FINAL REPORT

HNS – Establishing optimal rates of CRF nutrition.

HNS 43f

2000-2002

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HNS 43f: Establishing optimal rates of controlled release fertiliser (CRF) nutrition

1.1 Headline

- Rates of CRF of between 4 and 6 kg/m^3 will optimise growth and quality of both outdoor-grown and polythene tunnel-grown, spring-potted HNS species.
- CRF costs for unheated greenhouse-grown, autumn-potted HNS can be reduced without adverse effects on productivity by adopting an incorporation rate of around 4 kg/m^3.

1.2 Background and expected deliverables

A previous study (HNS 43d) showed that high quality HNS container plants could be grown using any of a range of commercially available CRFs in trial. The study reported here was carried out as a follow-on to identify optimal incorporation rates for one representative CRF formulation. Optimal rates are defined as the lowest rates of incorporation that will still reliably deliver retail-quality plants of a given species in a given production system. Such rates will minimize the costs of applying CRFs, and could have modest environmental benefits in reducing the extent of nutrient leaching from the containers.

The expected deliverables from this work were:

- Recommendations of CRF incorporation rates for a representative range of HNS species, grown in contrasting production systems and in two seasons.
- Indications of leaf nutrient levels associated with zero and near-optimal levels of incorporation of CRF.

1.3 Summary of the project and main conclusions

Experimentation

HNS species were grown at Efford as 3 litre container plants for spring marketing in the following calendar year using three different production systems (a separate range of species in each):

1. Spring-potted liners raised outside on sand-beds with overhead irrigation.
2. Spring-potted liners raised in polythene tunnels on capillary matting with spot watering.
3. Autumn-potted liners raised in an unheated glasshouse on capillary matting with spot watering.

CRF (Osmocote 12-14 Exact Standard 15N, 9P, 9K) was incorporated at potting into the peat-based compost at 0, 2, 4 or 6 kg/m^3, and growth and quality was assessed at the half-grown stage (production systems 1 and 2 only) and at the final marketing stage. Each treatment combination was tested twice (Yrs 1 and 2), and an additional set of containers for production system 1 was assessed in year 1 at a more northerly location (courtesy of Johnson's of Whixley).

Optimal CRF rates are given in Tables 1-3. Note: a score of 4-6 indicates retail quality achieved at 4 kg/m^3, but some further growth/quality enhancement given at 6 kg/m^3.

Optimal CRF rates for species grown outside from a spring potting (Table 1)

Retail-quality plants of all five species were obtained at Efford in year 1 by incorporating CRF at 4 kg/m^3. However, growth and quality were further enhanced in all species except *Cytisus* by increasing CRF to 6 kg/m^3. Optimal rates tended to be slightly higher in year 2 and a rate of 6 kg/m^3 gave markedly better quality plants of *Photinia* and *Vibernum* than 4 kg/m^3. Differences in optimal rate in year 1 between the northern and southern sites were not consistent across species, indicating that geographical location is not an important enough factor to influence general recommendations. Overall, it is recommended that growers adopt the manufacturer's recommended rate for incorporation of CRF, 5 kg/m^3. Given observed variation between years and locations, it would seem unwise to vary incorporation rates with species.

Table 1. Optimal CRF rates (kg/m^3) for HNS species raised outside from a spring potting

Species	Manufacturer's recommended rate	Optimal rate in trial		
		At Efford		At Whixley
		Yr 1	Yr 2	Yr 1
Chamaecyparis lawsoniana 'Ellwoodii'	5	4-6	4-6	4-6
Cytisus x *praecox*	5	4	4-6	4-6
Photinia x *fraseri* 'Red Robin'	5	4-6	6	4
Vibernum tinus 'Eve Price'	5	4-6	6*	4
Weigela 'Red Prince'	5	4-6	4-6	6

* based on half-grown sample only – plants lost on health grounds.

Optimal CRF rates for species grown in polythene tunnels from a spring potting (Table 2)

Optimal rates for the 5 species were very similar in years 1 and 2, being highest in *Choisya* (6 kg/m^3 both years) and lowest in *Pieris* (4 kg/m^3 in year 1, 4-6 kg/m^3 in year 2). Optimal rates were also very similar to those for species raised outside, and exactly the same for the only species common to both growing systems, *Photinia*. The same overall recommendation for CRF incorporation is made as for species raised outside, 5 kg/m^3. This is marginally higher than the manufacturer's recommended rate for species other than *Pieris*.

Table 2. Optimal CRF rates (kg/m^3) for HNS species raised in polythene tunnels from a spring potting

Species	Manufacturer's recommended rate	Optimal rate in trial	
		Yr 1	Yr 2
Ceanothus impressus 'Autumnal Blue'	4.5	4-6	4-6
Choisya ternate	4.5	6	6
Jasminum nudiflorum	4.5	4-6	4
Photinia x *fraseri* 'Red Robin'	4.5	4-6	6
Pieris 'Forest Flame'	3	4	4-6

Optimal CRF rates for species grown in an unheated glasshouse from an autumn potting (Table 3)

Optimal rates tended to be lower than for species potted in spring, and on the basis of this trial, 4 kg/m^3 can be considered an overall optimal CRF incorporation rate for species suited to this production system. This is lower than the manufacturer's recommended rate of 4.5 kg/m^3.

Table 3. Optimal CRF rates (kg/m^3) for HNS species raised in an unheated glasshouse from an autumn potting

Species	Manufacturer's recommended rate	Optimal rate in trial	
		Yr 1	Yr 2
Cistus 'Silver Pink'	4.5	4	4
Euonymous japonicus 'Ovatus Aureus'	4.5	4	--
Euonymous fortunei 'Gold Tip'	4.5	--	2
Hebe 'Red Edge'	4.5	2	4
Lavandula angustifolia 'Hidcote'	4.5	4	4
Lavatera 'Rosea'	4.5	4-6	--

Leaf nutrient levels

Nutrient analyses were carried out on plants growing with zero and near-optimal levels of CRF (generally, 4 kg/m^3) at the half-grown and final marketing stages to derive typical leaf element concentrations associated with sub-optimal and near-optimal nutrition.

Table 4 indicates typical values to be expected under these circumstances, for each of the production systems. Concentrations of N, P and K were about 40% higher in near-optimal CRF pots than in zero CRF pots, with rates somewhat higher in autumn-potted plants than in those potted in spring, particularly for K. As would be expected, values for Ca, Mg and Mn were, in all cases, lower in the near-optimal pots than in the zero CRF pots as a consequence of the preferential uptake of K working in association with the greater availability of K in the near-optimal pots.

Table 4. Leaf nutrient levels for two CRF incorporation rates, 0 and 4 kg/m^3. Data ± S.E.mean are for year 1, averaged over species, sampling occasion and location

Nutrient	CRF rate (kg/m^3)	Spring-potted, Outside*	Spring-potted, Polythene tunnel	Autumn-potted, Unheated g'house**
N (%)	0	1.0 ± 0.10	0.9 ± 0.09	1.1 ± 0.13
	4	1.3 ± 0.10	1.3 ± 0.10	1.6 ± 0.18
P (%)	0	0.11 ± 0.008	0.11 ± 0.014	0.13 ± 0.033
	4	0.16 ± 0.012	0.16 ± 0.021	0.18 ± 0.023
K (%)	0	1.1 ± 0.11	1.4 ± 0.20	1.7 ± 0.43
	4	1.5 ± 0.12	2.0 ± 0.25	2.2 ± 0.41
Ca (%)	0	1.3 ± 0.11	1.9 ± 0.23	1.4 ± 0.23
	4	1.1 ± 0.12	1.4 ± 0.16	1.1 ± 0.10
Mg (%)	0	0.43 ± 0.04	0.41 ± 0.05	0.59 ± 0.15
	4	0.34 ± 0.04	0.30 ± 0.04	0.51 ± 0.11
Mn (mg/kg)	0	274 ± 72	291 ± 88	170 ± 63
	4	98 ± 16	158 ± 48	97 ± 21

* the higher CRF rate for *Chamaecyparis* at Efford and Whixley, and for *Weigela* at Whixley was 6 kg/m^3; ** the higher CRF rate for all species except *Lavatera* was 2 kg/m^3

1.4 Financial benefits

In all cases, recommended CRF rates are rather close to the manufacturer's recommended rates, so it is unlikely that major savings of CRF can be made as a result of this research. However, it is worth noting that for CRF at £50 per 25 kg, the cost of incorporation at 5 kg/m^3 is about 3 pence per 3 litre pot. Reducing the rate of incorporation to 4 kg/m^3 will, therefore, save 0.6 pence per pot. Given that about 50 million pots are grown each year, such a reduction in CRF use would save £300k p.a. on an industry-wide basis.

1.5 Action points

- Review current CRF incorporation rates. For spring-potted HNS species, rates around 5 kg/m^3 can be expected to be optimal. For autumn-potted crops in unheated glass, a lower rate of around 4 kg/m^3 is likely to be adequate.
- Carry out regular nutrient analyses and establish nutrient concentrations under your production system that can be associated with sub-optimal and near-optimal nutrition. Analyses at the half-grown stage will allow remedial action to be carried out.

2. Science Section

2.1 Introduction

A study carried out during 1998/99 (HNS 43d) tested a range of controlled release fertilisers (CRFs) available at that time. This concluded that differences between CRFs, whilst statistically significant, were not large enough to warrant a recommendation that any one fertiliser was better than any other. HNS producers ought to be able to produce saleable plants with any of the CRFs tested, given application at manufacturers' recommended rates. However, in some cases manufacturers' recommended rates have appeared to be rather high. Thus, in HNS 43e, *Weigela* and *Viburnum tinus* produced plants of equal quality at 4 kg/m^3 of 12-14 month CRF as at the recommended 6 kg/m^3. It may be possible, therefore, to use reduced incorporation rates in some cases and so reduce costs and reduce nutrient leaching from containers.

There are three main HNS production systems, all for spring sales in the following year: 1) spring-potted, raised outside; 2) spring-potted, raised under plastic; 3) autumn-potted, raised in unheated glass. The environments in which plants grow in these three systems can differ appreciably, and this can affect CRF requirements. This is particularly so since the supply of nutrients to plants by CRF is mediated mainly by temperature and moisture. It is clearly necessary to derive CRF recommendations separately for each of the three production systems.

Currently, information on foliage nutrient levels associated with optimal and sub-optimal nutrition is sparse. However, indications along these lines would be very helpful as a spot check diagnostic during production.

2.2 Objectives

The overall aim of the project was to provide information to enable growers to produce quality HNS at the lowest CRF cost. The main specific objectives were:

1. To establish the lowest rates of CRF application giving retail-quality HNS for a range of species growing in contrasting production systems.
2. To establish a database of foliage nutrient levels associated with optimal and sub-optimal nutrition.

2.3 Materials and Methods

Three production environments were studied at HRI-Efford (50°44'N, 1°34'W):

1. spring-potted, raised outside
2. spring-potted, raised in polythene tunnels
3. autumn-potted, raised in an unheated glasshouse.

Young plants (9 cm liners) were transplanted to 3 litre containers at each potting: week 17 for spring-potting and week 17 for autumn-potting.

In year 1 of the study, the spring-potted plants raised outside at HRI-Efford were also grown at Johnson's of Whixley, near York (53°59'N, 1°10'W). The young plants, compost and treatments were as identical as possible at each site to allow direct comparison of CRF needs in both a southern and northern growing environment.

One species, *Photinia x fraseri* 'Red Robin', was common to both of the spring potted production systems, allowing direct comparison of CRF needs in the two growing environments.

Outside-raised plants were on Mypex covered sandbeds (Efford) or on gravel beds (Whixley), and were watered overhead. Plants raised under protection were on capillary matting with spot watering.

Species:

Spring-potted and raised outside:

Chamaecyparis lawsoniana 'Ellwoodii'
Cytisus x praecox
Photinia x fraseri 'Red Robin'
Viburnum tinus 'Eve Price'
Weigela 'Red Prince'

Spring-potted and raised in polythene tunnels

Ceanothus impressus 'Autumnal Blue'
Choisya ternata
Jasminum nudiflorum
Photinia x fraseri 'Red Robin'
Pieris 'Forest Flame'

Autumn-potted and raised in an unheated glasshouse

Cistus 'Silver Pink'
Hebe 'Red Edge'
Lavandula angustifolia 'Hidcote'
Euonymous japonicus 'Ovatus Aureus' (year 1 only)
Euonymous fortunei 'Gold Tip' (year 2 only)
Lavatera 'Rosea' (year 1 only)
Lavatera thuringiaca 'Memories' (year 2 only)

CRF treatments:

One representative CRF was chosen for this work, Osmocote 12-14 Exact Standard (15N+9P+9K+traces). This was incorporated into compost at the time of potting at rates of 0, 2, 4 and 6 kg/m^3. Compost was 100% Irish premium peat with 1.5 kg/m^3 Mg lime (adjusted for ericaceous species and conifers) and 750 g/m^3 suSCon green for vine weevil control.

Experimental Design

Treatments for each production system in each year (and site) were arranged using a randomised block design with three replications per treatment.

Spring outside: 5 species x 4 CRF treatments x 3 replications = 60 plots
Spring under plastic: 5 species x 4 CRF treatments x 3 replications = 60 plots
Autumn under glass: 5 species x 4 CRF treatments x 3 replications = 60 plots

Each plot comprised 10 plants, six of which were recorded and 4 of which served as guards.

Assessments

Spring-potted plants were assessed on two occasions, once in autumn and once at marketing in the following spring. Autumn-potted plants were assessed only at final marketing. Each species was assessed independently and the assessed variables were chosen specifically for a given species to show up observed differences in plant growth and development. In discussion of the data, an optimal CRF rate of 4-6 kg/m^3 indicates that retail quality is likely to be achieved at 4 kg/m^3, but some further growth/quality enhancement can be expected at 6 kg/m^3.

Full data sets are given in Appendix 3.2. In some cases (eg *Chamaecyparis*) objective size measurements were made, but most characters were scored subjectively by visual comparison with selected reference plants using a 1-5 scale, with 1 being the lowest score and 5 being the highest score. Whether all intermediate scale points were used depended on the extent of the variation encountered at that particular assessment. Thus, a scale of 1-5 was used when there was sufficient variation for five scale points to be recognized (i.e, plants were scored as either 1, 2, 3, 4 or 5), whilst a scale of 1,3,5 was used when there was less variation and only three scale points could be recognized. A scale of 1,5 was used when only two scale points could be recognized. In a few cases, a scale point 7 was added for plants that were clearly larger or more vigorous than any that had been scored as 5 in earlier assessments. For characters such as tip scorch, a 0 scale point was added to indicate an absence of the trait in question. Reference plants were put back into the trial after scoring had been completed. All plants of a given species were recorded against the same set of reference plants. Thus in year 1, the reference plants used at Efford were also used at Whixley and then returned to Efford. Scores at the two sites were, therefore, directly comparable. Dry weight determinations were made on three random plants per plot at the final spring assessments.

Several of the spring-potted species (*Ceanothus* and *Jasminium* in year 1*, Choisya, Photinia* and *Weigela* in both years) were trimmed back to a standard size after the autumn assessment. Dry weights of the plant trimmings were recorded.

Foliage analysis
Nutrient analyses were carried out on plants growing with 0 and 4 kg/m^3 CRF (occasionally 2 or 6 kg/m^3 – see Appendix 3.3) at the half-grown (spring-potted) and final marketing stages (spring and autumn-potted) in year 1 to derive typical leaf element concentrations associated with sub-optimal and near-optimal nutrition.

2.4 Results

2.4.1 CRF rates for spring-potted species, raised outside

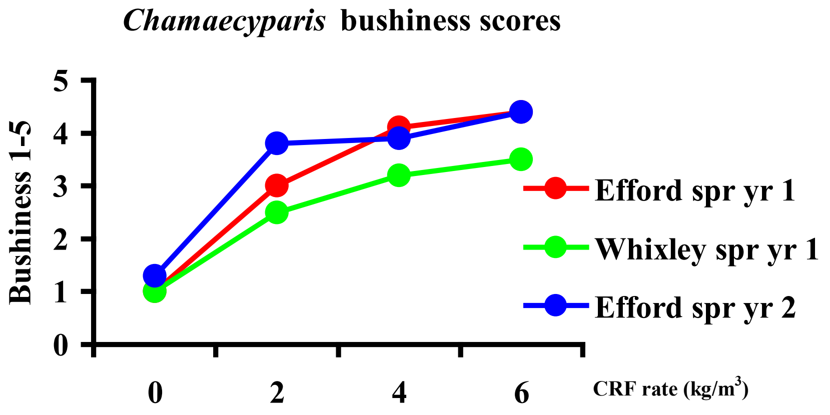
Note that harvest data means are given in Appendix 3.2.1

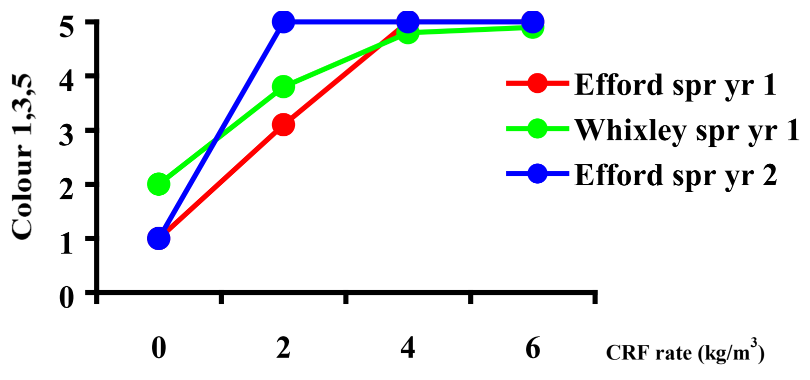
a) *Chamaecyparis lawsoniana* 'Ellwoodii'

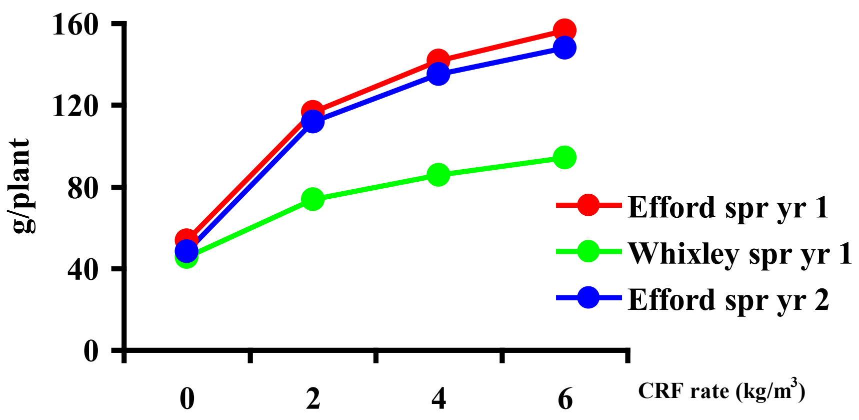
Key recorded parameters were bushiness (overall size), height, plant colour, incidence of tip scorch and biomass (dry weight). Trends are presented for bushiness, colour score and biomass at the final spring sample, and plates show the appearance of plants at marketing at Efford.

The intermediate, autumn sample at Efford (both years) and at Whixley showed that bushiness increased with increase in CRF rate to 4 kg/m^3, but that this parameter was not further significantly increased at 6 kg/m^3. However, bushiness was significantly greater at 6 kg/m^3 by the time of the final spring sample in each case. Plant height was also significantly greater at 6 kg/m^3 at the final sample at Efford, but not at Whixley or at Efford in year 2. In these cases, 4 kg/m^3 was optimal. 4 kg/m^3 was also optimal for colour score at the final spring sample in all cases. Use of CRF at any of the trialled rates increased tip scorch over the unfertilized control at the first autumn sample at both sites, but was not significantly greater at either 4 or 6 kg/m^3 than at 0 kg/m^3 by the time of the final spring sample. Plant biomass, an indicator of overall photosynthetic growth, increased with increase in CRF over the whole range tested, but was markedly lower at Whixley than at Efford. However, there is no known relationship between absolute plant dry weight at marketing and subsequent plant performance after growing on.

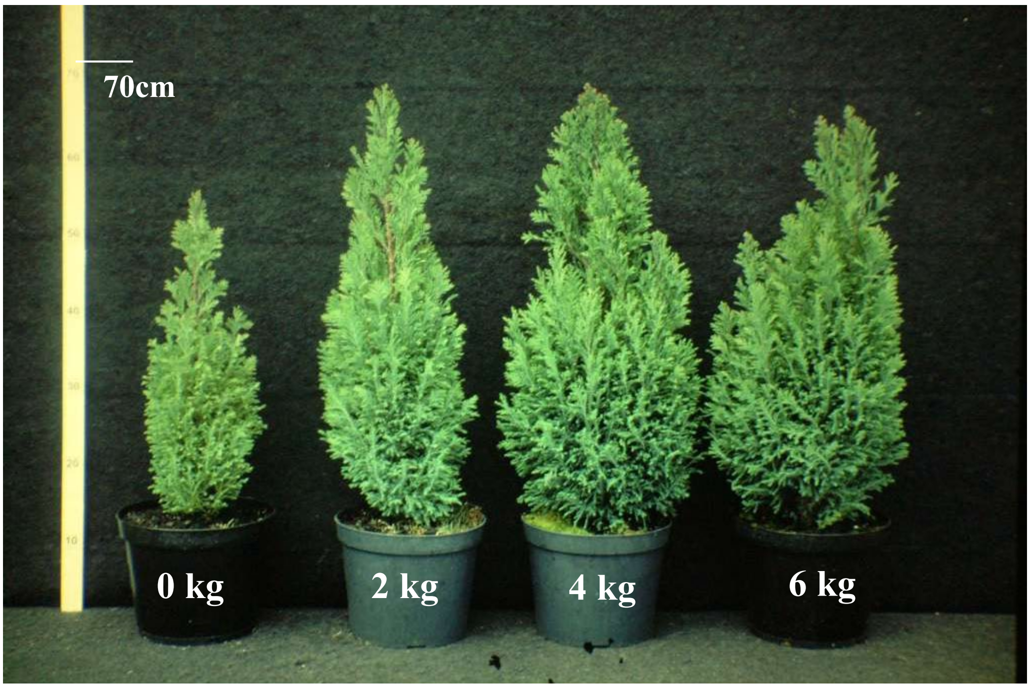
It was concluded that a CRF rate of 4 – 6 kg/m^3 was optimal for spring-planted, outside-raised plants of *Chamaecyparis*. This was in line with the manufacturer's recommended rate of 5 kg/m^3.







Chamaecyparis lawsoniana ‘Ellwoodii’ Year 1 Efford - Spring 2001



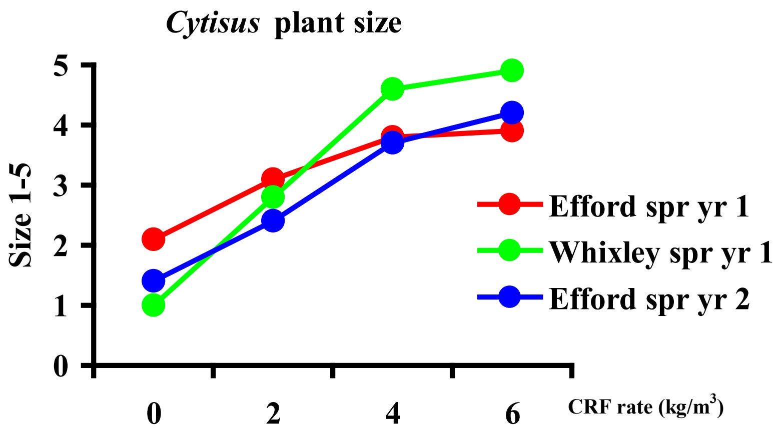
Chamaecyparis lawsoniana 'Ellwoodii' Year 2 Efford - Spring 2002

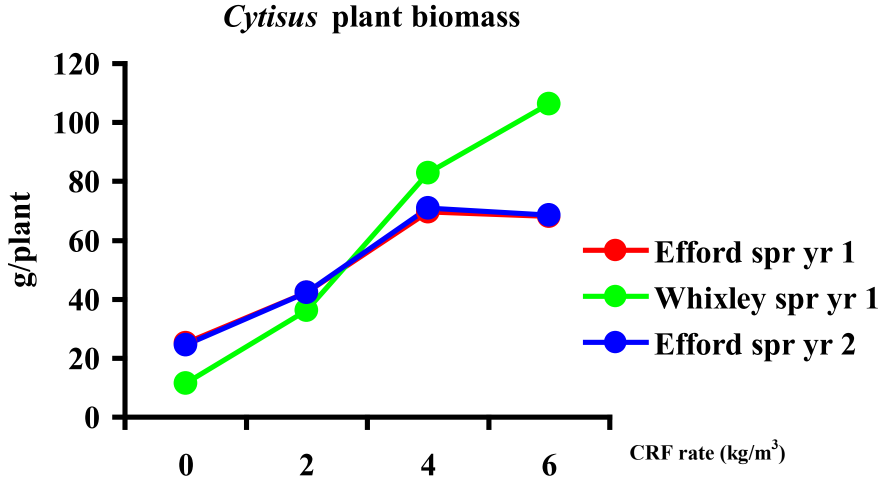
b) *Cytisus x praecox*

Key recorded parameters were comparative size, vigour (year 1, autumn only), flowering (Efford year 1, spring only) and final biomass. Trends are presented for final size and biomass, and plates show "average" plants at marketing at Efford in both years.

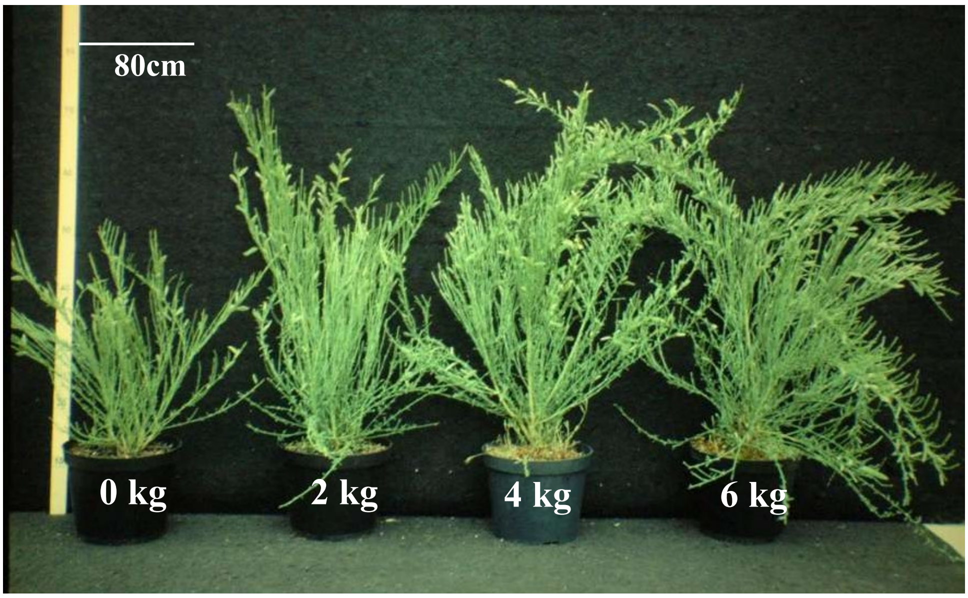
The optimal CRF rate for plant size was 4 kg/m^3 at the autumn harvest at Efford in both years, and at the final spring harvest at Efford in year 1. However, plants were significantly larger at 6 kg/m^3 by the final harvest at Efford in year 2. Plants were also larger at 6 kg/m^3 at the autumn sample at Whixley but this advantage was not maintained. Thus, plants at this site were no larger at 6 kg/m^3 than at 4 kg/m^3 by the final spring sample. In terms of final biomass, a CRF rate of 4 kg/m^3 proved optimal at Efford in both years 1 and 2, but much greater growth was achieved at Whixley at 6 kg/m^3. An interesting observation was the earlier flowering achieved in the 0 and 2 kg/m^3 CRF rates in year 1 at Efford. Clearly, flowering in this species is promoted by sub-optimal nutrition.

It was concluded that a CRF rate of 4 kg/m^3 was optimal for spring-planted, outside-raised plants of *Cytisus* at Efford in year 1, but that a higher rate, up to 6 kg/m^3, was optimal at Whixley and at Efford in year 2. This broadly matched the manufacturer's recommended rate of 5 kg/m^3.





Cytisus x praecox Year 1 Efford - Spring 2001



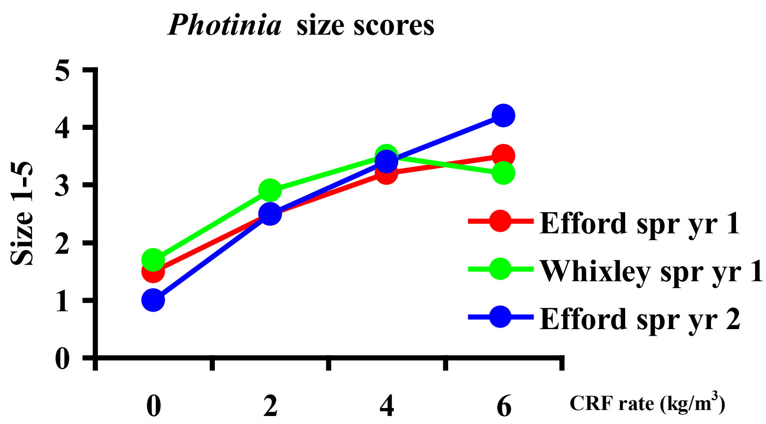
Cytisus x praecox Year 2 Efford - Spring 2002

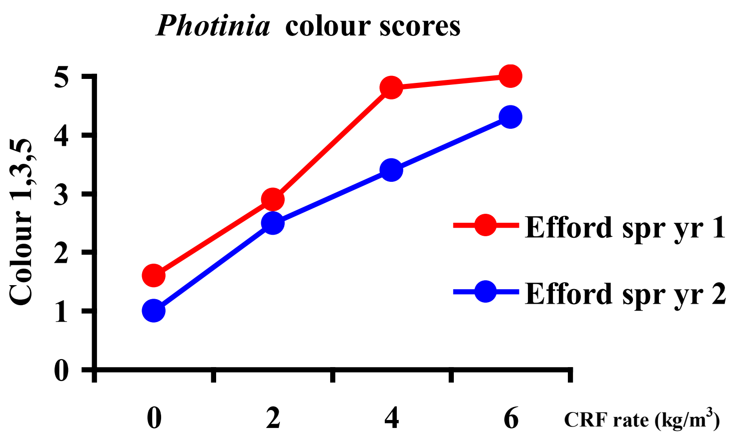
c) *Photinia x fraseri* 'Red Robin'

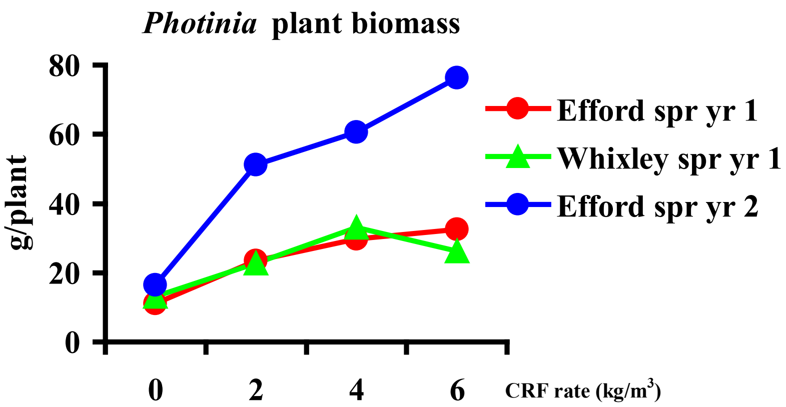
Key recorded parameters were comparative size, plant colour and new growth (except at final sampling at Whixley), number of main shoots (autumn sample at both sites in year 1) and final biomass (plus dry weight of trimmings in year 1). Trends are presented for final size, colour and biomass, and plates show plates show "average" plants at marketing at Efford in both years.

The optimal CRF rate for plant size was 4 kg/m^3 in year 1, although plants were initially larger at the 6 kg/m^3 rate at Whixley. It was noted that four plant deaths occurred at Whixley at this highest rate of CRF, compared to only one at 4kg/m^3 and none at lower rates. It was thought possible that the excessively fleshy growth on these larger plants was more prone to frost damage over winter causing plant deaths and a reduction in the growth benefits apparent in the autumn. In year 2, final plant size was greatest at 6 kg/m^3. Plants also had better (darker) colour at marketing at the 6 kg/m^3 rate at Efford in year 2, but there was no advantage of applying rates higher than 4 kg/m^3 at Efford in year 1. There was no final colour assessment at Whixley, but plants had best colour at 4 kg/m^3 at the intermediate, autumn sample. Plant biomass was extremely variable, and only in year 2 did there appear any benefit of increasing the CRF rate above 4 kg/m^3.

It was concluded that a CRF rate of 4 kg/m^3 was optimal for spring-potted, outside-raised plants of *Photinia* at Whixley in year 1, 4-6 kg/m^3 was optimal at Efford in year 1, and 6 kg/m^3 was optimal at Efford in year 2. These findings were in line with the manufacturer's recommended rate of 5 kg/m^3.


Photinia size scores
Size 1-5
5
4
3
2
1
0
0
2
4
6
CRF rate (kg/m³)
Efford spr yr 1
Whixley spr yr 1
Efford spr yr 2


Photinia colour scores
Colour 1,3,5
5
4
3
2
1
0
0
2
4
6
CRF rate (kg/m³)
Efford spr yr 1
Efford spr yr 2


Photinia plant biomass
g/plant
80
60
40
20
0
0
2
4
6
CRF rate (kg/m³)
Efford spr yr 1
Whixley spr yr 1
Efford spr yr 2

Photinia x fraseri 'Red Robin' Year 1 Efford - Spring 2001

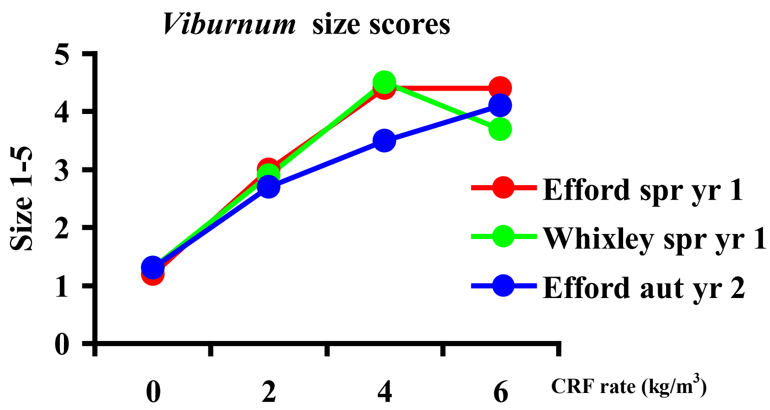
Photinia x fraseri 'Red Robin' Year 2 Efford - Spring 2002

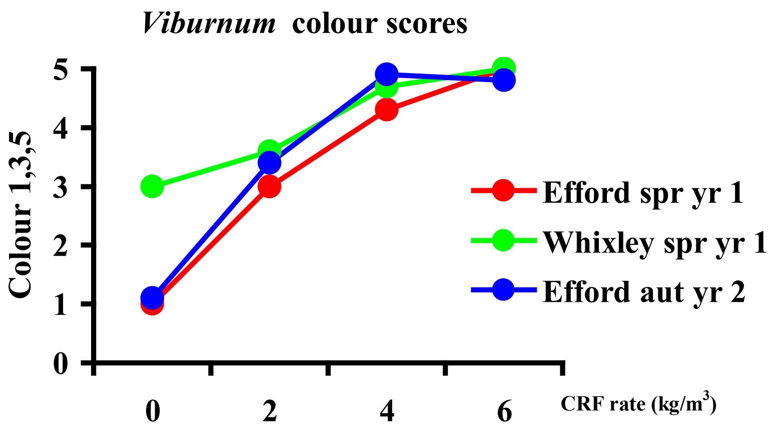
d) *Viburnum tinus* 'Eve Price'

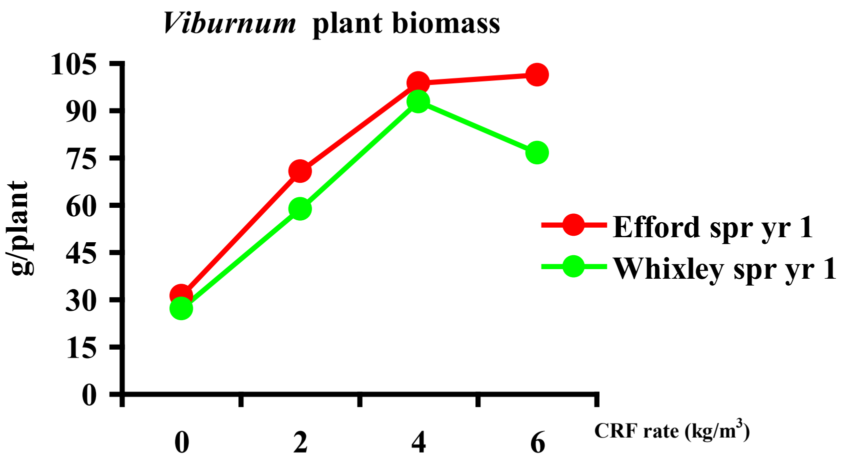
Key recorded parameters were comparative size, plant colour, flowering, new growth and final biomass. Trends are presented for size, colour and biomass, based on data from the final, spring sample in year 1 and the autumn sample at Efford in year 2. There was no spring sample in year 2 because plants had to be removed from trial due to the incidence of *Phytophthora ramorum* (Sudden Oak Death). Plates show "average" plants at marketing at Efford and Whixley in year 1.

Optimum CRF rate for plant size in year 1 was 4 kg/m^3 at both the autumn and spring samples at Efford and at Whixley. Indeed, at Whixley, plant size was significantly depressed at both sample times at 6 kg/m^3. In contrast, size was significantly enhanced at the 6 kg/m^3 rate at Efford in year 2 (autumn tested only). Plant colour was generally enhanced at the highest rate, 6 kg/m^3. 4 kg/m^3 proved the optimal CRF rate for biomass, with either no significant improvement at the higher rate (Efford year 1) or a marked decline at the higher rate (Whixley, year 1). This rate also optimized new growth, and a rate of 2 kg/m^3 or higher enhanced flowering.

It was concluded that, like *Photinia*, a CRF rate of 4 kg/m^3 was optimal for spring-potted, outside-raised plants of *Vibernum* at Whixley in year 1, 4-6 kg/m^3 was optimal at Efford in year 1, and 6 kg/m^3 was optimal at Efford in year 2. These findings were in line with the manufacturer's recommended rate of 5 kg/m^3.







Viburnum tinus ‘Eve Price’ Year 1 Efford - Spring 2001

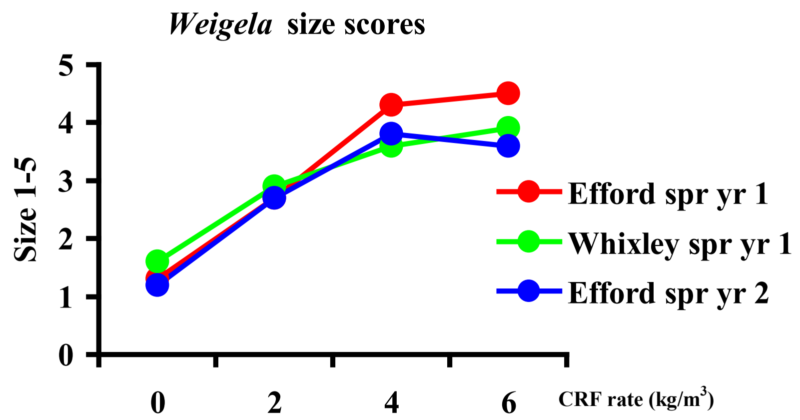
Viburnum tinus ‘Eve Price’ Year 1 Whixley - Spring 2001

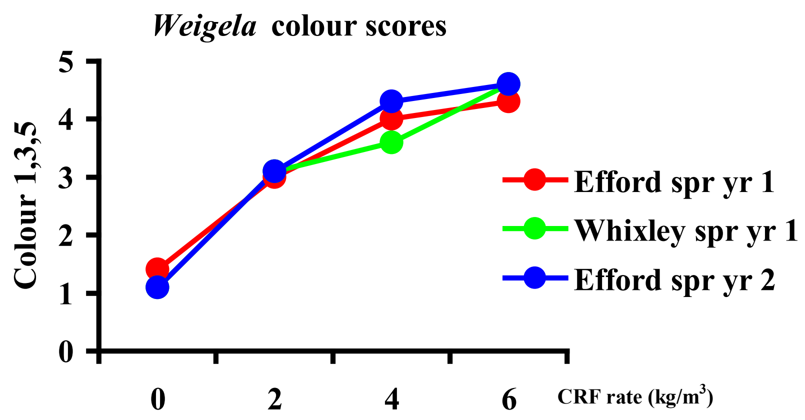
e) *Weigela* ‘Red Prince’

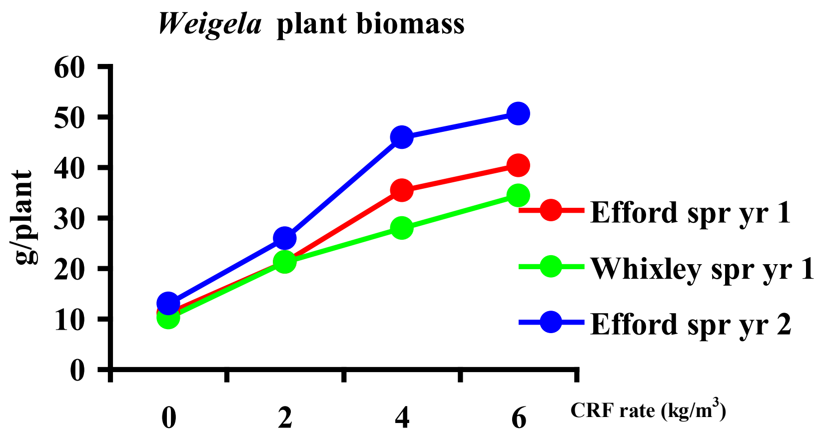
Key recorded parameters were comparative size, plant colour, flowering and final biomass. Trends are presented for size, colour and biomass, based on data from the final, spring samples and plates show “average” plants at marketing at Efford and at Whixley in year 1.

A CRF rate of 4 kg/m^3 was optimal for plant size at Efford in both years and on both sampling occasions. This was also the case at the final spring sample at Whixley, but early increase in size was greater at this site at 6 kg/m^3. Colour was generally best at the highest rate, 6 kg/m^3, particularly at Whixley, as was final biomass. Flowering was hardly affected by CRF rate.

It was concluded that the optimum CRF rate for spring-potted *Weigela*, raised outside, was 4-6 kg/m^3 at Efford and 6 kg/m^3 at Whixley. This was broadly in line with the manufacturer's recommended rate of 5 kg/m^3.







Weigela 'Red Prince' Year 1 Efford - Spring 2001

Weigela 'Red Prince' Year 1 Whixley - Spring 2001

2.4.2 CRF rates for spring-potted species, raised in plastic tunnels

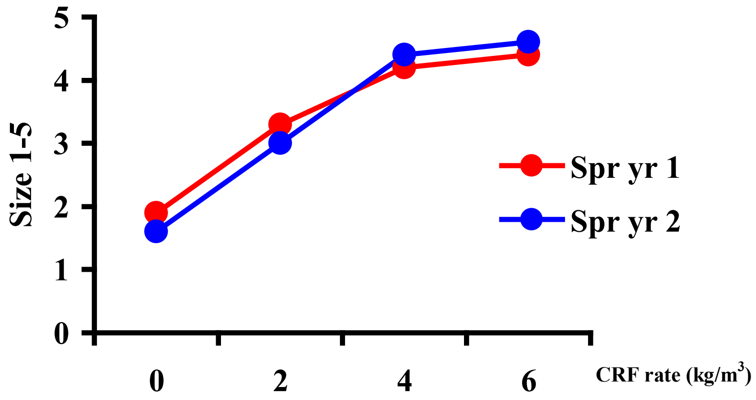
Note that harvest data means are given in Appendix 3.2.2. Plots were maintained only at Efford.

a) *Ceanothus impressus* 'Autumnal Blue'

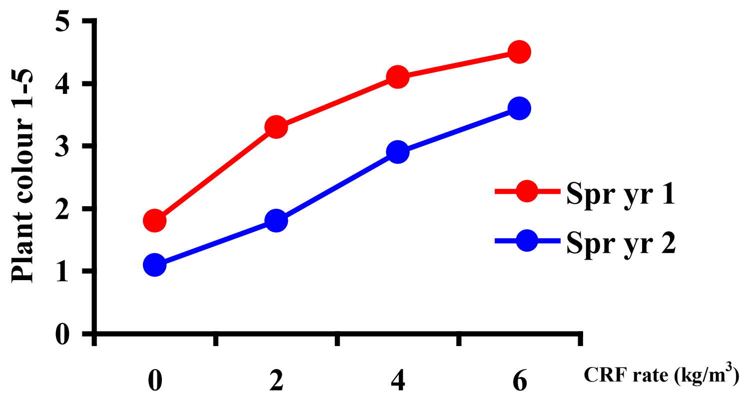
Key recorded parameters were plant size, plant colour, vigour, flowering (spring sample only) and biomass. Trends are presented for size, colour and biomass at the final spring sample, and plates show the appearance of plants at marketing at the end of each of the two years.

The CRF rate of 4 kg/m^3 was optimal for plant size in both years, but early extension growth was favoured by 6 kg/m^3 in year 2. Plants were better coloured at 6 kg/m^3 than at 4 kg/m^3 at the intermediate, autumn sample in year 1, but final differences were not significant. However, the final difference was significant in year 2 when plants were generally paler than in year 1. Flowering was not improved above a CRF rate of 4 kg/m^3 in year 1, and 2 kg/m^3 in year 2. Final biomass was greatest at 6 kg/m^3 in year 1, but at 4 kg/m^3 in year 2. CRF rate appeared to have relatively little effect on vigour. It was concluded that the optimal CRF rate for spring-potted *Ceanothus*, raised under plastic, was 4-6 kg/m^3 in both years. This was a little higher than the manufacturer's recommended rate of 4.5 kg/m^3.

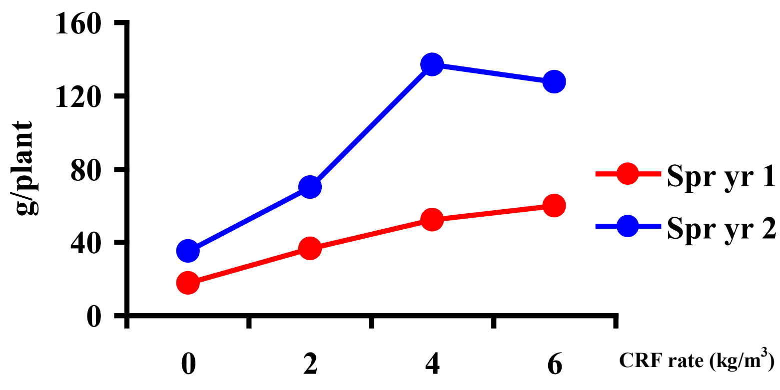
***Ceanothus* plant size**



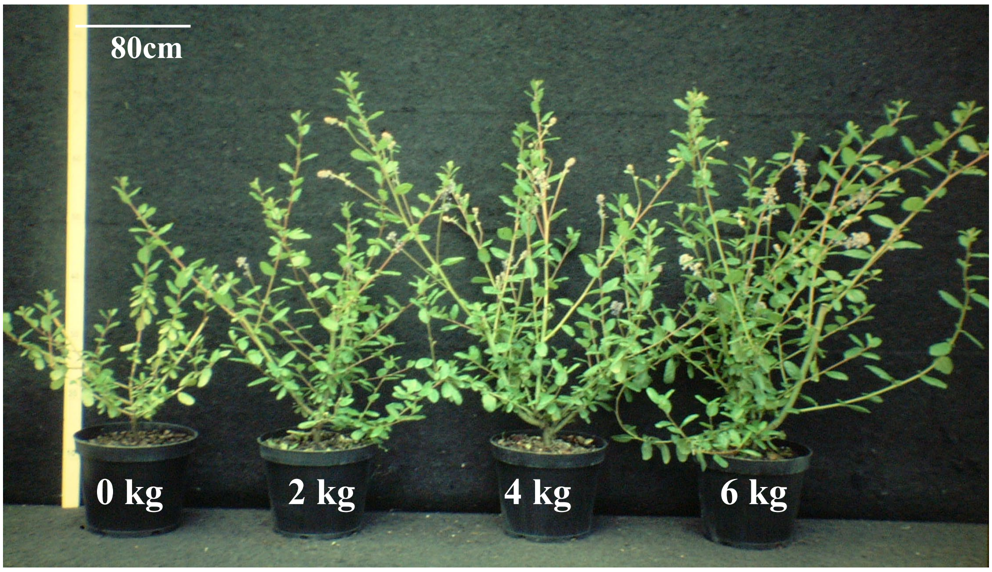
***Ceanothus* colour scores**



***Ceanothus* plant biomass**



Ceanothus impressus 'Autumnal Blue' Year 1 - Spring 2001

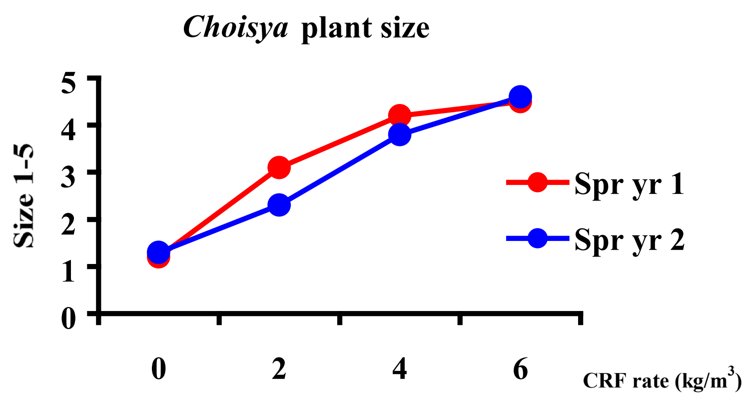


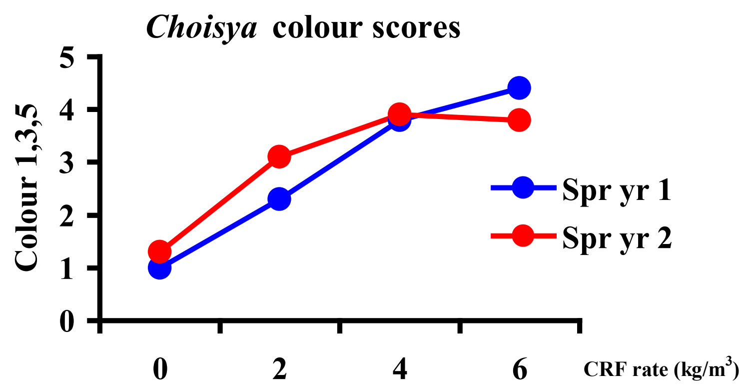
Ceanothus inpressus 'Autumnal Blue' Year 2 - Spring 2002

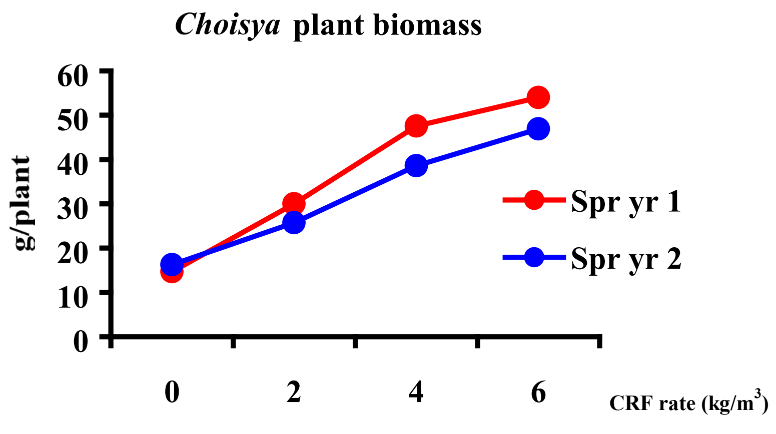
b) *Choisya ternata*

Key recorded parameters were size, plant colour, flowering (spring sample only) and biomass. Trends are presented for size, colour and biomass at the final spring sample, and plates show the appearance of plants at marketing at the end of each of the two years.

Plant size was greatest at final harvest at a CRF rate of 6 kg/m^3 in each of the two years, although size was no greater than at a rate of 4 kg/m^3 at the intermediate, autumn sample in year 2. Colour was also best at 6 kg/m^3 in year 1, but at 4 6 kg/m^3 in year 2. Flowering was little affected by CRF rate, but biomass increased with each increase in CRF to indicate maximum photosynthetic growth at 6 kg/m^3. Overall, 6 kg/m^3 appeared to be the optimal CRF rate for *C. ternata* potted in the spring and raised under plastic. This was higher than the manufacturer's recommended rate of 4.5 kg/m^3.


Choisya plant size
Size 1-5
5
4
3
2
1
0
0
2
4
6
CRF rate (kg/m3)
Spr yr 1
Spr yr 2


Choisya colour scores
Colour 1,3,5
5
4
3
2
1
0
0
2
4
6
CRF rate (kg/m3)
Spr yr 1
Spr yr 2


Choisya plant biomass
g/plant
60
50
40
30
20
10
0
0
2
4
6
CRF rate (kg/m3)
Spr yr 1
Spr yr 2

Choisya ternata Year 1 - Spring 2001

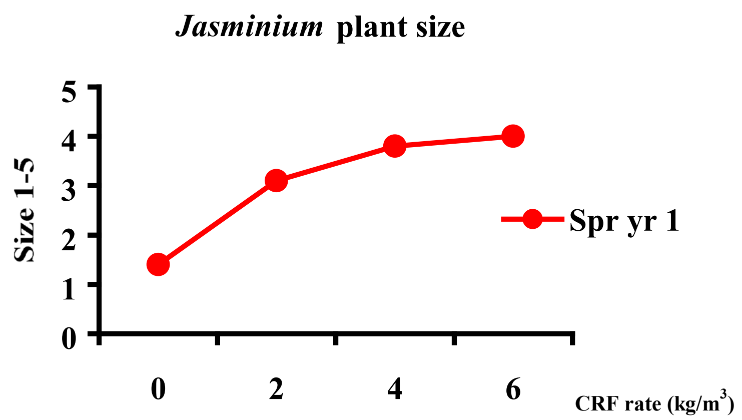
Choisya ternata Year 2 - Spring 2002

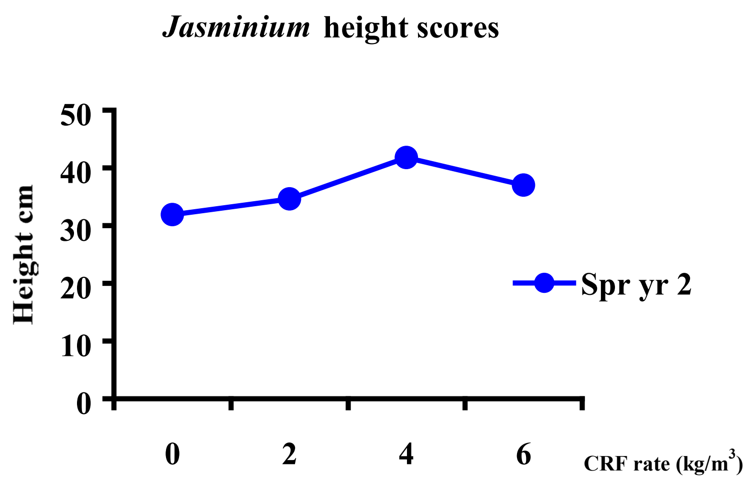
c) *Jasminium nudiflorum*

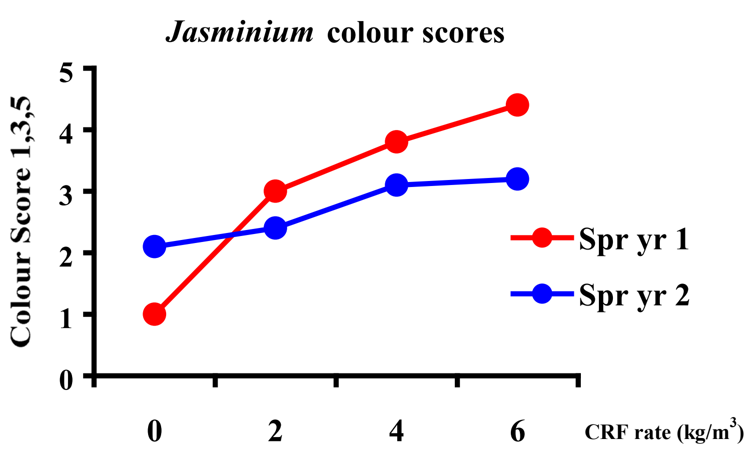
Key recorded parameters were height (size at the spring sample in year 1), plant colour, vigour and biomass. Trends are presented for height/size and colour at the final spring sample, and plates show the appearance of plants at marketing at the end of each of the two years.

Although height was initially greatest at 6 kg/m^3 in year 1, the optimal rate for plant size was 4 kg/m^3 at the final harvest. 4 kg/m^3 was also optimal for plant height at both samples in year 2. Plant colour was best at the highest rate in year 1, 6 kg/m^3, but there was no advantage in raising the rate above 4 kg/m^3 in year 2. 4 kg/m^3 also appeared to be the optimum rate for vigour in the autumn samples in both years. Biomass was greatest at 6 kg/m^3 in year 2, but 4 kg/m^3 was optimal in year 1.

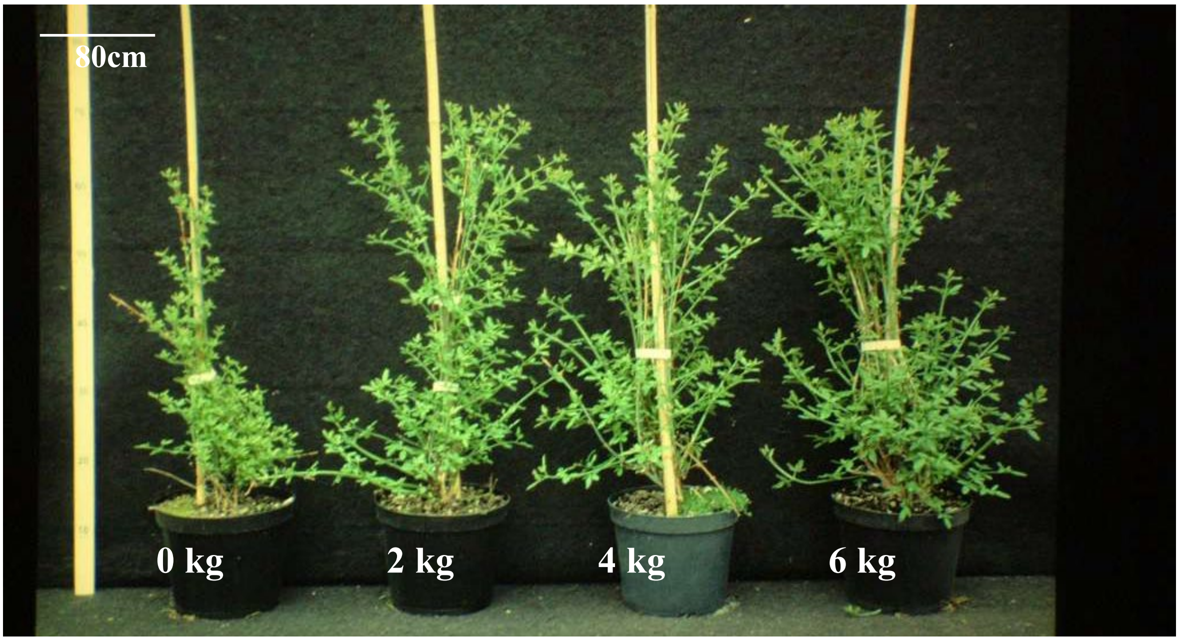
It was concluded that a CRF rate of 4-6 kg/m^3 was optimal in year 1 for *Jasminium* potted in spring and raised under plastic, whilst a lower rate, 4 kg/m^3, was optimal in year 2. This was broadly in line with the manufacturer's recommended rate of 4.5 kg/m^3.







Jasminium nudiflorum Year 1 - Spring 2001



Jasminium nudiflorum Year 2 - Spring 2002

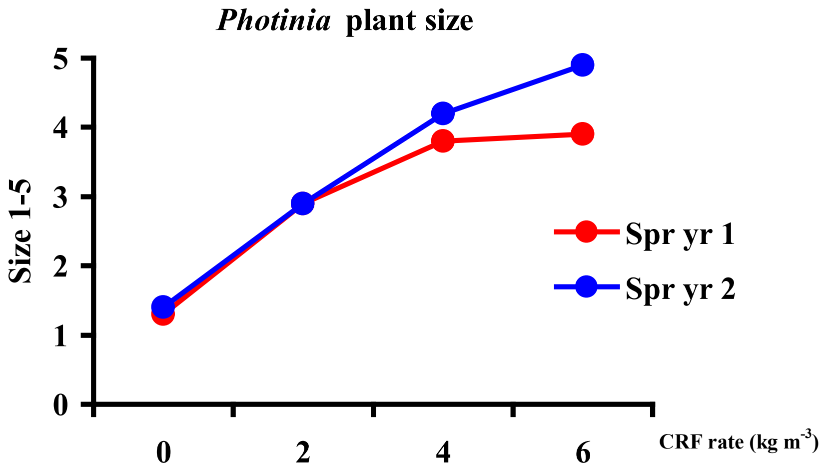
d) *Photinia x fraseri* 'Red Robin'

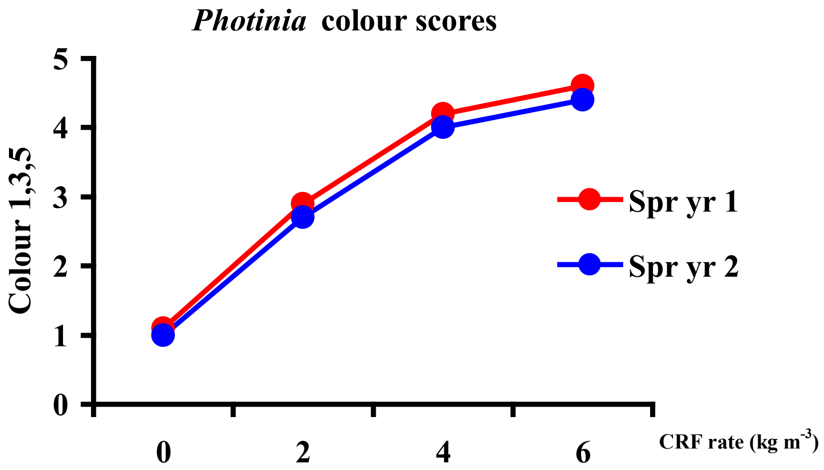
The *Photinia* grown under polythene differed in structural form from those raised outside. Under plastic, shoot growth tended to be more horizontal and this was particularly evident at the autumn assessment. However, once plants had been trimmed back, the growth that developed during the period up until marketing tended to be more vertical, eventually producing far better shaped plants. This was the case in both years of study.

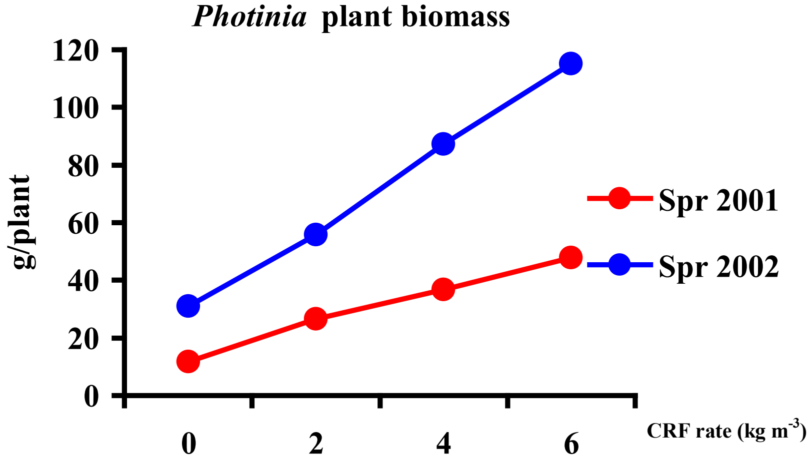
Key recorded parameters were plant size, colour, new growth and biomass, and trends are presented for each of these at the final spring sample in each of the years. Plates show the appearance of plants at marketing at the end of each of the two years.

The optimal rate of CRF for plant size was 4 kg/m^3 in year 1 and 6 kg/m^3 in year 2. Plant colour benefitted from 6 kg/m^3 at the autumn sample in both years, but by the final spring sample, there was no significant advantage of 6 kg/m^3 over 4 kg/m^3. Plant biomass at marketing was greatest at 6 kg/m^3 in each of the years.

It was concluded that a CRF rate of 4-6 kg/m^3 was optimal in year 1 for *Photinia* potted in spring and raised under plastic, whilst the highest rate, 6 kg/m^3, was optimal in year 2. This was somewhat higher than the manufacturer's recommended rate of 4.5 kg/m^3.







Photinia x fraseri 'Red Robin' (under plastic) Year 1 - Spring 2001

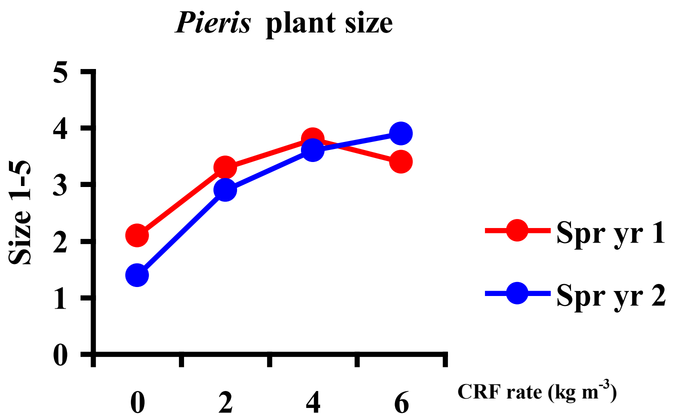
Photinia x fraseri 'Red Robin' (under plastic) Year 2 - Spring 2002

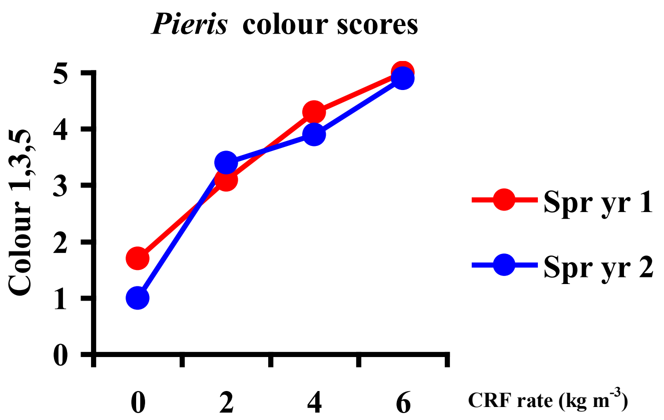
e) *Pieris* 'Forest Flame'

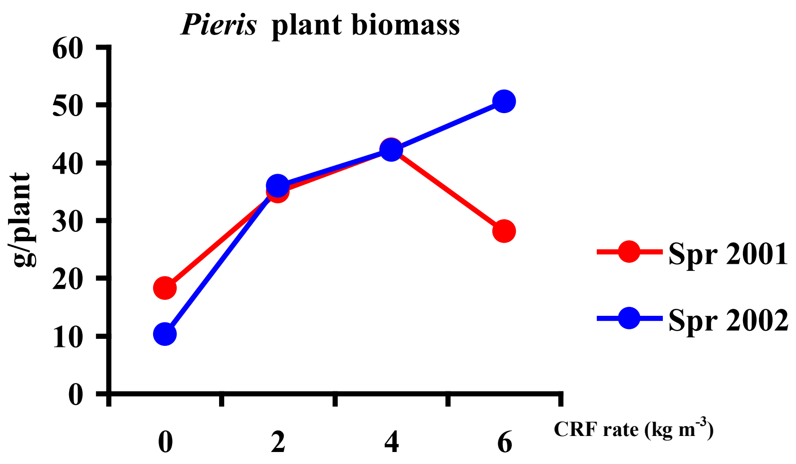
Key recorded parameters were plant size, colour, vigour (year 1 only), flowering (spring samples only) and biomass, and trends are presented for size, colour and biomass at the final spring sample in each of the years. Significance could not be assigned at the spring sample in year 1 because one of the replicates suffered wind scorch due to its northerly (end) position in the plastic tunnel and had to be discarded. Plates show the appearance of plants at marketing at the end of each of the two years.

Pieris proved to be particularly sensitive to CRF rate and initial growth in year 1 was best at 2 kg/m^3. Thus vigour scored highest at this rate at the autumn sample. However, by the spring sample, plants grown with only 2kg of CRF were beginning to show signs of nutrient deficiency, and both size and colour were improved at the 4 kg/m^3 rate. The optimal rate of CRF for plant size in year 2 was also 4 kg/m^3, but colour benefited from 6 kg/m^3. Flowering was extremely variable, being best at 2 kg/m^3 in year 1, but at 6 kg/m^3 in year 2. The optimal rate of CRF also varied for biomass in the two years, being best at 4 kg/m^3 in year 1 and at 6 kg/m^3 in year 2.

It was concluded that a CRF rate of 4 kg/m^3 was optimal in year 1 for *Pieris* potted in spring and raised under plastic, whilst 4-6 kg/m^3 was optimal in year 2. This was higher than the manufacturer's recommended rate of 3 kg/m^3.







Pieris 'Forest Flame' Year 1 - Spring 2001

Pieris 'Forest Flame' Year 2 - Spring 2001

2.4.3 CRF rates for autumn-potted species, raised in unheated glass

Note that harvest data means are given in Appendix 3.2.3. Trials were carried out only at Efford.

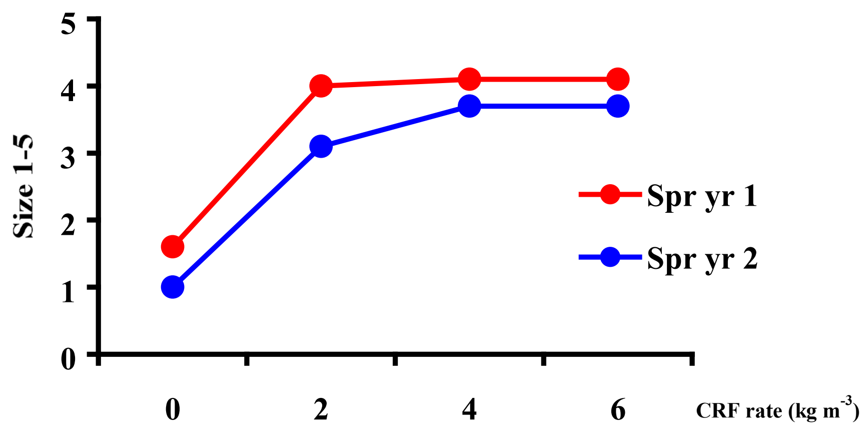
a) *Cistus* 'Silver Pink'

Key recorded parameters were plant size, quality, colour, flowering (year 1 only) and biomass, and trends are presented for size, colour and biomass at the spring sample in each of the years. Plates show the appearance of plants at marketing at the end of each of the two years.

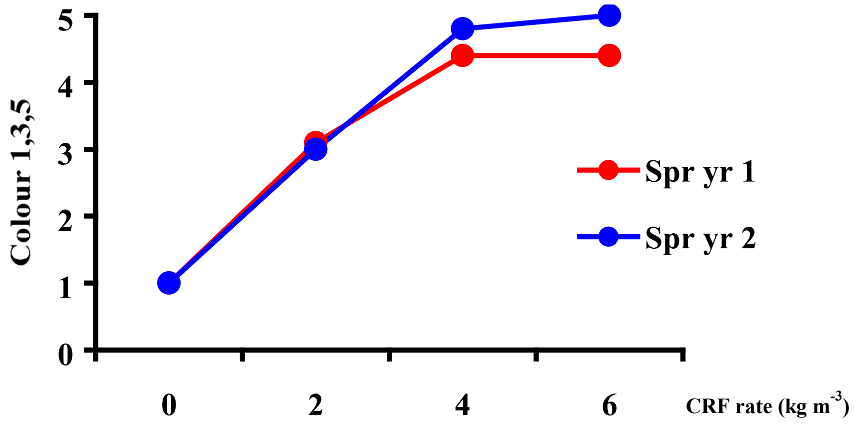
The optimal CRF rate for both plant size and biomass was 2 kg/m^3 in year 1 and 4 kg/m^3 in year 2. However foliage colour benefited from 4 kg/m^3 in both years. A quality assessment made in year 1 supported the view that 4 kg/m^3 was optimal under this production system. Flowering was very variable and there was no obvious relationship between this and CRF rate.

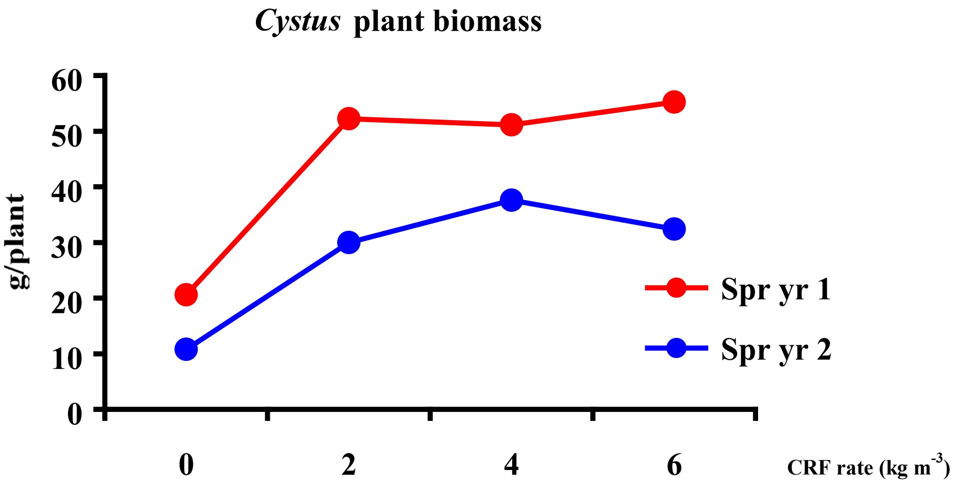
It was concluded that a CRF rate of 4 kg/m^3 was optimal in both years for *Cistus* potted in autumn and raised in cold glass. This was somewhat lower than the manufacturer's recommended rate of 4.5 kg/m^3.

***Cistus* plant size**



***Cistus* foliage colour scores**





Cistus 'Silver Pink' Year 1 - Spring 2001

Cistus ' Silver Pink' Year 2 - Spring 2002

b) *Euonymous*

Year 1 - *Euonymous japonicus* 'Ovatus Aureus'

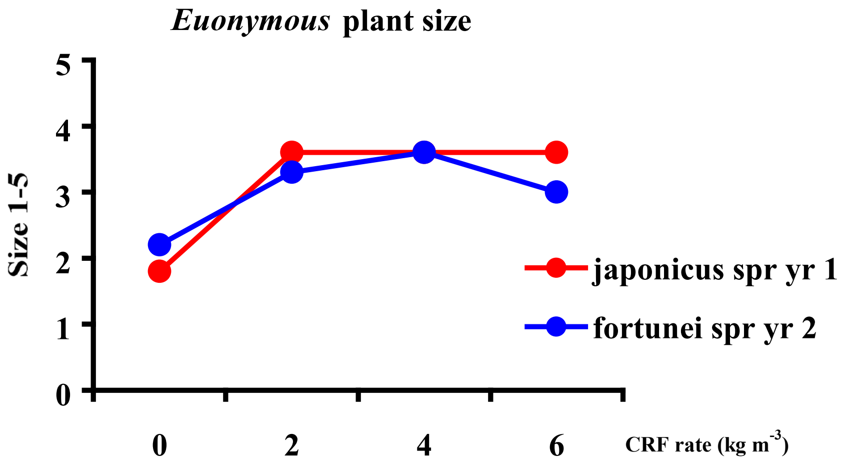
Parameters recorded were plant size, colour and biomass, and trends are presented for each of these at the spring sample in year 1. The optimal CRF rate for both plant size and biomass was 2 kg/m^3. However foliage colour benefited from incorporation of CRF up to 6 kg/m^3.

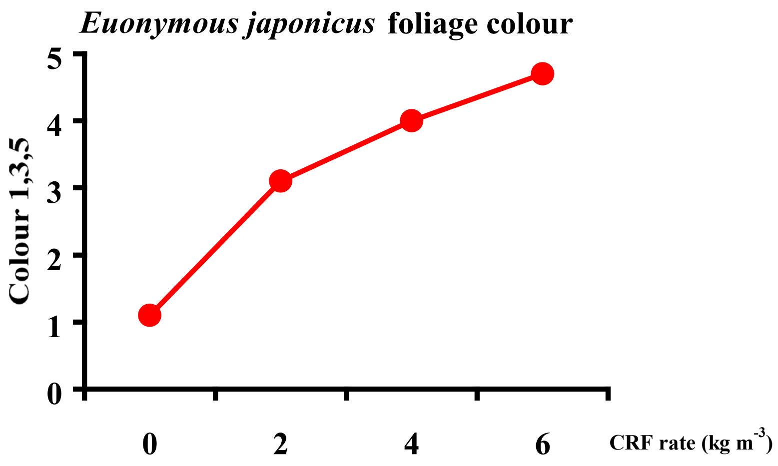
It was concluded that a CRF rate of 4 kg/m^3 was optimal given that foliage colour reached a satisfactory retail quality at this rate. This was somewhat lower than the manufacturer's recommended rate of 4.5 kg/m^3.

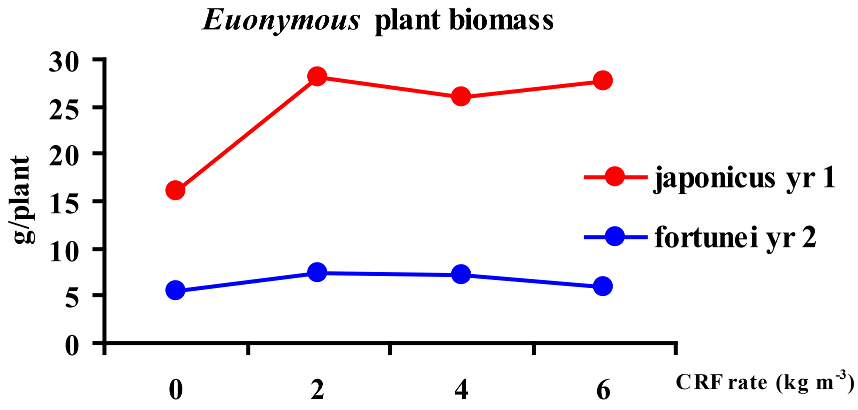
Year 2 - *Euonymous fortunei* 'Gold Tip'

Plant size and biomass were recorded at the spring sample in year 2 and trends are presented for each of these. There were no obvious colour differences between any of the treatments, so no colour scoring was undertaken. The plate shows representative plants of this species at the spring sample.

The optimal CRF rate for both recorded parameters was 2 kg/m^3 and it was concluded that there would be no advantage of exceeding this rate. This rate of 2 kg/m^3 is considerably lower than the manufacturer's recommended rate of 4.5 kg/m^3.





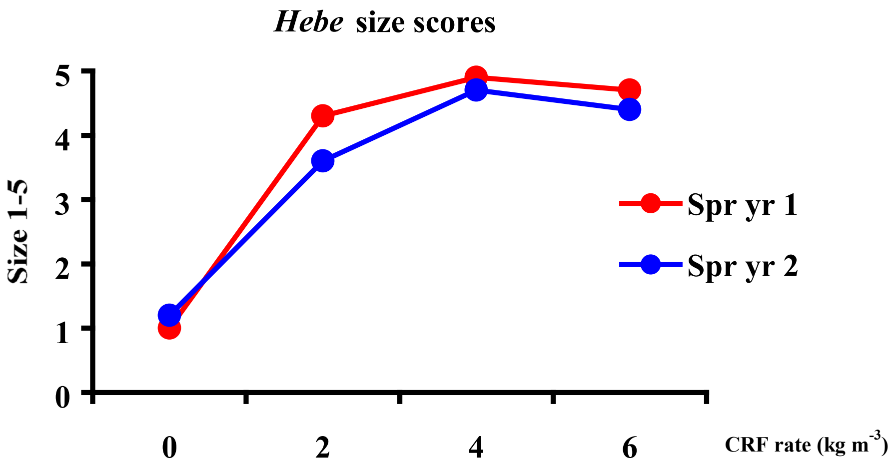


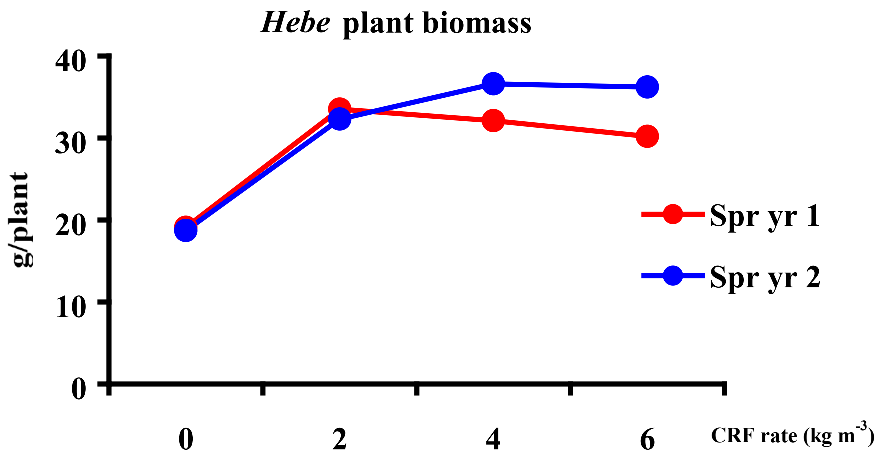
Euonymous fortunei 'Gold Tip' Year 2 - Spring 2002

c) *Hebe* 'Red Edge'

Parameters recorded were restricted to plant size and biomass, since CRF rate had no apparent effect on foliage colour. Trends are presented for each of these at the spring sample in each year, and plates show representative plants at marketing.

Plant size was greater at 4 kg/m^3 than at 2 kg/m^3 in year 1, but the difference was not significant. Biomass was also not further increased by raising the CRF rate above 2 kg/m^3. The optimum CRF rate for both characters was 4 kg/m^3 in year 2. The respective optimum rates for year 1 and year 2, 2 kg/m^3 and 4 kg/m^3, were lower than the manufacturer's recommended rate of 4.5 kg/m^3.





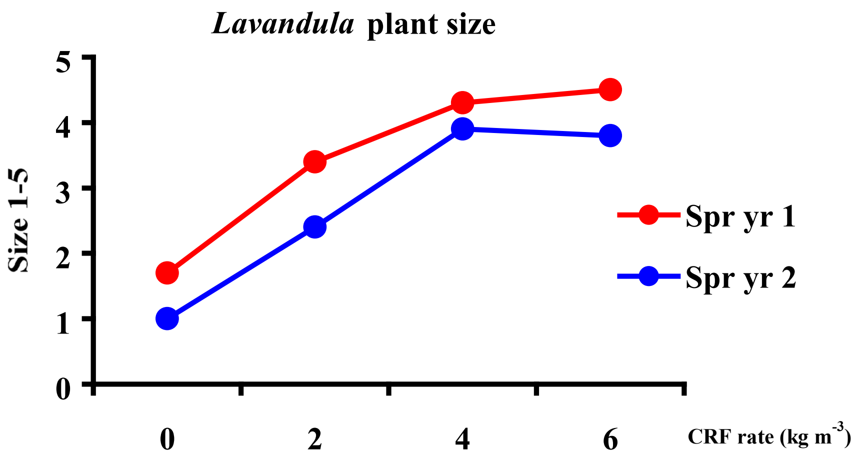
Hebe 'Red Edge' Year 1 - Spring 2001

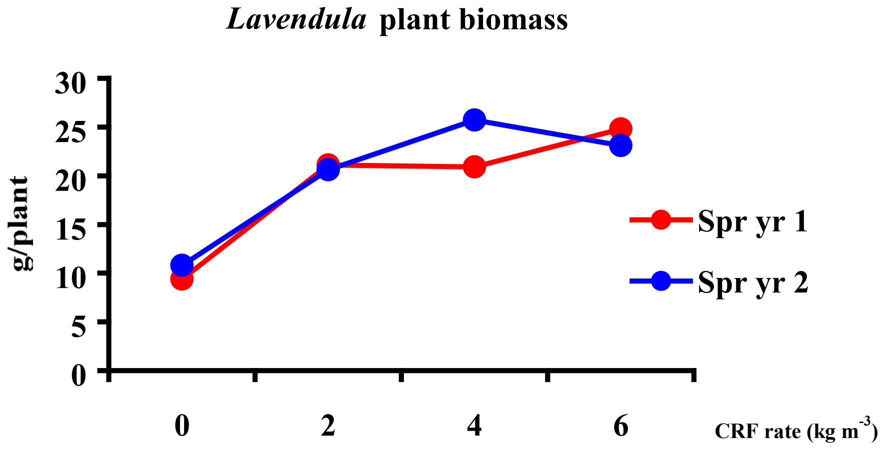
Hebe 'Red Edge' Year 2 - Spring 2002

d) *Lavandula angustifolia* 'Hidcote'

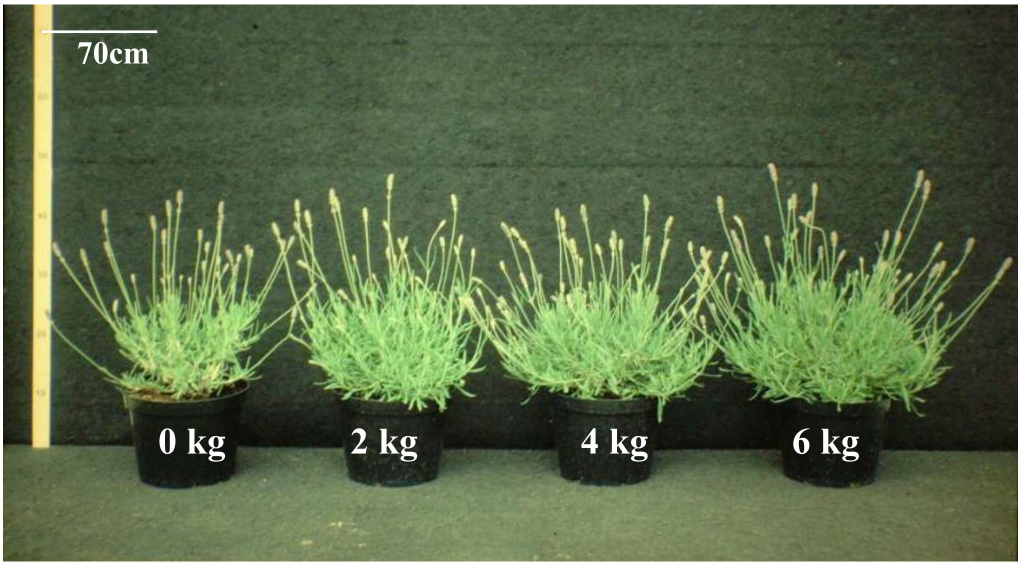
Parameters recorded were restricted to plant size and biomass since CRF rate had no apparent effect on foliage colour, except at 0 kg/m^3 in year 2 where plants finished paler and were beginning to yellow. Flowering was also not recorded although larger plants appeared to have more flowers. Trends are presented for size and biomass, and plates show representative plants at marketing in each of the years.

Maximum size was attained at 4 kg/m^3 in both years. Biomass was also greatest at this rate in year 2, but at 6 kg/m^3 in year 1. It was concluded that the overall optimum rate was 4 kg/m^3 in both years, somewhat below the manufacturer's recommended rate of 4.5 kg/m^3.





Lavandula angustifolia 'Hidcote' Year 1 – Spring 2001



Lavandula angustifolia 'Hidcote' Year 2 – Spring 2002

e) *Lavatera*

Year 1 - *Lavatera* 'Rosea'

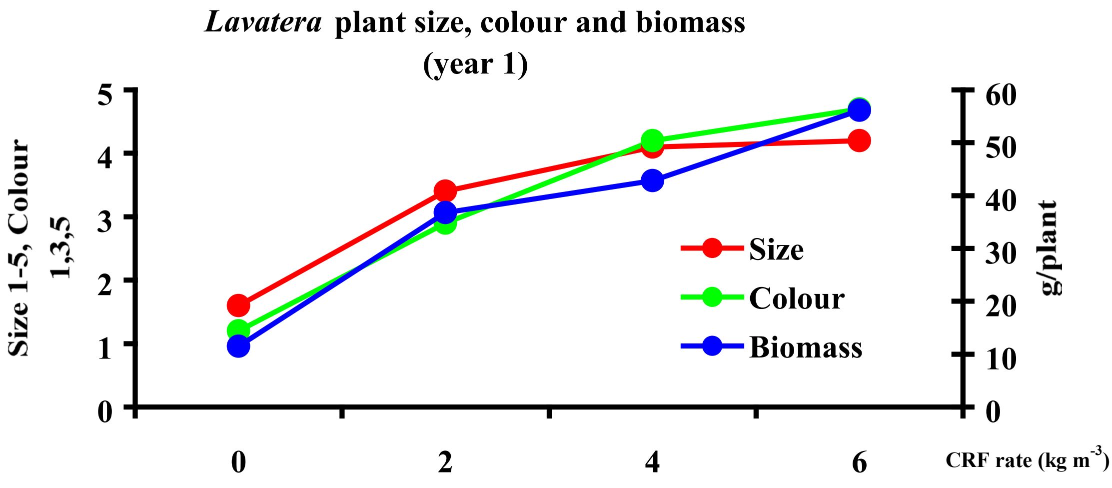
Parameters scored were plant size, vigour, colour and biomass. Trends are presented for each of these except vigour. The plate shows representative plants at the spring sampling.

At final harvest, plants grown with no CRF were showing distinct signs of nutrient deficiency; small with pale leaves and poor vigour. Plant size and vigour were maximised at 4 kg/m^3, whilst plant colour and biomass were further improved at 6 kg/m^3. There were no clear treatment differences in flowers produced.

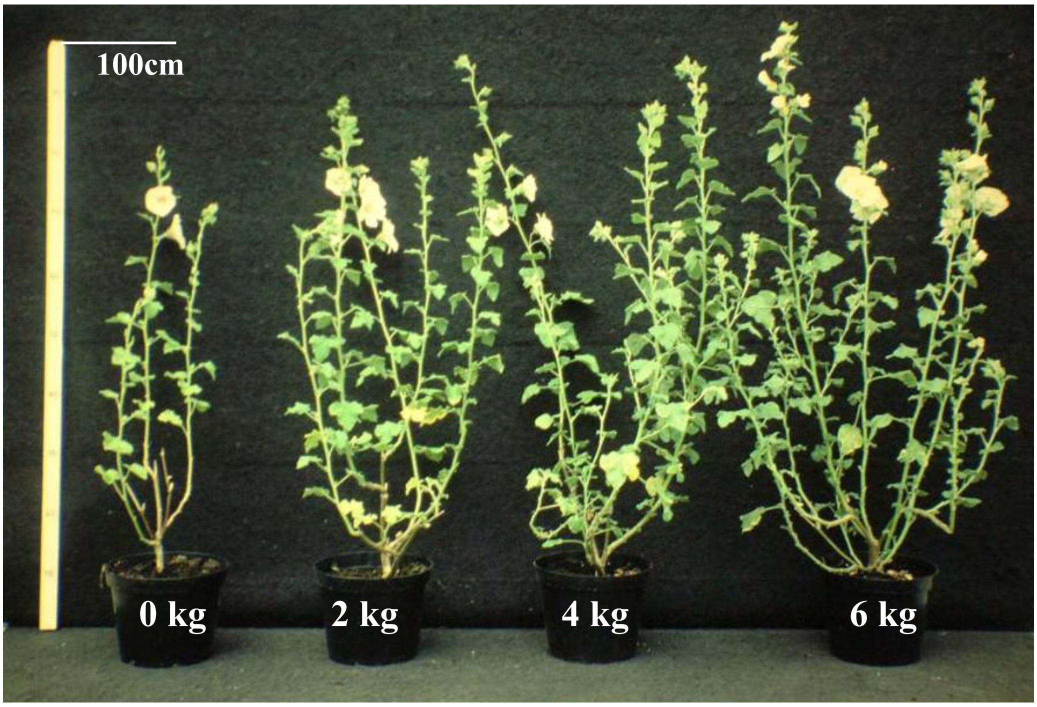
The optimum CRF rate was judged to be 4-6 kg/m^3, somewhat above the manufacturer's recommended rate of 4.5 kg/m^3 and above those concluded to be optimal for other species grown in this production system.

Year 2 - *Lavatera thuringiaca* 'Memories'

Plants of *Lavatera* in Year 2 were slightly damaged in transit and a significant number of plants subsequently died. As a result, no meaningful results were obtained.



Lavatera 'Rosea' Year 1 – Spring 2001



2.4.4 Leaf nutrient levels

Leaf nutrient analyses are given in Appendix 3.3. Table 5 summarizes data for year 1 carried out on plants growing with zero and near-optimal levels of CRF (generally, 4 kg/m^3), averaged over species, sampling occasion and location, as a step towards deriving typical leaf element concentrations associated with sub-optimal and near-optimal nutrition.

Table 5. Average leaf nutrient levels (± S.E.mean) for CRF rates of 0 and 4 kg/m^3.

Nutrient	CRF rate (kg/m^3)	Spring-potted, outside*	Spring-potted, polythene tunnel	Autumn-potted, unheated g'house**
N (%)	0 4	1.0 ± 0.10 1.3 ± 0.10	0.9 ± 0.09 1.3 ± 0.10	1.1 ± 0.13 1.6 ± 0.18
P (%)	0 4	0.11 ± 0.008 0.16 ± 0.012	0.11 ± 0.014 0.16 ± 0.021	0.13 ± 0.033 0.18 ± 0.023
K (%)	0 4	1.1 ± 0.11 1.5 ± 0.12	1.4 ± 0.20 2.0 ± 0.25	1.7 ± 0.43 2.2 ± 0.41
Ca (%)	0 4	1.3 ± 0.11 1.1 ± 0.12	1.9 ± 0.23 1.4 ± 0.16	1.4 ± 0.23 1.1 ± 0.10
Mg (%)	0 4	0.43 ± 0.04 0.34 ± 0.04	0.41 ± 0.05 0.30 ± 0.04	0.59 ± 0.15 0.51 ± 0.11
Mn (mg/kg)	0 4	274 ± 72 98 ± 16	291 ± 88 158 ± 48	170 ± 63 97 ± 21

* the higher CRF rate for *Chamaecyparis* at Efford and Whixley, and for *Weigela* at Whixley was 6 kg/m^3; ** the higher CRF rate for all species except *Lavatera* was 2 kg/m^3

Concentrations of N, P and K were about 40% higher in near-optimal CRF pots than in zero CRF pots, with rates somewhat higher in autumn-potted plants than in those potted in spring, particularly for K. As would be expected, values for Ca, Mg and Mn were, in all cases, lower in the near-optimal pots than in the zero CRF pots as a consequence of the preferential uptake of K working in association with the greater availability of K in the near-optimal pots.

2.5 Conclusions

2.5.1 CRF rates (Tabular summaries of optimal CRF rates appear in Tables 1-3, Section 1.3)

Species grown outside from a spring potting

Retail-quality plants of all five species were obtained at Efford in year 1 by incorporating CRF at 4 kg/m^3. However, growth and quality were further enhanced in all species except *Cytisus* by increasing CRF to 6 kg/m^3. Optimal rates tended to be slightly higher in year 2 and a rate of 6 kg/m^3 gave markedly better quality plants of *Photinia* and *Vibernum* than 4 kg/m^3. Differences in optimal rate in year 1 between the northern and southern sites were not consistent across species, indicating that geographical location is not an important enough factor to influence general recommendations. Overall, it is recommended that growers adopt the manufacturer's recommended rate for incorporation of CRF, 5 kg/m^3. Given observed variation between years and locations, it would seem unwise to vary incorporation rates with species.

Species grown in plastic tunnels from a spring potting

Optimal rates for the 5 species were very similar in years 1 and 2, being highest in *Choisya* (6 kg/m^3 both years) and lowest in *Pieris* (4 kg/m^3 in year 1, 4-6 kg/m^3 in year 2). Optimal rates were also very similar to those for species raised outside, and exactly the same for the only species common to both growing systems, *Photinia*. The same overall recommendation for CRF incorporation is made as for species raised outside, 5 kg/m^3. This is marginally higher than the manufacturer's recommended rate for species other than *Pieris*.

Species grown in unheated glass from an autumn potting

Optimal rates tended to be lower than for species potted in spring, and on the basis of this trial, 4 kg/m^3 can be considered an overall optimal CRF incorporation rate for species suited to this production system. This is lower than the manufacturer's recommended rate of 4.5 kg/m^3.

2.5.2 Leaf nutrient levels

Leaf nutrient levels to be associated with sub-optimal and near-optimal nutrition were determined for the trials at Efford and Whixley. It is expected that these will prove useful as an indicator of nutrition in other locations, but this remains to be determined. It is recommended that growers carry out regular nutrient analyses and establish expected nutrient concentrations at their own sites and under their own production systems. Analyses at the half-grown stage will allow remedial action to be carried out.

3. Appendices

Appendix 3.1 Weather data

Year 1 (2000 – 2001)

Efford

The growing season was unusually wet, especially from September until February (Fig. 3.1.1). This was associated with an unusually mild November and December, severe cold spells in January, and an unusually cool spring (Fig. 3.1.2). Highest temperatures were recorded in week 35 in 2000 and in weeks 20 and 22 (just prior to marketing) in 2001. Temperatures under the plastic tunnel were on average 0.5 °C higher than outside, but up to 5°C higher in January and February, and again around marketing (Figure 3.1.3). However, this latter may have been due to recording error. The unheated glasshouse averaged around 3.5 °C warmer than outside.

Whixley

As at Efford, rainfall at Whixley was particularly marked during autumn and early winter. Outside temperatures followed a similar pattern to those at Efford, but averaged 1.6°C cooler over the season as a whole (Fig. 3.1.2).

Year 2 (2001 – 2002)

Efford

Year 2 was generally drier than year 1, but rainfall was higher immediately prior to marketing (Fig. 3.1.1). Overall, the average outside temperature in year 2 was very close to that in year 1, but tended to be lower in winter and higher in spring (Fig. 3.1.2). Temperatures under the plastic tunnel were on average 1.0 °C higher than outside (Fig. 3.1.4), whilst those in the unheated glass were on average 2.5 °C warmer than outside, with the largest temperature differences observed from December until March.

Figure 3.1.1 Total monthly rainfall

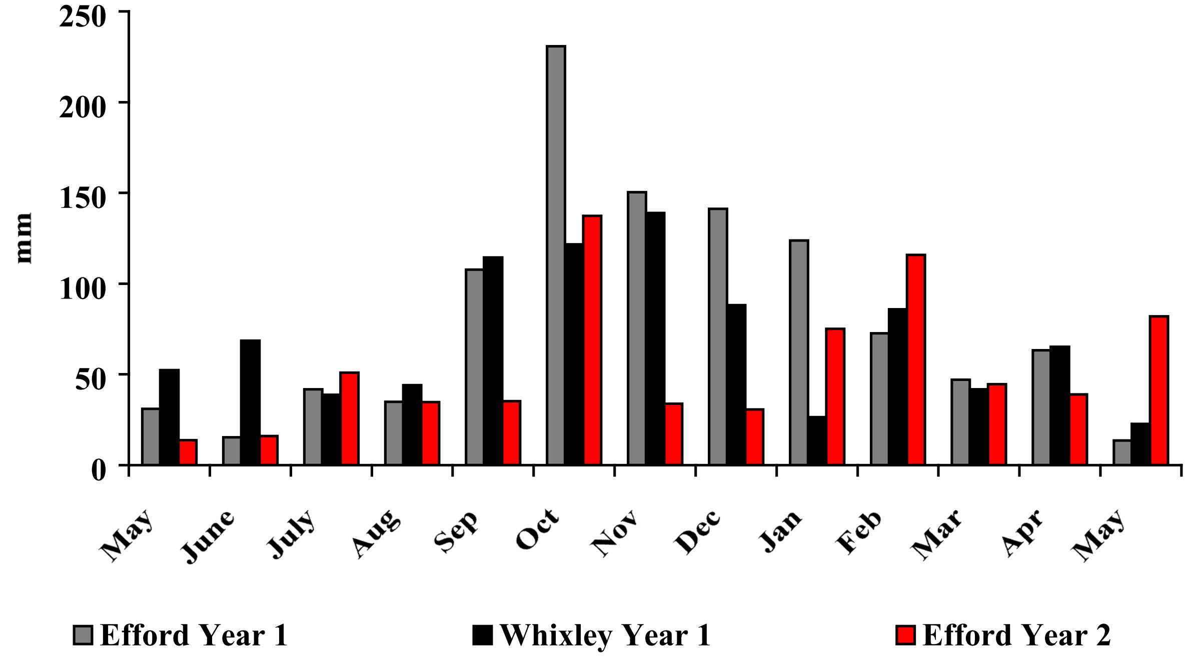


Fig 3.1.2 Weekly average outside temperatures

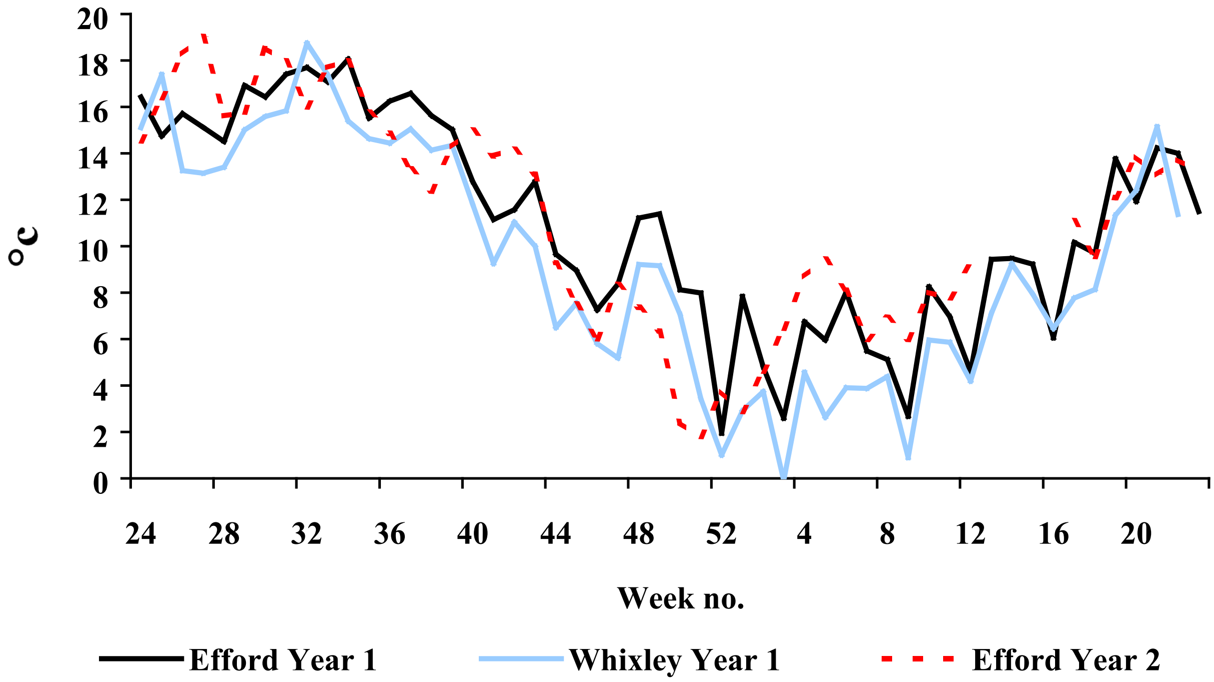


Fig 3.1.3 Weekly average temperatures in the three environments at Efford in year 1

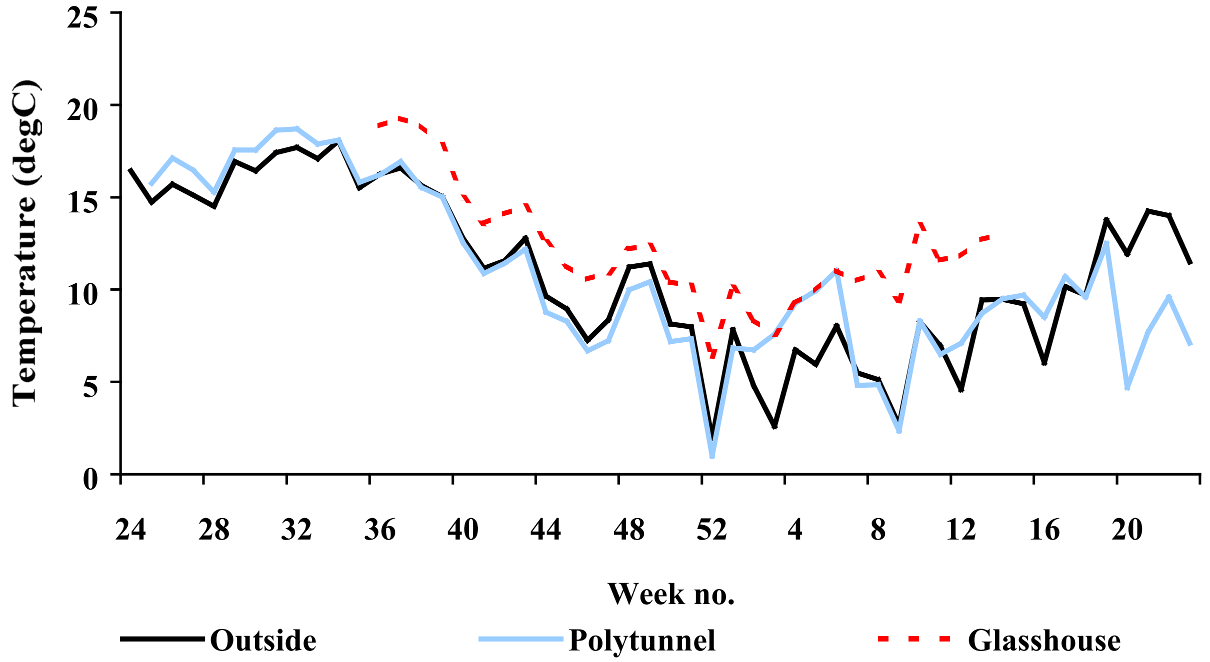
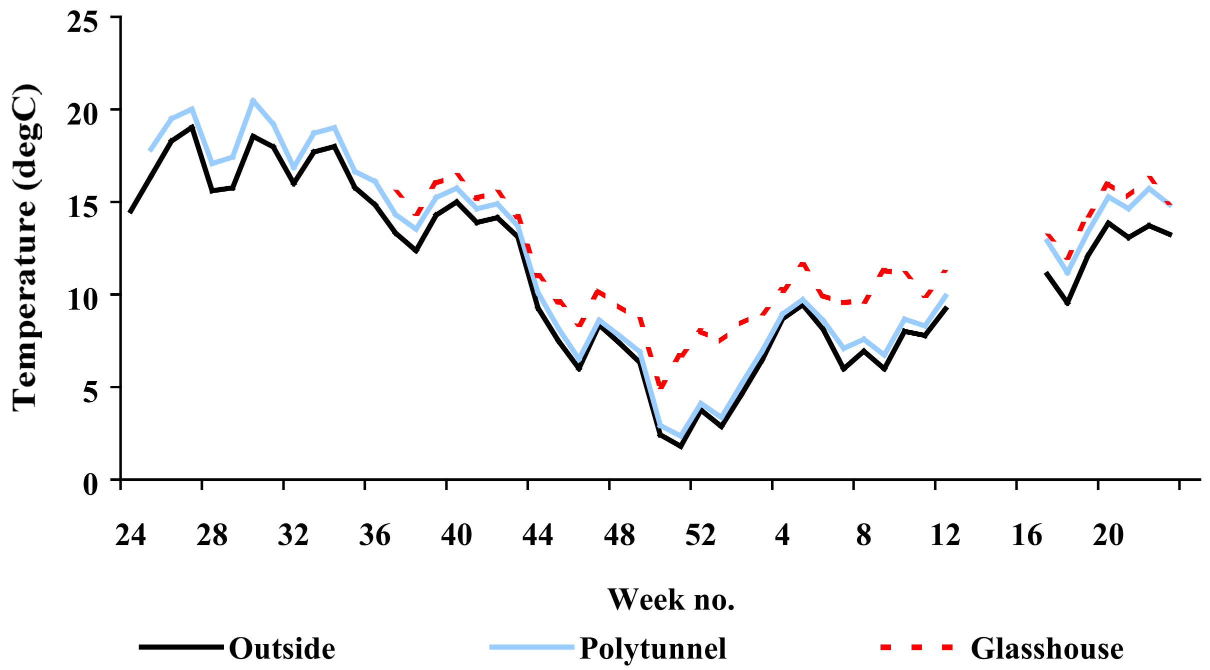


Fig 3.1.4 Weekly average temperatures in the three environments at Efford in year 2



Appendix 3.2 Plant data

Subjective scoring scales

Whilst some of the characters in the summary Tables that follow were scored objectively as weight, number of shoots etc, many characters were scored subjectively by visual comparison with selected reference plants. Such assessments used a 1-5 scale, with 1 being the lowest score (smallest, palest, least bushy etc) and 5 being the highest score (largest, darkest, most bushy etc). Whether all intermediate scale points were used depended on the extent of the variation encountered at that particular assessment. Thus, a scale of 1-5 indicates that there was sufficient variation for five scale points to be recognized (i.e, plants were scored as either 1, 2, 3, 4 or 5), whilst a scale of 1,3,5 indicates that there was less variation and that only three scale points could be recognized. A scale of 1,5 indicates that only two scale points could be recognized (e.g. either pale or dark foliage) and in such cases statistical analysis was not possible. In a few cases, a scale point 7 was added for plants that were clearly larger or more vigorous than any that had been scored as 5 in earlier assessments. For characters such as tip scorch, a 0 scale point was added to indicate an absence of the trait in question. The particular scoring scales used are given within each Table.

Table 3.2.1 Spring-potted, raised outside

a) *Chamaecyparis lawsoniana* 'Elwoodii'

Efford yr 1	Autumn 2000				Spring 2001				
		Bushiness	Colour	Tip		Bushiness	Colour	Tip	
	Height	Score	Score	Scorch	Height	Score	Score	Scorch	Biomass
CRF rate	(cm)	1-5	1,3,5	1,3,5	(cm)	1-5	1,3,5	0,1,3,5,	(g/plant)
Zero	38.7	1.0	1.0	1.0	40.6	1.1	1.0	1.0	53.9
2 kg/m^3	47.6	3.4	3.6	2.9	52.7	3.0	3.1	3.2	116.5
4 kg/m^3	46.3	4.4	5.0	3.3	51.4	4.1	5.0	1.8	141.9
6 kg/m^3	49.8	4.4	4.9	2.7	55.1	4.4	5.0	2.2	156.5
Mean	45.6	3.3	3.6	2.5	50.0	3.2	3.5	2.0	117.2
Significance	<0.001	<0.001	<0.001	0.007	<0.001	<0.001	<0.001	ns	<0.001
d.f.	6	6	6	6	6	6	6	6	24
L.S.D	3.01	0.33	0.56	1.04	3.37	0.23	0.19	1.43	13.68

Whixley yr 1	Autumn 2000				Spring 2001				
		Bushiness	Colour	Tip		Bushiness	Colour	Tip	
	Height	Score	Score	Scorch	Height	Score	Score	Scorch	Biomass
CRF rate	(cm)	1-5	1,3,5	1,3,5	(cm)	1-5	1-5	0-5	(g/plant)
Zero	39.3	1.7	2.3	1.0	42.8	1.0	2.0	1.4	45.6
2 kg/m^3	34.6	2.6	3.0	2.6	38.7	2.5	3.8	1.2	74.1
4 kg/m^3	39.1	3.2	3.0	3.2	43.3	3.2	4.8	1.9	85.7
6 kg/m^3	39.9	3.5	4.2	2.8	43.1	3.5	4.9	0.6	94.2
Mean	38.2	2.7	3.1	2.39	42.0	2.6	3.9	1.3	74.9
Significance	0.027	0.004	0.036	0.018	ns	<0.001	<0.001	ns	<0.001
d.f.	6	6	6	6	6	6	6	6	24
L.S.D	3.34	0.73	1.15	1.21	3.50	0.29	0.84	1.98	12.72

Efford yr 2	Autumn 2001				Spring 2002				
		Bushiness	Colour	Tip		Bushiness	Colour	Tip	
	Height	Score	Score	Scorch	Height	Score	Score	Scorch	Biomass
CRF rate	(cm)	1,3,5	1,5	0,1	(cm)	1-5	1,5	0,1,3,5	(g/plant)
Zero	27.9	1.0	1.0	0.0	32.6	1.3	1.0	0.2	48.3
2 kg/m^3	33.9	4.0	5.0	0.9	38.3	3.8	5.0	1.1	112.0
4 kg/m^3	39.4	4.9	5.0	0.9	43.9	3.9	5.0	2.0	135.1
6 kg/m^3	38.3	5.0	5.0	0.9	42.8	4.4	5.0	1.5	148.0
Mean	34.8	3.7	4.0	0.7	39.4	3.4	4.0	1.2	110.8
Significance	0.04	<0.001	-	<0.001	0.01	<0.001	-	0.24	<0.001
d.f.	6	6	-	6	6	6	-	6	24
L.S.D	7.95	0.38	-	0.18	5.74	0.25	-	1.97	13.59

b) *Cytisus x praecox*

Efford yr 1	Autumn 2000		Spring 2001		
	Size Score	Vigour Score	Size Score	Flowering Score	Biomass
CRF rate	1-5	1,3,5	1-5	0,1,3,5	(g/plant)
Zero	1.4	1.2	2.1	2.9	25.1
2 kg/m^3	2.4	3.0	3.1	3.3	42.4
4 kg/m^3	3.3	4.7	3.8	1.0	69.6
6 kg/m^3	3.2	4.4	3.9	0.9	68.1
Mean	2.6	3.3	3.2	2.0	51.3
Significance	0.004	<0.001	<0.001	0.002	<0.001
d.f.	6	6	6	6	24
L.S.D	0.81	1.07	0.49	0.99	23.40

Whixley	Autumn 2000		Spring 2001	
	Size Score	Vigour Score	Size Score	Biomass
CRF rate	1-5,7	1-5,7	1-5	(g/plant)
Zero	0.2	2.4	1.0	11.6
2 kg/m^3	2.7	5.7	2.8	36.3
4 kg/m^3	5.8	7.0	4.6	82.8
6 kg/m^3	6.7	7.0	4.9	106.3
Mean	3.8	5.5	3.3	59.3
Significance	<0.001	<0.001	<0.001	<0.001
d.f.	6	6	6	24
L.S.D	0.92	0.69	0.45	7.57

Efford yr 2	Autumn 2001	Spring 2002	
	Size Score	Size Score	Biomass
CRF rate	1-5	1-5	(g/plant)
Zero	1.3	1.4	24.5
2 kg/m^3	2.5	2.4	42.4
4 kg/m^3	3.9	3.7	70.9
6 kg/m^3	4.1	4.2	68.6
Mean	2.9	2.9	51.6
Significance	<0.001	<0.001	<0.001
d.f.	6	6	24
L.S.D	0.45	0.47	10.14

c) *Photinia x fraseri* 'Red Robin'

Efford yr 1	Autumn 2000				Spring 2001			
	Size	Colour	No of		Size	Colour	New	
	Score	Score	Main	Trimmings	Score	Score	Growth	Biomass
CRF rate	1-5	1,3,5	Shoots	(g/plant)	1-5	1,3,5	0,1,3,5	(g/plant)
Zero	1.0	1.3	3.2	7.9	1.5	1.6	1.7	11.0
2 kg/m^3	2.6	2.9	3.4	24.5	2.5	2.9	2.8	23.5
4 kg/m^3	3.7	4.3	3.9	39.7	3.2	4.8	3.0	29.7
6 kg/m^3	4.1	4.7	4.2	45.6	3.5	5.0	2.5	32.6
Mean	2.9	3.3	3.7	29.4	2.7	3.6	2.5	24.2
Significance	<0.001	<0.001	ns	<0.001	0.041	<0.001	ns	<0.001
d.f.	6	6	6	6	6	6	6	24
L.S.D	0.83	0.50	0.99	10.16	1.4	0.53	1.53	9.80

Whixley	Autumn 2000				Spring 2001	
	Size	Colour	No. of		Size	
	Score	Score	Main	Trimmings	Score	Biomass
CRF rate	1-5	1,3,5	Shoots	(g/plant)	1-5	(g/plant)
Zero	1.6	3.2	2.7	6.1	1.7	13.2
2 kg/m^3	2.8	4.0	3.2	19.9	2.9	22.8
4 kg/m^3	3.1	4.7	3.6	32.2	3.5	33.0
6 kg/m^3	4.1	4.5	3.8	35.8	3.2	26.6
Mean	2.9	4.1	3.3	23.5	2.8	23.9
Significance	0.001	<0.001	0.004	<0.001	<0.001	<0.001
d.f.	6	6	6	6	6	24
L.S.D	0.78	0.21	0.45	8.71	0.38	7.58

Efford yr 2	Autumn 2001		Spring 2002			
	Size	Colour	Size	Colour	New	
	Score	Score	Score	Score	Growth	Biomass
CRF rate	1-5	1,3,5	1-5	1-5	1-5	(g/plant)
Zero	1.3	1.1	1.0	1.0	1.4	16.4
2 kg/m^3	3.0	3.0	2.5	2.5	2.1	51.2
4 kg/m^3	3.8	4.4	3.4	3.4	3.1	60.6
6 kg/m^3	4.2	5.0	4.2	4.3	3.1	76.3
Mean	3.1	3.4	2.8	2.8	2.4	51.1
Significance	0.002	<0.001	<0.001	<0.001	0.003	<0.001
d.f.	6	6	6	6	6	24
L.S.D	1.01	0.29	0.25	0.24	0.75	15.30

d) *Viburnum tinus* 'Eve Price'

Efford yr 1	Autumn 2000				Spring 2001				
	Size Score	Colour Score	Flowering Score	New Growth	Size Score	Colour Score	Flowering Score	New Growth	Biomass
CRF rate	1-5	1,3,5	1-5	1-5	1-5	1,3,5	1-5	1-5	(g/plant)
Zero	1.0	1.0	1.1	1.1	1.2	1.0	1.7	1.3	31.3
2 kg/m^3	2.4	3.3	2.2	2.8	3.0	3.0	3.7	2.4	70.8
4 kg/m^3	4.2	5.0	3.1	4.0	4.4	4.3	3.6	3.7	98.8
6 kg/m^3	4.2	5.0	3.0	4.4	4.4	5.0	4.0	4.2	101.3
Mean	3.0	3.6	2.4	3.1	3.2	3.3	3.3	2.9	75.6
Significance	<0.001	<0.001	0.042	0.002	<0.001	<0.001	0.005	<0.001	<0.001
d.f.	6	6	6	6	6	6	6	6	24
L.S.D	0.70	0.33	1.4	1.16	0.69	0.33	1.02	0.67	16.72

Whixley	Autumn 2000				Spring 2001			
	Size Score	Colour Score	Flowering Score	New Growth	Size Score	Colour Score	New Growth	Biomass
CRF rate	1-5	1,3,5	1-5	1-5	1-5	1,3,5	1-5	(g/plant)
Zero	1.2	3.1	2.4	2.6	1.3	3.0	1.4	27.1
2 kg/m^3	3.0	3.0	2.8	3.7	2.9	3.6	1.7	58.7
4 kg/m^3	4.8	3.1	2.2	4.5	4.5	4.7	2.7	92.9
6 kg/m^3	4.1	3.8	3.1	3.7	3.7	5.0	2.6	76.7
Mean	3.3	3.2	2.6	3.6	3.1	4.1	2.1	63.9
Significance	<0.001	0.033	ns	0.011	<0.001	<0.001	ns	<0.001
d.f.	6	6	6	6	6	6	6	24
L.S.D	0.69	0.52	1.78	0.88	0.63	0.43	1.36	13.09

Efford yr 2	Autumn 2001*			
	Size Score	Colour Score	Flowering Score	New Growth
CRF rate	1-5	1,3,5	1,3,5	1-5
Zero	1.3	1.1	1.4	1.0
2 kg/m^3	2.7	3.4	3.3	2.9
4 kg/m^3	3.5	4.9	3.8	3.7
6 kg/m^3	4.1	4.8	4.3	3.7
Mean	2.9	3.6	3.2	2.8
Significance	<0.001	<0.001	<0.001	<0.001
d.f.	6	6	6	6
L.S.D	0.35	0.58	0.68	0.77

* Plants removed from trial before Spring record due to *Phytopthora ramorum* (Sudden Oak Death)

e) We*igela* 'Red Prince'

Efford yr 1	Autumn 2000			Spring 2001			
	Size	Colour		Size	Colour	Flowering	
	Score	Score	Trimmings	Score	Score	Score	Biomass
CRF rate	1-5	1,3,5	(g/plant)	1-5	1,3,5	1-5	(g/plant)
Zero	1.3	1.6	15.6	1.3	1.4	3.3	11.2
2 kg/m^3	2.8	2.9	35.1	2.7	3.0	3.1	21.3
4 kg/m^3	3.8	4.2	48.5	4.3	4.0	3.6	35.4
6 kg/m^3	4.0	4.7	53.3	4.5	4.3	3.6	40.4
Mean	3.0	3.3	38.1	3.2	3.2	3.4	27.8
Significance	0.002	<0.001	<0.001	<0.001	<0.001	ns	<0.001
d.f.	6	6	6	6	6	6	24
L.S.D	0.99	0.64	11.93	0.38	0.38	1.47	5.06

Whixley	Autumn 2000			Spring 2001			
	Size	Colour		Size	Colour	Flowering	
	Score	Score	Trimmings	Score	Score	Score	Biomass
CRF rate	1-5,7	1,3,5	(g/plant)	1-5	1,3,5	1-5	(g/plant)
Zero	0.6	3.0	8.3	1.6	1.1	1.7	10.2
2 kg/m^3	2.9	3.1	31.1	2.9	3.1	2.1	21.3
4 kg/m^3	4.1	3.2	49.2	3.6	3.6	2.8	28.0
6 kg/m^3	6.3	4.0	69.7	3.9	4.6	2.8	34.4
Mean	3.5	3.3	39.6	3.0	3.1	2.4	23.5
Significance	<0.001	<0.001	<0.001	<0.001	<0.001	0.029	<0.001
d.f.	6	6	6	6	6	6	24
L.S.D	1.53	0.27	9.18	0.43	0.48	0.78	2.55

Efford yr 2	Autumn 2001	Spring 2002			
	Size	Size	Colour	Flowering	
	Score	Score	Score	Score	Biomass
CRF rate	1-5	1-5	1,3,5	1-5	(g/plant)
Zero	1.1	1.2	1.1	2.4	13.1
2 kg/m^3	1.9	2.7	3.1	2.1	25.9
4 kg/m^3	3.8	3.8	4.3	2.8	46.0
6 kg/m^3	4.1	3.6	4.6	2.9	50.6
Mean	2.7	2.8	3.3	2.6	33.9
Significance	<0.001	<0.001	<0.001	ns	<0.001
d.f.	6	6	6	6	24
L.S.D	0.55	0.73	0.31	0.99	10.12

Table 3.2.2 Spring potted, raised in plastic tunnels

a) *Ceanothus impressus* 'Autumnal blue'

Efford yr 1	Autumn 2000				Spring 2001				
	Size	Colour	Vigour		Size	Colour	Flowering	Vigour	
	Score	Score	Score	Trimmings	Score	Score	Score	Score	Biomass
CRF rate	1-5	1-5	1,3,5	(g/plant)	1-5	1-5	0-5	1-5	(g/plant)
Zero	2.2	1.7	1.3	11.2	1.9	1.8	0.7	1.4	17.9
2 kg/m^3	4.0	3.2	3.3	39.6	3.3	3.3	1.7	3.1	36.7
4 kg/m^3	4.6	4.2	3.9	50.3	4.2	4.1	2.8	4.3	52.4
6 kg/m^3	4.8	4.8	4.2	56.9	4.4	4.5	2.3	4.7	59.8
Mean	3.9	3.5	3.2	39.5	3.4	3.4	1.9	3.3	41.7
Significance	<0.001	<0.001	0.003	0.015	<0.001	<0.001	0.002	<0.001	<0.001
d.f.	6	6	6	6	6	6	6	6	24
L.S.D	0.82	0.44	1.11	24.35	0.60	0.64	0.78	0.66	7.32

Efford yr 2	Autumn 2001			Spring 2002				
	Size	Colour	Vigour	Size	Colour	Flowering	Vigour	
	Score	Score	Score	Score	Score	Score	Score	Biomass
CRF rate	1-5	1-5	1,3,5	1-5	1-5	1,3,5	1-5	(g/plant)
Zero	1.3	1.8	1.3	1.6	1.1	0.4	1.2	35.1
2 kg/m^3	3.3	2.6	2.8	3.0	1.8	1.1	2.3	70.0
4 kg/m^3	4.1	3.9	4.7	4.4	2.9	1.2	3.7	136.9
6 kg/m^3	4.8	4.3	4.7	4.6	3.6	0.7	4.2	127.5
Mean	3.7	3.2	3.4	3.4	2.3	0.9	2.8	92.4
Significance	<0.001	<0.001	<0.001	<0.001	<0.001	ns	<0.001	<0.001
d.f.	6	6	6	6	6	6	6	24
L.S.D	0.51	0.52	0.88	0.68	0.48	0.70	0.40	15.49

b) *Choisya ternata*

Efford yr 1	Autumn 2000			Spring 2001			
	Size	Colour		Size	Colour	Flowering	
	Score	Score	Trimmings	Score	Score	Score	Biomass
CRF rate	1-5	1,3,5	(g/plant)	1-5	1-5	0,1,3,5	(g/plant)
Zero	1.3	2.3	0.4	1.2	1.0	2.7	14.7
2 kg/m^3	3.0	3.4	14.2	3.1	2.3	1.6	30.0
4 kg/m^3	3.7	4.0	25.6	4.2	3.8	1.6	47.6
6 kg/m^3	4.6	4.8	33.9	4.5	4.4	1.2	54.0
Mean	3.1	3.6	18.5	3.2	2.9	1.8	36.6
Significance	<0.001	<0.001	<0.001	<0.001	<0.001	ns	<0.001
d.f.	6	6	6	6	6	6	24
L.S.D	0.57	0.59	3.83	0.35	0.37	1.60	6.88

Efford yr 2	Autumn 2001		Spring 2002			
	Size Score	Colour Score	Size Score	Colour Score	Flowering Score	
CRF rate	1-5	1-5	1-5	1,3,5	0,1,3,5	Biomass (g/plant)
Zero	1.4	2.5	1.3	1.3	1.3	16.3
2 kg/m^3	2.4	3.0	2.3	3.1	1.9	25.7
4 kg/m^3	3.6	4.4	3.8	3.9	0.9	38.6
6 kg/m^3	3.7	3.4	4.6	3.8	1.8	46.9
Mean	2.8	3.4	3.0	3.0	1.5	31.9
Significance	<0.001	<0.001	<0.001	0.003	ns	<0.001
d.f.	6	6	6	6	6	24
L.S.D	0.54	0.36	0.34	1.01	1.33	7.71

c) ***Jasminum nudiflorum***

Efford yr 1	Autumn 2000				Jan 2001	Spring 2001		
	Height	Colour Score	Vigour Score	Trimmings	Flowering Score	Size Score	Colour Score	Biomass
CRF rate	(cm)	1,3,5	1,3,5	(g/plant)	1,3,5	1-5	1,3,5	(g/plant)
Zero	61.9	1.0	1.0	1.2	1.3	1.4	1.0	11.8
2 kg/m^3	110.8	4.0	3.1	11.7	3.1	3.1	3.0	25.8
4 kg/m^3	122.9	4.7	4.7	23.6	3.2	3.8	3.8	30.4
6 kg/m^3	134.7	4.9	4.6	32.0	4.0	4.0	4.4	31.4
Mean	107.6	3.7	3.3	17.1	2.9	3.1	3.1	27.1
Significance	<0.001	<0.001	<0.001	<0.001	0.005	<0.001	<0.001	<0.001
d.f.	6	6	6	6	6	6	6	24
L.S.D	13.18	0.33	0.66	4.52	1.08	0.61	0.29	5.07

Efford yr 2	Autumn 2001		Spring 2002		
	Height	Vigour Score	Height	Colour Score	Biomass
CRF rate	(cm)	1,3,5	(cm)	1,3,5	(g/plant)
Zero	23.5	2.2	31.9	2.1	7.0
2 kg/m^3	31.0	2.5	34.6	2.4	8.3
4 kg/m^3	33.5	2.9	41.8	3.1	8.5
6 kg/m^3	30.4	2.8	37.0	3.2	15.2
Mean	29.6	2.6	36.3	2.7	9.8
Significance	ns	ns	ns	ns	ns
d.f.	6	6	6	6	24
L.S.D	19.31	2.14	20.21	0.84	6.51

d) *Photinia x fraseri* 'Red Robin'

Efford yr 1	Autumn 2000				Spring 2001				
	Size Score	Colour Score	No. main	Trimmings	Size Score	New Growth Colour*	Old Growth Colour	New Growth	Biomass (g/plant)
CRF rate	1-5	1,3,5	Shoots	(g/plant)	1-5	1,3,5	1,3,5	1-5	
Zero	1.3	1.3	2.7	4.6	1.3	1.2	1.1	1.3	11.8
2 kg/m^3	3.0	3.6	3.5	23.5	2.9	3.1	2.9	2.9	26.5
4 kg/m^3	4.2	4.6	3.8	42.0	3.8	4.4	4.2	3.6	36.7
6 kg/m^3	4.6	5.0	4.6	47.6	3.9	4.4	4.6	3.9	47.8
Mean	3.3	3.6	3.6	29.4	3.0	3.3	3.2	2.9	30.7
Significance	<0.001	<0.001	ns	<0.001	<0.001	<0.001	<0.001	0.004	<0.001
d.f.	6	6	6	6	6	6	6	6	24
L.S.D	0.69	0.40	1.55	10.5	0.56	0.58	0.69	1.06	10.68

Efford yr 2	Autumn 2001		Spring 2002			
	Size Score	Colour Score	Size Score	Colour Score	New Growth	Biomass
CRF rate	1-5	1,3,5	1-5	1-5	1-5	(g/plant)
Zero	1.7	1.3	1.4	1.0	1.2	30.9
2 kg/m^3	2.8	2.9	2.9	2.7	3.2	55.9
4 kg/m^3	4.2	3.7	4.2	4	3.4	87.3
6 kg/m^3	5.0	4.7	4.9	4.4	3.4	115.2
Mean	3.4	3.1	3.4	3.0	2.8	72.3
Significance	<0.001	<0.001	<0.001	<0.001	0.024	<0.001
d.f.	6	6	6	6	6	24
L.S.D	0.17	0.64	0.50	0.49	1.43	14.14

e) *Pieris* 'Forest Flame'

Efford yr 1	Autumn 2000		
	Size Score	Colour Score	Vigour Score
CRF rate	1-5	1,3,5	1,3,5
Zero	1.9	1.7	3.4
2 kg/m^3	4.1	3.1	4.9
4 kg/m^3	3.6	4.3	4.2
6 kg/m^3	2.7	4.7	2.3
Mean	3.1	3.4	3.7
Significance	0.021	0.001	ns
d.f.	6	6	6
L.S.D	1.23	1.00	1.78

N.B. One of the replicates of *Pieris* was located at the far north end of the tunnel and plants suffered from wind damage / scorch. As a result, scores from these plants had to be omitted from the Spring 2001 data, and statistical analysis could not be done.

Efford yr 1 continued	Spring 2001						
CRF rate	Size Score 1-5	Lower Colour Score 1,3,5	Upper Colour Score 1-5	New Growth Score 0,1,3,5	Flowering Score 0,1,3,5	Vigour Score 1,3,5	Biomass (g/plant)
Zero	2.1	1.7	2.3	1.7	1.0	3.6	18.3
2 kg/m^3	3.3	3.1	2.9	2.0	3.1	4.8	35.0
4 kg/m^3	3.8	4.3	2.3	3.2	2.3	4.7	42.3
6 kg/m^3	3.4	5.0	1.7	3.1	1.3	3.9	28.1
Mean	3.2	3.5	2.3	2.5	1.9	4.3	30.9
Significance	-	-	-	-	-	-	-
d.f.	-	-	-	-	-	-	-
L.S.D	-	-	-	-	-	-	-

Efford yr 2	Autumn 2001		April 2002		May 2002		
CRF rate	Size Score 1-5	Colour Score 1,3,5	New Growth Score 0,1,3,5	Flowering Score 0,1,3,5	Size Score 1-5	Lower Foliage Colour 1,3,5	Biomass (g/plant)
Zero	1.4	2.0	3.3	0.3	1.4	1.0	10.3
2 kg/m^3	3.1	4.4	3.8	2.4	2.9	3.4	36.0
4 kg/m^3	3.6	3.8	3.6	3.4	3.6	3.9	42.2
6 kg/m^3	4.1	3.7	2.9	4.2	3.9	4.9	50.6
Mean	3.1	3.5	3.4	2.6	3.0	3.3	36.8
Significance	<0.001	<0.001	ns	<0.001	<0.001	<0.001	<0.001
d.f.	6	6	6	6	6	6	24
L.S.D	0.048	0.22	1.25	1.12	0.51	0.50	7.09

Table 3.2.3 Autumn potted, raised in unheated glasshouse

a) *Cistus* 'Silver Pink'

Efford yr 1			Spring 2001		
	Size	Visual Appeal	Colour	Flowering	
	Score	Score	Score	Score	Biomass
CRF rate	1-5	1,3,5	1,3,5	0-5	(g/plant)
Zero	1.6	1.0	1.0	1.4	20.6
2 kg/m^3	4.0	3.2	3.1	2.3	52.2
4 kg/m^3	4.1	4.0	4.4	1.7	51.1
6 kg/m^3	4.1	3.7	4.4	1.9	55.2
Mean	3.4	3.0	3.3	1.9	44.8
Significance	<0.001	<0.001	<0.001	ns	<0.001
d.f.	6	6	6	6	24
L.S.D	0.57	0.96	0.92	1.35	8.06

Efford yr2		Spring 2002	
	Size Score	Colour Score	Biomass
CRF rate	1-5	1,3,5	(g/plant)
Zero	1.0	1.0	10.8
2 kg/m^3	3.1	3.0	30.0
4 kg/m^3	3.7	4.8	37.6
6 kg/m^3	3.7	5.0	32.4
Mean	2.9	3.4	27.7
Significance	<0.001	<0.001	<0.001
d.f.	6	6	24
L.S.D	0.45	0.21	3.87

b) *Euonymous*

Yr 1 – *E. japonicus* 'Ovatus Aureus'

Efford yr 1		Spring 2001	
	Size Score	Colour Score	Biomass
CRF rate	1-5	1,3,5	(g/plant)
Zero	1.8	1.1	16.0
2 kg/m^3	3.6	3.1	28.0
4 kg/m^3	3.6	4.0	25.9
6 kg/m^3	3.6	4.7	27.7
Mean	3.2	3.2	20.3
Significance	0.002	<0.001	<0.001
d.f.	6	6	24
L.S.D	0.67	0.48	6.30

Yr 2 – *E. fortunei* 'Gold Tip'

Efford yr 2	Spring 2002	
	Size Score	Biomass
CRF rate	1-5	(g/plant)
Zero	2.2	5.5
2 kg/m^3	3.3	7.5
4 kg/m^3	3.6	7.2
6 kg/m^3	3.0	5.9
Mean	3.0	6.5
Significance	0.004	ns
d.f.	6	24
L.S.D	0.58	1.77

c) *Hebe* 'Red Edge'

Efford yr 1	Spring 2001	
	Size Score	Biomass
CRF rate	1,3,5	(g/plant)
Zero	1.0	19.1
2 kg/m^3	4.3	33.5
4 kg/m^3	4.9	32.1
6 kg/m^3	4.7	30.2
Mean	3.7	28.7
Significance	<0.001	<0.001
d.f.	6	24
L.S.D	0.84	4.44

Efford yr 2	Spring 2002	
	Size Score	Biomass
CRF rate	1-5	(g/plant)
Zero	1.2	18.7
2 kg/m^3	3.6	32.3
4 kg/m^3	4.7	36.6
6 kg/m^3	4.4	36.2
Mean	3.5	31.0
Significance	<0.001	<0.001
d.f.	6	24
L.S.D	0.40	3.99

d) *Lavandula angustifolia* 'Hidcote'

Efford yr 1	Spring 2001	
	Size Score	Biomass
CRF rate	1-5	(g/plant)
Zero	1.7	9.4
2 kg/m^3	3.4	21.1
4 kg/m^3	4.3	20.9
6 kg/m^3	4.5	24.8
Mean	3.5	19.1
Significance	<0.001	<0.001
d.f.	6	24
L.S.D	0.67	3.62

Efford yr 2	Spring 2002	
	Size Score	Biomass
CRF rate	1-5	(g/plant)
Zero	1.0	10.8
2 kg/m^3	2.4	20.6
4 kg/m^3	3.9	25.7
6 kg/m^3	3.8	23.1
Mean	2.8	20.0
Significance	<0.001	<0.001
d.f.	6	24
L.S.D	0.76	4.16

e) *Lavatera* 'Rosea'

Efford yr 1	Spring 2001			
	Size Score	Vigour Score	Colour Score	Biomass
CRF rate	1-5	1,3,5	1,3,5	(g/plant)
Zero	1.6	1.2	1.2	11.5
2 kg/m^3	3.4	3.1	2.9	36.8
4 kg/m^3	4.1	4.0	4.2	42.8
6 kg/m^3	4.2	4.3	4.7	56.1
Mean	3.3	3.2	3.3	36.8
Significance	<0.001	<0.001	<0.001	<0.001
d.f.	6	6	6	24
L.S.D	0.70	0.37	0.33	5.7

Note - No *Lavatera* year 2 data

Appendix 3.3 Foliage Nutrient Levels
Data are means of 3 replicates.

Table 3.3.1 Spring-potted, raised outside - Efford (Eff.) and Whixley (Whx.)

a) ***Chamaecyparis lawsoniana*** **'Ellwoodii'**

	Nutrient starved 0 kg/m³				Optimal nutrition 6 kg/m³			
	Autumn		Spring		Autumn		Spring	
	Eff.	Whx.	Eff.	Whx.	Eff.	Whx.	Eff.	Whx.
Nitrogen (%)	0.66	1.00	0.45	0.82	1.25	1.73	1.02	1.22
Phosphorus (%)	0.09	0.11	0.08	0.08	0.20	0.29	0.15	0.17
Potassium (%)	1.30	1.33	0.75	0.79	2.09	2.38	1.28	1.27
Calcium (%)	1.25	2.02	1.17	1.17	0.92	1.65	0.90	1.05
Magnesium (%)	0.22	0.32	0.15	0.21	0.20	0.31	0.14	0.19
Manganese (mg/kg)	311.83	482.61	233.88	251.5	134.80	341.88	31.50	113.24

b) ***Cytisus x praecox***

	Nutrient starved 0 kg/m³				Optimal nutrition 4 kg/m³			
	Autumn		Spring		Autumn		Spring	
	Eff.	Whx.	Eff.	Whx.	Eff.	Whx.	Eff.	Whx.
Nitrogen (%)	1.34	1.73	1.84	1.95	1.56	1.75	1.91	2.64
Phosphorus (%)	0.14	0.10	0.11	0.10	0.22	0.19	0.15	0.25
Potassium (%)	0.88	0.89	0.70	1.18	1.46	1.27	1.45	1.47
Calcium (%)	0.77	0.64	0.63	0.87	0.28	0.35	0.41	0.79
Magnesium (%)	0.49	0.41	0.35	0.44	0.19	0.27	0.18	0.37
Manganese (mg/kg)	947.14	1190.2	212.19	738.64	151.76	161.29	65.00	72.75

c) ***Photinia x fraseri*** **'Red Robin'**

	Nutrient starved 0 kg/m³				Optimal nutrition 4 kg/m³			
	Autumn		Spring		Autumn		Spring	
	Eff.	Whx.	Eff.	Whx.	Eff.	Whx.	Eff.	Whx.
Nitrogen (%)	0.93	1.00	0.78	1.03	1.28	1.38	1.11	135
Phosphorus (%)	0.09	0.09	0.09	0.09	0.14	0.14	0.14	0.18
Potassium (%)	2.22	1.46	1.81	1.08	2.43	1.62	2.15	1.47
Calcium (%)	1.45	1.47	1.90	2.06	1.42	1.38	1.83	2.42
Magnesium (%)	0.34	0.36	0.39	0.49	0.26	0.27	0.31	0.43
Manganese (mg/kg)	50.58	26.46	48.78	36.13	48.09	30.37	38.83	51.33

d) *Viburnum tinus* 'Eve Price'

	Nutrient starved 0 kg/m³				**Optimal nutrition 4 kg/m³**			
	Autumn		Spring		Autumn		Spring	
	Eff.	Whx.	Eff.	Whx.	Eff.	Whx.	Eff.	Whx.
Nitrogen (%)	0.68	0.76	0.48	0.70	1.30	1.04	0.67	0.82
Phosphorus (%)	0.07	0.08	0.20	0.06	0.11	0.12	0.07	0.08
Potassium (%)	0.80	0.71	0.70	0.72	1.58	1.53	1.05	1.02
Calcium (%)	1.00	1.23	0.97	1.08	1.06	0.88	0.90	0.99
Magnesium (%)	0.42	0.53	0.42	0.47	0.39	0.41	0.33	0.41
Manganese (mg/kg)	143.64	143.34	173.05	147.09	133.47	109.66	115.45	107.28

e) *Weigela* 'Red Prince'

	Nutrient starved 0 kg/m³				**Optimal nutrition 4 kg/m³at Eff. 6 kg/m³ at Whx.**			
	Autumn		Spring		Autumn		Spring	
	Eff.	Whx.	Eff.	Whx.	Eff.	Whx.	Eff.	Whx.
Nitrogen (%)	0.63	1.10	1.00	1.22	0.81	1.00	0.92	1.55
Phosphorus (%)	0.08	0.15	0.14	0.14	0.11	0.12	0.14	0.19
Potassium (%)	0.48	1.28	1.69	1.58	0.85	0.78	1.26	2.56
Calcium (%)	2.18	1.60	1.70	0.95	1.64	1.26	1.23	1.00
Magnesium (%)	0.99	0.69	0.45	0.49	0.73	0.69	0.39	0.40
Manganese (mg/kg)	124.57	95.84	64.97	61.91	91.94	53.94	43.44	46.73

Table 3.3.2 Spring-potted, raised in plastic tunnels- Efford only

a) *Ceanothus impressus* 'Autumnal Blue'

	Nutrient starved 0 kg/m³		**Optimal nutrition 4 kg/m³**	
	Autumn	Spring	Autumn	Spring
Nitrogen (%)	0.63	0.98	1.34	1.18
Phosphorus (%)	0.08	0.11	0.10	0.12
Potassium (%)	0.96	1.36	1.92	1.97
Calcium (%)	1.88	1.94	1.26	1.22
Magnesium (%)	0.31	0.32	0.19	0.19
Manganese (mg/kg)	399.26	332.62	230.93	71.39

b) ***Choisya ternata***

	Nutrient starved 0 kg/m³		Optimal nutrition 4 kg/m³	
	Autumn	Spring	Autumn	Spring
Nitrogen (%)	0.94	0.82	1.11	1.18
Phosphorus (%)	0.12	0.12	0.14	0.16
Potassium (%)	0.89	0.91	1.00	1.16
Calcium (%)	2.91	3.20	1.54	2.57
Magnesium (%)	0.63	0.62	0.48	0.52
Manganese (mg/kg)	82.90	103.20	65.77	106.20

c) ***Jasminum nudiflorum***

	Nutrient starved 0 kg/m³		Optimal nutrition 4 kg/m³	
	Autumn	Spring	Autumn	Spring
Nitrogen (%)	0.95	1.67	1.00	2.12
Phosphorus (%)	0.11	0.23	0.13	0.34
Potassium (%)	1.43	2.79	1.71	3.79
Calcium (%)	1.57	0.85	0.78	1.11
Magnesium (%)	0.55	0.37	0.29	0.33
Manganese (mg/kg)	189.90	114.01	55.83	102.49

d) ***Photinia x fraseri*** **'Red Robin'**

	Nutrient starved 0 kg/m³		Optimal nutrition 4 kg/m³	
	Autumn	Spring	Autumn	Spring
Nitrogen (%)	0.83	0.79	1.26	1.01
Phosphorus (%)	0.10	0.09	0.13	0.15
Potassium (%)	2.03	1.71	2.12	1.95
Calcium (%)	1.78	2.07	1.62	1.56
Magnesium (%)	0.36	0.42	0.27	0.25
Manganese (mg/kg)	58.46	76.25	50.76	44.50

e) ***Pieris*** **'Forest Flame'**

	Nutrient starved 0 kg/m³		**Optimal nutrition 4 kg/m³**	
	Autumn	Spring	Autumn	Spring
Nitrogen (%)	0.78	0.72	1.53	1.20
Phosphorus (%)	0.08	0.07	0.20	0.16
Potassium (%)	1.28	0.86	2.92	1.93
Calcium (%)	1.14	1.24	0.94	1.26
Magnesium (%)	0.23	0.25	0.23	0.23
Manganese (mg/kg)	758.84	795.48	385.91	461.39

Table 3.3.3 Autumn-potted, raised in unheated glasshouse (Efford only)

a) ***Cistus*** **'Silver Pink'**

	Spring	
	Nutrient starved 0 kg/m³	**Optimal nutrition 2 kg/m³**
Nitrogen (%)	0.68	1.08
Phosphorus (%)	0.06	0.09
Potassium (%)	0.75	1.15
Calcium (%)	1.30	1.09
Magnesium (%)	0.34	0.28
Manganese (mg/kg)	401.95	137.45

b) ***Hebe*** **'Red Edge'**

	Spring	
	Nutrient starved 0 kg/m³	**Optimal nutrition 2 kg/m³**
Nitrogen (%)	1.17	2.04
Phosphorus (%)	0.06	0.17
Potassium (%)	0.89	1.99
Calcium (%)	1.21	1.28
Magnesium (%)	0.57	0.65
Manganese (mg/kg)	138.20	135.17

c) *Lavandula angustifolia* 'Hidcote'

	Spring	
	Nutrient starved 0 kg/m³	**Optimal nutrition 2 kg/m³**
Nitrogen (%)	1.37	1.41
Phosphorus (%)	0.24	0.22
Potassium (%)	3.05	3.12
Calcium (%)	1.18	0.98
Magnesium (%)	0.78	0.67
Manganese (mg/kg)	101.01	74.33

d) *Euonymous japonicus* 'Ovatus Aureus'

	Spring	
	Nutrient starved 0 kg/m³	**Optimal nutrition 2 kg/m³**
Nitrogen (%)	1.11	1.70
Phosphorus (%)	0.13	0.21
Potassium (%)	1.39	1.56
Calcium (%)	1.16	0.88
Magnesium (%)	0.22	0.23
Manganese (mg/kg)	26.12	27.03

e) *Lavatera* 'Rosea'

	Spring	
	Nutrient starved 0 kg/m³	**Optimal nutrition 4 kg/m³**
Nitrogen (%)	1.41	1.94
Phosphorus (%)	0.15	0.19
Potassium (%)	2.17	3.20
Calcium (%)	2.38	1.41
Magnesium (%)	1.06	0.73
Manganese (mg/kg)	180.88	109.11