Project Title	HONS: Over-wintering in Different Peat Substitutes and Assessment of Nursery Trials
Project number:	HNS 127a
Project leader:	Ralph Noble, Warwick HRI
Report:	Final report, June 2007
Key staff:	Andreja Dobrovin-Pennington
Location of project:	Warwick HRI, Wellesbourne and 6 commercial nurseries
Project coordinators:	Mr John Woodhead (Hillier Nurseries) Mr David Hooker (Hillier Nurseries) Mr Patrick Fairweather (Fairweathers)
Date project commenced:	October 2006
Date completion due:	June 2007
Key words:	woody ornamental, herbaceous perennial, peat, growing media paper waste, carpet wool waste

The results and conclusions in this report are based on a series of experiments 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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CONTENTS

Grower Summary

Headline

- Both composted paper pulp waste and carpet shearing waste offer benefits to the production of a range of container grown HONS species when included in growing media.

Background and expected deliverables

The Waste Into Rooting Media 'WIRM' project (HNS 127) identified two types of waste materials that have a potential value in growing media for a range of HONS species. These were composted paper or cardboard wastes and shearing waste from wool carpet production.

Both materials showed promising results in 2005. Composted paper wastes appeared to be particularly suitable for herbaceous perennial species and *Chamaecyparis*. Carpet shearing waste was suitable for the liners and finished pots of some woody ornamentals (e.g. *Viburnum* spp.), some herbaceous perennials (e.g. Geranium) and also showed some potential for lavenders and clematis.

These materials have a potential value, both as a partial substitute for peat and as a source of plant nutrients, and therefore improved growth compared with that in peat media.

This trial (HNS 127a) was set up in 2006 to examine these growing media components. To obtain full information, the plants needed to be over-wintered after the WIRM project was completed.

The commercial objectives of the project were:

- To assess the effect of inclusion of composted paper / cardboard and carpet shearing wastes on the over-wintering and subsequent quality of a range of woody ornamental and herbaceous perennial species.

- To set up and assess commercial nursery trials using the above materials on a range of HONS species.

- To liaise with growing media producers on the feasibility of incorporating these new growing media components into commercial mixes.

Summary of the project and main conclusions

The effect of including carpet shearing waste in the growing media of a range of woody ornamentals and herbaceous perennials in 2 and 3 L pots and 9 cm liners was examined in experiments at Warwick HRI and in trials at four commercial nurseries. The effect of substituting 50% of peat with three different types of composted paper waste was also examined in experiments at Warwick HRI and at two commercial conifer nurseries.

Main conclusions

- The inclusion of carpet shearing waste in the growing medium improved the growth and leaf colour of a range of woody ornamentals in 2 and 3 L pots and 9 cm liners. An inclusion rate of carpet shearing waste of 12.5% by volume generally produced better results than a 25% inclusion rate.

- The growth benefit to *Viburnum tinus* plants in liners from the carpet waste was carried on after potting into 3 L pots.

- Carpet waste improved the growth of summer grown lavenders in liners but resulted in an excessively high growing media EC for over-wintered lavenders. It may be possible to avoid this effect by reducing or omitting controlled release fertiliser from the over-wintered mix.

- The material was found to be unsuitable for *Rudbeckia* 'Goldsturm' grown in 3L pots, and for liners of *Oenothera* and *Physocarpus.*

- A growing medium containing 50% by volume of composted paper pulp waste performed as well as a peat control for *Clematis*, *Chamaecyparis, Spiraea* and *Viburnum*. The treatment also increased flower size in *Clematis*.

- Of the composted paper wastes used, paper pulp performed better than paper crumb and cardboard wastes. However, for *Chamaecyparis*, a 50% composted paper crumb treatment appeared to perform significantly better when plants were kept outside rather than under polythene.

Financial benefits

The use of wastes from paper and carpet production in growing media for HONS has the potential to:

- Improve the growth, quality and flowering of a range of herbaceous perennials and woody ornamentals in finished pots and liners.

- Reduce the need for controlled release fertilisers and lime in growing media.

- Reduce the incidence of soil-borne diseases caused by pathogens such as *Phytophthora* and *Pythium* species by the incorporation of composted paper wastes in growing media. This aspect was not investigated in this project, but is supported by a significant amount of research into disease suppression using composts.

- Improve the environmental image of the HONS industry by reducing peat consumption and reducing waste landfilling of other industries.

Action points for growers

- Carpet shearing waste should be tested at incorporation rates of 12.5% v/v or less in growing media for liners of herbaceous perennials and woody ornamentals (Warwick HRI can be contacted about the availability and use of this material, and on growing media producers that can supply a mixed product).

- The use of carpet shearing waste in growing media should be tested in finished pots of genera and species shown to have particularly benefited from this material.

Woody ornamentals:

Berberis	*Ceanothus*	*Chamaecyparis*	*Chaenomeles*
Cotoneaster	*Clematis*	*Cytisus*	*Euonymus*
Griselinia	*Hydrangea*	*Lonicera*	*Viburnum*

Herbaceous perennials:

Agapanthus	*Digitalis*	*Lavandula* (spring/summer grown)

- Other species which should be tested for the incorporation of carpet shearing waste in the growing medium are those which are likely to benefit from a slow release form of nitrogen and ericaceous species, due to the fall in media pH.

- Further development in commercial-scale composting of paper wastes is required before growers can gain access to this material. It is anticipated that further work in this area will commence in 2007, particularly as the materials create a disposal problem for paper mills.

Science Section

Introduction

The project Waste Into Rooting Media 'WIRM' (HNS 127) identified two types of waste materials that have a potential value in growing media for a range of HONS species. These were composted paper or cardboard wastes and shearing waste from wool carpet production.

The above materials showed promising results in 2005/6 trials. Composted paper wastes appeared to be particularly suitable for herbaceous perennial species and *Chamaecyparis*. Carpet shearing waste was suitable for the liners and finished pots of some woody ornamentals (e.g. *Viburnum* spp.), some herbaceous perennials (e.g. Geranium) and also showed some potential for lavenders and clematis.

These materials have a potential value, both as a source of plant nutrients, and therefore improved growth compared with that in peat media, and also as partial substitutes for peat. These waste products are currently landfilled, so their use in growing media should not add significantly to the cost of peat/bark mixes.

Calvin Chong and co-workers at the University of Guelph in Canada have conducted research into the use of paper production by-products for use in HONS production. Their work has mainly compared these media with bark-based products rather than peat (Chong & Cline, 1993; Chong & Purvis; 2004; Chong et al.,1991). They have only used woody ornamental species and not herbaceous perennials. The paper by-products in Canada may also have different characteristics to those available in the UK. However, results obtained in the WIRM project confirmed the results of the Canadian work, which showed that the performance of paper wastes in growing media was improved by composting with a nitrogen source (ammonium sulphate or urea). Composted materials have the potential to suppress soil-borne pathogens such as *Phytophthora* species (Noble & Coventry, 2005) and compost made from specific types of paper production are more consistent than those prepared from green wastes.

The aims of this work were:

(i) To assess the effect of over-wintering on the performance of different growing media components using a range of woody ornamental and herbaceous species.
(ii) To asses the performance of composted paper crumb waste as a growing media component for a range of conifer species in pots and liners on commercial nurseries.
(iii) To assess the performance of carpet shearing waste as a growing media component for a range of woody ornamental and herbaceous perennial species in pots and liners on commercial nurseries.
(iv) To disseminate the results and further develop the commercial production of the growing media components.

Materials and Methods

Over-wintered experiments on plants from the WIRM trials

The following test materials and inclusion rates were set up as part of the WIRM project

(a) Paper crumb waste, composted with ammonium sulphate

(b) Paper pulp waste, composted with urea

(c) Cardboard compacter waste, composted with urea

(d) Carpet shearing waste.

The paper and cardboard wastes were incorporated at 50% by volume and the carpet shearing waste at 25% by volume. Standard peat or peat/bark mixes (depending on species) were used as controls. The rates of base fertilizer (0 or 0.5 kg/m^3) and controlled release fertiliser (3, 4 or 5 kg/m^3 depending on species) were the same in each of the treatments. The 9 cm liners of *Viburnum* produced in the different treatments were potted-up into a standard peat/bark mix.

The following test species were used:

Clematis montana 'Tetrarose' (3 L pots)

Chamaecyparis lawsoniana 'Ellwoodii' (3 L pots)

Viburnum tinus 'French White' (3 L pots and 9 cm liners potted into 3 L pots)

Spiraea japonica 'Candlelight' (2 L pots).

For each test species, there were six replicates of each treatment (12 replicates of peat controls), arranged in a randomised block design. The *Clematis* and *Viburnum* were grown in an open-sided polythene tunnel and the *Chamaecyparis* and *Spiraea* were grown outside.

The effect of inclusion of eight different sources of carpet shearing waste at 25% by volume in a peat-based mix was examined on the flowing test species:

Agapanthus 'Regal Beauty' (9 cm liners)

Two commercial herbaceous peat-based mixes were used as controls. Plants were raised in a polythene tunnel and over-wintered with frost protection at Fairweathers. There were six replicate plants of each carpet source treatment and the two peat-based controls.

All the plants were grown on Mypex matting with overhead sprinkler irrigation.

Commercial Nursery Trials

Hillier Nurseries Ltd, Ampfield, Hants.

(a) Herbaceous mix, Test species: *Rudbeckia fulgida* var. *sullivantii* 'Goldsturm'

Treatments

1. Peat-based Herbaceous mix
2. Herbaceous mix + 25% carpet shearing waste (180 Litres)
3. Herbaceous mix + 12.5% carpet shearing waste (180 Litres)

Sincrocell 12 and Sincrostart 12:14:24 were added to the carpet shearing waste fractions at 3 kg/m^3 and 0.5 kg/m^3 respectively

Plants were potted into 3 L pots on 24 May 2006 and grown outside on Mypex matting with sprinkler irrigation.

(b) Woody ornamental mix, Test species: *Viburnum tinus* 'French white'

Treatments

1. Peat-based Woody ornamental mix
2. Woody ornamental mix + 25% carpet shearing waste (180 Litres)
3. Woody ornamental mix + 12.5% carpet shearing waste (180 Litres)

Sincrocell 12 was added to the carpet shearing waste fractions at 4 kg/m^3

Plants were potted into 3 L pots on 24 May 2006 and grown in an open sided polythene tunnel on Mypex matting with sprinkler irrigation.

Fairweather's, Beaulieu, Hants.

Test species (all in 9 cm liners):

Digitalis parviflora 'Milk Chocolate'

Lavandula stoechas 'Purple Wings'

Lonicera japonica 'Halls Prolific'

Nepeta 'Nimbus'

Verbena 'Claret'

Oenothera cinaeus 'Crown Imperial'

Spiraea japonica 'White Gold'

Treatments

1. Herbaceous mix
2. Herbaceous mix + 25% carpet shearing waste (180 Litres)
3. Herbaceous mix + 12.5% carpet shearing waste (180 Litres)

Sincrocell 12 and Sincrostart 12:14:24 were added to the carpet shearing waste fractions at 3 kg/m^3 and 0.5 kg/m^3 respectively. Plants were potted during the week of 24 May 2006. The *Digitalis*, *Lavandula* and *Lonicera* were grown outside and the *Nepeta*, *Verbena*, *Oenothera* and *Spiraea* were grown in an open-ended polythene tunnel. The plants were grown on Mypex matting with sprinkler irrigation.

New Pace Nurseries Ltd, Almodington, West Sussex

Test species (all in 9 cm liners):

Berberis x *ottawensis* 'Superba'

Ceanothus thyrsiflorus var. *repens*

Chaenomeles x *superba* 'Knap Hill Scarlet'

Cotoneaster radicans 'Eichholz'

Cytisus 'Boskoop Ruby'

Escallonia rubra var. *macrantha*

Euonymus fortunei 'Emerald 'n' Gold'

Griselinia littoralis

Hydrangea macrophylla 'la France'
Physocarpus opulifolius 'Diabolo'
Spiraea japonica 'Candlelight'
Treatments
1. New Place potting mix
2. New Place potting mix + 25% carpet shearing waste
3. New Place potting mix + 12.5% carpet shearing waste

Sincrocell 12 and Sincrostart 12:14:24 were added to the carpet shearing waste fractions at 3 kg/m^3 and 0.5 kg/m^3 respectively. Plants were potted during the week of 24 May 2006 and grown on Mypex matting in a frost protected glasshouse with overhead irrigation.
At least 36 pots of each treatment with each test species were prepared.

Stourbank Nurseries, Wimbourne, Dorset.
Test species: Eight *Lavendula* cultivars
Lavandula angustifolia cvs. 'Artic Snow' 'Imperial Gem' 'Lodden Blue' 'Lodden Pink'
Lavandula stoechas cvs. 'Papillon' 'Leucantha Alba' 'Rocky Road' 'Tiara'
Treatments
1. Standard peat-based lavender mix
2. Lavender mix + 12.5% carpet shearing waste (180 Litres)
3. Lavender mix + 6.3% carpet shearing waste (180 Litres)

Sincrocell 12 was added to the carpet shearing waste fractions at 2 kg/m^3
Plants were potted into 2 L pots on 20 September 2006 and grown in a frost protected glasshouse with sub-irrigation. There were 13 replicate plants of each cultivar and growing medium treatment.

Golden Grove Nursery, Boston, Lincs.
Test species (1 L pots):
Chamaecyparis lawsoniana 'Ellwoods Gold Pillar'
Chamaecyparis lawsoniana 'Ellwoods Pillar'
Chamaecyparis lawsoniana 'Silver Threads'
Chamaecyparis pisifera 'Boulevard'
Juniperus chinensis 'Pyrimadalis'
Juniperus squamata 'Blue Carpet'
Treatments
1. Standard conifer mix (Osmocote at 3 kg/m^3)
2. Shamrock peat + 50% composted paper waste crumb (180 Litres); Sincrocell 12 and Sincrostart 12:14:24 added to the mix at 3 kg/m^3 and 0.5 kg/m^3 respectively
3. Shamrock peat + 50% composted paper waste crumb (180 Litres); Plantacote (2.3kg/m^3) added by Golden Grove Nursery.
4. As treatment (3) using Hi-End Osmocote.

Plants were potted up on 31 May 2006 and grown in a polythene structure on Mypex matting with sprinkler irrigation. There were 12 replicate plants of each treatment.

Evesham Vale Propagators Ltd, Evesham, Worcs.

Test species (9 cm liners): *Chamaecyparis lawsoniana* 'Ellwoodii'

Treatments

1. Standard conifer mix
2. Shamrock peat + 50% composted paper waste crumb (180 Litres); Sincrocell 12 and Sincrostart 12:14:24 were added to the mix at 5 kg/m^3 and 0.5 kg/m^3 respectively

Plants were potted up on 2 August 2006 and grown outside with sprinkler irrigation.

Analyses of growing media

At the end of the experiments, the pH and EC of the growing media in the pots was determined on two replicate samples according to methods in Anon. (2000a,b).

Results

Over-wintered experiments on plants from the WIRM trials

Initial pH and EC values of growing media used in these experiments are shown in HDC report HNS 127, Tables 15 and 17.

Samples taken at the end of the growing periods of each crop showed that the pH values of the media containing 25% carpet shearing waste were lower and those containing 50% composted paper wastes higher than those of the peat controls (Table 1). Across different species, pH values in the same treatments were similar.

The final EC values were slightly higher in the 50% composted paper waste treatments than in the peat control, except for *Chamaecyparis* grown in 50% paper crumb waste (Table 2). All the media containing 25% carpet shearing waste had significantly higher EC values than the peat controls at the end of the cropping periods. The final EC values of the *Chamaecyparis* media were lower than those of the other species, reflecting the greater nutrient uptake of the conifer during the growing period.

Table 1. Final pH of peat control and 50% and 25% peat substitute media

Treatment	*Chamaecyparis*	*Clematis*	*Spiraea*	*Viburnum*
Peat Control	5.59	5.73		5.80
Paper crumb 50%	7.76	7.70		7.66
Paper pulp 50%	7.74	8.07		7.95
Cardboard 50%	7.23	7.16		6.93
Carpet 25%	4.53	4.25		4.17

Table 2. Final electrical conductivity (µS/cm) of peat control and 50% and 25% peat substitute media

Treatment	*Chamaecyparis*	*Clematis*	*Spiraea*	*Viburnum*
Peat Control	220	388		385
Paper crumb 50%	160	398		510
Paper pulp 50%	244	513		423
Cardboard 50%	309	570		454
Carpet 25%	461	892		904

- *Clematis montana* 'Tetrarose'

Top dry weight of plants grown in 50% composted paper pulp or 25% carpet waste were significantly greater than the peat control (Fig. 1, Photo 1). The composted paper wastes produced fewer base branches than the peat control or 25% carpet waste treatments. The 25% carpet waste treatment produced plants with the darkest leaves and the 50% composted paper crumb waste produced plants with the palest leaves. The treatments did not significantly affect the number of buds and flowers (Fig. 1, Photo 1). However, the 50% composted paper pulp and cardboard treatments resulted in larger flowers than the other treatments (Photo 1).

- *Chamaecyparis lawsoniana* 'Ellwoodii'

The 25% carpet waste treatment resulted in the greatest top dry weight, and plants with a more 'bluish' colour than the other treatments (Fig. 2, Photo 2). However, these plants also showed signs of tip scorch (Photo 2). The treatments did not significantly affect plant height or the number of base branches.

- *Viburnum tinus* 'French White'

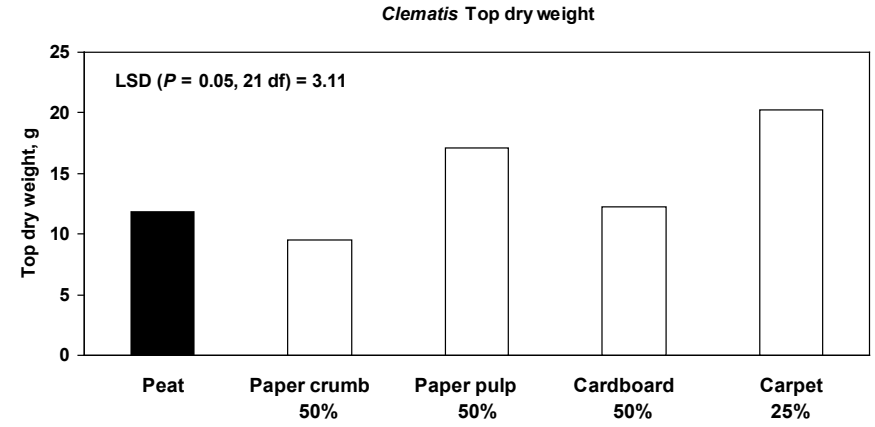
The 50% composted paper waste treatments produced taller plants with a slightly greater top dry weight than the peat control or 25% carpet waste treatments (Fig. 3, Photo 3). Plants grown in the 25% carpet waste treatment had the darkest leaves and produced the most buds and flowers.

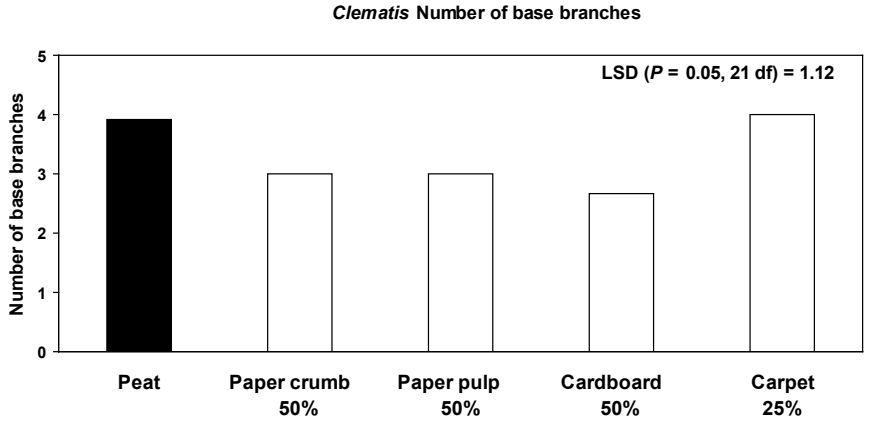
Plants grown in liner media containing carpet shearing waste and then potted on into peat resulted in larger plants which had darker leaves and more flowers than liners grown in peat (Fig. 4, Photo 4). The 50% rate of carpet waste resulted in larger plants with more flowers than the 25% rate. Plants grown in liner media containing 50% composted paper crumb or cardboard wastes were slightly smaller than plants grown in peat-based liner media.

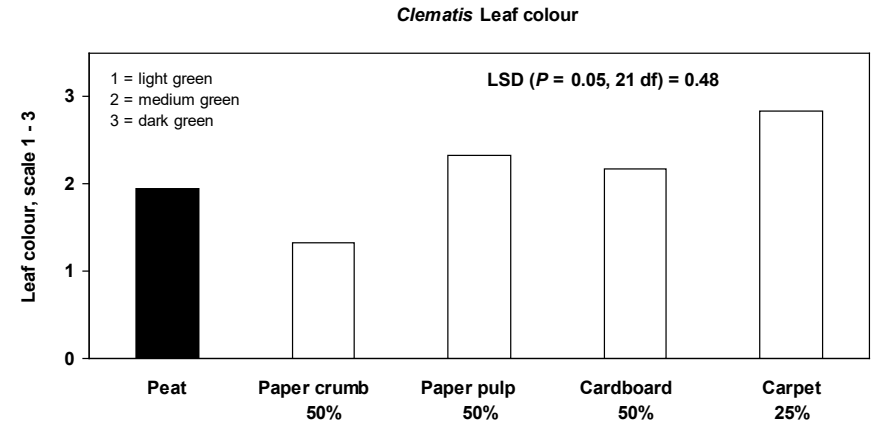
- *Spiraea japonica* 'Candlelight'

Plants grown in 50% composted cardboard waste had a lower top dry weight but there were no significant differences in plant height or flower stem number between the treatments (Fig. 5, Photo 5). The leaves of plants grown with 25% carpet shearing waste were significantly greener than those of the other treatments, but too green for this cultivar (Fig. 5, Photo 5).

Figure 1. *Clematis Montana* 'Tetrarose' assessments







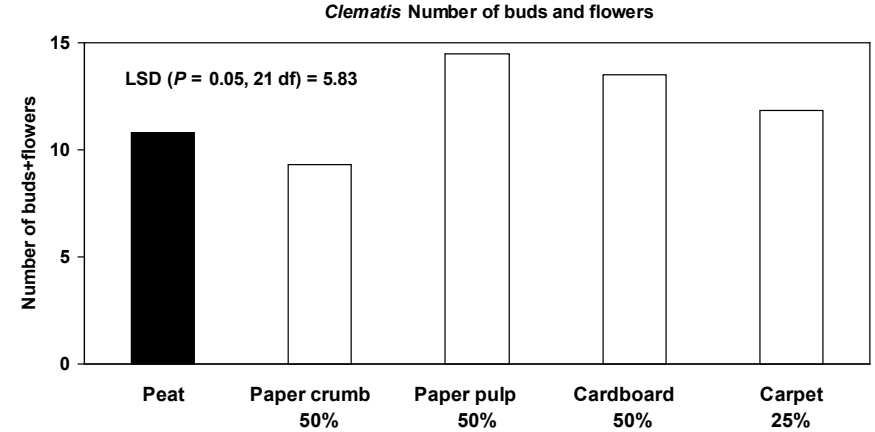
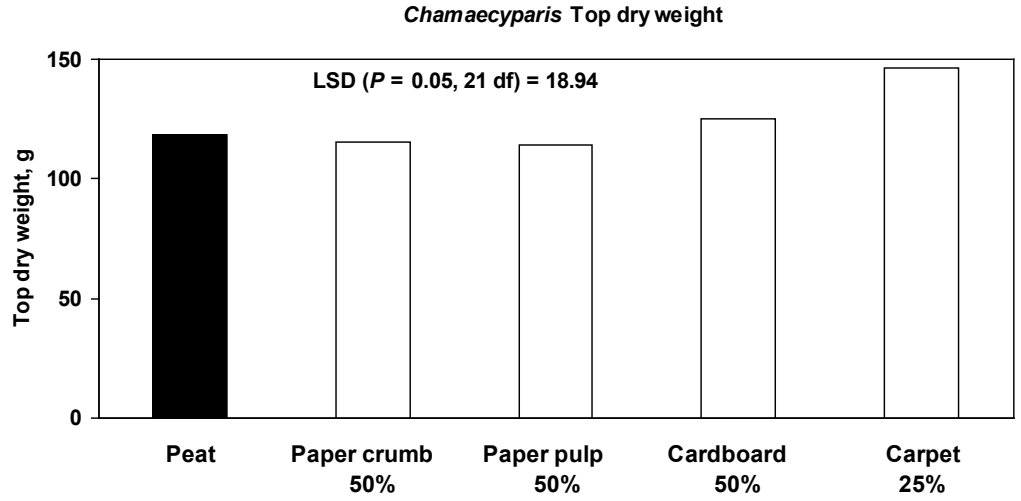
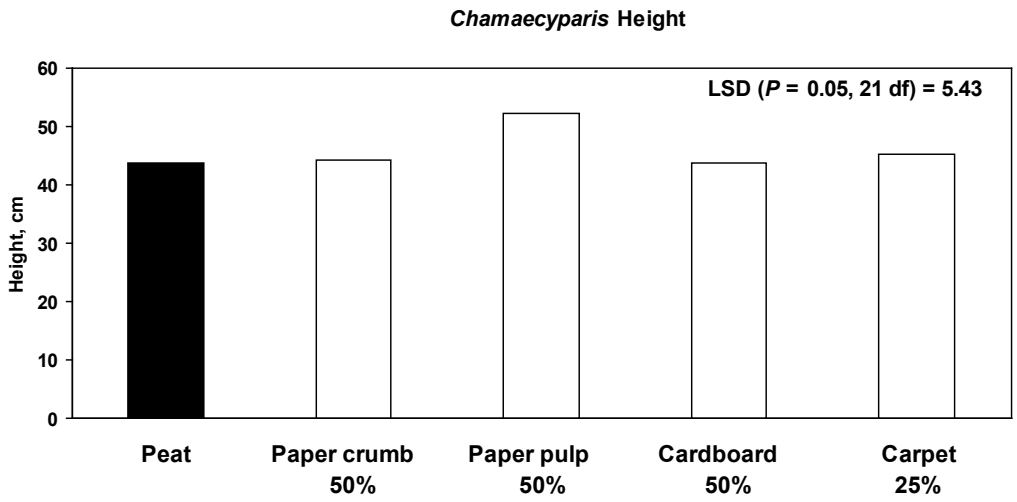


Figure 2. *Chamaecyparis lawsoniana* 'Ellwoodii' assessments.





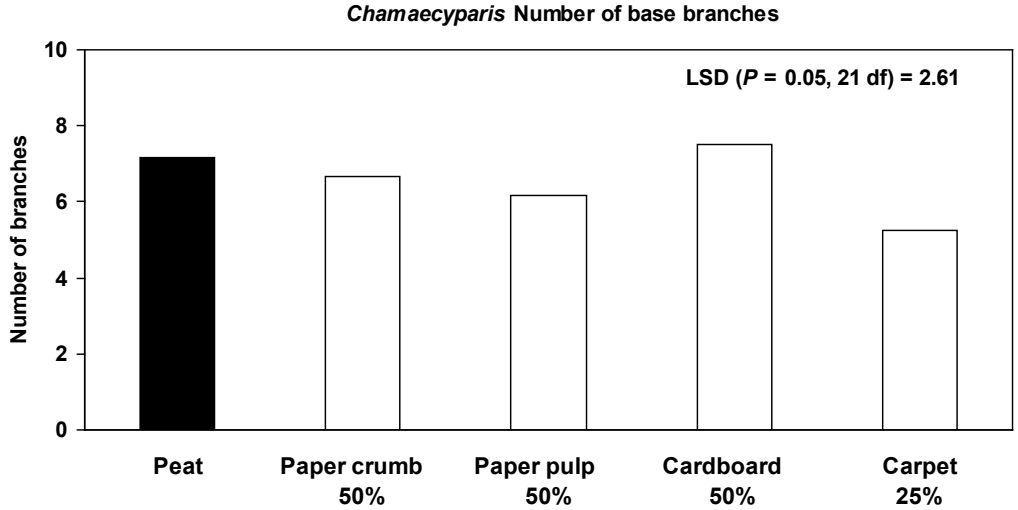
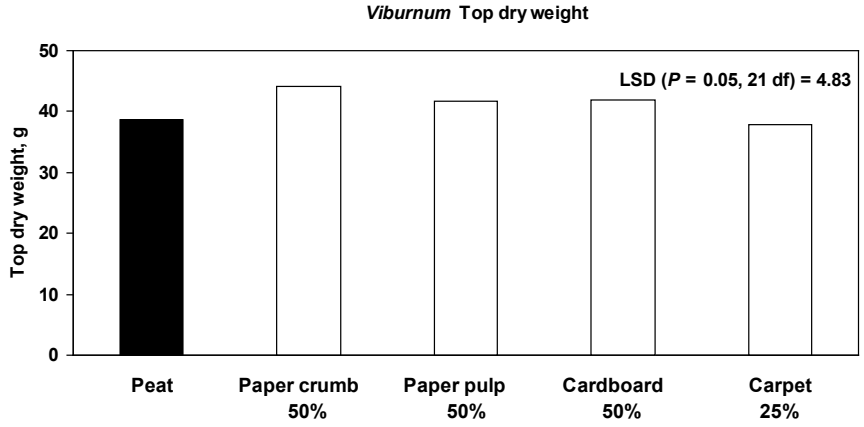
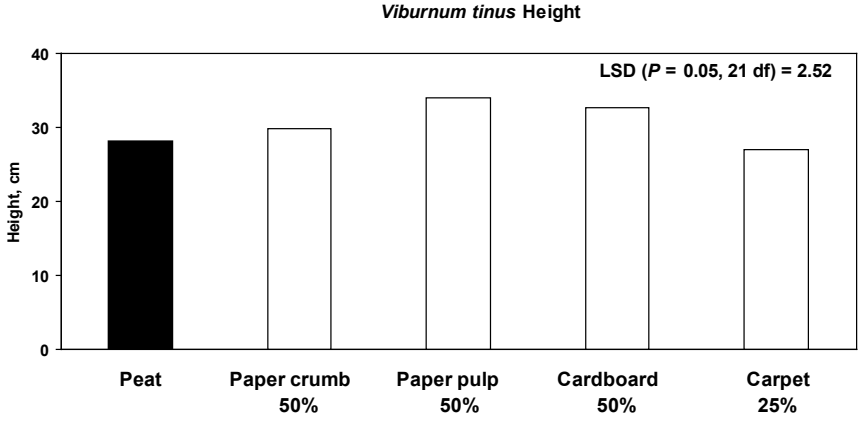
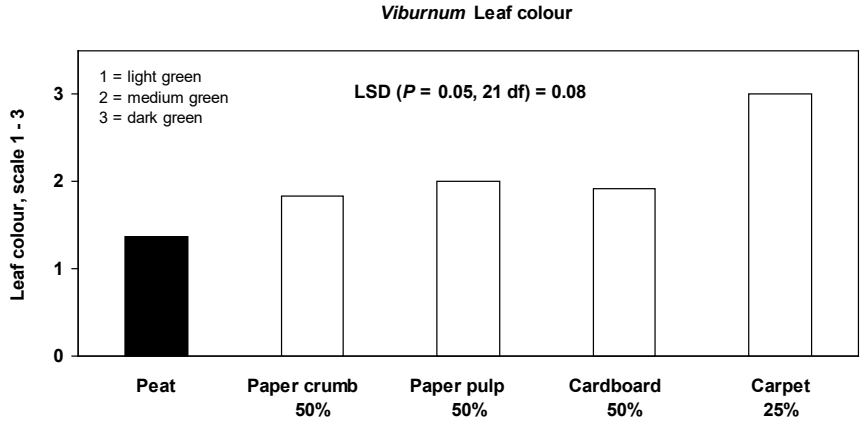


Figure 3. *Viburnum tinus* 'French White' assessments







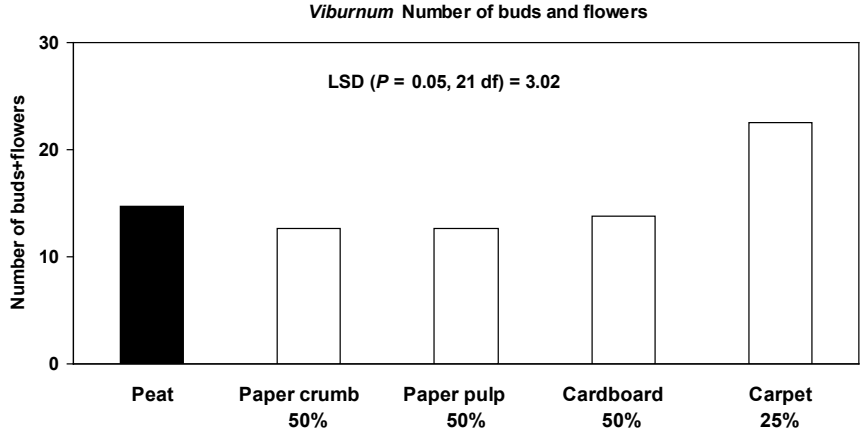


Figure 4. *Viburnum tinus* 'French White' grown in liners containing different media and grown on in 3 L pots with a peat-based medium

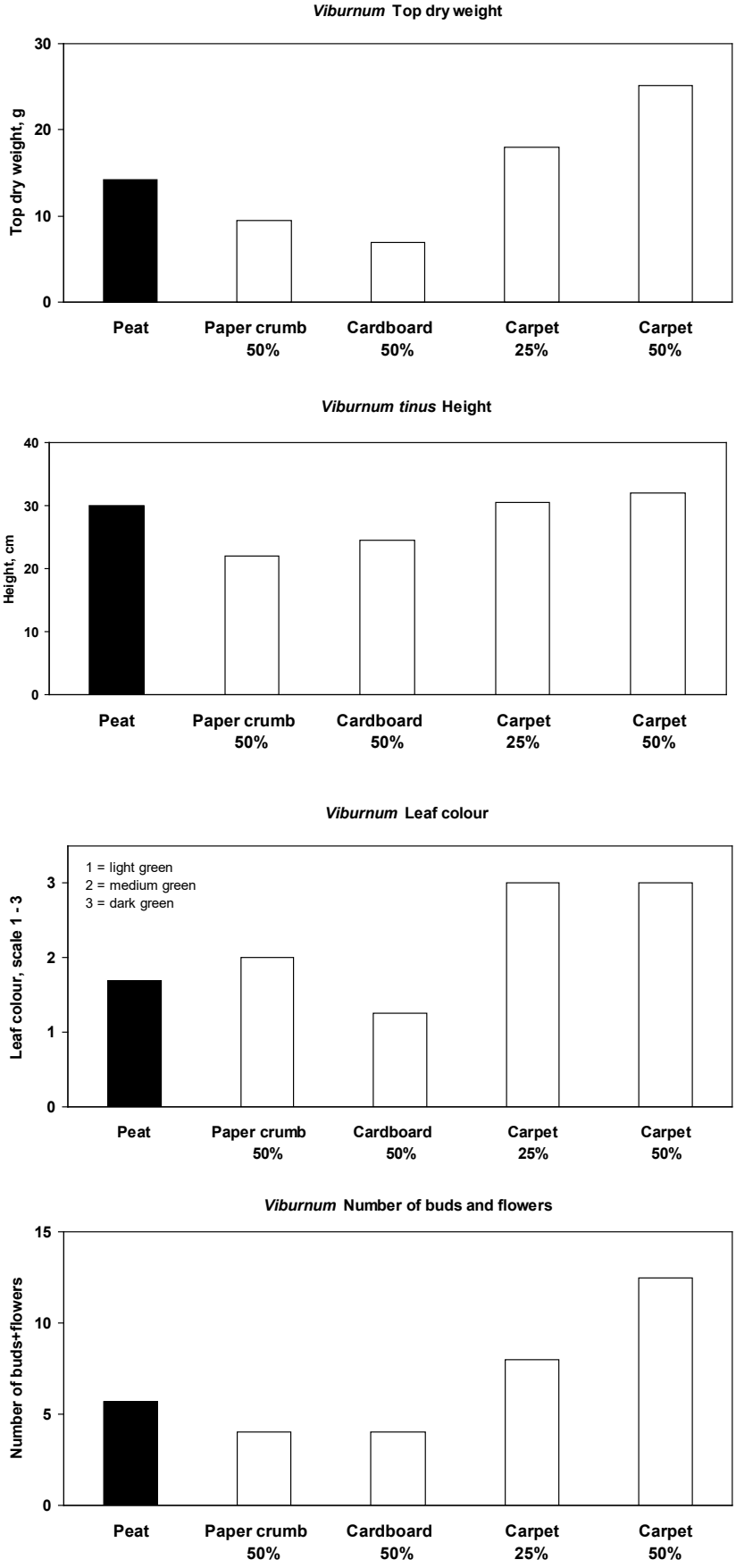
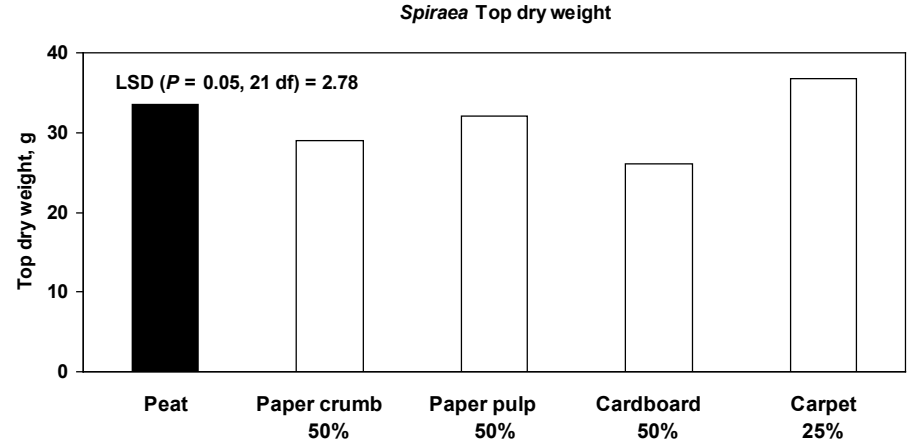
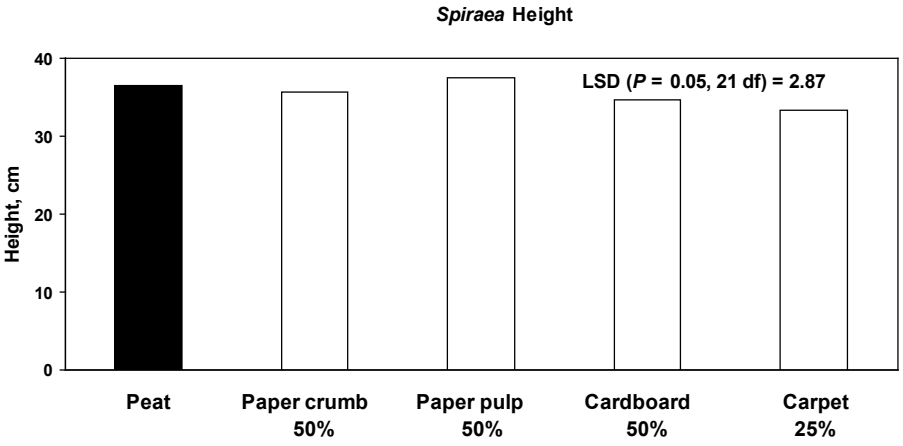
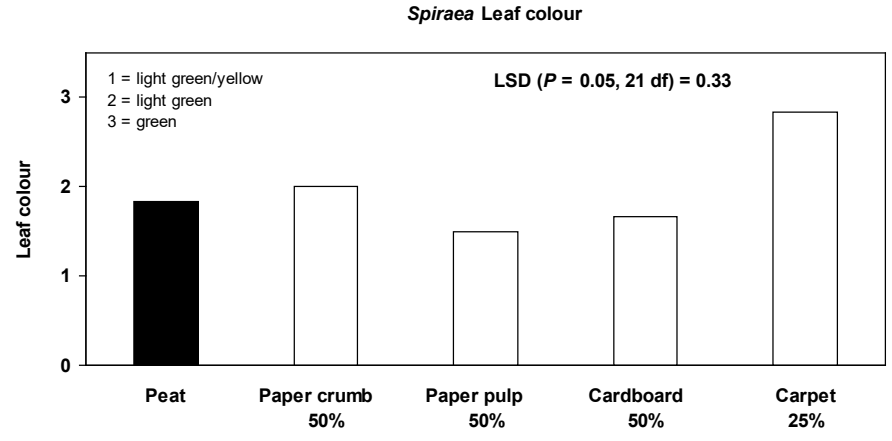
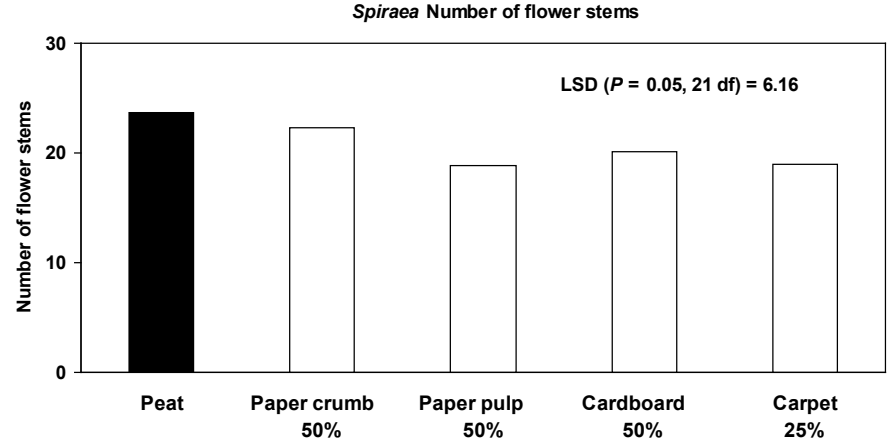


Figure 5. *Spiraea japonica* 'Candlelight' assessments





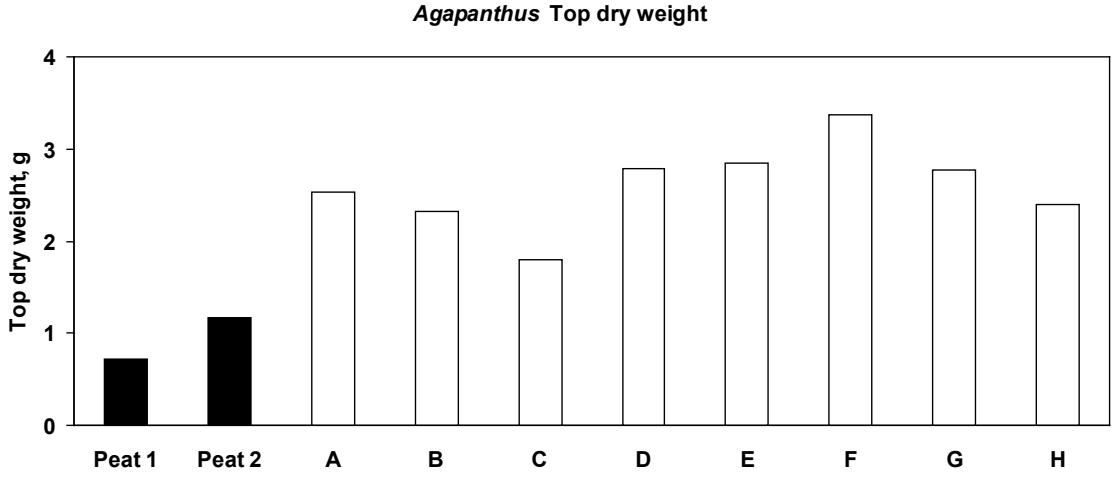




- *Agapanthus* 'Regal Beauty' (9 cm liners)

All the media prepared with 25% carpet waste resulted in larger plants with more base shoots and darker leaves than the two peat control media (Fig. 6, Photo 6). Carpet waste F (Victoria Carpets) produced the best result, although the analyses of the carpet wastes were similar (HDC Report HNS 127).

Figure 6. *Agapanthus* Regal Beauty' 9 cm liner assessments. Plants were grown in two peat-based controls or in peat-based media containing 25% v/v of eight different carpet wastes labeled A to H.



Commercial Nursery Trials

Hillier Nurseries Ltd, Ampfield, Hants.

(a) Herbaceous mix, *Rudbeckia* 'Goldsturm'

Plants were assessed on 2 August 2006. Plants growing in 12.5 and 25% carpet waste had darker leaves but significantly fewer flowers than those growing in peat media (Photo 7).

(b) Woody ornamental mix, *Viburnum* 'French white'

Plants were assessed on 19 September 2006. Plants growing in 12.5 and 25% carpet waste were taller and had darker leaves than those growing in the peat control (Table 3, Photo 8). Plant dry weight and the number of flowers and buds were not affected by the treatments.

Table 3. Effect of amendment of peat/bark mix with 12.5 and 25% carpet shearing waste on *Viburnum tinus* 'French White'. Values are the means of six replicate plants.

Treatment	Top dry Weight, g	Height mm	Flower and bud number	Leaf colour *	Final media	
					pH	EC µS/cm
Peat (Indoor mix)	43.6	382	25.7	1.2	5.83	192
12.5% Carpet waste	43.7	425	27.7	2.3	4.76	367
25% Carpet waste	42.4	422	26.7	2.8	4.08	396

* 1 = palest, 3 = darkest

Fairweather's, Beaulieu, Hants.

- Plant assessments made on 19 September 2006.

Digitalis 'Milk Chocolate'

Plants growing in the 12.5 and 25% carpet waste were much larger and had darker green leaves than the peat control plants. Leaves of plants growing in 25% carpet waste were slightly darker than those in 12.5% treatment.

Lavandula 'Purple Wings'

Plants were marketed in August 2006 before a formal assessment was made. Plants growing in 12.5 and 25% carpet waste were lusher than the control treatment.

Lonicera 'Halls Prolific'

Plants growing in the 12.5% treatment were larger than those in the peat control or 25% carpet waste treatments. The leaves of plants growing in the carpet waste treatments were darker green than those of the control plants.

Nepeta 'Nimbus'

Plants growing in the 12.5 and 25% carpet waste treatments had darker but smaller leaves and more flowers than the peat control.

Verbena 'Claret'

Initial growth was more vigorous in 12.5 and 25% carpet waste treatments than in the control. At the time of the assessment, plants had been pruned to a standard height so there were no obvious differences between the treatments. Since this is a short term crop, no further assessments were made.

Oenothera 'Crown Imperial'

Plants growth was reduced by the addition of the carpet waste to the growing medium. The plants were discarded before the next assessment.

Spiraea 'White Gold'

Plant growth and leaf size were better in the 12.5% carpet waste treatment than in the 25% treatment or peat control (Photo 12).

- Final Plant assessments made on 6 February 2007 and 20 March 2007.

Digitalis 'Milk Chocolate'

All the plants survived over-wintering. The assessment was similar to that made on 19 September 2006. There was no difference in the plants grown in the 12.5 and 25% rates of the carpet waste; both rates produced plants that were larger and darker green than the peat controls (Fig. 7, Photo 9).

Lonicera 'Halls Prolific'

The assessment was similar to that made on 19 September 2006, with the 12.5% rate of carpet waste producing the best result (Photo 10). The plants were marketed in February 2007 and no further assessments were made.

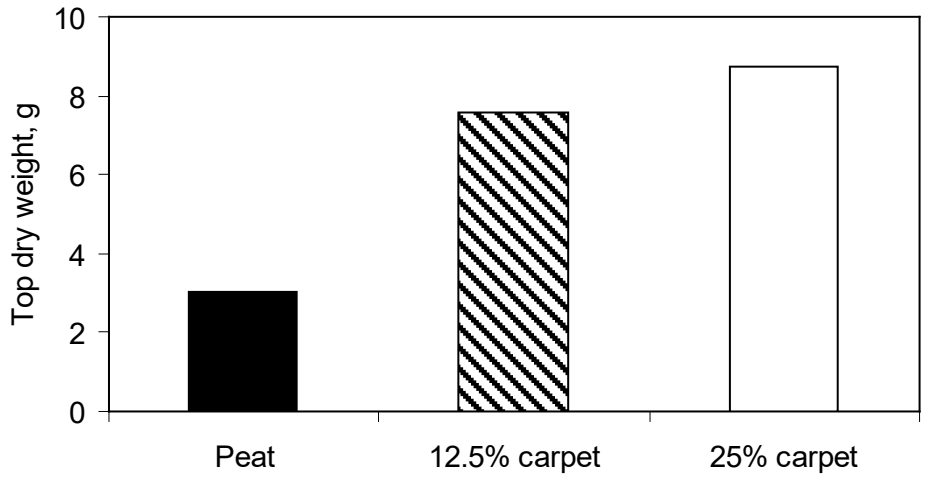
Spiraea ‘White Gold’

The growing media containing 12.5 and 25% carpet waste were much wetter than those of the control resulting in water-logging and root rot.

Nepeta ‘Nimbus’

There was no obvious difference between the treatments (Photo 11).

Figure 7. Digitalis ‘Milk Chocolate’ grown in 9 cm liners at Fairweathers, Top dry weight, g
Values are the means of six replicate plants.



New Place Nurseries Ltd, Almodington, West Sussex

- Plant assessments made on 2 August 2006.

For *Berberis* ‘Superba’, *Ceanothus* var. *repens* and *Hydrangea* ‘la France’, plant growth increased with increasing amount of carpet waste inclusion (Photo 13). For *Cotoneaster* ‘Eichholz’ and *Spiraea* ‘Candlelight’, the 12.5 and 25% rates of carpet wastes produced similar improvements in plant growth and leaf colour over the control (Photo 13). For the other species, there were no obvious differences between the treatments at this stage.

- Plant assessments made on 6 February 2007.

For the following species plant growth and leaf colour was significantly better with carpet waste treatments than in the control: *Berberis* ‘Superba’, *Ceanothus* var. *repens*, *Chaenomeles* ‘Knap Hill Scarlet’, *Cotoneaster* ‘Eichholz’, *Cytisus* ‘Boskoop Ruby’, *Euonymus* ‘Emerald ‘n’ Gold’, *Griselinia littoralis*, *Hydrangea* ‘la France’. There were no clear differences between the 12.5 and 25% rates of carpet waste. For *Spiraea* ‘Candlelight’ there was a slight improvement in growth in plants in the 12.5% carpet waste treatment compared with the control and 25% carpet waste treatment. For *Physocarpus* ‘Diabolo’ there was a negative effect of the carpet waste amendment on plant growth.

- Final Plant assessments made on 20 March 2007.

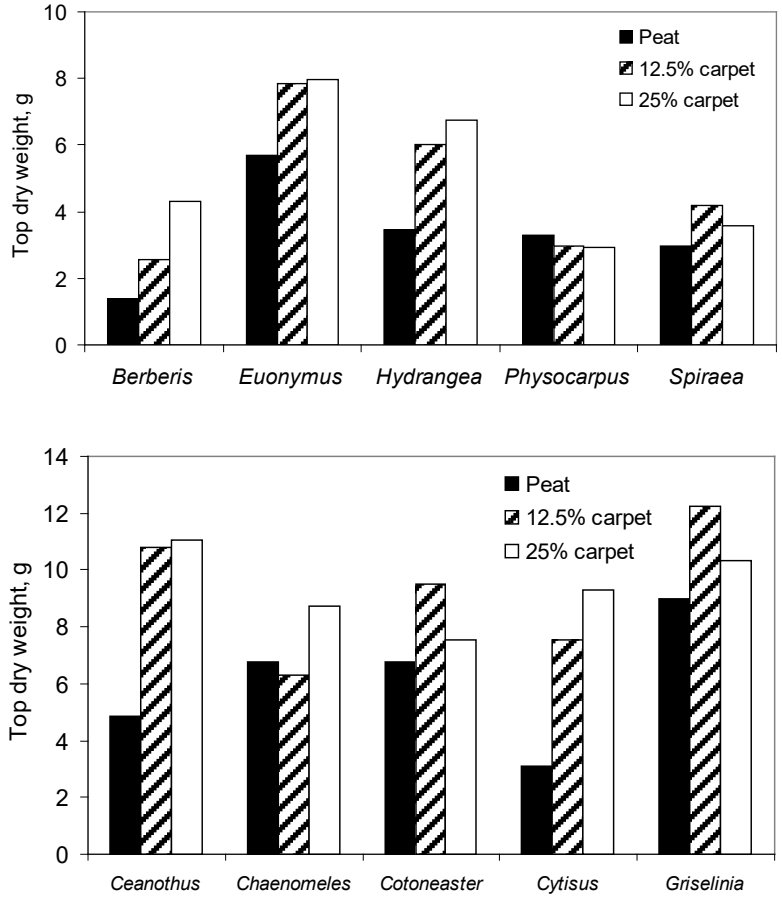
Nearly all the plants in the control and 12.5% carpet waste treatments survived (Table 4). Plant survival in the 25% carpet waste treatment was poorer for *Berberis* ‘Superba’, *Cytisus* ‘Boskoop Ruby’, *Physocarpus* ‘Diabolo’ and *Spiraea* ‘Candlelight’. Inclusion of carpet waste improved the growth and leaf colour of the following species, with the 12.5% rate generally giving the best results: *Cytisus*, *Chaenomeles, Spiraea*, *Cotoneaster Ceanothus,*

Hydrangea, Griselinia and *Euonymus* (Fig. 7, Photos 14 and 15). Plant growth and survival were poorer in *Physocarpus* 'Diabolo' following amendment of the growing medium with carpet shearing waste (Table 4).

Table 4. Percentage of surviving plants (recorded on 36 to 54 plants) and final plant top dry weight

Species / cultivar	Surviving plants control	12.5 % carpet	25% carpet
Berberis 'Superba'	100	96	69
Ceanothus var. *repens*	94	100	100
Chaenomeles 'Knap Hill Scarlet'	100	100	89
Cotoneaster 'Eichholz'	100	100	100
Cytisus 'Boskoop Ruby'	100	100	85
Euonymus 'Emerald 'n' Gold'	100	100	100
Griselinia littoralis	100	100	100
Hydrangea 'la France'	96	96	93
Physocarpus 'Diabolo'	100	89	51
Spiraea 'Candlelight'	100	100	69

Figure 7. Top dry weight, g of different species grown in 9 cm liners at New Place Nurseries. Each value is the mean of six replicate plants.



Stourbank Nurseries, Wimbourne, Dorset.

- Plant assessments made on 6 February 2007.

Lavandula angustifolia cvs. 'Artic Snow' and 'Imperial Gem'

Some of the plants growing in the 6.3% carpet waste treatment and most of the plants growing in the 12.5% carpet waste treatment were turning brown.

Lavandula stoechas cvs. 'Papillon' 'Leucantha Alba' 'Rocky Road' and 'Tiara'

Plants growing in the 6.3% carpet waste were more vigorous than the control treatment plants. Some of the plants growing in the 12.5% carpet waste treatment were turning brown.

- Final plant assessments made on 20 March 2007.

For the *Lavandula stoechas* cultivars, plant survival was poorer in the 25% carpet waste treatment than in the control or 12.5% carpet waste treatments (Table 5). Stem length of cultivars 'Leucantha Alba' and 'Rocky Road' was too long following amendment of the growing medium with carpet shearing waste (Photo 16). Top dry weight and flower number were not affected by the inclusion of 6.3% carpet waste in the growing medium (Figs. 8 and 9). For *L. angustifolia* cultivars, survival was also poor in the 12.5% carpet waste treatment, with the exception cv. 'Lodden Pink' (Photo 17). Top dry weight and flower number of cultivars 'Artic Snow' and 'Loddon Pink' were not affected by inclusion of 6.3% carpet waste in the media (Figs. 8 and 9).

The inclusion of 6.3% carpet waste in the growing media resulted in a decrease in the final pH but increase in the final EC (Table 5). The difference in final EC between the peat control and 6.3% carpet waste treatments for the cultivar 'Leucantha Alba' was relatively small. This cultivar also responded better to the inclusion of carpet waste in the media than several other cultivars (Table 5, Figs. 8 and 9).

Table 5. Number of surviving plants (out of 13) and analysis of final growing media of *Lavandula* cultivars grown at Stourbank Nurseries

	Surviving plants			Final media pH		Final EC µS/cm	
Species/ cultivar	control	6.3% carpet	12.5 % carpet	control	6.3% carpet	control	6.3% carpet
Lavandula stoechas							
Leucantha Alba	13	12	6	5.87	5.30	1424	1570
Papillon	13	13	11	5.96	5.65	700	1821
Rocky Road	13	13	7	6.05	5.33	942	1460
Tiara	13	12	12	6.07	5.52	925	1771
Lavandula angustifolia							
Arctic Snow	11	9	0	5.99	5.12	715	1220
Imperial Gem	13	9	4	n.d.	n.d.	n.d.	n.d.
Lodden Blue	11	9	2	n.d.	n.d.	n.d.	n.d.
Lodden Pink	13	13	3	5.93	5.23	829	1858

n.d. not determined

Figure 8. Top dry weight (g) of *Lavandula* cultivars grown at Stourbank Nurseries. Each value is the mean of six replicate plants.

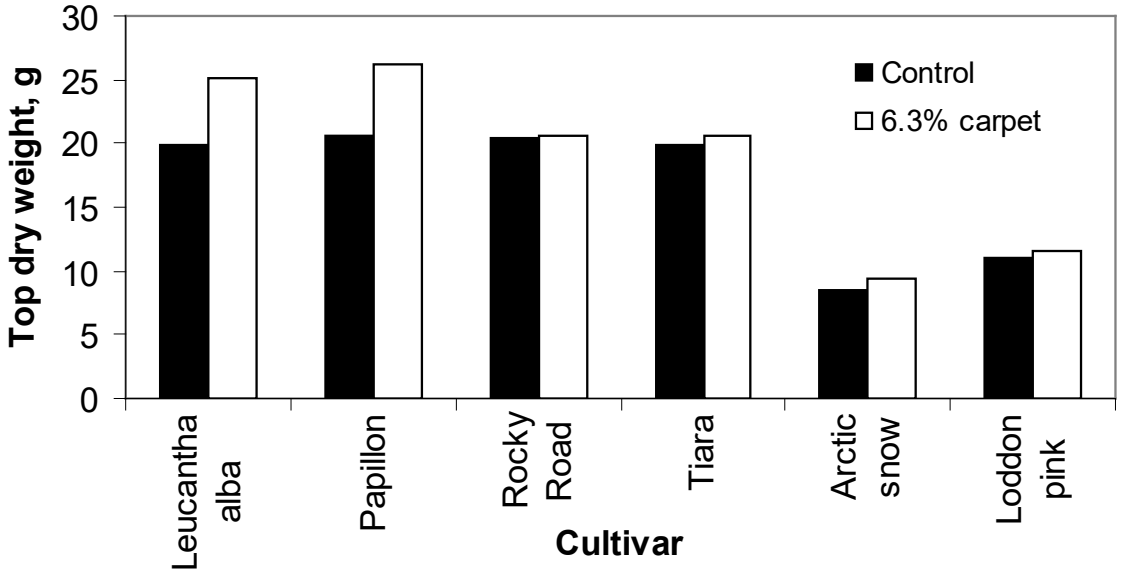
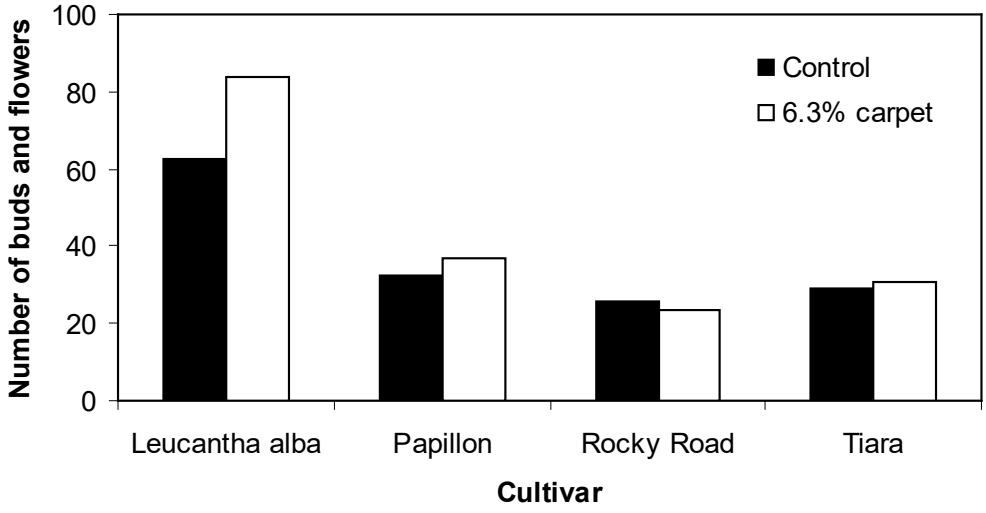


Figure 9. Buds and flowers of *Lavandula stoechas* cultivars grown at Stourbank Nurseries. Each value is the mean of six replicate plants.



Golden Grove Nursery, Boston, Lincs.

- Plants assessments made on 8 September 2006.

Plant growth in the 50% paper crumb waste treatments was reduced in all the species, except in *Juniperus horizontalis* 'Lime Glow', compared with the standard peat conifer mix.

- Plant assessments made on 30 January 2007 and on 17 April 2007 (Final).

The difference between treatments was similar to that recorded in the previous assessment, with only *Juniperus horizontalis* 'Lime Glow' producing results in the 50% paper crumb compost comparable with that the control (Table 6, Photo 19). Growth was generally poorer in the paper compost media containing Plantacote than in the media containing Sincrocell or Hi-End Osmocote.

The final pH values of the media containing 50% composted paper crumb waste were significantly higher than those of the peat control (Table 6). Conversely, the EC values were significantly lower.

Table 6. Top dry weight (g) and final media analysis of *Chamaecyparis lawsoniana* 'Ellwoodii' grown in peat control and 25% composted paper crumb with different controlled release fertilizers. Values are the means of six replicate plants.

Treatment	Top dry weight, g	Final media pH	Final media EC mS/cm
Peat mix	5.36	4.3	1048
Paper + Sincrocell	4.14	7.1	618
Paper + Osmocote Hi-End	5.28	7.2	738
Paper + Plantacote	4.53	7.3	543

Evesham Vale Propagators Ltd, Evesham, Worcs.

There was no difference in growth between the control and 50% paper crumb treatments. Plants growing in the 50% paper crumb treatment required less water during the summer than the control treatment. Plants were marketed in January 2007 before a formal assessment was made.

Discussion

The inclusion of 25% by volume of carpet shearing waste in growing media resulted in greener leaf colour for all the woody ornamentals grown in 3L pots, an improvement in growth of *Clematis* and *Chamaecyparis*, and an improvement in growth of *Agapanthus* and a range of woody ornamentals grown in liners. This confirms earlier promising results reported in HDC report HNS 127.However, the increase in growing medium EC and lack of growth response in *Viburnum* and *Spiraea* in 3L pots indicate that the 25% rate of carpet waste was too high or that the rate of controlled release fertiliser should be reduced. This was confirmed by the nursery trials where a 12.5% rate of carpet waste performed as well or better than the 25% rate. The benefit of adding carpet shearing waste to liner media for *Viburnum tinus* was carried forward after potting-on into a standard peat-based mix. For *Spiraea japonica* 'Candlelight', the greener leaf colour resulting from adding 25% carpet waste to the growing medium was undesirable. The material was found to be unsuitable for *Rudbeckia* 'Goldstrum' grown in 3 L pots, and for liners of *Oenothera* and *Physocarpus.*

For summer grown liners of *Lavandula*, the 12.5% rate of carpet shearing waste resulted in an increase in growth and improvement in leaf colour. At an inclusion rate of 6.3%, carpet shearing waste resulted in an initial increase in growth for over-wintered *Lavandula* but resulted in plants that were not as compact as the control plants. The final growing medium pH was too low and the final EC was too high for *Lavandula* following amendment with carpet shearing waste. A better result may be obtained for over-wintered lavenders by omitting controlled release fertiliser, and addition of some composted paper waste which would add P and K and offset the fall in pH.

The results obtained with *Agapanthus*, and previous results reported in HNS 127, show that all the sources of carpet shearing waste used in the trials were suitable, and performed better than the non-amended peat control treatments.

Of the 50% by volume composted paper waste treatments, the pulp waste generally performed better than the paper crumb or cardboard wastes and was comparable with the peat control, in spite of having the highest pH. It is likely that for all the composted paper wastes, a 50% rate was too high. This was particularly evident in one of the conifer nursery trials (Golden Grove) where the 50% paper crumb waste resulted in a high growing medium pH and poor plant growth. This may have been due to the trial being conducted under polythene. At Warwick HRI and Evesham Vale nursery, where *Chamaecyparis* was grown outside, there was no significant difference between plants grown in peat or 50% composted paper crumb waste.

The results of HDC project HNS 127 showed that the main benefit in amending growing media with composted paper wastes was for herbaceous perennials. However, the good results obtained with composted paper pulp for *Chamaecyparis*, *Clematis, Spiraea* and *Viburnum* indicate that the material should be examined at lower inclusion rates, particularly since composted materials have been shown to suppress soil-borne pathogens such as *Phytophthora* species (Noble & Coventry, 2005). This aspect needs to be examined in experiments specifically designed to examine disease control.

Composted paper waste may be complementary to carpet waste in growing media since it increases pH and supplies P and K, whereas carpet waste reduces pH and supplies mainly N. The low bulk density of the carpet waste would also offset the higher bulk density of the composted paper waste. The optimum method of composting of paper wastes (duration and nitrogen source) needs to be examined in large-scale commercial composting systems.

Conclusions

1. For a range of woody ornamentals, the addition of carpet shearing waste reduced the pH and increased the EC of peat-based growing media by the end of the crop. Composted paper wastes increased the pH of peat-based growing media but had only a small effect on EC.
2. The inclusion of carpet shearing waste in the growing medium improved the growth and leaf colour of a range of woody ornamentals in 3L pots and liners.
3. An inclusion rate of carpet shearing waste of 12.5% by volume generally produced better results than a 25% inclusion rate.
4. The growth benefit to *Viburnum tinus* plants in liners from the carpet waste was carried on after potting into 3L pots.
5. Carpet waste improved the growth of summer grown lavenders in liners but resulted in an excessively high growing media EC for over-wintered lavenders. It may be

possible to avoid this effect by omitting controlled release fertilizer from the over-wintered mix.

6. The material was found to be unsuitable for *Rudbeckia* 'Goldsturm' grown in 3 L pots, and for liners of *Oenothera* and *Physocarpus.*
7. A growing medium containing 50% by volume of composted paper pulp waste performed as well as a peat control for *Clematis*, *Chamaecyparis, Spiraea* and *Viburnum*. The treatment also increased flower size in *Clematis*.
8. Of the composted paper wastes used, paper pulp performed better than paper crumb and cardboard wastes. However, for *Chamaecyparis*, a 50% composted paper crumb treatment appeared to perform significantly better when plants were kept outside rather than under polythene.

Technology transfer

Current work is examining the commercial-scale mixing and blending of carpet shearing wastes and composted paper wastes with several growing media producers. Commercial nursery trials are in progress with commercially mixed batches of media prepared with carpet shearing waste for a range of woody ornamentals in pots and liners. Growers wishing to test these materials can contact Warwick HRI regarding supply of mixed media from growing media producers.

Glossary

EC: electrical conductivity

Cardboard waste: a compacter waste from recycled cardboard production

Paper crumb: a small fibre waste fraction from recycled newsprint production

Paper pulp: a waste fraction from paper production using virgin pulp

Top dry weight: the weight of the aerial parts of the plant after oven heating to dryness.

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Appendices

Table A1. Leaf colour scores for different plant species relating to Royal Horticultural Society Colour Card numbers. Score 1 = palest, score 3 = darkest.

Species	Score 1	Score 2	Score 3
Clematis montana 'Tetrarose'	146D/151A	146B/146C	146A/148A
Spiraea japonica 'Candlelight'	144C	144B	144A
Viburnum tinus 'French White'	147B	147A	139A

Photo 1. *Clematis montana* ‘Tetrarose’ grown in (left to right) peat control, 25% carpet waste, 50% composted paper crumb, paper pulp and cardboard wastes

Photo 2. *Chamaecyparis lawsoniana* ‘Ellwoodii’ grown in (left to right) peat control, 25% carpet waste, 50% composted paper crumb, paper pulp and cardboard wastes

Photo 3. *Viburnum tinus* ‘French White’ grown in (left to right) peat control, 25% carpet waste, 50% composted paper crumb, paper pulp and cardboard wastes

Photo 4. *Viburnum tinus* ‘French White’ raised from plants grown in liners containing (left to right) peat control, 25% carpet waste and 50% composted paper mill crumb and cardboard waste. All liners were grown on in peat based media.

Photo 5. *Spiraea japonica* ‘Candlelight’ grown in (left to right, top row), 25% carpet waste and 50% composted cardboard waste, (left to right, bottom row) 50% composted paper crumb waste, peat control and 50% composted paper pulp waste.

Photo 6. *Agapanthus* ‘Regal Beauty’ grown in peat controls (left end of rows) and media containing 25% of different carpet shearing wastes

Photo 7. *Rudbeckia* ‘Goldsturm’ at Hillier Nurseries growing in (left to right) peat control and 12.5% and 25% carpet waste

Photo 8. *Viburnum tinus* ‘French White’ at Hillier Nurseries growing in (left to right) peat control and 12.5% and 25% carpet waste

Photo 9. *Digitalis* ‘Milk Chocolate’ at Fairweathers growing in peat control (left) and 12.5% carpet waste (right)

Photos 10a and b. *Lonicera* ‘Halls Prolific’ at Fairweathers growing in (left to right) peat control, and 12.5% and 25% carpet waste, photographed on 19 September 2006 (upper) and 6 February 2007 (lower)

Photo 11. *Nepeta* ‘Nimbus’ at Fairweathers growing (left to right) peat control and 12.5% and 25% carpet waste. Photographed 19 September 2006

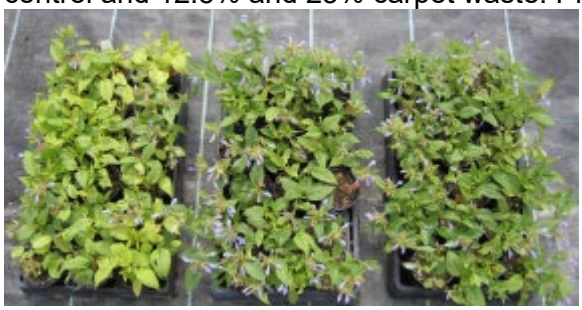

Photo 12. *Spiraea* ‘White Gold’ at Fairweathers growing in (left to right) peat control and 12.5% and 25% carpet waste. Photographed 19 September 2006

Photo 13. *Ceanothus* var. repens, *Hydrangea* ‘la France’, *Cotoneaster* ‘Eicholz’ and *Spiraea* ‘Candlelight’ at New Place Nurseries growing in (left to right) peat control and 12.5% and 25% carpet waste; photographed 19 September 2006

Photo 14. *Cytisus, Chaenomeles, Spiraea* and *Cotoneaster* growing in (left to right) 25% and 12.5% carpet shearing waste and peat control. Photographed on 5 April

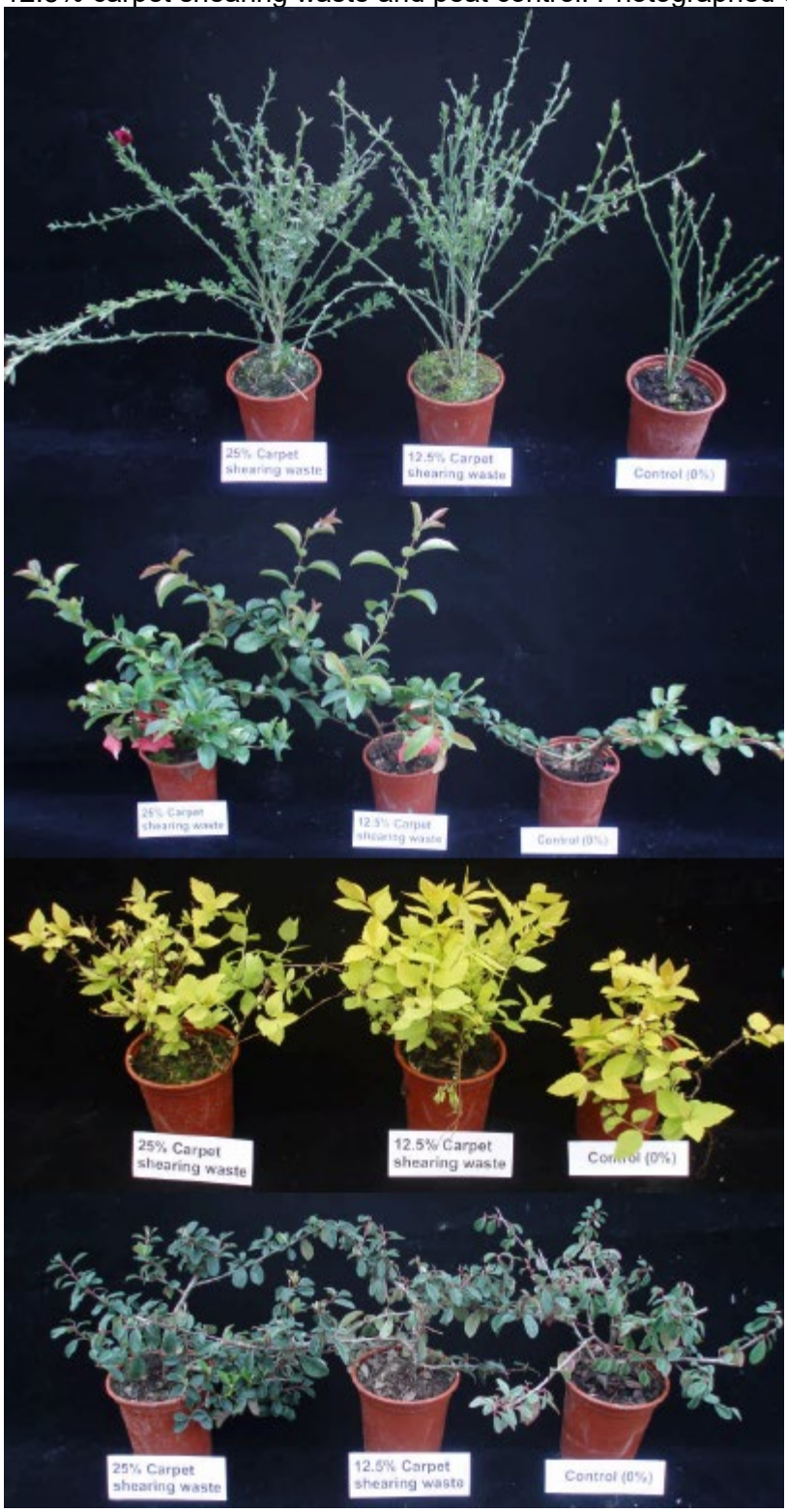

Photo 15. *Ceanothus, Hydrangea, Griselinia* and *Euonymous* growing in (left to right) 25% and 12.5% carpet shearing waste and peat control. Photographed on 5 April

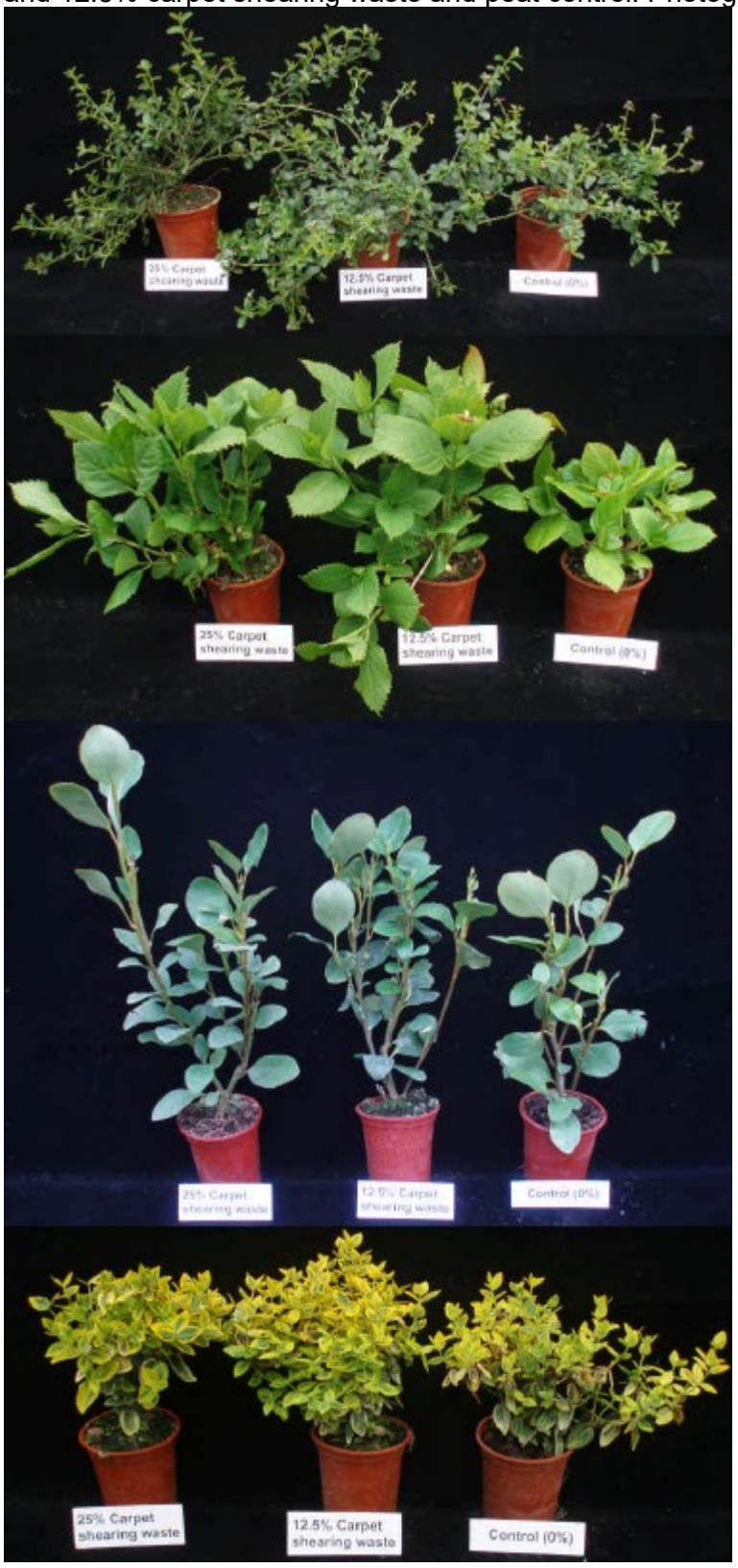

Photo 16. *Lavandula stoechas* cvs. ‘Leucantha Alba’ and ‘Rocky Road’ ‘Papilon’ and ‘Tiara’ growing in 6.5% carpet shearing waste (left) and peat control (right)

Photo 17. *Lavandula angustifolia* cvs ‘Artic Snow’ and ‘Lodden Pink’ growing in 6.5% carpet shearing waste (left) and peat control (right)

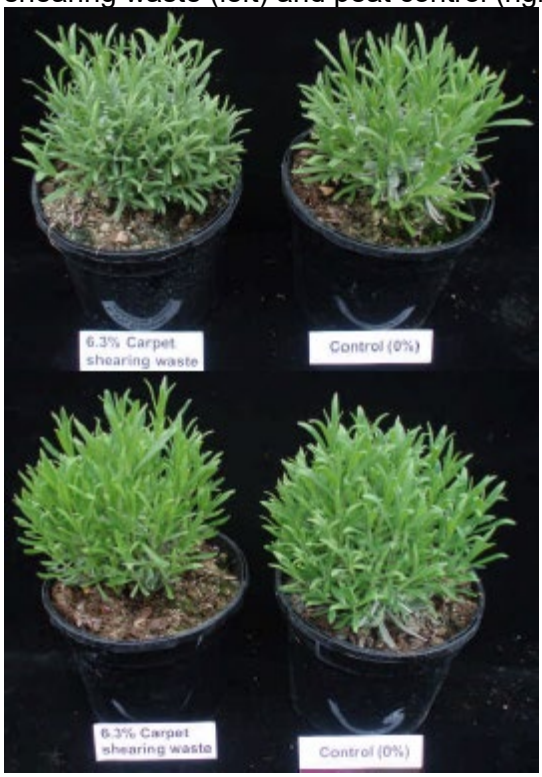

Photo 19. *Juniperus horizontalis* ‘Lime Glow’ growing in composted paper mill waste (top two trays with Osmocote and Plantacote, lower right tray with Sincrocell) and peat control (lower left tray) Photographed on 17 April 2007.