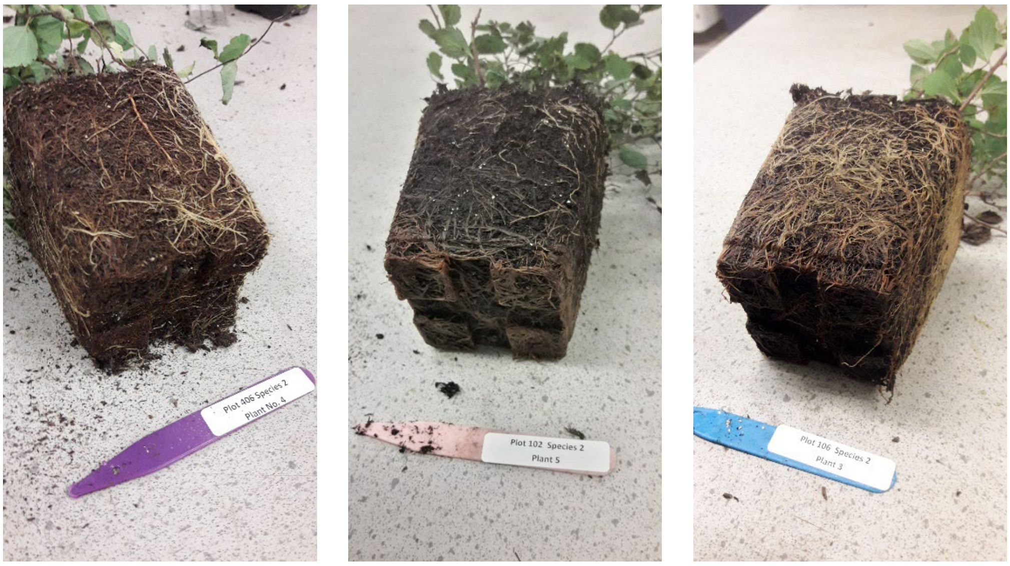

Figure 19. *Spiraea* representative plants with root scores 2 – 4, as labelled (no plants scored ‘1’)

1) 2) 3) 4)

Figure 20. *Geranium* representative plants with root scores 1 – 4, as labelled

1) 2) 3) 4)

Figure 21. *Tradescantia* representative plants with root scores 1 – 4, as labelled

Plant height

Plant height was measured for each plot in September and November 2019. Plants were measured to the tip of the growing point in each species, except for *Geranium*, which was measured to the tallest leaf.

Fresh and dry weight

Fresh and dry weight measurements were collected at the end of the trial (November 2019) from the same plants that had been monitored for plant height, quality and root condition. Plants were cut at the stem base and fresh weight was recorded. Dry weight was recorded after plants were dried in an oven at 80°C for 96 hrs.

Random samples

Plant tissue analysis

The remaining plants, which weren't monitored for quality, height or weight, were randomly sampled for plant tissue at the end of the trial in November. The newest, mature and fully expanded leaves were sampled for tissue analysis. Replicate plots were combined for each species and feed rate in sealed, labelled bags, which were cold-stored until they could be collected by NRM laboratories. A further tissue analysis for *Prunus* was completed on 21 January to assess the change in nutrient content over winter.

Growing media analysis

At the end of the trial, after 14 November 2019, plants had been removed for all other assessments; the root balls were broken up and the growing media removed from as close to the centre of the pot as possible. Replicate plots were aggregated by species and feed rate into sealed, labelled bags and stored in a cold-store prior to collection by NRM laboratories. Growing media from the CRF trial was analysed both with the remaining CRF prills ground and unground, in order to account for the nutritional value remaining in the prills. A further growing media analysis for the CRF and liquid feed trials was completed on 21 January 2020 to assess the change in nutrient content over winter.

<u>Water analysis</u>

Site mains water was analysed (NRM) prior to the start of the trial (10 May) in order to account for the nutritional content of the irrigation water and for comparison to the run-off water which was collected at the end of the trial from the troughs under the CRF plots on 11 November.

Weekly assessments

Weekly assessments were carried out between 27 June and 31 October on the plants which were not subject to quality, height and weight assessments to avoid causing any damage which could affect these results.

- EC and moisture content (4 June onwards) were recorded using a Terros 12 sensor and Decagon ProCheck reader prior to application of liquid feed or irrigation. The Terros 12 sensor developed faults on two occasions (26 July and 3 October) and was replaced. Assessments resumed in week 31, and then week 42 (**Table 6**).
- Leaf greenness was measured using a Soil Plant Analysis Development (SPAD) device. Readings were taken from the newest, mature and fully open leaves. SPAD reading were unsuccessful for the *Tradescantia* at week 26 assessment.
- Any weeds present in the pots were identified and removed from the trial.

Figure 22. Taking leaf chlorophyll readings during weekly assessments using a SPAD device

Temperature and humidity records

Temperature and humidity was recorded using two Tinytag data loggers, one suspended over each trial area.

Pest and disease management

Plants were monitored for pests and diseases throughout the trial. Both the CRF and liquid feed trials were treated with applications of plant protection products on three dates, and there were regular releases of macrobiologicals to protect the trial plants.

Powdery mildew:

- bupirimate (as Nimrod, 0.5 L/ha) was applied on 19 July; a repeat application (1.0 L/ha) was made on 31 July.
- boscalid + pyraclostrobin (as Signum, 1.35 L/ha) was applied on 8 November.

Aphids.

- *Aphidius colmani* was released weekly after *Aphis gossypii* was identified in the crop.
- thiacloprid (as Calypso, 0.45 L/ha) was applied on 8 November

Two-spotted spider mite.

- *Amblyseius andersoni* was released as a preventative control for two-spotted spider mite on 26 July.
- Once spider mite was identified in the crop *Phytoseiulus persimilis* was released every two weeks from 31 July.

Statistical analysis

Two-way ANOVA (Genstat edition 18.2) was used to analyse data. Plant quality and root quality were scored on a non-parametric scale, however analysis of variance was deemed appropriate by ADAS statistician Chris Dyer, since the scale was linear.

Results

The results for the CRF and liquid feed trials are presented separately; they were managed as two separate trials with different methodologies and the results are not directly comparable. For the CRF trial, the plots were comprised of high-sided trays with drainage holes with a sump below to collect run-off, each containing 15 plants (**Figure 8**). For the liquid feed trial, plants were placed in non-draining trays so any run-off water and nutrients were available for the plants to take up (**Figure 9**). Data for the interim and final assessments are presented separately for the CRF trial (**Table 9**) and the Liquid Feed trial (**Table 10**). Two assessments were carried out, the interim assessment on the 14 September 2019, and the final assessment on 8 November.

<u>CRF trial</u>

Plant height. At the interim assessment, the general trend was for plant height to increase with dose rate; the exception was the *Prunus*, where greatest growth was achieved at the low dose rate (2 g/L) (**Table 9, Figure 23**). Plant height was markedly greater at the high dose rate (6 g/L, p=0.054) than both of the lower dose rates (4 g/L and 2 g/L) for *Spiraea* (but not for *Prunus*, *Geranium* or *Tradescantia*). By the final assessment, there was no clear trend between plant height and dose rate across the species. However, for *Spiraea,* plant height was significantly greater at the high dose rate (6.0 g/L) than the lower dose rates (p=0.013).

Plant quality. There was no clear trend between plant quality and dose rate across the species. At the interim assessment, plant quality was significantly greater at the high dose rate (6 g/L, p=0.320) than the lower dose rates for the *Spiraea*, but there were no significant differences in plant quality for the other species. By the final assessment plant quality was not significantly different for any species (**Table 10, Figure 24**).

Root quality. There was no clear trend between root quality and dose rate across the species, and there were no significant differences in root quality for any species either at the interim or final assessment. See below for further comments relating to *Spirea* root quality.

Fresh weight. Fresh weight, assessed at the end of the trial, increased with dose rate for all species. However, there were no significant differences due to dose rate for any species.

Dry weight. Dry weight, assessed at the end of the trial, increased with dose rate for all species except for *Tradescantia*, where the highest dry weight was achieved at the 4 g/L dose rate (**Table 10, Figure 25**). However, there were no significant differences due to dose rate for any species.

<u>Liquid feed trial</u>

Plant height. Similar to the CRF trial, the general trend at the interim assessment was for plant height to increase with dose rate with the exception of *Prunus*, where greatest growth was achieved at the low dose rate (0.5%) (**Table 9, Figure 26**). By the final assessment the trends in plant height were less clear, although the *Prunus* still achieved the greatest plant height at the low dose rate, and the *Spiraea* and *Tradescantia* at the high dose rate (2.0%); for the *Geranium*, the greatest height was achieved at the 1.0% rate. There were no significant differences due to dose rate for any species at either assessment.

Plant quality. There were no clear trends in plant quality at the interim assessment, except that plant quality scores for *Prunus* were lower at the high dose rate (2.0%) (**Table 9, Figure 27**). The *Spiraea* and *Geranium* achieved significantly greater plant quality scores in the 1.0% dose rate (p=0.034), and the *Tradescantia* at the 2.0% dose rate (p=0.032). By the final assessment, plant quality was significantly greater at the high dose rate (2.0%) for *Spiraea* (p=0.027), and at the 1.0% and 2.0% dose rates for the *Geranium* (p=0.027).

Root quality. Significantly greater root quality was achieved by the *Prunus* at the 1.0% and 2.0% dose rates (p=0.007), and by the *Geranium* at the 0.5% and 1.0% rates (p=0.007) at the interim assessment. However, there were no significant differences due to dose rate for any species at the final assessment. See below for further comments relating to *Spirea* root quality.

Fresh weight. Fresh weight, assessed at the end of the trial, was greatest at the 1.0% dose rate for all species except for the *Prunus*. The *Prunus* achieved the greatest fresh weight at the 2.0% rate. There were no statistically significant differences due to dose rate for any species.

Dry weight. Dry weight, assessed at the end of the trial, was greatest at the 1.0% dose rate for all species except for the *Prunus* (**Table 9, Figure 28**). The *Prunus* achieved the greatest fresh weight at the 0.5% rate. There were no statistically significant differences due to dose rate for any species.

Table 9. CRF trial. Average plant height, plant quality, root quality, fresh weight and dry weight at the interim (19 September 2019, week 38) and final assessments (8 November 2019, week 44). ns = differences not significant. a and b Indices indicate significantly different data, comparing treatments within species. Plant quality score: scale 0-5: (0 = dead; 1 = very poor quality; 2 = poor quality; 3 = good quality, some damage visible; 4 = very good quality, very little damage; 5 = excellent quality, no damage visible). Root quality score: scale 0-4 (0 = no root development; 1 = rooting in up to 25% of pot; 2 = rooting in 26 – 50% of pot; 3 = rooting in 51 – 75% of pot; 4 = rooting in 76 – 100% of pot).

		Interim assessment			Final assessment				
Species	**Dose rate**	**Ave. plant height (cm)**	**Ave. plant quality**	**Ave. root quality**	**Ave. plant height (mm)**	**Ave. plant quality**	**Ave. root quality**	**Ave. fresh weight (g)**	**Ave. dry weight (g)**
Prunus lusitanica 'Myrtifolia'	2 g/L	17.0	4.6	2.2	19.4	3.8	1.8	13.2	5.2
	4 g/L	16.2	4.5	2.0	18.4	3.4	2.4	12.3	4.8
	6 g/L	16.5	4.3	2.5	19.8	3.8	1.8	14.2	5.0
Spiraea japonica 'Sparkling champagne'	2 g/L	24.0	4.3	3.9	26.0[b]	3.9	3.9	8.5	3.7
	4 g/L	24.1	4.1	3.7	29.9[b]	2.9	3.7	9.2	4.0
	6 g/L	33.2	4.3	3.8	35.8[a]	3.8	3.9	10.8	4.7
Geranium x *cantabrigiense* 'Westray'	2 g/L	15.5	3.6[b]	3.7	16.90	2.4	3.3	18.4	5.4
	4 g/L	17.1	4.0[b]	3.5	19.15	2.2	2.5	22.7	6.0
	6 g/L	17.7	4.6[a]	3.7	19.98	3.0	3.2	23.1	6.0
Tradescantia pallida 'Purple Sabre'	2 g/L	35.1	4.6	3.5	34.0	4.1	3.2	90.8	7.4
	4 g/L	36.5	4.7	3.6	35.8	4.1	3.1	94.0	8.0
	6 g/L	37.2	5.0	3.6	34.2	4.3	3.2	99.1	6.3
	s.e.d.	2.091	0.2408	0.1962	1.972	0.4050	0.3283	7.62	0.931
	l.s.d.	4.255	0.4899	0.3991	4.013	0.8240	0.6679	15.51	1.894
	F pr.	0.054	0.0320	0.859 ns	0.013	0.605 ns	0.111 ns	0.994 ns	0.569 ns

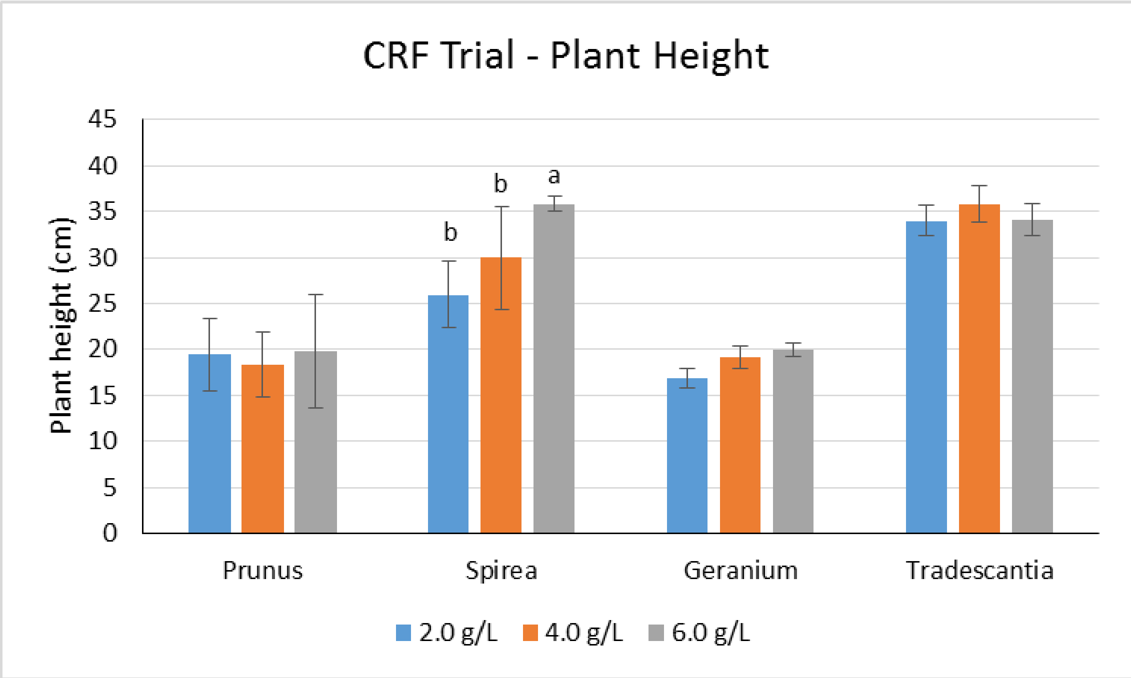

Figure 23. CRF trial. Average plant height at the final assessment (8 November 2019, week 44). Indices indicate significantly different data, comparing treatments within species. Statistically significant scores for the *Spiraea* only.

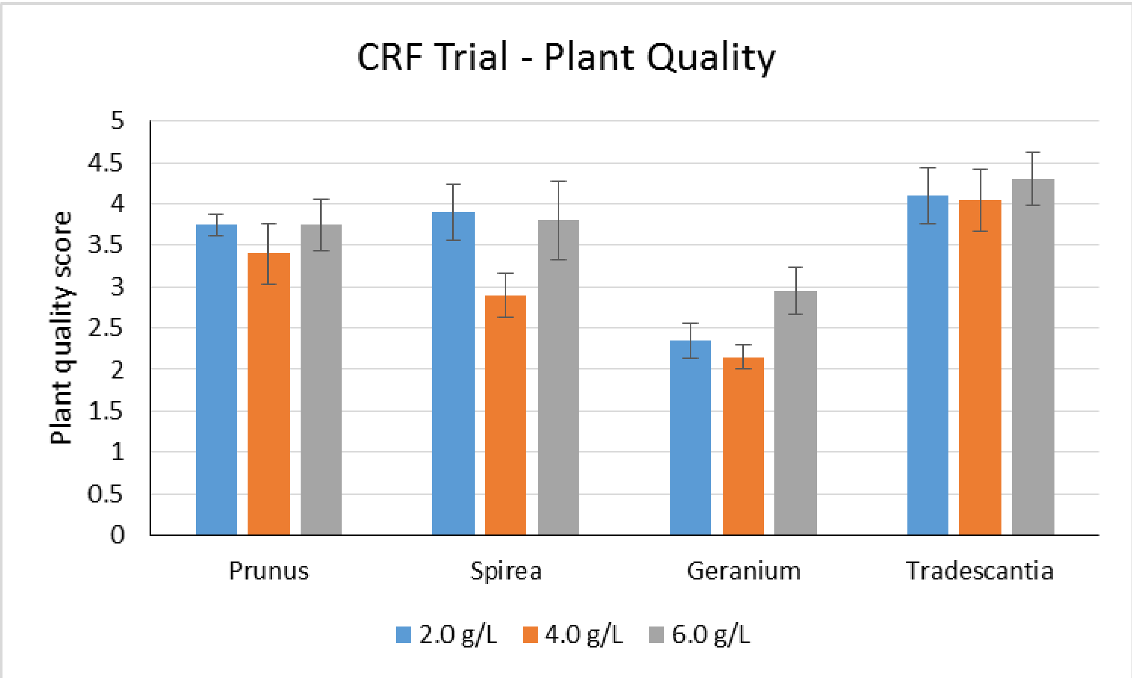

Figure 24. CRF trial. Average plant quality at the final assessment (8 November 2019, week 44). Plant quality score: scale 0-5: (0 = dead; 1 = very poor quality; 2 = poor quality; 3 = good quality, some damage visible; 4 = very good quality, very little damage; 5 = excellent quality, no damage visible). Scores are not statistically significant.

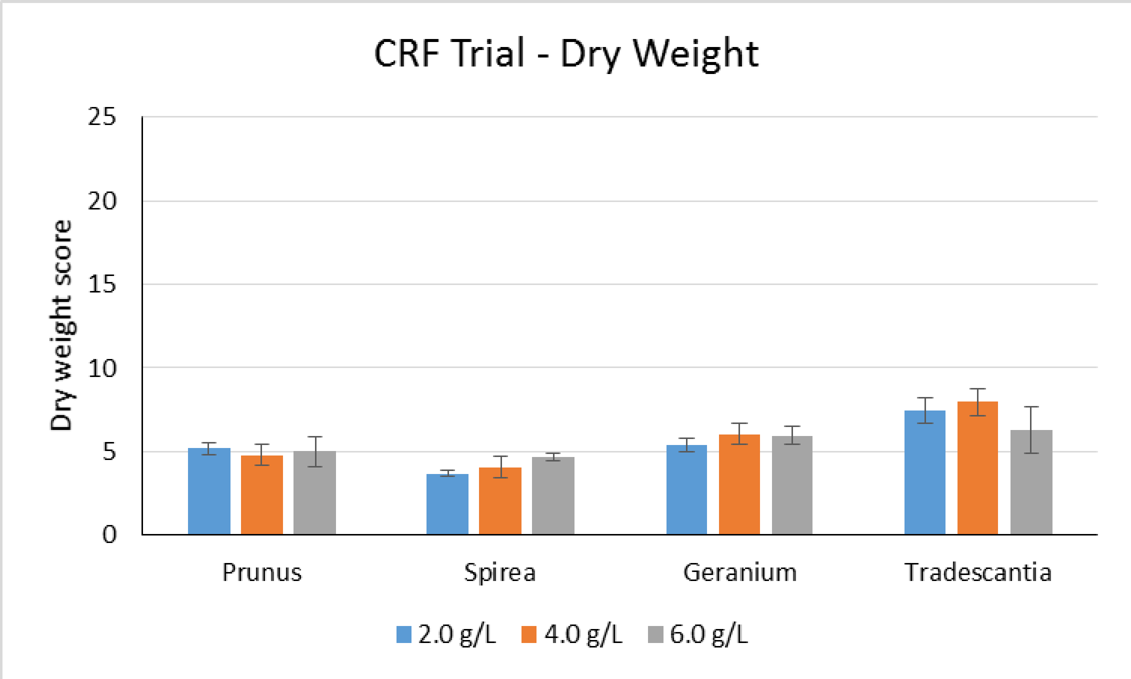

Figure 25. CRF trial. Average dry weight at the final assessment (8 November 2019, week 44). Scores are not statistically significant.

Table 10. Liquid feed trial. Average plant height, plant quality, root quality, fresh weight and dry weight at the interim (19 September 2019, week 38) and final assessments (8 November 2019, week 44). ns = differences not significant. a and b indices indicate significantly different data, comparing treatments within species. Plant quality score: scale 0-5: (0 = dead; 1 = very poor quality; 2 = poor quality; 3 = good quality, some damage visible; 4 = very good quality, very little damage; 5 = excellent quality, no damage visible). Root quality score: scale 0-4 (0 = no root development; 1 = rooting in up to 25% of pot; 2 = rooting in 26 – 50% of pot; 3 = rooting in 51 – 75% of pot; 4 = rooting in 76 – 100% of pot).

		Interim assessment			Final assessment				
Species	**Dose rate**	**Ave. plant height (cm)**	**Ave. plant quality**	**Ave. root quality**	**Ave. plant height (cm)**	**Ave. plant quality**	**Ave. root quality**	**Ave. fresh weight (g)**	**Ave. dry weight (g)**
Prunus lusitanica 'Myrtifolia'	0.5%	25.50	5.00	2.75[a]	24.78	4.55	3.70	22.45	8.50
	1.0%	20.15	5.00	3.25[b]	21.77	4.40	3.40	22.11	7.98
	2.0%	19.58	4.95	3.41[b]	22.56	4.35	3.65	22.80	7.38
Spiraea japonica 'Sparkling champagne'	0.5%	20.70	2.90[a]	3.75	22.82	4.15[a]	3.85	10.80	5.06
	1.0%	21.75	3.65[b]	3.80	26.38	4.30[a]	3.95	14.76	5.94
	2.0%	28.18	3.10[a]	3.85	30.30	3.30[b]	3.85	13.37	5.00
Geranium x *cantabrigiense* 'Westray'	0.5%	13.35	4.15[b]	3.60[a]	14.55	4.05[a]	3.80	35.86	8.74
	1.0%	15.25	4.75[a]	3.65[a]	16.74	4.70[b]	3.85	44.64	9.88
	2.0%	18.55	4.65[a]	3.15[b]	15.82	4.75[b]	3.65	42.91	9.11
Tradescantia pallida 'Purple Sabre'	0.5%	34.53	4.70[a]	3.75	34.86	4.25	3.80	143.82	11.20
	1.0%	31.63	4.70[a]	4.00	35.68	4.80	3.85	154.48	16.47
	2.0%	37.40	3.90[b]	4.00	36.20	4.75	3.85	145.50	9.63
	s.e.d.	3.813	0.137	0.177	5.589	0.325	0.176	6.470	2.608
	l.s.d.	7.757	0.280	0.361	11.370	0.661	0.359	13.170	5.306
	F pr.	0.296 ns	0.034	0.007	0.600 ns	0.027	0.546 ns	0.871 ns	0.580 ns

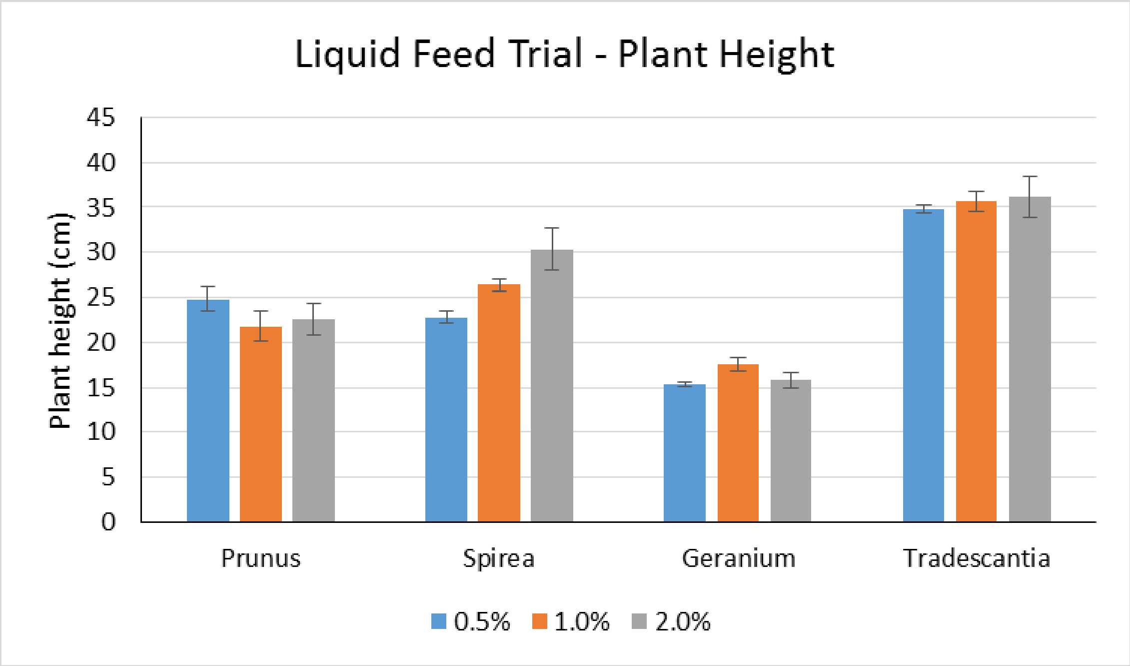

Figure 26. Liquid feed trial. Average plant height at the final assessment (8 November 2019, week 44). Plant heights are not statistically significant.

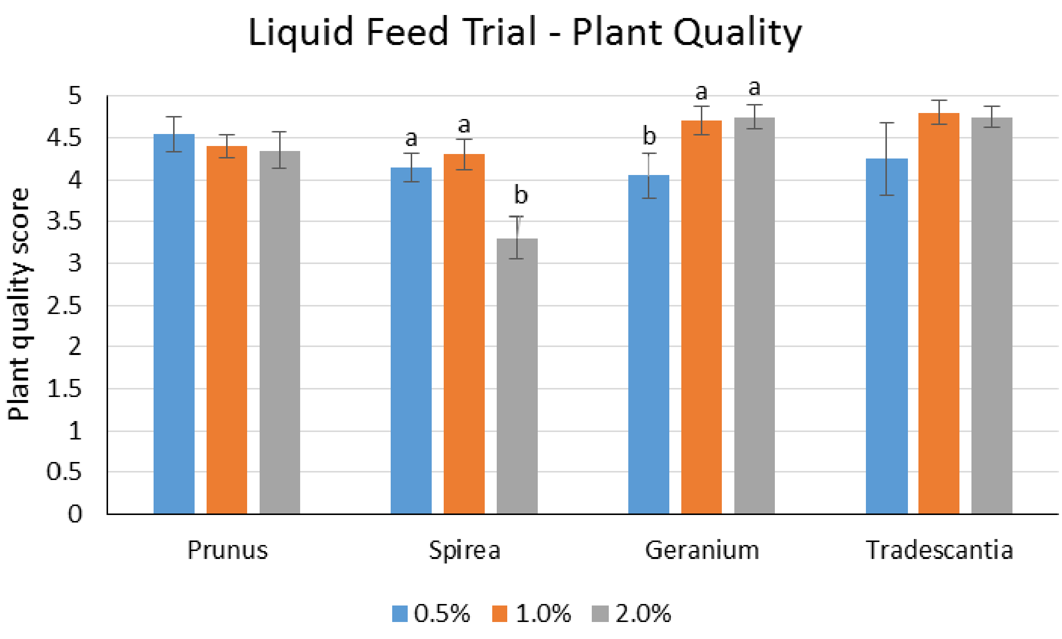

Figure 27. Liquid feed trial. Average plant quality at the final assessment (8 November 2019, week 44). Plant quality score: scale 0-5: (0 = dead; 1 = very poor quality; 2 = poor quality; 3 = good quality, some damage visible; 4 = very good quality, very little damage; 5 = excellent quality, no damage visible). Indices indicate significantly different data, comparing treatments within species. Statistically significant scores for the *Spiraea* and *Geranium* only.

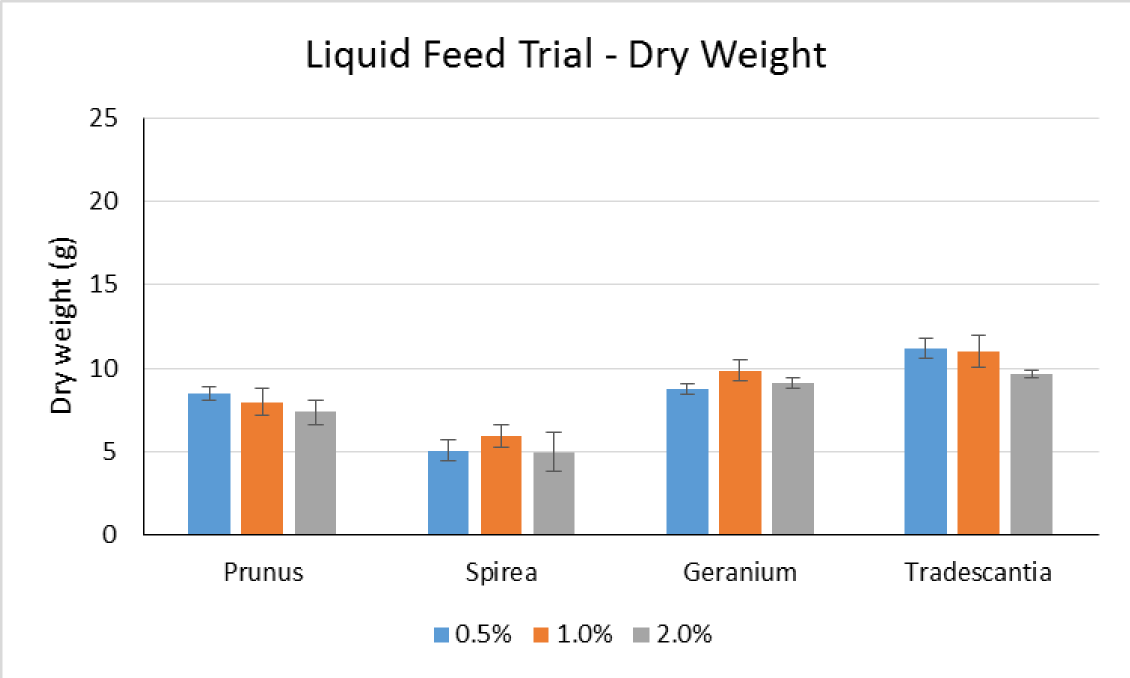

Figure 28. Liquid feed trial. Average dry weight at the final assessment (8 November 2019, week 44). Scores are not statistically significant.

Spiraea japonica **'Sparkling champagne'**

After two hot days in week 32, the *Spiraea* developed symptoms of scorch (**Figure 29**). However, there was a consistent pattern among the replicates. For the liquid feed trial, plants treated at the higher dose rate (2%) generally exhibited root growth with greater resilience to drought (**Figure 30**). Higher and medium dose rates also encouraged faster regrowth after the episode. Those treated at the lower rate (0.5%) suffered the most. The CRF trial was similarly affected, but to a lesser extent since plants in the CRF trial were generally kept drier and the plants were likely to have stronger root systems.

Rate	Week 32	Week 34	Week 41
2%			
1%			
0.5%			

Figure 29. Spiraea in the liquid feed trial recovering from a scorch event from week 32 to week 44 at three dose rates: 0.5%, 1% and 2%.

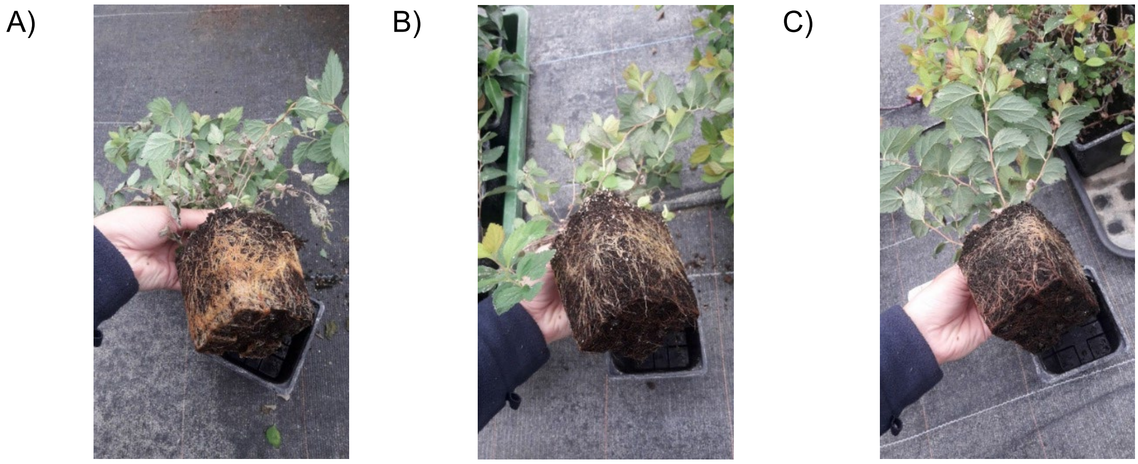

Figure 30. Root development in liquid fed *Spiraea* in the mid-season assessment, September. Liquid feed treatments: A) 2%, B) 1% and C) 0.5%.

Growing media electrical conductivity (EC) and leaf chlorophyll content (SPAD) measurements

Growing media EC and leaf chlorophyll (SPAD) were assessed each week to provide an indication of general trends in terms of available nutrient (salt) levels (EC) and N uptake (SPAD) by the plants. The purpose was to build up records to explore nutrient use during the course of the trial as an indication of the level of nutrition available to the plants, and with a view to using this technology to inform nutrient management decisions in future years of this project. Measurement were taken at the same day and time each week, prior to irrigation application. Graphs are presented in the Appendices for the CRF trial (**Appendix 20** to **Appendix 23)** and the liquid feed trial (**Appendix 24** to **Appendix 27**).

The temperature at the time the EC measurements were taken has been included in the graphs. Dips in EC values coincide with spikes in temperature and drier substrate early in the trial, particularly in weeks six and seven, after which the irrigation regime appears more in-step with the temperature. EC data has been adjusted to account for 20% growing media moisture.

The EC was lower in the CRF trial where the irrigation water was permitted to drain, washing any salts through rather than building up in the substrate. Plots in the liquid feed trial were held in non-drain trays to ensure all of the liquid feed applied was taken up by the plants, and this will have contributed to the higher EC readings in some treatments.

<u>CRF trial</u>

EC was generally in line with CRF dose rate – highest for 6 g/L dose rate treatments, and lower for the 2 g/L rate. Higher EC suggests more nutrients / salts remain in the substrate.

***Prunus lusitanica* ‘Myrtifolia’**. The EC in the 2 g/L and 4 g/L treatments was similar, and lower than the 6 g/L treatment, particularly towards the end of the trial. The SPAD readings suggest leaf chlorophyll levels were lower at the low CRF rate, but similar at the higher (4 g/L and 6 g/L) rates (**Appendix 20**).

***Spiraea japonica* ‘Sparkling champagne’**. *Spiraea* leaf chlorophyll content was similar for all CRF rates throughout the trial, but EC remained higher in the 6 g/L treatment, particularly from week 32 onwards, while the EC of the 4 g/L treatment fell below the level for the 2 g/L treatment during the later stages of the trial (**Appendix 17**).

***Geranium* x *cantabrigiense* ‘Westray’**. EC readings indicated that while there was some surplus feed available to the *Geranium* early in the trial, by the latter stages nutrients remained mainly in the 6 g/L treatment. The SPAD readings were similar for all treatments (**Appendix 18**).

***Tradescantia pallida* ‘Purple Sabre’**. The EC and SPAD readings were similar for all treatments, with consistently high leaf chlorophyll and low substrate EC. (**Appendix 19**).

<u>Liquid feed trial</u>

***Prunus lusitanica* ‘Myrtifolia**. The EC was substantially higher in the 2.0% treatment. The SPAD readings were relatively similar for all treatments (**Appendix 24**).

***Spiraea japonica* ‘Sparkling champagne’**. The EC was higher in the 2.0% treatment. The SPAD readings were similar for all treatments (**Appendix 25**).

***Geranium* x *cantabrigiense* ‘Westray’**. The EC was substantially higher in the 2.0% treatment, than the 0.5% and 1.0% readings. The SPAD readings were similar for all treatments (**Appendix 26**).

***Tradescantia pallida* ‘Purple Sabre’**. The EC and SPAD readings were similar for all treatments, with consistently high leaf chlorophyll and low substrate EC, suggesting that the *Tradescantia* maximised nutrient uptake at all dose rates; EC was falling away in the 0.5% treatment from week 28, suggesting lower uptake of nutrients (**Appendix 27**).

Growing media analysis

Although the EC and nutrient levels appear high in the ground CRF analyses, the nutrients are not usually released (and available to the plants) in a single dose; they are released over time in response to temperature. These high ECs would not cause root damage. By January, nutrient reserves had reduced in the ground samples in all treatment, but levels were still sufficient to support plant growth. Full analysis results are presented in **Appendix 3** to **Appendix 10**.

CRF trial

***Prunus lusitanica* 'Myrtifolia'**. Limited nutrients remained available to the plants in November 2019 at lower CRF rates in unground samples, with N, P and potassium (K) values at either deficiency level or just above (**Table 11, Appendix 3**). However, the results of the ground analysis indicated a high level of nutrient reserves in the CRF. Between the November 2019 and January 2020 sampling, nutrients were released from the CRF and were available to the plants. By January, nutrient reserves had reduced in the ground samples in all treatments.

Table 11. CRF trial. *Prunus lusitanica* 'Myrtifolia'. Ground and unground growing media analyses. Figures in red = very low level, deficiency; brown = low level; black = normal range; and green = high CRF (in reserves present in ground samples).

CRF - PRUNUS			pH	EC	Ammonia-N	Nitrate-N	P	K	Mg
Date		T		uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l
	Unused		5.5	288	56	102	22	50	32
Nov 2019	Unground	2 g/L	5.6	234	4	25	4	35	39
	Unground	4 g/L	5.3	154	10	27	6	35	18
	Unground	6 g/L	5.3	498	43	120	32	142	81
	Ground	2 g/L	5.2	941	215	207	118	276	110
	Ground	4 g/L	5.0	1756	482	470	253	598	195
	Ground	6 g/L	5.3	1196	261	260	146	389	143
Jan 2020	Unground	2 g/L	6.1	162	3	6	4	13	22
	Unground	4 g/L	5.7	297	11	59	17	64	53
	Unground	6 g/L	5.8	216	9	44	11	68	30
	Ground	2 g/L	5.8	351	41	43	35	76	45
	Ground	4 g/L	5.5	847	173	201	106	260	103
	Ground	6 g/L	5.6	702	138	160	83	239	80

***Spiraea japonica* 'Sparkling champagne'.** Limited nutrients remained available to the plants in November 2019 at lower CRF rates in unground samples, with N, P and K values at deficiency level at both the 2 g/L and 4 g/L dose rates (**Table 12, Appendix 4**). However, the results of the ground analysis indicated a high level of nutrient reserves the CRF for all treatments. By January 2020, higher nutrient levels were available to the plants in the unground samples, with nutrient reserves slightly reduced in all treatments in the ground samples. EC was high in the unground samples at the 6 g/L CRF rate in November 2019 and in the 4 g/L and 6 g/L rates in January 2020. The EC is expected to be higher in the ground samples as this is an indication of the total salts remaining in the CRF.

Table 12. CRF trial. *Spiraea japonica* 'Sparkling Champagne'. Ground and unground growing media analyses. Figures in red = very low level, deficiency; brown = low level; black = normal range; blue = excessive; and green = high CRF reserves present in ground samples.

SPIREA - CRF			pH	EC	Ammonia-N	Nitrate-N	P	K	Mg
Date		T		uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l
	Unused		5.5	288	56	102	22	50	32
Nov 2019	Unground	2 g/L	5.5	147	0.6	1	2	13	22
	Unground	4 g/L	5.6	196	5	9	6	24	33
	Unground	6 g/L	5.5	570	64	86	40	161	79
	Ground	2 g/L	5.2	1107	249	205	1331	330	141
	Ground	4 g/L	5.2	1327	262	316	148	408	180
	Ground	6 g/L	5.3	1617	423	370	205	567	168
Jan 2020	Unground	2 g/L	6.3	237	15	18	11	64	23
	Unground	4 g/L	5.7	669	72	141	61	205	105
	Unground	6 g/L	6.1	922	115	167	77	338	108
	Ground	2 g/L	6.1	500	79	77	48	156	48
	Ground	4 g/L	5.5	1105	210	264	125	366	149
	Ground	6 g/L	5.4	1713	361.7	380	199	643	190

***Geranium* x *cantabrigiense* 'Westray'**. Limited nitrate-N was available to the plants in all treatments in November 2019 and at the 2 g/L and 4 g/L dose rates in January 2020 (**Table 13, Appendix 5**). The results of the ground analysis indicated a high level of nutrient reserves the CRF for all treatments with nutrient reserves slightly reduced in the ground samples in January 2020.

Table 13. CRF trial. *Geranium x cantabrigiense 'Westray'*. Ground and unground growing media analyses. Figures in red = very low level, deficiency; brown = low level; black = normal range; and green = high CRF reserves present in ground samples.

GERANIUM - CRF			pH	EC	Ammonia-N	Nitrate-N	P	K	Mg
Date		T		uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l
	Unused		5.5	288	56	102	22	50	32
Nov 2019	Unground	2 g/L	5.2	289	33	32	23	60	36
	Unground	4 g/L	5.5	245	39	44	25	59	22
	Unground	6 g/L	5.4	286	13	16	10	78	42
	Ground	2 g/L	5.3	781	172	121	95	240	86
	Ground	4 g/L	5.3	1487	419	366	199	530	140
	Ground	6 g/L	5.4	657	128	138	72	219	77
Jan 2020	Unground	2 g/L	6.2	247	11	9	9	64	24
	Unground	4 g/L	6.1	321	23	19	16	91	35
	Unground	6 g/L	5.5	322	30	70	28	121	33
	Ground	2 g/L	5.8	833	168	146	92	258	78
	Ground	4 g/L	5.6	1172	260	236	131	395	109
	Ground	6 g/L	5.5	1105	247	260	138	424	108

***Tradescantia pallida* 'Purple Sabre'**. Limited nutrients remained available to the plants in November 2019 at lower CRF rates in unground samples, with N, K and magnesium (Mg) values at deficiency level at both the 2 g/L and 4 g/L dose rates (**Table 14, Appendix 6**). The

Tradescantia appears to have needed less P than provided in the CRF, and levels were relatively high in the unground samples at the 2 g/L and 4 g/L rates particularly at the 6 g/L rate (excessive). By January 2020, P levels remained at relatively high levels at the 2 g/L and 4 g/L rates, and excessive for the 6 g/L rate in the unground samples. The results of the ground analysis indicated nutrient reserves the CRF for all treatments, both in November 2019 and January 2020. EC was high in the unground samples at the 6 g/L CRF in January 2020.

Table 14. CRF trial. *Tradescantia pallida* 'Purple Sabre'. Ground and unground growing media analyses. Figures in red = very low level, deficiency; brown = low level; black = normal range; blue = excessive; and green = high CRF reserves present in ground samples.

TRADESCANTIA - CRF			pH	EC	Ammonia-N	Nitrate-N	P	K	Mg
Date		T		uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l
	Unused		5.5	288	56	102	22	50	32
Nov 2019	Unground	2 g/L	5	84	8	14	10	8	2
	Unground	4 g/L	5	146	24	28	19	26	6
	Unground	6 g/L	5	361	68	70	48	75	26
	Ground	2 g/L	4.8	909	241	184	133	266	77
	Ground	4 g/L	4.6	528	128	88	73	137	38
	Ground	6 g/L	4.9	2019	598	496	297	676	183
Jan 2020	Unground	2 g/L	6	257	43	54	30	51	24
	Unground	4 g/L	5	162	31	30	19	37	6
	Unground	6 g/L	5	627	155	127	88	173	41
	Ground	2 g/L	5	742	175	170	96	222	65
	Ground	4 g/L	5	793	215	185	112	258	58
	Ground	6 g/L	5	1543	452	367	225	504	125

Liquid feed trial

***Prunus lusitanica* 'Myrtifolia'**. Available nitrate-N at the 0.5% liquid feed rate, and Ammonia-N at all dose rates were at deficiency levels both in November 2019 and January 2020 (**Table 15**, **Appendix 7**). P was available at excessive levels at the 2% rate in November 2019, and marginally lower in January 2020. Otherwise, nutrient levels were generally within an acceptable range.

Table 15. Liquid feed trial. *Prunus lusitanica* 'Myrtifolia'. Unground growing media analyses. Figures in red = very low level, deficiency; brown = low level; black = normal range; blue = excessive. Data for June 2019 relates to ADAS Boxworth mains water.

PRUNUS - LF			EC	Ammonia-N	Nitrate-N	P	K	Mg
Date	**T**	**pH**	**uS/cm**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
June 2019		5.5	288	56	102	22	50	32
Nov 2019	0.5%	6.5	182	1	7	11	76	6
	1.0%	5.3	154	10	27	6	35	18
	2.0%	5.7	487	1	126	104	387	35
Jan 2020	0.5%	6.6	190	3	3	6	69	12
	1.0%	6.1	212	2	20	19	140	11
	2.0%	6.3	284	3	38	42	231	12

***Spiraea japonica* 'Sparkling champagne'**. Available nitrate-N at the 0.5% and 1.0% liquid feed rates, and Ammonia-N at all dose rates were at deficiency levels both in November 2019 and January 2020 (**Table 16, Appendix 8).** P was available at excessive levels at the 2% rate in November 2019, but at an acceptable level in January 2020. Mg was at deficiency levels at the 0.5% rate in November 2019, and at the 0.5% and 1.0% rates in January 2020. EC was high in the 2% treatment in January 2020.

Table 16. Liquid feed trial. *Spiraea japonica* 'Sparkling champagne'. Unground growing media analyses. Figures in red = very low level, deficiency; brown = low level; black = normal range; blue = excessive. Data for June 2019 relates to ADAS Boxworth mains water.

SPIREA - LF			EC	Ammonia-N	Nitrate-N	P	K	Mg
Date	**T**	**pH**	**uS/cm**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
June 2019		5.5	288	56	102	22	50	32
Nov 2019	0.5%	6.5	215	0.6	11	15	96	7
	1.0%	5.3	305	0.8	70	34	204	20
	2.0%	5.7	639	7.5	159	122	531	45
Jan 2020	0.5%	6.6	259	1.9	8	15	149	9
	1.0%	6.1	342	4.2	27	32	249	10
	2.0%	6.3	468	2.0	117	93	380	38

***Geranium x cantabrigiense* 'Westray'**. Available nitrate-N at the 0.5% liquid feed rate, and Ammonia-N at all dose rates were at deficiency levels both in November 2019 and January 2020 (**Table 17, Appendix 9**). Both P and K were available at excessive levels at the 2% rate in November 2019; P levels remained excessive in January 2020. Mg was at deficiency levels at the 0.5% rate both in November 2019 and January 2020, and at the 2.0% rate in January 2020.

Table 17. Liquid feed trial. *Geranium x cantabrigiense 'Westray'*. Unground growing media analyses. Figures in red = very low level, deficiency; brown = low level; black = normal range; blue = excessive. Data for June 2019 relates to ADAS Boxworth mains water.

GERANIUM - LF			EC	Ammonia-N	Nitrate-N	P	K	Mg
Date	T	pH	uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l
June 2019		5.5	288	56	102	22	50	32
Nov 2019	0.5%	6.5	176	0.6	4	10	56	3
	1.0%	5.3	296	0.6	20	15	142	13
	2.0%	5.7	650	0.8	203	76	478	52
Jan 2020	0.5%	6.6	148	1.6	1	8	68	5
	1.0%	6.1	223	2.1	7	10	131	10
	2.0%	6.3	542	2.7	119	67	399	40

***Tradescantia pallida* 'Purple Sabre'**. Available nutrients were at deficiency levels for all nutrients except for P both in November 2019 and January 2020 (**Table 18, Appendix 10**). P was the only nutrient to be available above deficiency level. *Tradescantia* is a vigorous plant, and known to be a heavy feeder, and it may have benefited from a higher dose rate than 2.0%.

Table 18. Liquid feed trial. *Tradescantia pallida* 'Purple Sabre'. Unground growing media analyses. Figures in red = very low level, deficiency; brown = low level; black = normal range; blue = excessive. Data for June 2019 relates to ADAS Boxworth mains water.

TRADESCANTIA - LF			EC	Ammonia-N	Nitrate-N	P	K	Mg
Date	T	pH	uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l
June 2019		5.5	288	56	102	22	50	32
Nov 2019	0.5%	6.5	49	1.7	1.6	6	5	0.4
	1.0%	5.3	38	0.7	1.1	10	4	0.2
	2.0%	5.7	42	0.8	2	17	4	0.3
Jan 2020	0.5%	6.6	41	2.3	<0.6	7	2	0.4
	1.0%	6.1	35	2.5	0.6	4	2	0.2
	2.0%	6.3	73	5.9	8.2	23	22	0.6

Run-off water analysis

Full analysis reports for the mains water at ADAS Boxworth and the run-off from the CRF trial are presented in **Appendix 15**.

For all species, more N leaching occurred as dose rate increased (**Figure 31**). Neither of the woody species (*Prunus* and *Spirea*) appear to have benefited from the 4 g/L and 6 g/L treatments, as leaching increased at these rates. The lowest level of N was leached by *Tradescantia*, a heavy feeder, at the 6 g/L rate. For *Geranium* and *Tradescantia*, there was the lowest amount of leaching at both the 2 g/L and 4 g/L rates.

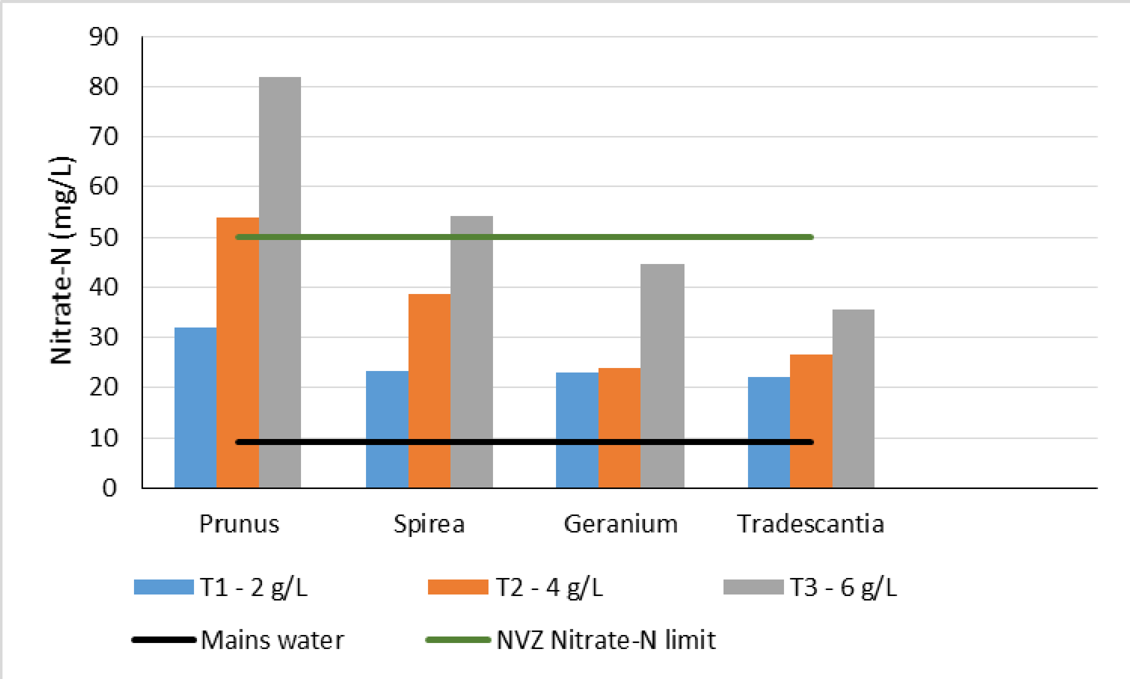

Figure 31. Nitrate-N quantity in run-off water. 14 November 2019. Black horizontal line: nitrate level in the mains water at ADAS Boxworth. Green horizontal line: NVZ drinking water nitrate-N limit (50 mg/L)

There was no clear trend across the species for P leaching. P doesn't generally leach in the same way as N, as it tends bind more tightly to substrate particles. More P leached at the highest dose rate for all species except for the *Geranium*, but most notably for the *Tradescantia*, as more was supplied than the plants needed.

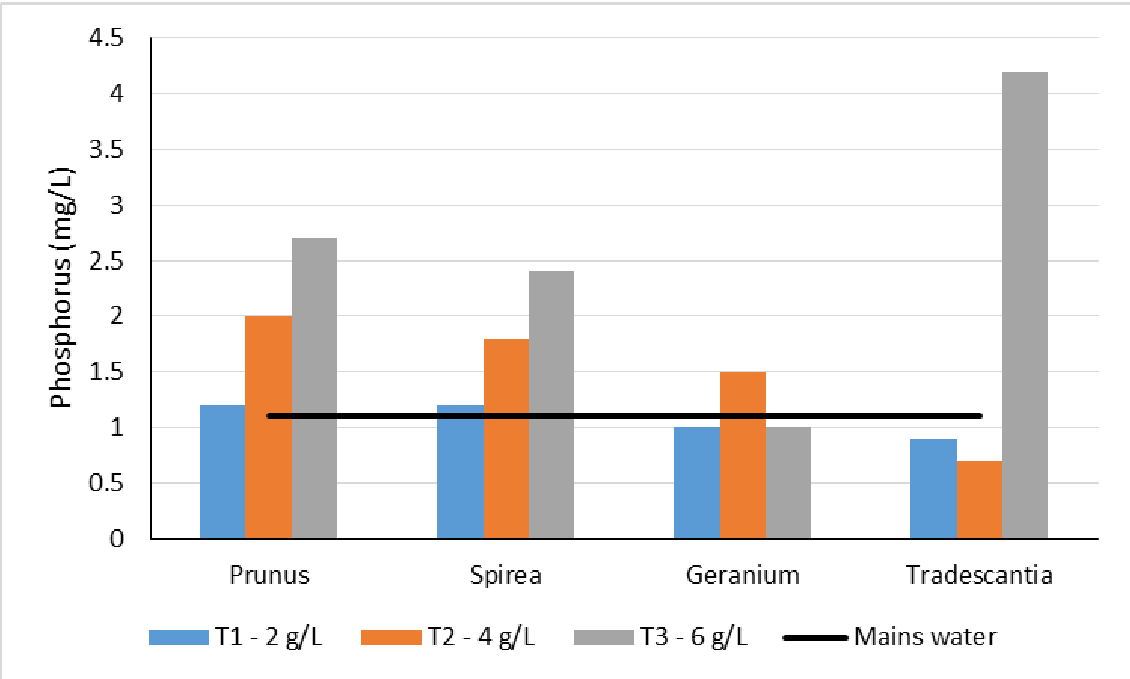

Figure 32. Phosphorus quantity in run-off water. 14 November 2019. Black horizontal line: phosphate level in the mains water at ADAS Boxworth

Tissue analysis

The full analysis results are presented in **Appendix 11** to **Appendix 14**. The graphs below present the data for leaf N and P; the data has been converted from mg/kg dry matter (ppm) to % dry matter (% dry matter = ppm/10,000) for consistency between the N and P data.

<u>CRF trial</u>

Leaf N content increases with CRF dose rate to some extent for all species (**Figure 33**). Comparing with standard leaf N data (**Mills and Jones, 1996**) reveals that at the start of the trial, leaf N content was lower than the standard data for all species except for the *Spiraea*, which was higher. By the end of the trial, leaf N was within range for the *Prunus* at the 2 g/L and 4 g/L CRF rates, but higher than the standard data at the 6 g/L CRF rate. Leaf N was low for both the *Geranium* and *Tradescantia* in all treatments, and high for the *Spiraea*.

Prunus leaf nutrient levels (N, P, K, Mg, and calcium (Ca) decreased between November 2019 and January 2020, with the exception of P at the 4 g/L CRF rate.

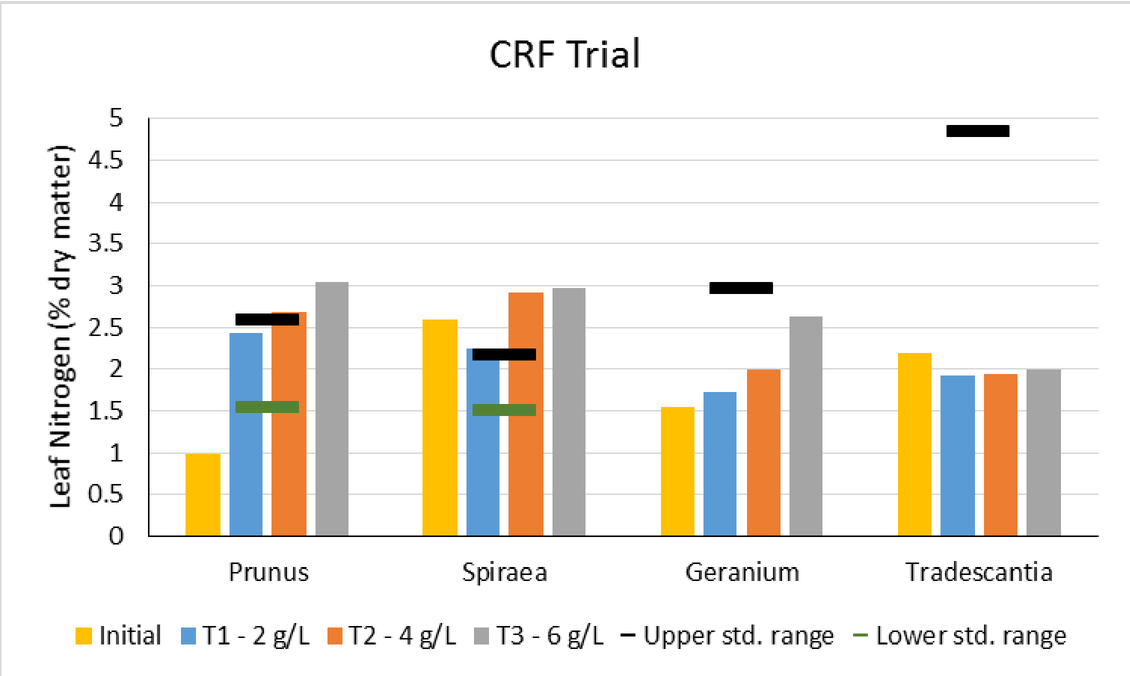

Figure 33. CRF trial. Leaf nitrogen content. Samples taken at the start of the trial on 26 June 2019, and at the final assessment on 14 November 2019. Standard nutrient ranges (% dry matter): *Prunus* 1.53-2.59; *Spiraea* 1.50-2.16; *Geranium* 2.96-2.96; *Tradescantia* 4.84-4.84. Green and black horizontal lines indicate standard nutrient ranges. Note: for *Geranium* and *Tradescantia* there is no lower standard range.

Leaf P content increases with CRF dose rate to some extent for all species (**Figure 34**). Similar to leaf N, when compared with standard leaf P data (**Mills and Jones, 1996**), this trial reveals that at the start, leaf P content was lower than the standard data for all species except for the *Spiraea*, which was higher. By the end of the trial, leaf P was lower than the standard data for all *Geranium* and *Tradescantia* in all treatments. It was higher than the standard data for all *Prunus* and *Spiraea* treatments, except for *Spiraea* at the 2 g/L CRF rate which was within the standard data range.

Prunus leaf nutrient levels (N, P, K, Mg, and Ca) decreased between November 2019 and January 2020, with the exception of Ca at the 2% dose rate.

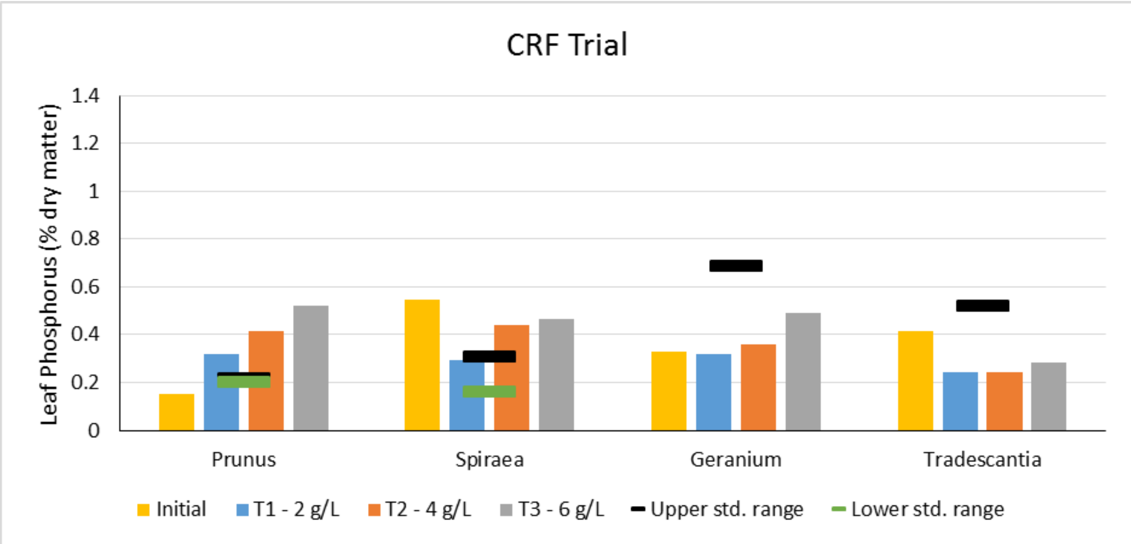

Figure 34. CRF trial. Leaf phosphorus content. Samples taken at the start of the trial on 26 June 2019, and at the final assessment on 14 November 2019. Standard nutrient ranges (% dry matter): *Prunus* 0.2-0.22; *Spiraea* 0.16-0.31; *Geranium* 0.69-0.69; *Tradescantia* 0.52-0.52. Note: for *Geranium* and *Tradescantia* there is no lower standard range.

<u>Liquid feed trial</u>

Leaf N content increases with liquid feed dose rate for the *Spirea* and *Tradescantia*, but did not follow a trend for the *Prunus* or *Geranium* (**Figure 35**). Comparison with standard leaf N data (**Mills and Jones, 1996**) reveals that at the start of the trial, leaf N content was lower than the standard data for all species except for the *Spiraea*, which was higher. By the end of the trial, leaf N was above the standard data for all species and treatments except for the *Prunus* high dose rate (2.0%), which was within range, and all *Tradescantia* treatments, which were below the standard data range.

Leaf P content increased with liquid feed dose rate for all species except for the *Prunus* (**Figure 36**). Comparison with standard leaf P data (**Mills and Jones, 1996**) reveals that at the start of the trial, leaf P content was lower than the standard data for all species except for the *Spiraea*, which was higher. Leaf P was below the standard data range for all species and dose rates, except for the *Tradescantia* low dose treatment (0.5%), which was within the range.

Weed presence

The weed species identified were groundsel, willow herb, dandelion, sow thistle, annual meadow-grass, moss, bitter cress, and liverwort. Weeds were very low in number or percentage cover and randomly distributed within the trial. Therefore these data did not warrant statistical analysis. All weeds were removed after identification.

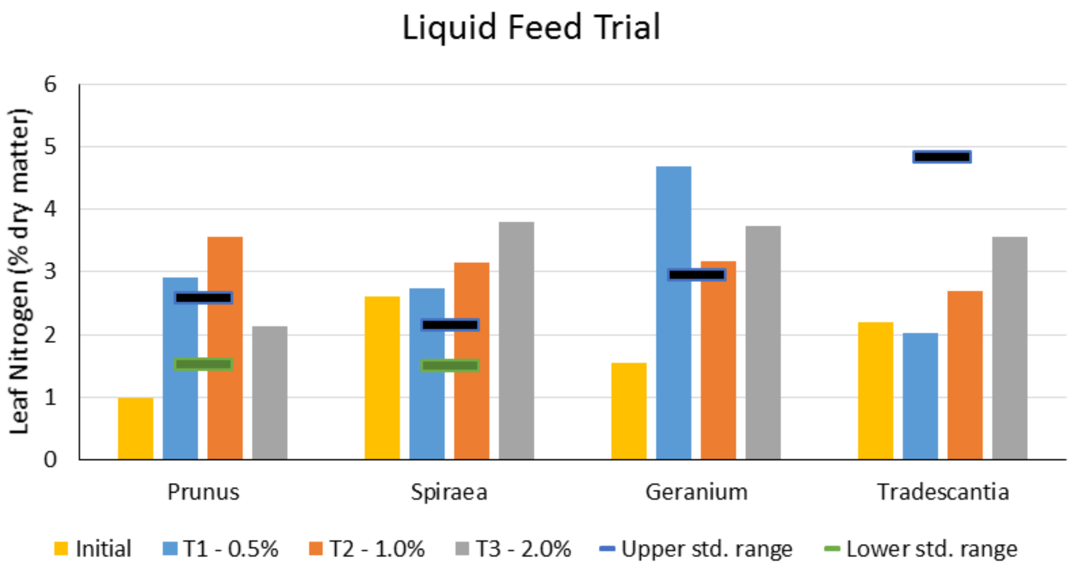

Figure 35. Liquid feed trial. Leaf nitrogen content. Samples taken at the start of the trial on 26 June 2019, and at the final assessment on 14 November 2019. Standard nutrient ranges (% dry matter): *Prunus* 1.53-2.59; *Spiraea* 1.50-2.16; *Geranium* 2.96-2.96; *Tradescantia* 4.84-4.84. Note: for *Geranium* and *Tradescantia* there is no lower standard range.

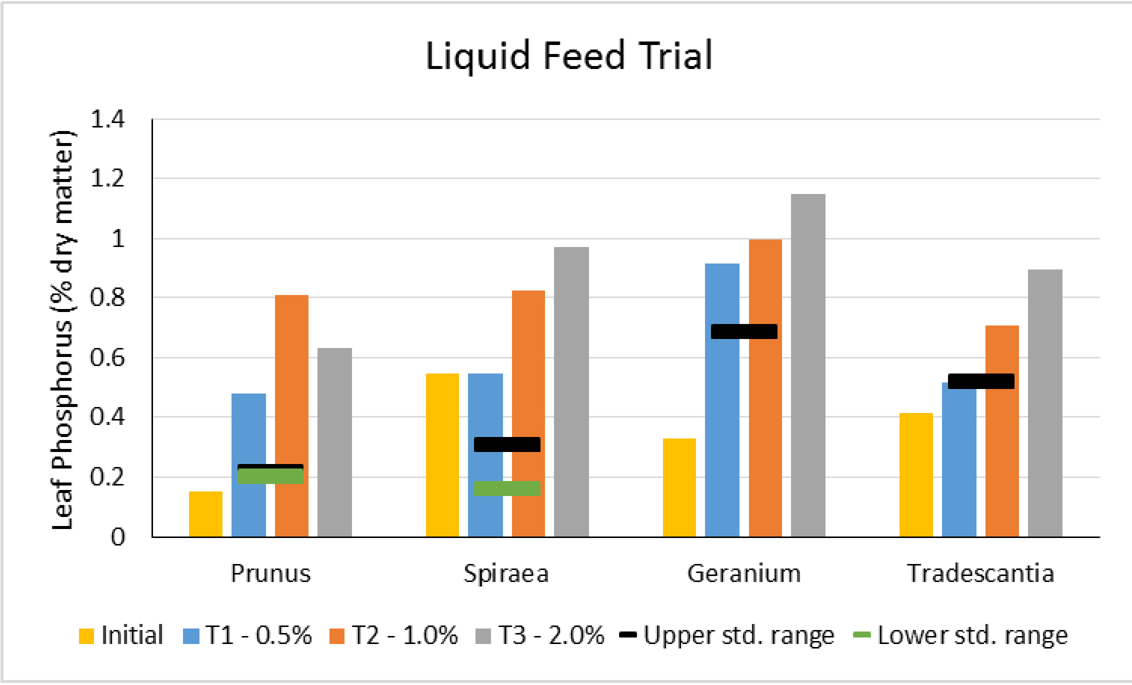

Figure 36. Liquid feed trial. Leaf phosphorus content. Samples taken at the start of the trial on 26 June 2019, and at the final assessment on 14 November 2019. Standard nutrient ranges (% dry matter): *Prunus* 0.2-0.22*; Spiraea* 0.16-0.31; *Geranium* 0.69-0.69; *Tradescantia* 0.52-0.52. Note: for *Geranium* and *Tradescantia* there is no lower standard range.

Discussion

Although the *Spiraea, Geranium* and *Tradescantia* did appear to benefit from the high CRF rate through increased plant height, this may not be the optimum rate and further examination will clarify the effect of reduced nutrient application. The run-off analysis indicated that there may be an opportunity to reduce nutrient rates without impacting on plant quality, and this would also reduce potential leaching of N and phosphate into the groundwater.

Prunus lusitanica is generally considered to be a vigorous species, but in this trial it produced greater growth and acceptable plant quality at the lowest feed rates, with increased nitrate in the run-off at the higher dose rates in the CRF trial.

N and P levels in the run-off water were generally greatest in the *Prunus*, however the *Tradescantia* appears to have limited P uptake at the 6 g/L rate with high levels in the run-off (4.2 mg/L) compared with the *Prunus* (2.7 mg/L), *Spiraea* (2.4 Mg/L) and *Geranium* (1.0 mg/L). In this trial the *Tradescantia* did not appear to need the amount of P provided in the CRF as there were low levels in the leaf tissue and high levels in the substrate, and in the run-off water at the high CRF rate. It is worth noting that not all of the P would usually be released by the CRF, and some would become unavailable over time due to forming complexes with Ca, for example. Although the *Tradescantia* performed better at the higher feed rates in both trials, in the liquid feed trial this did not translate into improved plant quality; leaf tissue N levels were low, and this suggests that the liquid feed rate may have provided insufficient nutrients.

Growing media EC was higher in the liquid feed (LF) trial than the CRF trial. For example, for *Prunus* in week 34 the EC was measured as 445 µS/cm in the LF trial, and as 157 µS/cm in the CRF trial. This may be because the plants in the LF trial were in non-draining trays which prevented salts from being washed through the growing media, while the CRF trial was set-up in a system designed to allow water and nutrients to drain through for collection of the run-off water for analysis.

The weekly EC measurements were a useful tool to provide an indication of the nutrient status of the growing media and leaf tissue, identifying clear differences due to plant response to treatments and plant vigour. However, substrate moisture levels affect the measurements, so readings need to be taken at the same time of day, and at the same point within the irrigation regime on each occasion. In this trial, dips in EC coincided with particularly hot weather conditions and reduced growing media moisture.

Leaf chlorophyll (SPAD) readings were similar across all treatments for all species, except for the *Prunus* in this trial, which may be an indication that the treatments were not sufficiently different to affect leaf chlorophyll for the majority of subjects in this trial. Leaf chlorophyll appeared to be within specific ranges for each plant. For example, they were around 30 to 40 for *Spirea*, but 35 to 50 for *Tradescantia,* and these findings were common across the LF and CRF trials.

Conclusions

The trials in year 1 of this project were designed to provide baseline data to inform trial work in years 2 and 3. While the results indicated some interesting trends, the majority of the results were not statistically significant, and further work will determine the reproducibility of the results before any firm recommendations can be made. Visual deficiency symptoms were not a feature in year 1, and lower nutrient rates, including base fertiliser, in future trials would push nutrient uptake towards the lower critical thresholds.

A number of tissue N and P measurements obtained within these trials were outside the published standard ranges (**Mills and Jones, 1996**) with no visible deficiency symptoms.

These results demonstrate the need to improve understanding of plant vigour; for some species, good quality plants can be grown at low CRF rates, but for others high feed rates are needed to produce marketable crops. *Prunus lusitanica* is generally considered to be a vigorous plant, but in this trial performed better at the lowest dose feeds (2 g/L and 2% dose rates), with nitrates in the run-off water above the NVZ nitrate limit at higher dose rates. The *Spiraea, Geranium* and *Tradescantia* all performed better at the higher dose rates. However, detailed monitoring and analysis revealed different plant requirements for specific plant nutrients, i.e. *Tradescantia* performed better overall at the high feed rates, but appears to need lower levels of P. Greater understanding of plant vigour enables plants to be arranged within vigour groups so that fertilisers can be applied according to plant need, thereby affording the grower better management of input costs and nutrient run-off.

Knowledge and Technology Transfer

- Growing media developments and nutrient management in hardy nursery stock production. Coles Nurseries. 12 September 2019. Presentation and workshop demonstration of trial.
- Herbaceous Perennials Technical Discussion Group presentation. Environmental protection best practice - nutrient management and water treatment and recycling on nurseries. 25 February 2020. Presentation.
- Final report March 2020

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- SinclairPro
- ICL
- The Scientific Support team at ADAS

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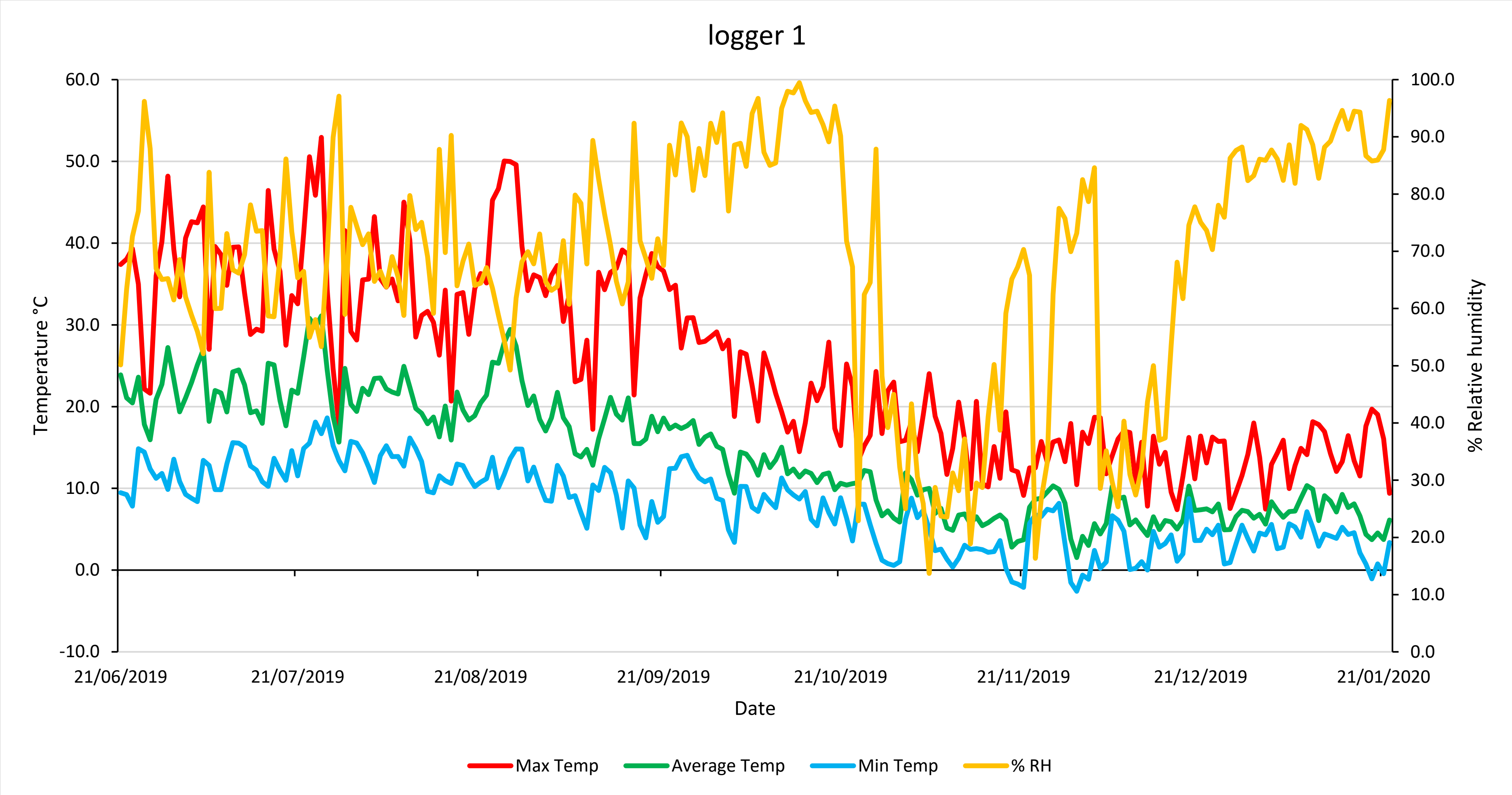
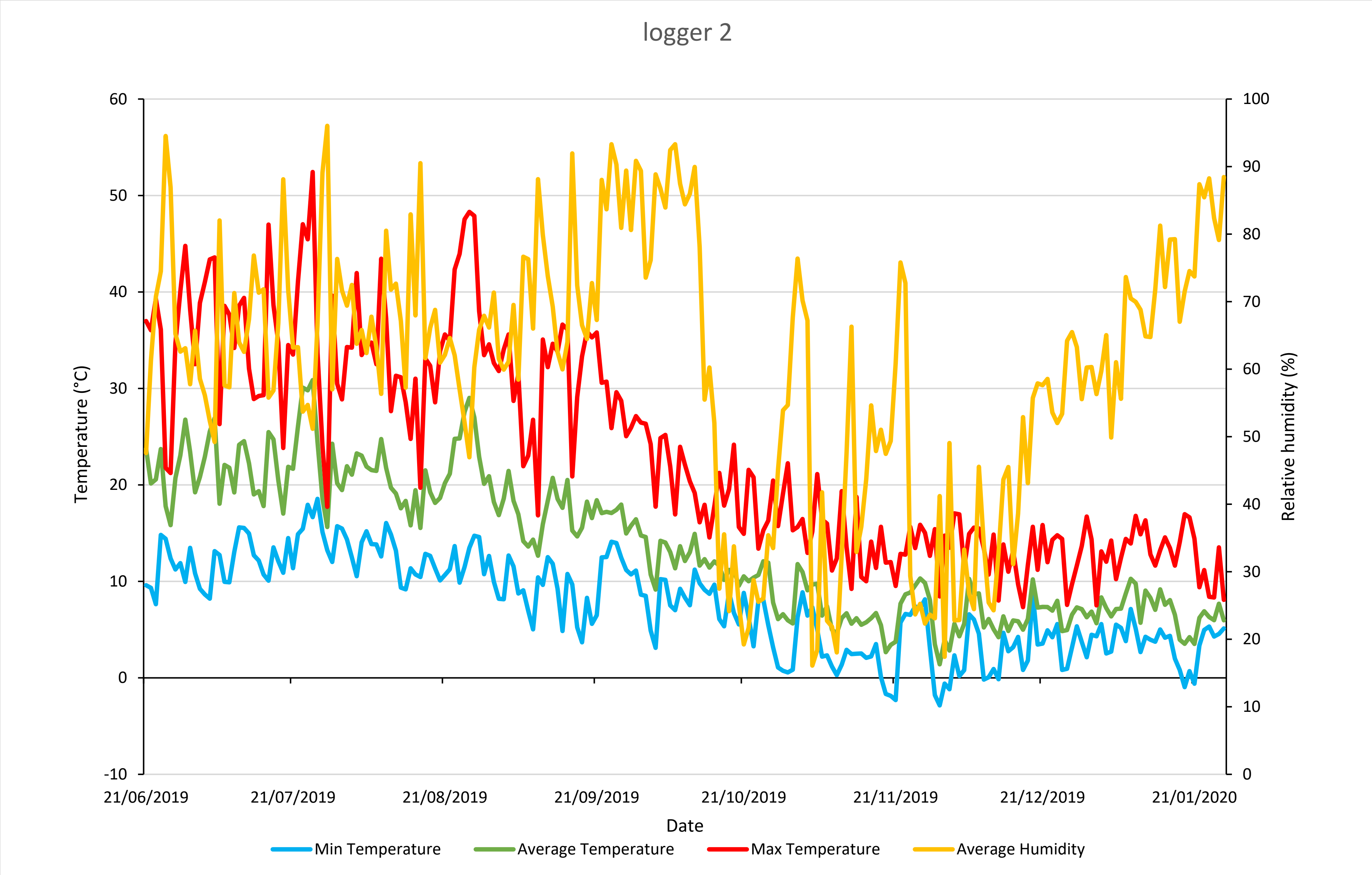
Appendices

Appendix 1. Polytunnel temperature and humidity. CRF trial



Appendix 2. Polytunnel temperature and humidity. Liquid feed trial



Appendix 3. Growing media analyses. CRF trial. *Prunus lusitanica* 'Myrtifolia' T1 = 2 g/L, T2 = 4 g/L, T3 = 6 g/L. U=unused, G=ground and UG=unground

Trt		Date	pH	EC	NH_4-N	NO_3-N	Total N	P	K	Mg	Ca	Fe	Cu	Mn	Zn	Na	B	SO_4	Cl	Density	Dry matter	Dry density
		2019		uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	kg/m³	%	kg/m³
Unused		26 Jun	5.5	288	55.8	101.6	157.4	21.8	49.9	32.1	22.1	0.56	0.01	0.14	0.05	15.1	0.22	93.8	16.10	276	36.70	101.30
T1	U	14 Nov	5.6	234	3.6	24.9	28.5	4	35	39.4	33.7	1.05	0.02	0.03	0.07	55.7	0.07	239.1	123.1	436	22.4	97.7
T2	U	14 Nov	5.3	154	9.9	26.7	36.5	6.3	35.3	18.4	17.3	0.5	0.04	0.03	0.05	27.6	0.09	120.8	52.6	339	28.4	96.3
T3	U	14 Nov	5.3	498	42.6	119.9	162.5	32.2	142	81.2	74	1.74	0.18	0.24	0.19	54.8	0.22	420.1	110.5	362	26.2	94.8
T1	G	21 Nov	5.2	941	214.7	207.1	421.8	118.2	276	109.6	90.4	2.95	0.2	0.57	1.04	61.5	0.77	924.3	103.80	436	22.40	97.70
T2	G	21 Nov	5.0	1756	482.2	470.1	952.4	252.5	598	194.6	151.9	6.47	0.56	1.69	1.99	71.6	0.99	1836.1	116.00	339	28.40	96.30
T3	G	21 Nov	5.3	1196	260.8	260.4	521.2	145.9	389	142.8	130.3	4.12	0.35	0.92	1.28	69.9	0.53	1156.3	125.40	362	26.20	94.80
		2020																				
T1	U	24 Jan	6.1	162	2.6	5.5	8.1	3.6	12.5	21.8	29	0.32	0.02	<0.01	0.05	49.6	0.11	163.3	94.7	359	21.5	77.2
T2	U	24 Jan	5.7	297	11.4	59.2	70.6	16.7	64.4	53.2	62.3	1.17	0.06	0.11	0.18	46.6	0.13	270.5	79.2	359	24.5	88
T3	U	24 Jan	5.8	216	8.9	43.5	52.4	11.3	68.4	29.7	33.7	0.85	0.06	0.03	0.22	37.8	0.17	188.1	58.2	369	24	88.6
T1	G	24 Jan	5.8	351	41.4	43.4	84.8	35.2	75.6	44.6	59.5	0.88	0.11	0.1	0.28	54.1	0.16	402.1	92.7	359	21.5	77.2
T2	G	24 Jan	5.5	847	173.4	200.5	373.9	105.8	260	103.3	116.2	3.3	0.23	0.57	0.81	53	0.7	866.3	83.1	359	24.5	88
T3	G	24 Jan	5.6	702	137.8	160	297.8	83.2	239	79.7	85.3	3.08	0.21	0.4	0.85	50.5	0.72	691.1	70.9	369	24	88.6

Appendix 4. Growing media analyses. CRF trial. *Spiraea japonica* 'Sparkling champagne'. T1 = 2 g/L, T2 = 4 g/L, T3 = 6 g/L. U=unused, G=ground and UG=unground

Trt		Date	pH	EC	NH_4-N	NO_3-N	Total N	P	K	Mg	Ca	Fe	Cu	Mn	Zn	Na	B	SO4	Cl	Density	Dry matter	Dry density
		2019		uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	kg/m³	%	kg/m³
Unused		26 Jun	5.50	288	55.8	101.6	157.4	21.8	49.9	32.1	22.1	0.56	0.01	0.14	0.05	15.1	0.22	93.8	16.10	276	36.70	101.30
T1	U	14 Nov	5.5	147	0.6	1.2	1.3	1.5	12.5	22.4	20.1	0.44	0.02	0.01	0.06	45.9	0.05	160.5	93.7	313	31.1	97.3
T2	U	14 Nov	5.6	196	4.8	9.2	13.9	6.1	23.7	32.7	29.4	0.66	0.03	0.01	0.08	54.4	0.09	244.7	99.1	283	35.1	99.3
T3	U	14 Nov	5.5	570	64	85.5	149.5	40	160.6	78.8	79.1	2.03	0.27	0.1	0.33	87.4	0.24	636.5	166.1	339	29.9	101.4
T1	G	21 Nov	5.20	1107	248.8	204.8	453.6	1331	330.1	140.9	102.9	4.38	0.36	0.54	1.35	92.5	0.75	1223.3	146.10	313	31.10	97.30
T2	G	21 Nov	5.20	1327	261.6	316.1	577.7	148.4	408.4	179.6	138.2	4.89	0.42	0.69	1.41	96.2	0.64	1215.5	159.00	283	35.10	99.30
T3	G	21 Nov	5.30	1617	423.4	370.1	793.5	204.8	567.4	167.5	152.6	6.00	1.06	1.01	1.69	79.7	0.85	1676.2	118.40	339	29.90	101.40
		2020																				
T1	U	24 Jan	6.3	237	14.7	18.2	32.9	11.3	64.4	22.8	26.3	0.54	0.03	<0.01	0.12	63.2	0.18	210.7	121.4	520	18.8	97.8
T2	U	24 Jan	5.7	669	72.3	140.8	213.1	60.8	204.6	104.6	85.9	2.88	0.12	0.19	0.38	76.6	0.4	583.3	135.7	510	21	107.1
T3	U	24 Jan	6.1	922	115.1	167.1	282.2	76.8	338.3	107.8	117.8	2.30	0.30	0.24	0.70	114.3	0.58	856.9	211.4	620	18.5	114.7
T1	G	24 Jan	6.1	500	79.2	76.9	156.2	47.5	155.8	48	49.5	1.55	0.09	0.18	0.36	66	496.9	0.29	117.6	520	18.8	97.8
T2	G	24 Jan	5.5	1105	210.4	263.9	474.2	124.7	365.6	148.9	119.2	4.56	0.22	0.47	0.80	83.4	0.49	1043.7	142.7	510	21	107.1
T3	G	24 Jan	5.4	1713	361.7	379.7	741.4	199.3	642.7	190.1	196.6	5.67	0.63	0.91	1.23	119	0.82	1677.8	193.2	620	18.5	114.7

Appendix 5. Growing media analyses. CRF trial. *Geranium* x *cantabrigiense* 'Westray'. T1 = 2 g/L, T2 = 4 g/L, T3 = 6 g/L. U=unused, G=ground and UG=unground.

		Date	pH	EC	NH_4-N	NO_3-N	Total N	P	K	Mg	Ca	Fe	Cu	Mn	Zn	Na	B	SO_4	Cl	Density	Dry matter	Dry density
Trt		**2019**		**uS/cm**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**kg/m³**	**%**	**kg/m³**
Unused		26 Jun	5.5	288	55.8	101.6	157.4	21.8	49.9	32.1	22.1	0.56	0.01	0.14	0.05	15.1	0.22	93.8	16.10	276	36.70	101.30
T1	U	14 Nov	5.2	289	32.6	31.7	64.3	23.3	60	35.9	29.9	1.05	0.04	0.07	0.11	64.6	0.06	376.0	68.2	379	25.9	98.2
T2	U	14 Nov	5.5	245	39.2	44.1	83.2	25.2	59.2	21.9	22.3	1.07	0.06	0.05	0.17	31.9	0.07	241.2	36.5	372	23.6	87.8
T3	U	14 Nov	5.4	286	12.7	15.8	28.6	10.2	78.4	41.5	35.6	1.62	0.29	0.11	0.21	73.0	0.09	450.9	64.3	239	33.8	80.8
T1	G	21 Nov	5.3	781	172.1	120.7	292.8	94.9	239.9	86.0	6.08	2.58	0.15	0.37	0.69	76.2	0.47	847.3	71.10	379	25.90	98.20
T2	G	21 Nov	5.3	1487	419.3	365.6	784.9	198.5	530.1	139.7	115.9	5.79	0.36	1.15	1.34	64.5	0.82	1574.1	58.10	372	23.60	87.80
T3	G	21 Nov	5.4	657	128.2	137.8	266	72.1	219.2	77.3	75.2	2.41	0.4	0.42	0.60	62.0	0.27	735.2	62.30	239	33.80	80.80
		2020																				
T1	U	24 Jan	6.2	247	10.6	8.7	19.3	8.6	63.7	23.6	26.8	0.74	0.04	0.01	0.15	76.1	0.12	294.4	95.6	599	18.5	110.8
T2	U	24 Jan	6.1	321	22.5	18.8	41.3	15.9	91.2	34.5	40.1	1.21	0.06	0.05	0.26	87.6	0.18	363.7	140.2	602	18.5	111.4
T3	U	24 Jan	5.5	322	30.4	70.3	100.6	28.4	121.3	32.5	42.8	1.14	0.08	0.11	0.15	36.4	0.26	229.5	57.8	386	26.8	103.4
T1	G	24 Jan	5.8	833	167.6	145.8	313.3	92.0	257.7	78.3	74.4	3.29	0.12	0.44	0.76	100.6	0.36	835.9	115.1	599	18.5	110.8
T2	G	24 Jan	5.6	1172	260.1	235.6	495.7	131.1	394.7	108.8	107.3	4.59	0.30	0.70	1.50	92.7	0.58	1169.3	132.4	602	18.5	111.4
T3	G	24 Jan	5.5	1105	246.9	260.4	507.2	137.8	423.9	108.2	112.1	5.21	0.47	0.77	0.85	67.6	0.68	1061.7	77.8	386	26.8	103.4

Appendix 6. Growing media analyses. CRF trial. *Tradescantia pallida* 'Purple Sabre'. T1 = 2 g/L, T2 = 4 g/L, T3 = 6 g/L. U=unused, G=ground and UG=unground.

		Date	pH	EC	NH_4-N	NO_3-N	Total N	P	K	Mg	Ca	Fe	Cu	Mn	Zn	Na	B	SO_4	Cl	Density	Dry matter	Dry density
Trt		2019		uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	kg/m^3	%	kg/m^3
Unused		26 Jun	5.5	288	55.8	101.6	157.4	21.8	49.9	32.1	22.1	0.56	0.01	0.14	0.05	15.1	0.22	93.8	16.1	276	36.70	101.30
T1	U	14 Nov	4.7	84	7.8	14.4	22.2	10.1	8.1	1.7	3.7	0.66	0.02	0.01	0.03	33.2	0.05	73.0	7.5	392	25.20	98.8
T2	U	14 Nov	4.6	146	23.6	27.9	51.6	18.9	25.7	6.4	8.8	2.09	0.09	0.01	0.03	41.6	0.11	142.6	8.9	273	31.80	86.8
T3	U	14 Nov	4.7	361	67.9	70.3	138.2	48.0	74.7	25.5	34.9	4.63	0.16	0.08	0.13	71.8	0.26	419.4	11.7	349	25.10	87.6
T1	G	21 Nov	4.8	909	241	183.7	424.7	133.2	265.8	77.0	68.7	5.19	0.29	0.54	0.48	76.5	0.54	912.1	18.6	392	25.20	98.80
T2	G	21 Nov	4.6	528	127.7	88.3	216	73.2	136.9	38.2	36.7	4.14	0.39	0.23	0.17	57.7	0.40	507.0	13.6	273	31.80	86.80
T3	G	21 Nov	4.9	2019	597.6	496.3	1093.9	296.9	675.6	182.6	158.5	8.82	1.48	1.95	1.36	95.8	1.71	2169.9	60.5	349	25.10	87.60
		2020																				
T1	U	24 Jan	5.5	257	42.6	54.3	96.9	30.1	50.7	23.9	23.9	2.08	0.04	0.05	0.09	55.8	0.18	245.0	29.1	346	30.20	104.5
T2	U	24 Jan	5.4	162	31.3	30.0	61.3	19.2	37.1	5.7	7.5	1.63	0.04	0.03	0.09	40.5	0.19	141.2	23.4	366	24.20	88.6
T3	U	24 Jan	5.1	627	155	127.1	282.1	87.6	173.1	41.1	38.3	6.75	0.45	0.22	0.33	78.7	0.46	610.3	28.9	439	25.40	111.5
T1	G	24 Jan	5.2	742	175.4	170.0	345.4	95.5	222.2	64.5	63.5	4.10	0.19	0.30	0.53	67.1	0.37	709.9	36.9	346	30.20	104.5
T2	G	24 Jan	5.3	793	214.5	184.9	399.4	112.1	257.5	58.4	57.7	4.71	0.15	0.38	0.89	63.7	0.51	751.6	33.9	366	24.20	88.6
T3	G	24 Jan	4.8	1543	451.8	366.9	818.7	224.5	503.6	124.5	104.0	10.10	0.82	1.11	1.55	92.0	0.96	1553.5	41.0	439	25.40	111.5

Appendix 7. Growing media analyses. Liquid feed trial. *Prunus lusitanica* ‘Myrtifolia’. T1 = 0.5%, T2 = 1.0%, T3 = 2.0%. U=unused, G=ground and UG=unground.

Trt		Date	pH	EC	NH_4-N	NO_3-N	Total N	P	K	Mg	Ca	Fe	Cu	Mn	Zn	Na	B	SO_4	Cl	Density	Dry matter	Dry density
		2019		uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	kg/m^3	%	kg/m^3
Unused		26 Jun	5.5	288	55.8	101.6	157.4	21.8	49.9	32.1	22.1	0.56	0.01	0.14	0.05	15.1	0.22	93.8	16.1	276	36.7	101.3
T1	U	14 Nov	6.5	182	0.6	6.7	6.9	10.5	75.5	6.3	10.4	0.36	0.04	0.01	0.10	40.7	0.20	111.6	95.5	656	15.9	104.3
T2	U	14 Nov	5.3	154	9.9	26.7	36.5	6.3	35.3	18.4	17.3	0.50	0.04	0.03	0.05	27.6	0.09	120.8	52.6	339	28.4	96.3
T3	U	14 Nov	5.7	487	0.7	125.7	126.4	104.3	386.6	35.4	50.0	1.65	0.06	0.14	0.38	44.1	0.47	223.1	87.2	605	17.7	107.1
		2020																				
T1	U	24 Jan	6.6	190	3.3	2.7	6.0	5.5	68.5	12.4	16.3	0.35	0.03	0.03	0.08	65.9	0.18	142.7	125.0	556	16.9	94.0
T2	U	24 Jan	6.1	212	2.1	19.7	21.8	19.4	139.7	11.4	13.1	0.61	0.04	0.03	0.14	48.0	0.19	156.2	95.3	416	20.5	85.3
T3	U	24 Jan	6.3	284	2.5	38.1	40.7	41.6	230.9	12.1	15.9	0.95	0.07	0.05	0.34	51.7	0.39	184.2	102.6	436	22.1	96.4

Appendix 8. Growing media analyses. Liquid feed trial. *Spiraea japonica* ‘Sparkling champagne’. T1 = 0.5%, T2 = 1.0%, T3 = 2.0%. U=unused, G=ground and UG=unground.

Trt		Date	pH	EC	NH_4-N	NO_3-N	Total N	P	K	Mg	Ca	Fe	Cu	Mn	Zn	Na	B	SO_4	Cl	Density	Dry matter	Dry density
		2019		uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	kg/m^3	%	kg/m^3
Unused		26 Jun	5.5	288	55.8	101.6	157.4	21.8	49.9	32.1	22.1	0.56	0.01	0.14	0.05	15.1	0.22	93.8	16.1	276	36.7	101.3
T1	U	14 Nov	6.7	215	0.6	11.0	11.3	14.8	96.1	6.7	11.3	0.38	0.05	0.01	0.12	58.9	0.18	109.8	128.5	689	15.9	109.6
T2	U	14 Nov	5.9	305	0.8	70.2	71.0	33.5	204.4	19.6	24.3	0.72	0.06	0.01	0.17	49.9	0.25	144.7	100.6	678	16.8	113.9
T3	U	14 Nov	5.9	639	7.5	158.7	166.1	122.3	531.1	44.6	41.8	1.89	0.17	0.04	0.35	97.5	0.61	321.5	143.8	704	17.4	122.5
		2020																				
T1	U	24 Jan	7.0	259	1.9	8.4	10.4	15.0	148.6	8.5	12.2	0.44	0.05	0.03	0.11	74.7	0.13	130.3	163.4	720	14.5	104.4
T2	U	24 Jan	6.6	342	4.2	27.0	31.2	32.0	248.7	10.1	11.4	0.59	0.09	0.02	0.18	75.6	0.19	217.0	161.8	741	15.7	116.3
T3	U	24 Jan	6.2	468	2.0	117.2	119.2	92.8	379.8	38.1	42.0	0.59	0.06	0.04	0.16	69.4	0.41	191.4	111.8	452	18.7	84.5

Appendix 9. Growing media analyses. Liquid feed trial. *Geranium* x *cantabrigiense* ‘Westray’. T1 = 0.5%, T2 = 1.0%, T3 = 2.0%. U=unused, G=ground and UG=unground.

		Date	pH	EC	NH_4-N	NO_3-N	Total N	P	K	Mg	Ca	Fe	Cu	Mn	Zn	Na	B	SO_4	Cl	Density	Dry matter	Dry density
Trt		2019		uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	kg/m³	%	kg/m³
Unused		26 Jun	5.5	288	55.8	101.6	157.4	21.8	49.9	32.1	22.1	0.56	0.01	0.14	0.05	15.1	0.22	93.8	16.1	276	36.70	101.30
T1	U	14 Nov	6.3	176	0.6	4.0	4.5	10.0	55.8	3.1	7.4	0.53	0.04	0.01	0.10	66.0	0.05	158.9	66.0	659	17.6	116
T2	U	14 Nov	5.9	296	0.6	19.5	20.0	15.3	142.3	12.7	14.8	1.82	0.06	0.05	0.21	104.7	0.05	307.7	104.9	648	24.2	156.8
T3	U	14 Nov	5.8	650	0.8	202.9	203.7	76.3	478.2	52.2	47.6	1.51	0.12	0.19	0.47	88.9	0.22	255.2	106.4	699	18.7	130.7
		2020																				
T1	U	24 Jan	6.4	148	1.6	1.4	3.0	8.1	68.1	5.4	7.2	0.58	0.03	0.02	0.05	58.7	0.14	138.2	72.6	466	18.7	87.1
T2	U	24 Jan	6.3	223	2.1	6.7	8.8	10.1	130.7	10	11.2	1.21	0.07	0.03	0.23	76.3	0.10	226.7	102.6	410	23.3	95.5
T3	U	24 Jan	6.1	542	2.7	119.0	121.7	66.6	399.3	39.9	46.5	1.59	0.08	0.08	0.33	102.6	0.29	288.6	143.1	688	15.6	107.3

Appendix 10. Growing media analyses. Liquid feed trial. *Tradescantia pallida* ‘Purple Sabre’. T1 = 0.5%, T2 = 1.0%, T3 = 2.0%. U=unused, G=ground and UG=unground.

Trt		Date		EC	NH_4-N	NO_3-N	Total N	P	K	Mg	Ca	Fe	Cu	Mn	Zn	Na	B	SO_4	Cl	Density	Dry matter	Dry density
		2019	pH	uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	kg/m³	%	kg/m³
Unused		26 Jun	5.5	288	55.8	101.6	157.4	21.8	49.9	32.1	22.1	0.56	0.01	0.14	0.05	15.1	0.22	93.8	16.10	276	36.7	101.30
T1	U	14 Nov	5.2	49	1.7	1.6	3.3	6.1	4.9	0.4	2.5	2.06	0.03	0.03	0.02	20.9	0.07	16.4	20.30	674	20.0	134.8
T2	U	14 Nov	5.0	38	0.7	1.1	1.9	10.2	3.7	0.2	2.0	2.00	0.03	0.03	0.02	15.8	0.09	10.4	11.80	472	19.7	93.0
T3	U	14 Nov	4.7	42	0.8	2.0	2.8	17	3.8	0.3	1.7	4.37	0.03	0.02	0.02	20.7	0.15	11.1	9.70	436	22.3	97.2
		2020																				
T1	U	24 Jan	5.8	41	2.3	<0.6	2.8	6.5	2.4	0.4	0.4	1.07	0.03	<0.01	0.02	21.4	0.1	22.7	15.30	466	20.5	95.5
T2	U	24 Jan	5.4	35	2.5	0.6	3.1	4.4	1.7	0.2	<0.1	0.59	0.02	<0.01	<0.02	12.2	0.15	13.3	14.10	450	18.5	83.3
T3	U	24 Jan	5.4	73	5.9	8.2	14.1	22.9	21.5	0.6	0.9	1.67	0.05	0.01	0.04	29.1	0.13	27.3	21.60	468	20.6	96.4

Appendix 11.Tissue analyses. *Prunus lusitanica* 'Myrtifolia'. Liquid feed trial: T1 = 0.5%, T2 = 1.0%, T3 = 2.0%. CRF trial: T1 = 2 g/L, T2 = 4 g/L, T3 = 6 g/L

Treatment		Date	Total N DUMAS % w/w	P mg/kg	K mg/kg	Ca mg/kg	Mg mg/kg	S mg/kg	Mn mg/kg	Cu mg/kg	Zn mg/kg	Fe mg/kg	B mg/kg
Initial		26 /06/2019	0.984	1522	5240	6928	1411	777	16.4	2.7	11.1	44.2	17.3
T1	CRF	14/11/2019	2.439	3170	10427	13952	4527	1407	70.1	2.6	16.5	204.0	25.7
T2	CRF	14/11/2019	2.685	4135	10009	15266	5021	1564	78.7	3.0	19.9	140.0	27.4
T3	CRF	14/11/2019	3.046	5195	11444	15083	5045	1700	84.6	4.3	22.4	129.0	28.5
T1	CRF	24/01/2020	2.172	2501	7861	11279	3300	1294	53.0	2.1	16.1	124.0	23.9
T2	CRF	24/01/2020	2.497	3329	8068	12701	3960	1660	64.1	2.3	17.2	106.0	26.7
T3	CRF	24/01/2020	2.767	4079	9579	13001	4038	1906	66.1	3.2	19.2	113.0	25.8
T1	LF	14/11/2019	2.91	4830	13511	14863	4043	1609	65.8	1.4	15.0	123.0	29.6
T2	LF	14/11/2019	3.551	8075	16756	15013	3952	1716	105.0	2.3	21.1	133.0	29.6
T3	LF	14/11/2019	2.132	6312	23458	27675	7873	2239	68.3	2.2	17.9	88.6	41.1
T1	LF	24/01/2020	2.465	4367	10385	12252	3077	1468	54.6	2.0	18.1	97.7	28.2
T2	LF	24/01/2020	3.162	7629	14895	12650	3142	1724	97.3	2.1	21.0	123.0	29.1
T3	LF	24/01/2020	4.03	8422	20053	12268	2886	2177	101.0	3.0	22.5	103.0	28.8

Appendix 12.Tissue analyses. *Spiraea japonica* 'Sparkling champagne'. Liquid feed trial: T1 = 0.5%, T2 = 1.0%, T3 = 2.0%. CRF trial: T1 = 2 g/L, T2 = 4 g/L, T3 = 6 g/L

Treatment		Date	Total N DUMAS % w/w	P mg/kg	K mg/kg	Ca mg/kg	Mg mg/kg	S mg/kg	Mn mg/kg	Cu mg/kg	Zn mg/kg	Fe mg/kg	B mg/kg
Initial		26 Jun	2.601	5453	18726	11072	1915	1906	115	18.8	97.3	188	43.5
T1	CRF	14 Nov	2.254	2933	12765	20548	7208	1771	547	2.8	32.5	465	27.8
T2	CRF	14 Nov	2.926	4419	16134	19753	6654	2074	361	4.3	43.9	282	26.5
T3	CRF	14 Nov	2.976	4638	16779	20670	6834	2098	358	4.5	47.8	325	26.4
T1	LF	14 Nov	2.745	5471	19158	17615	5066	1891	241	2.8	46.4	107	26.4
T2	LF	14 Nov	3.157	8235	18472	21429	7872	2349	359	3.8	71.1	114	24.4
T3	LF	14 Nov	3.808	9733	34614	15982	6347	2835	320	4.8	65.8	98.7	19.6

Appendix 13. Tissue analyses. *Geranium* x *cantabrigiense* 'Westray'. Liquid feed trial: T1 = 0.5%, T2 = 1.0%, T3 = 2.0%. CRF trial: T1 = 2 g/L, T2 = 4 g/L, T3 = 6 g/L

Treatment		Date	Total N DUMAS % w/w	P mg/kg	K mg/kg	Ca mg/kg	Mg mg/kg	S mg/kg	Mn mg/kg	Cu mg/kg	Zn mg/kg	Fe mg/kg	B mg/kg
Initial		26 Jun	1.541	3302	18162	6751	3047	1244	16.9	2.2	27.5	115	34.8
T1	CRF	14 Nov	1.73	3165	14358	33569	9580	2218	135	2.0	20.3	147	41.1
T2	CRF	14 Nov	1.999	3577	14632	32219	9093	2794	123	2.3	19.7	151	43.4
T3	CRF	14 Nov	2.625	4922	17922	29916	9925	4445	128	3.3	26.1	151	44.1
T1	LF	14 Nov	4.692	9141	22602	13271	3462	2002	111	3.5	27.3	106	30.7
T2	LF	14 Nov	3.167	9960	26998	24126	8085	3307	118	3.5	24.8	119	46.4
T3	LF	14 Nov	3.732	11500	35096	25932	8133	4498	145	4.6	28.8	140	68.9

Appendix 14. Tissue analyses. *Tradescantia pallida* 'Purple Sabre'. Liquid feed trial: T1 = 0.5%, T2 = 1.0%, T3 = 2.0%. CRF trial: T1 = 2 g/L, T2 = 4 g/L, T3 = 6 g/L

Treatment		Date	Total N DUMAS % w/w	P mg/kg	K mg/kg	Ca mg/kg	Mg mg/kg	S mg/kg	Mn mg/kg	Cu mg/kg	Zn mg/kg	Fe mg/kg	B mg/kg
Initial		26 Jun	2.195	4150	28525	24269	16640	4671	153	10.8	71.9	204	18.2
T1	CRF	14 Nov	1.916	2439	9769	46214	20090	8802	114	6.1	33.4	127	27.6
T2	CRF	14 Nov	1.939	2436	7967	44452	18580	8730	106	6.2	31.5	137	30.0
T3	CRF	14 Nov	1.998	2835	10390	44709	16720	9463	108	7.4	36.3	135	29.4
T1	LF	14 Nov	2.019	5164	14376	48001	14990	5804	113	7.6	34.9	163	29.4
T2	LF	14 Nov	2.694	7098	21472	40553	12690	6010	104	10.3	39.8	137	28.8
T3	LF	14 Nov	3.570	8939	30465	35591	10796	6980	116	11.2	43.9	171	31.5

Appendix 15. CRF trial. ADAS Boxworth mains water (10/05/2019) and run-off water NFT analyses (14/11/2019). (NRM). ADAS Mains water: carbonate <10 mg/L; Alkalinity as HCO_3 279 mg/L

Species / Treatment	pH	EC	NH_4-N	NO_3-N	P	K	Mg	Ca	Fe	Cu	Mn	Zn	Na	B	SO_4	Cl
		uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ADAS Boxworth Mains water	7.4	618	-	9.1	1.1	3.0	3.84	111.6	<0.01	<0.01	<0.01	0.03	13.7	0.02	29.4	36.1
Run-off water																
Prunus T1	8.2	1329	0.9	32.0	1.2	20.0	35.0	197.7	0.03	0.01	0.01	0.01	59.3	0.1	181.8	157.5
Prunus T2	8.2	1625	0.2	53.9	2.0	29.0	47.3	221.9	0.05	0.01	0.01	0.03	75.9	0.1	255.9	183.9
Prunus T3	8.3	1920	0.3	81.8	2.7	52.0	63.4	259.4	0.04	0.01	0.01	0.04	81.8	0.2	276.2	186.6
Spiraea T1	8.4	1104	0.3	23.1	1.2	16.0	20.4	185.7	0.03	0.01	0.01	0.01	44.5	0.1	115.4	108.3
Spiraea T2	8.2	1304	0.6	38.5	1.8	24.0	28.9	193.4	0.03	0.01	0.01	0.02	53.8	0.2	149.1	131.7
Spiraea T3	8.2	1412	0.3	54.2	2.4	39.0	39.7	206.0	0.04	0.01	0.01	0.03	56.4	0.2	196.1	130.3
Geranium T1	8.4	1222	0.6	22.8	1.0	18.0	24.0	199.5	0.04	0.01	0.01	0.02	59.7	0.2	175.9	159.5
Geranium T2	8.3	1130	0.3	23.9	1.5	22.0	25.9	176.1	0.04	0.01	0.01	0.01	50.6	0.1	150.6	117.1
Geranium T3	8.4	1456	0.7	44.5	1.0	27.0	28.0	242.1	0.02	0.01	0.01	0.01	61.3	0.1	164.5	144.7
Tradescantia T1	8.4	1023	0.4	22.1	0.9	11.0	13.9	180.1	0.06	<0.01	<0.01	0.01	40.5	0.1	92.3	89.7
Tradescantia T2	8.4	1080	0.2	26.7	0.7	14.0	17.4	171.7	0.07	<0.01	<0.01	0.01	48.0	0.1	103.6	114.4
Tradescantia T3	8.3	1023	0.4	35.3	4.2	19.0	19.4	160.3	0.07	<0.01	<0.01	0.01	38.7	0.1	103.5	87.0

Appendix 16. *Prunus lusitanica* ‘Myrtifolia’. CRF and liquid feed trials - treatment effects

CRF rate		Liquid feed rate	
2 g / L		0.5%	
4 g / L		1%	
6 g / L		2%	

Appendix 17. *Spiraea japonica* ‘Sparkling Champagne’. CRF and liquid feed trials - treatment effects

CRF rate		Liquid feed rate	
2 g / L		0.5%	
4 g / L		1%	
6 g / L		2%	

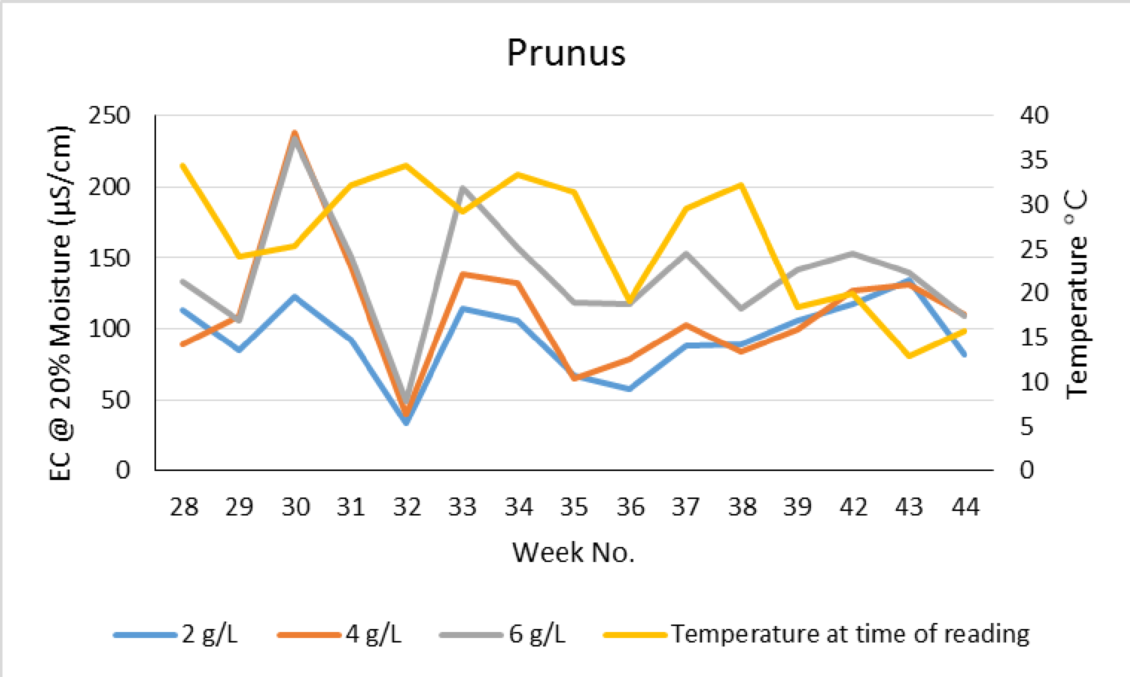
Appendix 18. *Geranium* x *cantabrigiense* 'Westray'. CRF and liquid feed trials - treatment effects

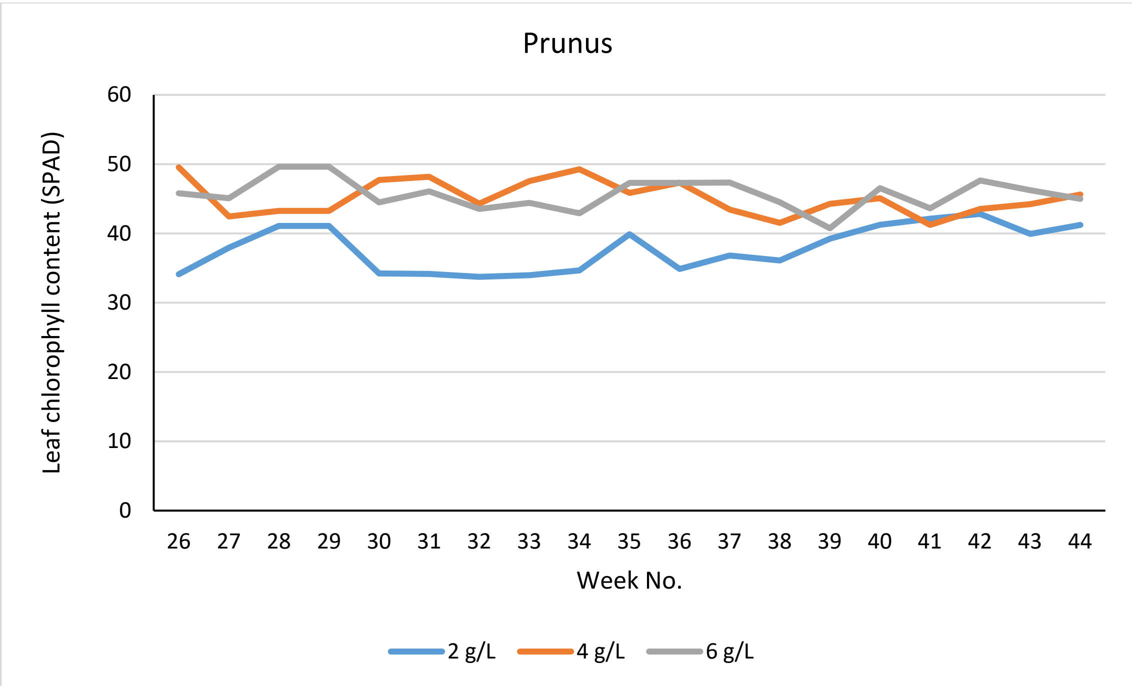
CRF rate		Liquid feed rate	
2 g / L		0.5%	
4 g / L		1%	
6 g / L		2%	

Appendix 19. *Tradescantia pallida* 'Purple Sabre'. CRF and liquid feed trials - treatment effects

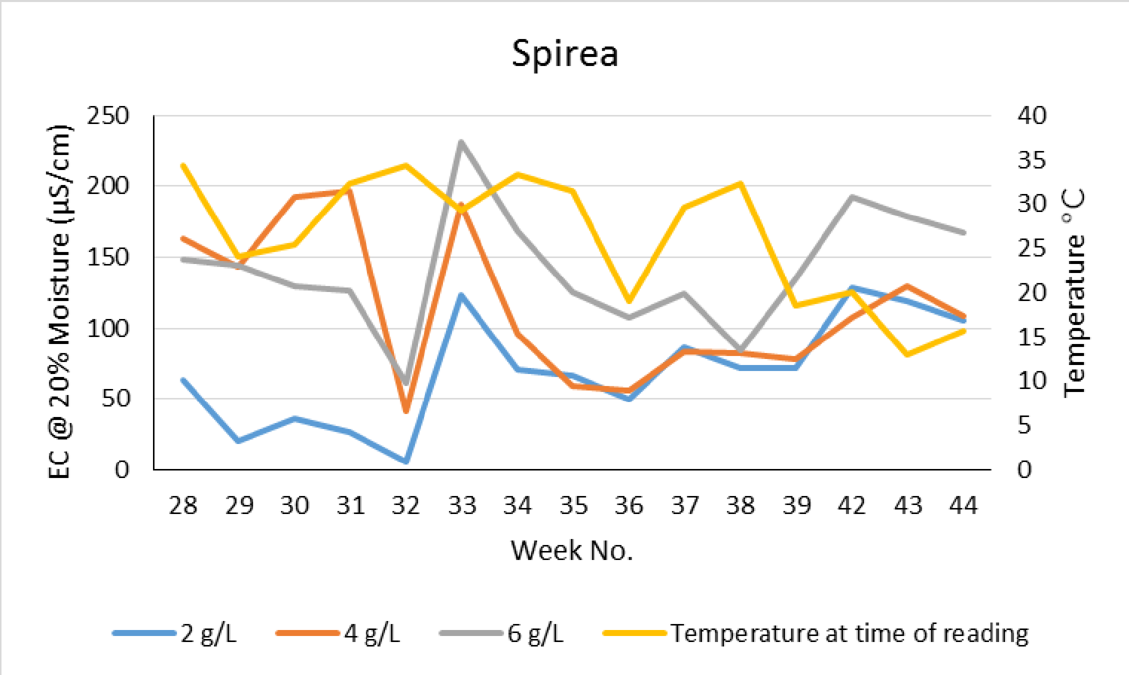
CRF rate		Liquid feed rate	
2 g / L		0.5%	
4 g / L		1%	
6 g / L		2%	

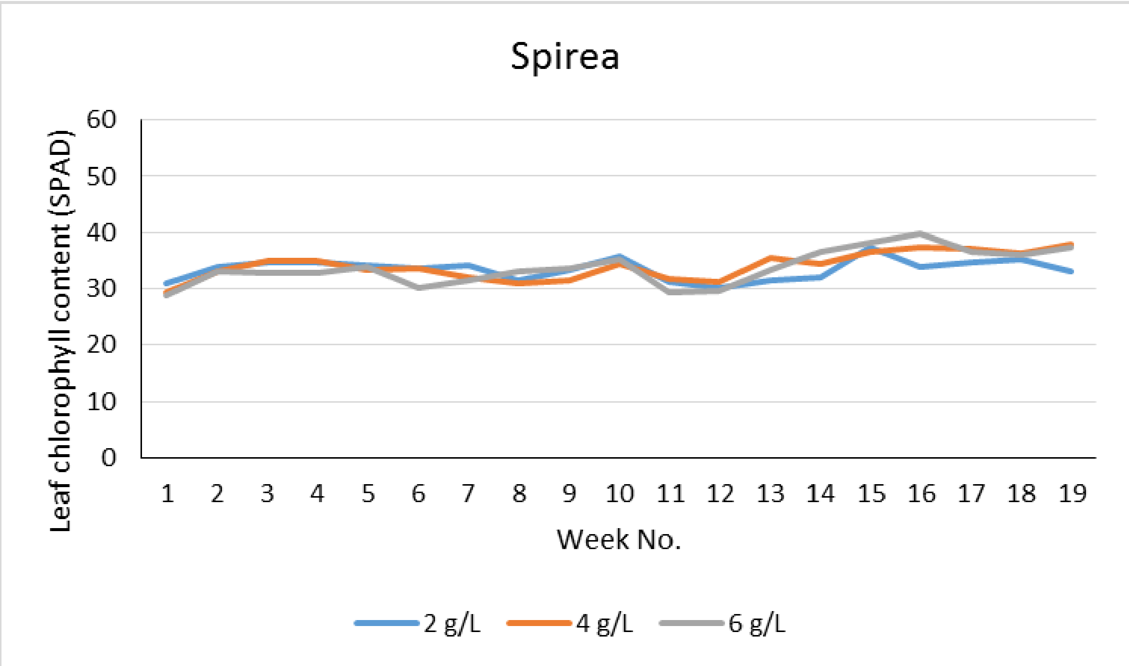
Appendix 20. CRF trial. *Prunus lusitanica* 'Myrtifolia'. Electrical conductivity (EC) adjusted to 20% moisture content, and leaf chlorophyll content (SPAD), measured weekly.



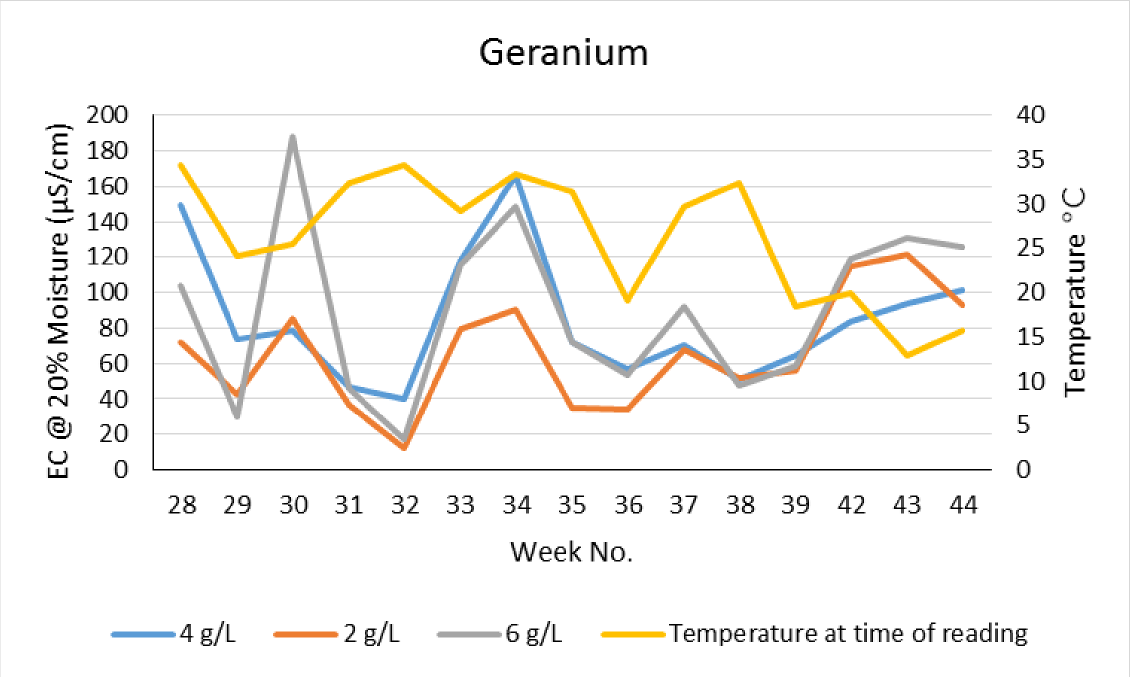


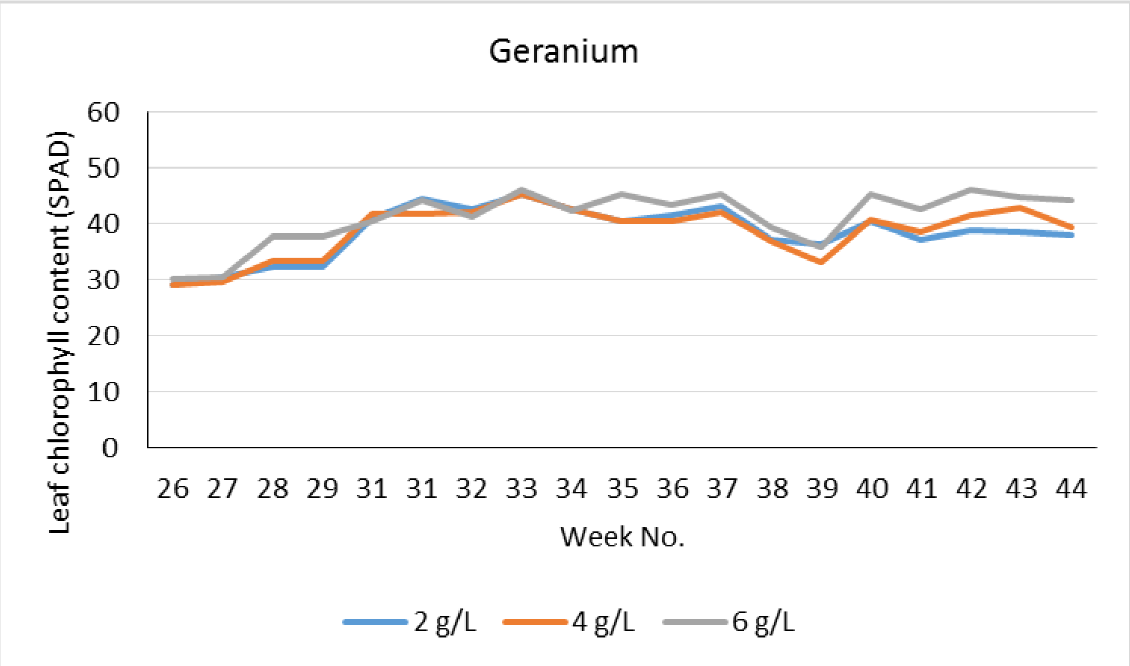
Appendix 21. CRF trial. *Spiraea japonica* 'Sparkling champagne'. Electrical conductivity (EC) adjusted to 20% moisture content, and leaf chlorophyll content (SPAD), measured weekly.



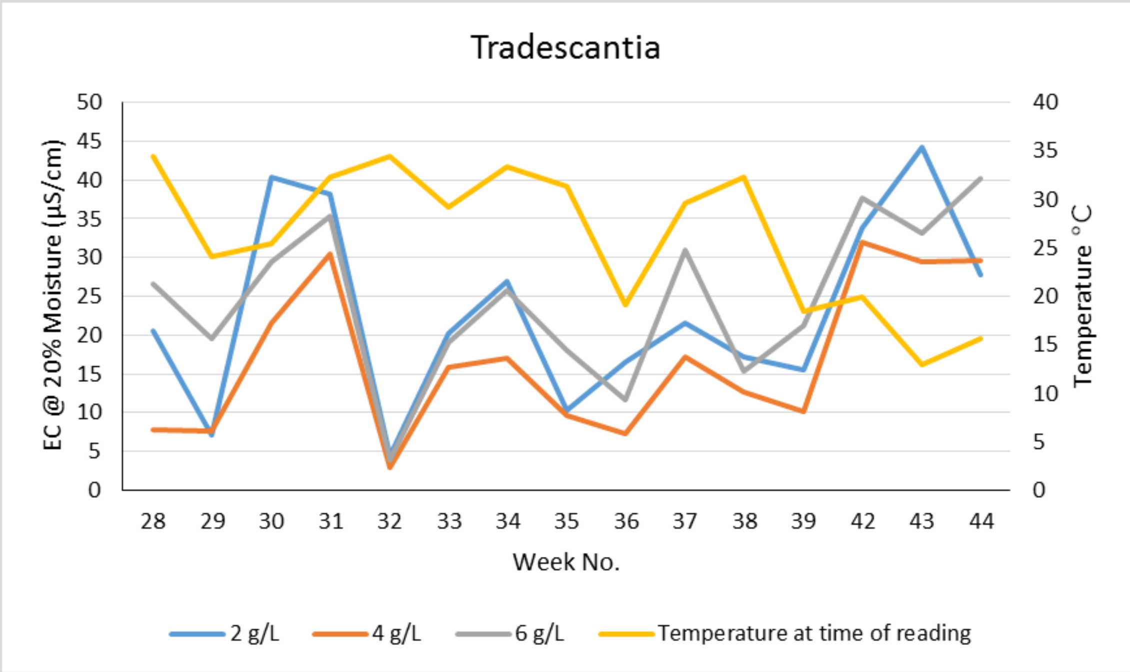


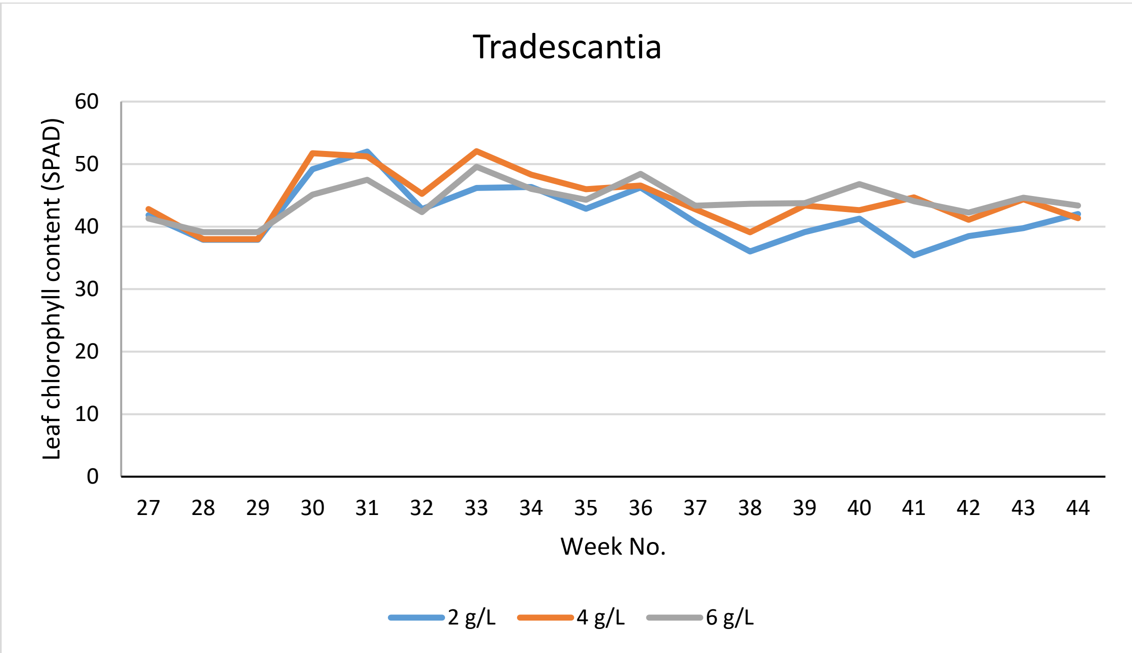
Appendix 22. CRF trial. *Geranium* x *cantabrigiense* 'Westray'. Electrical conductivity (EC) adjusted to 20% moisture content, and leaf chlorophyll content (SPAD), measured weekly.



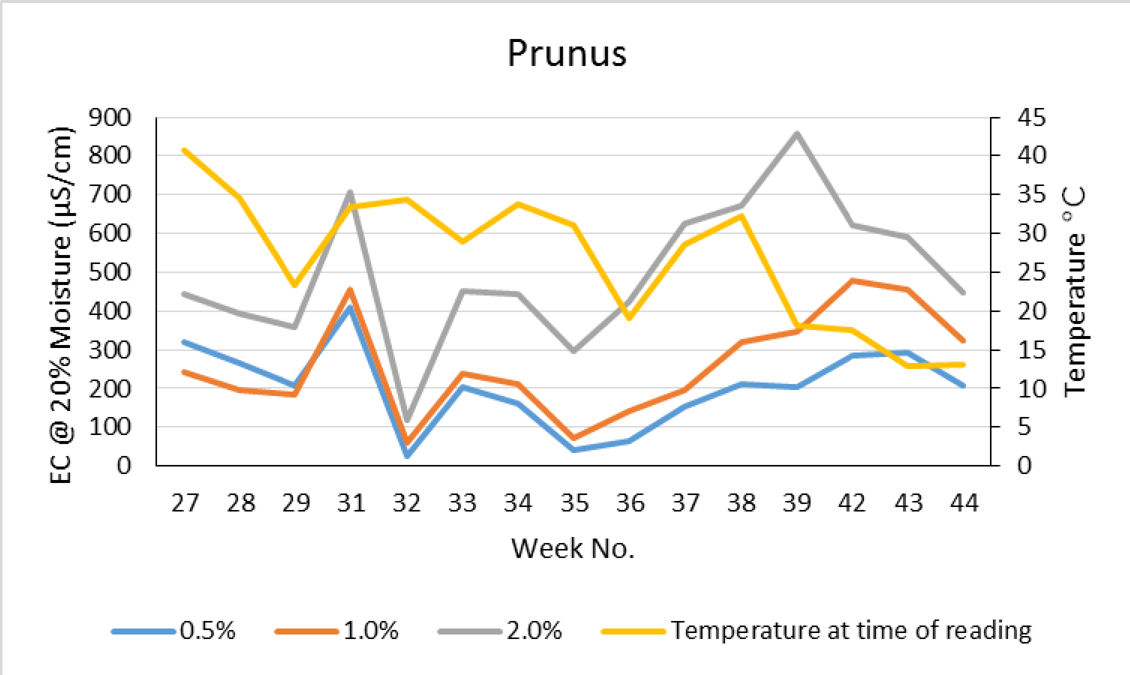


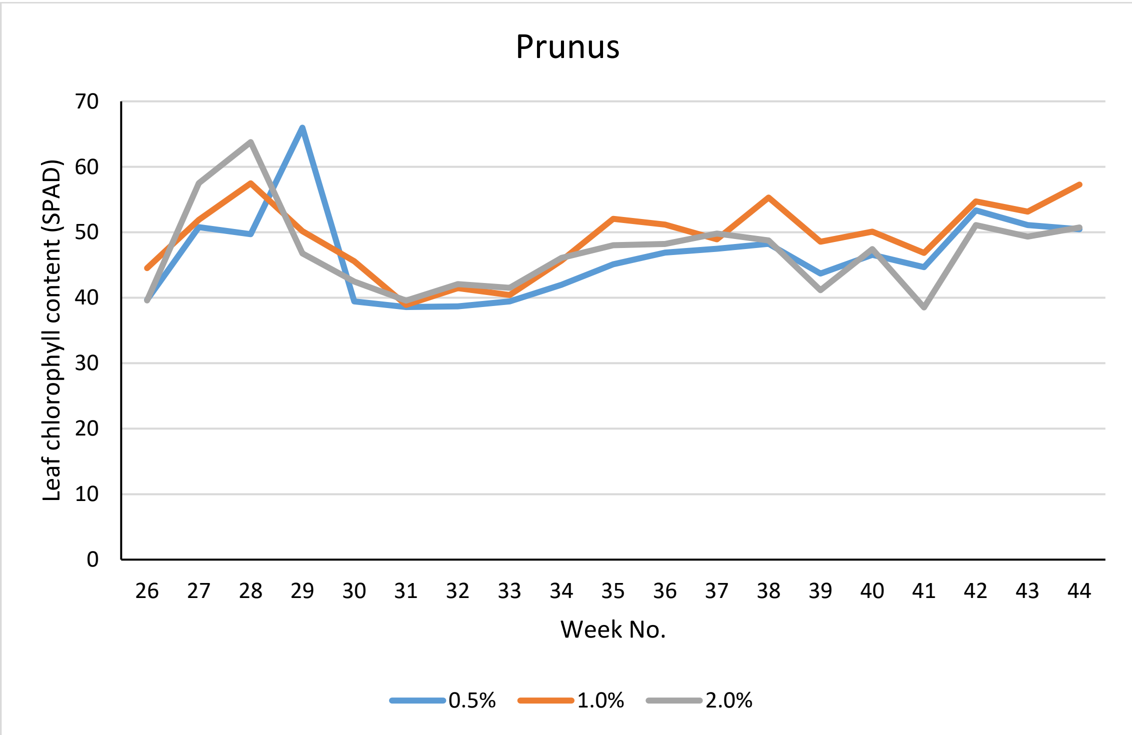
Appendix 23. CRF trial. *Tradescantia pallida* 'Purple Sabre'. Electrical conductivity (EC) adjusted to 20% moisture content, and leaf chlorophyll content (SPAD), measured weekly.



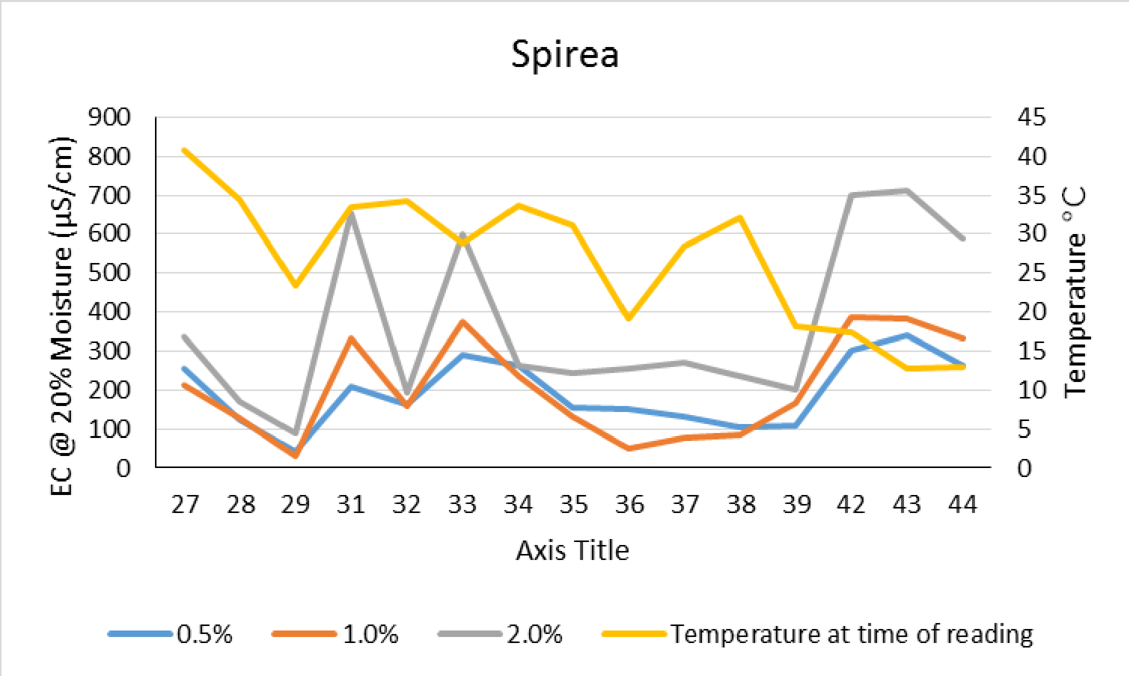


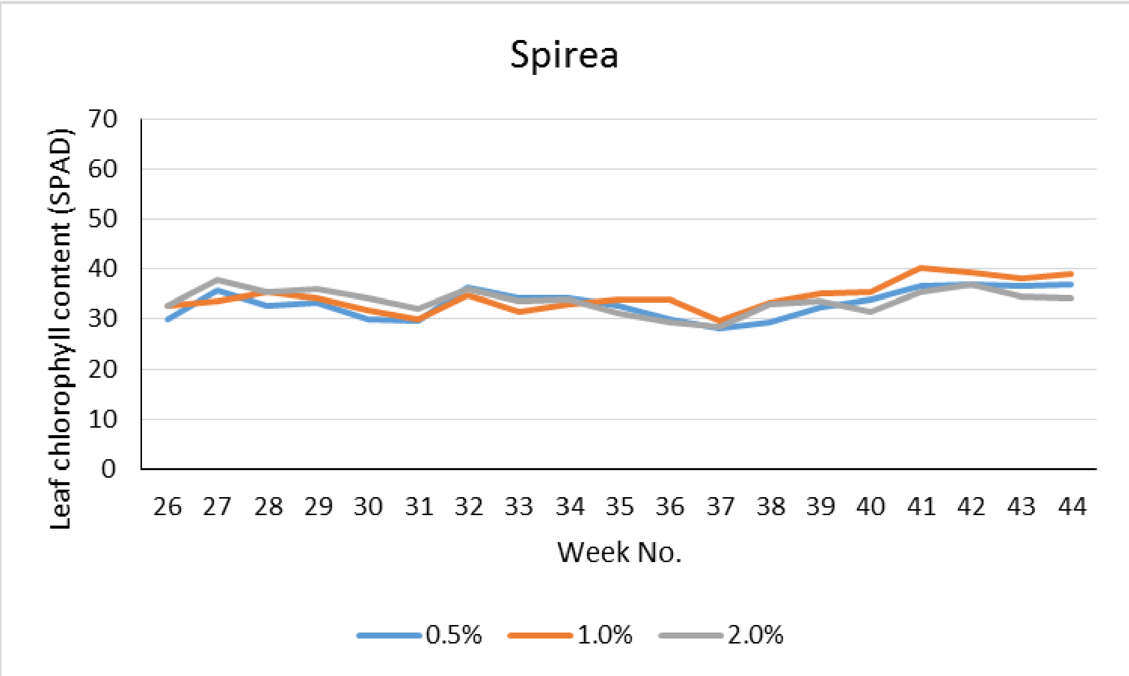
Appendix 24. Liquid feed trial. *Prunus lusitanica* 'Myrtifolia'. Electrical conductivity (EC) adjusted to 20% moisture content, and leaf chlorophyll content (SPAD), measured weekly.



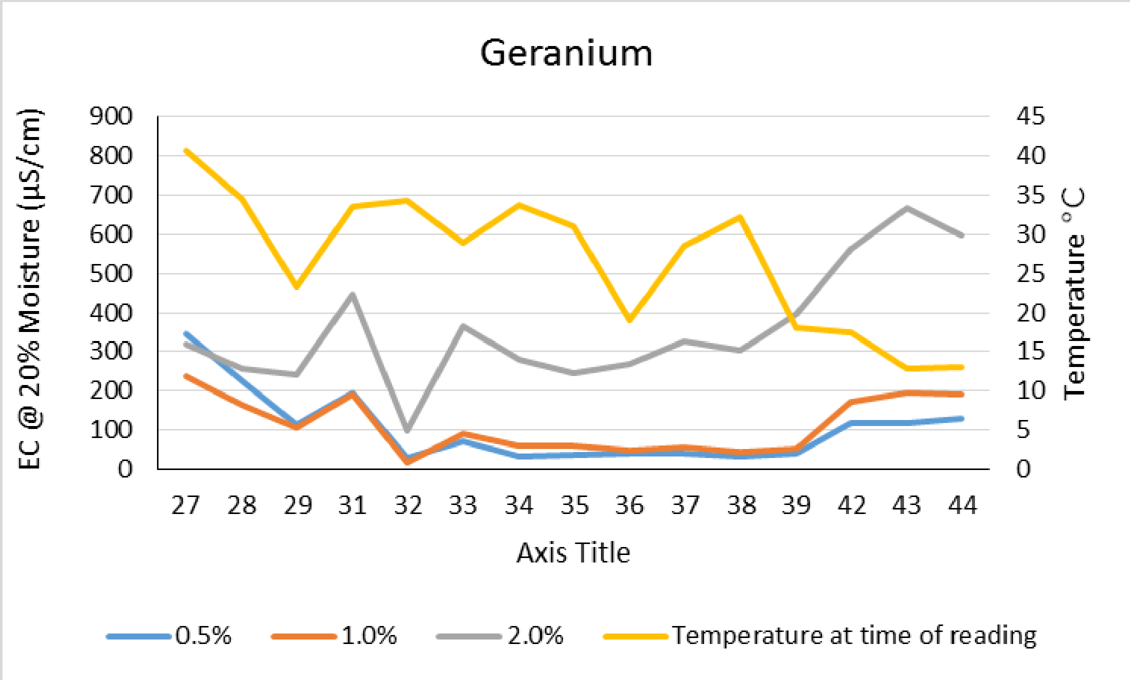


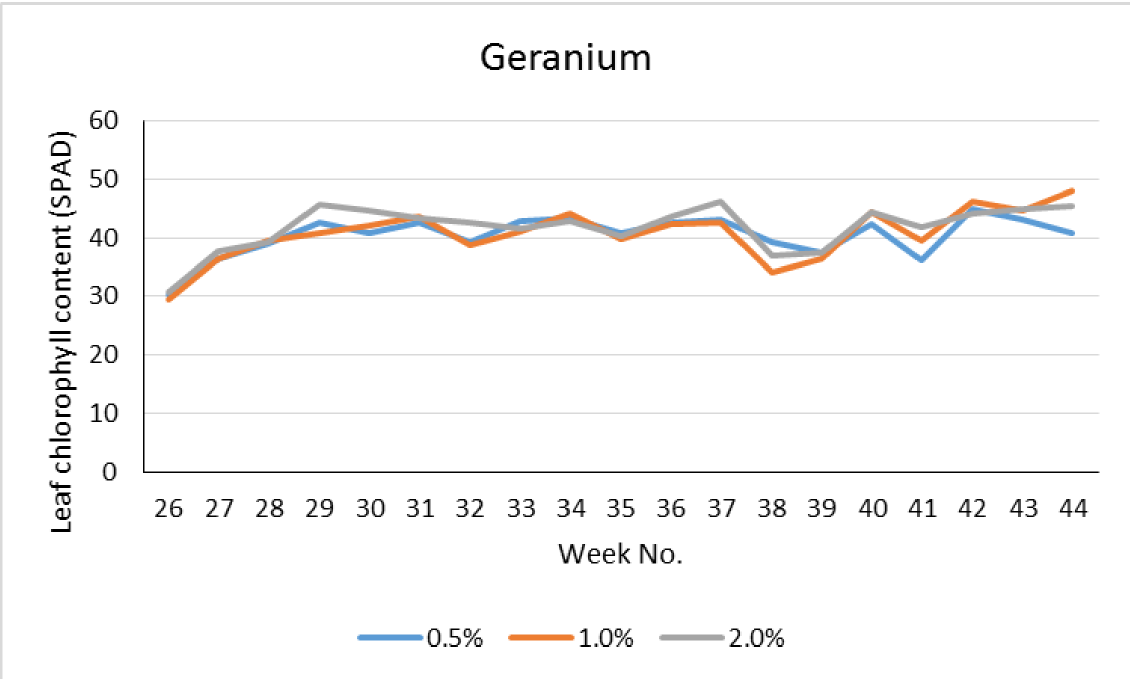
Appendix 25. Liquid feed trial. *Spiraea japonica* 'Sparkling Champagne'. Electrical conductivity (EC) adjusted to 20% moisture content, and leaf chlorophyll content (SPAD), measured weekly





Appendix 26. Liquid feed trial. *Geranium* x *cantabrigiense* 'Westray'. Electrical conductivity (EC) adjusted to 20% moisture content, and leaf chlorophyll content (SPAD), measured weekly.





Appendix 27. Liquid feed trial. *Tradescantia pallida* 'Purple Sabre'. Electrical conductivity (EC) adjusted to 20% moisture content, and leaf chlorophyll content (SPAD), measured weekly.