Grower Summary

PO 019

The Bedding and Pot Plant Centre – new product opportunities for bedding and pot plant growers

Final 2017

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The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

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GROWER SUMMARY

Headline

- Omex SW7, Serenade ASO* and Signum* applied as pre-sticking dip treatments improved rooting of Geranium cuttings (* no label approval); Rhizopon was effective as a quick dip on younger cuttings, but not as a long dip or on older cuttings.
- Fifteen glass coating products tested on new glass reduced light transmission and altered light quality.
- Response of autumn flowering ornamentals to polythene films varied with species and type of film; beneficial effects occurred in compactness, flowering period and overall plant quality.
- None of the nine herbaceous perennials grown over winter with minimal heat input were marketable by week 13/14; however five were at or just beginning to flower.

Background

The Bedding and Pot Plant Centre (BPPC) has been established to address the needs of the industry via a programme of work to trial and demonstrate new product opportunities and practical solutions to problems encountered on nurseries. Knowledge transfer events including trial open days and study tours were also included in the programme.

The work programme is guided by a grower-led Management Group that includes members of the BPOA Technical Committee and representatives from Baginton Nurseries, Coventry the host nursery for the BPPC. The agreed objectives for the second year of the Bedding and Pot Plant Centre were:

1. To improve cutting success
2. To reduce occurrence of leaf spotting and chlorosis in *Verbena*
3. To characterise environmental effects, ease of use and durability of glass coatings
4. To identify spectral films that improve plant production
5. To develop cold store treatments to induce flowering in hellebore before Christmas
6. To advance the marketing window of perennials by overwintering under glass and polythene

Summary

Objective 1: Improving cutting success

The 2015 AHDB/BPOA US study tour provided the inspiration for this trial, where Dr John Dole (Floriculture Professor, NCSU, North Carolina State University) presented a summary of trials carried out to resolve cutting quality problems that develop during delays in transit or as a result of incorrect storage, including loss of condition, dehydration and disease. In the UK, growers are increasingly taking advantage of the widening range of plant varieties available as un-rooted cuttings from an international market. This trial builds on the US work and incorporates treatments based on grower feedback and products available in the UK.

This trial was carried out between March and May 2016. Cuttings of Geranium Green Leaf Series ‘Bianca’ were sourced from Young Plants, and dispatched from the mother stock in Addis Ababa, Ethiopia, on 19 March (week 11). On receipt (24 March, week 12), the packaging was opened to release any ethylene that had built up, and then refrigerated. The cuttings were treated with Omex SW7, Signum, Fructose, Rhizopon AA tablets and Serenade ASO; Signum and Serenade ASO were applied under an experimental permit. Each was applied as a quick dip (prior to sticking - QD, 5 second, cut end of cuttings only), a long dip (prior to sticking - LD, 30 minute full submersion) and as a spray (after sticking), with relevant water controls. Once stuck, the cuttings were watered in and rooted under glass (15°C, vented at 21°C, 90% RH) on a heated bench (21°C). It had been planned that the cuttings would be stuck three (sticking 1) and six (sticking 2) days after dispatch from the mother stock.

Due to a delay in transit, cuttings were stuck in two batches; the first within 24 hours and the second 5 days after arrival (six and 10 days after dispatch from Ethiopia). The delay resulted in ethylene damage within transit resulting in chlorosis and premature senescence on the lower leaves which were removed, particularly for the second sticking.

Cuttings treated with Omex SW7 (LD, long dip) had greener, brighter foliage immediately after treatment compared with the other treatments and the untreated control. Serenade ASO left a white residue on the foliage when the cuttings were removed from the dip treatments (**Figure 1**).

Cuttings were assessed for quality and the number with visible roots at 11 days after treatment (DAT). Treatments had little effect on plant quality. The exception was the Rhizopon long dip, a treatment not recommended by the manufacturer, which reduced quality in both batches (**Table 1**). Rooting was significantly improved by Omex SW7 quick dip (sticking 1) and long dip (sticking 2), by Signum quick dip (sticking 2 only), by Rhizopon AA quick dip (sticking 1 only) and Serenade ASO long dip (sticking 1 and 2). With both batches there was a trend for

the long dip water treatment to improve rooting compared with untreated cuttings, and a number of other treatments in both sticking 1 (Omex SW7, Signum, fructose and Rhizopon AA spray treatments) and sticking 2 (Signum spray treatment; all fructose and Rhizopon AA treatments; and Serenade ASO quick dip treatment) although none of these differences were statistically significant.

The purpose of this trial was to improve root and cutting quality whilst reducing rooting time, compared with the untreated control. The results indicate Omex SW7, Serenade ASO and Signum dip treatments can improve rooting. Rhizopon used as a quick dip significantly improved rooting of 6-day old cuttings, but not the older cuttings. Further work is planned for 2016 which will look at replicating the most promising treatments and treatment combinations.

Table 1. The effect on plant quality and rooting of pre-sticking treatments applied to 6-day old and 11-day old cuttings of Geranium 'Bianca'

Treatment		Mean cutting quality (of 15 cuttings)		Mean no. rooted (of 15 cuttings)	
Product	Method	6 day old cuttings†	11 day old cuttings††	6 day old cuttings†	11 day old cuttings††
Untreated	-	3.0	2.9	0.5	1.5
Water	Spray	2.8	3.0	0.5	1.75
	Quick dip	3.0	3.0	1.5	2.5
	Long dip	2.7	3.0	1.0	3.0
Omex SW7	Spray	2.9	2.9	0.8	3.0
	Quick dip	3.0	2.3	2.0	3.75
	Long dip	2.8	2.7	3.8	3.25
Signum	Spray	2.7	3.0	0.5	2.0
	Quick dip*	2.9	3.0	2.0	4.0
	Long dip*	2.4	3.0	1.5	2.75
Fructose	Spray	2.8	2.8	0.8	1.75
	Quick dip	2.9	2.9	1.0	2.0
	Long dip	3.0	3.0	1.0	2.25
Rhizopon AA	Spray	2.9	3.0	0.6	1.5
	Quick dip	2.1	1.0	4.5	0.75
	Long dip	0.5	0.4	2.0	0.5
Serenade ASO	Spray	2.7	3.0	1.0	3.0
	Quick dip*	2.9	3.0	1.0	2.75
	Long dip*	2.9	3.0	2.5	3.5

Cutting quality: Cutting quality was assessed on a scale of 0-5 (0 = dead; 1 = very poor, yellow; 2 = green but no new growth, small; 3 = green with new leaves developing; 4 = green with new growth and 5 = good quality, marketable. Rooting success: values in bold are significantly better than untreated. *No label recommendations. †Assessed 11 days after treatment. †† Assessed 13 days after treatment

Figure 1. Sticking 1: untreated (left), Omex SW7, LD (centre) and Serenade ASO, LD (right) treatments <1 hr after application. LD = long dip

Objective 2: *Verbena* leaf spot and chlorosis

Leaf problems have been encountered with *Verbena* at various nurseries, including chlorotic leaf margins and necrotic spots. The cause is unknown. No pathogen has been associated with symptoms. Trials were devised to investigate the influence of irrigation regime, growing medium pH and trace element delivery on symptom occurrence.

Two trials were carried out between March and May 2016 (spring trial) and from May to July 2016 (summer trial). Treatments were irrigation management (dry, standard and wet), pH (4.5, 5.8 and 6.5) and trace element delivery (fritted and un-fritted trace elements). *Verbena* varieties were *V*. 'Quartz Blue' (spring and summer trials); and *V*. 'Obsession Scarlet' and *V*. 'Temari Blue' (summer trial only).

The few symptoms observed occurred in the summer trial *V*. 'Quartz blue' dry treatment. These results were not statistically significant. The observed symptoms were low levels of marginal chlorosis (**Figure 2**). Further work is planned for 2017 that will focus on water quality to try to determine if this induces the symptom.

Figure 2. Leaf chlorosis in *Verbena* 'Quartz Blue', dry treatment, 12 July, 8 WAT (left) and on a commercial nursery (right)

Objective 3: Environmental effects and ease of use of some spectral filters (glass coatings)

Glasshouses are designed to maximise light transmission while minimising the effects of solar heating (taller glasshouses reduce the rate of solar heating). However, the large differences in light that occur through the seasons means that crops can receive too much light and heat in the summer and not enough light in the winter. Removable glass coatings provide a flexible method for managing light transmission and altering the spectral properties of glasshouses through the seasons. A range of glass coatings were trialled for durability and ease of use.

New panes of 3 mm horticultural glass (single batch, 610 mm^2) were mounted onto an array of wooden A-frames, coated with a range of coating products and exposed to the elements between April and November 2016 (**Figure 3**). Light transmission and spectra measurements were recorded for a variety of glass coating products from Mardenkro (ReduFuse, ReduFuse IR, ReduHeat and ReduSol), Hermadix (D-Fuse Floriculture, D-Fuse, Vegetable, DeGree, Q Heat, Q3, Q4) and Sudlac (Optifuse, Optifuse IR, Optimix RB, TransPAR and Eclipse LD) and compared with untreated standard glass and untreated diffuse glass.

Figure 3. Arrangement of glass panes on A-frame structures at Baginton Nurseries, 2016

For this trial, glass coating products were applied by hand pressure sprayers as opposed to spray guns or mechanical application, and they were applied to individual glass panes, rather than a large expanse of glass.

The silicon coating applied to new glass to make it easier to separate panes prevented the spectral coatings from adequately adhering to the glass. The first application and silicon were removed using a release agent (Removit) and the treatments re-applied, achieving even coverage.

Light diffusing products (e.g. ReduFuse and TransPar) had a greater tendency to run at the dose rates used in this trial, however most products generally spread as they dried to produce a fairly even coat. No difficulties were experienced with blocked nozzles.

Coatings designed to diffuse light (ReduFuse, D-fuse, Optifuse) or to provide shading (Eclipse, ReduSol, Q3 and Q4) had little influence on the spectrum of transmitted light but changed the total amount of light that was transmitted (**Figure 4**). All products were observed to diffuse light to some extent, although the diffusion (haze factors) was not determined. Products designed to reduce solar heating caused by sunlight (Q Heat, TransPAR, ReduHeat) reduced transmission of light with wavelengths greater than 650 nm (i.e. in the red region of the PAR spectrum) and of UV light (315 – 400 nm, predominantly UV-A). The reduction of UV transmission may have little impact of crop performance when used on glass structures as glass also removes UV light from the spectrum but may have greater effect if used on structures constructed from UV transmitting plastics. The corresponding products produced by the different manufacturers were observed to have similar light transmitting qualities. The measured transmittance values were found to be similar to those reported by the manufacturers.

Durability was determined as the change in light transmission between the first and final light transmission measurements. The greatest difference occurred in the shade products (Redusol, Q4, Q4 and Eclipse LD), where transmission increased by 16%, 16% and 5% respectively over the time period. However, growers do not always require a long period of time for shading or spectral amendment, preferring products to weather as the season progresses and light levels reduce. Duration can be adjusted by changing the concentration of the solution applied; duration is longer with a higher concentration solution. Growers should determine their needs prior to application.

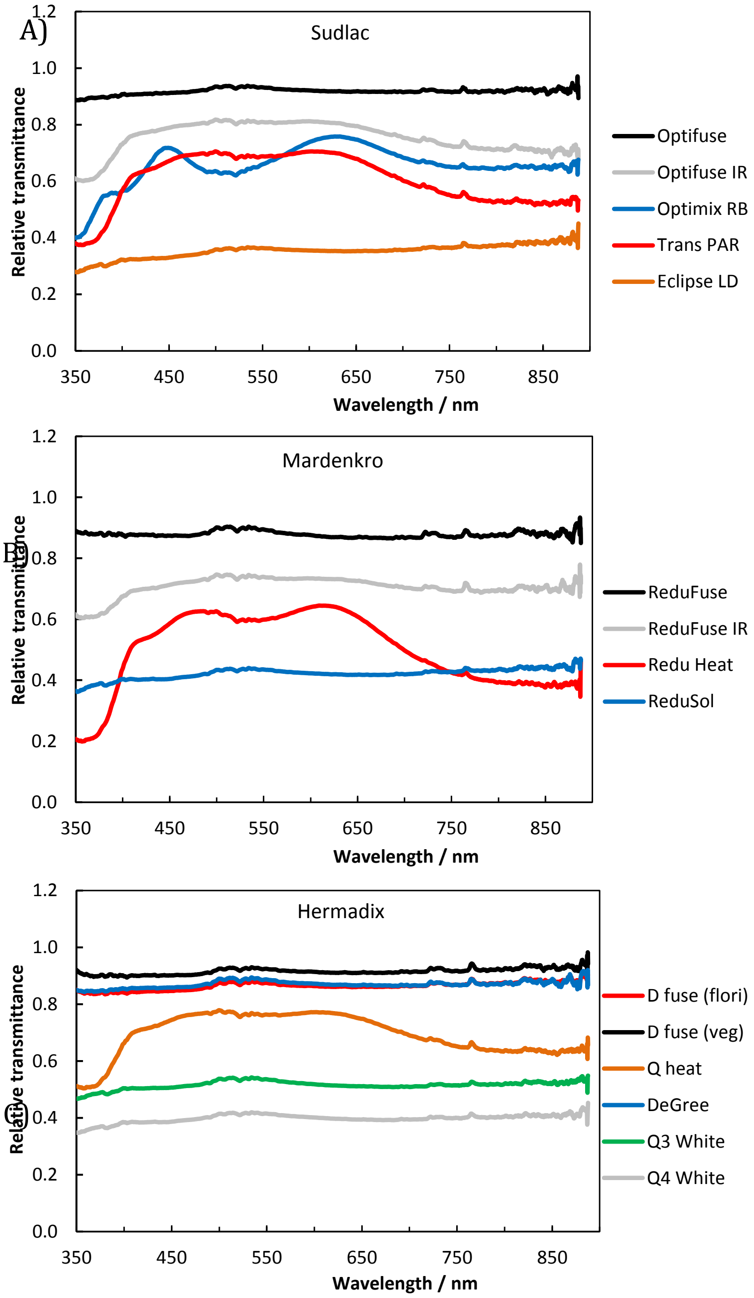

Figure 4. The relative mean transmission spectra of the different glass coatings. Spectra are grouped based on the manufacturer that produced the products **A)** Sudlac, **B)** Mardenkro and **C)** Hermadix. Transmission spectra were calculated relative to the transmission of glass and so exclude the influence of glass. Data provided by Dr Phil Davis, STC

Objective 4: Spectral filters (films) that improve plant production

Growers are keen to reduce their reliance on chemical inputs through adoption of cultural and non-chemical methods, and this can include the use of spectral filters (films). A range of spectral filters are available capable of manipulating the light spectra afforded to the crop beneath, influencing plant growth and quality, and the incidence of some pests and diseases. A demonstration trial was established to investigate the effect of a range of spectral filter films on plant growth and quality.

Work was carried out between June and November 2016, under four separate polythene tunnels covered with SunSmart Blue (new and old), Lumisol and Luminance, and a glasshouse. Potential degradation of film over time was investigated using a tunnel that had been covered with SunSmart Blue film in 2009, compared with one re-covered with this film in February 2015. Plug plants of eight species (*Bellis* 'Medicis' Mixed, *Cheiranthus* 'Sugar Rush' Mixed, *Cineraria* 'Silver Dust', *Cyclamen* 'Metis Decora' Mixed, Pansy 'Matrix' Autumn Select Mixed, Polyanthus 'Piano' Mixed, Primrose 'Bonneli' Mixed and *Viola* 'Sorbet XP' Autumn Select Mixed) were transplanted into 6-packs using a peat (60%) / woodfibre (40%) growing medium. The *Cyclamen* were transplanted in week 22, and the remaining species in week 34. Plants were set down in the five treatment areas and grown as a commercial crop. Plants were monitored for pests and diseases, with pesticide treatments applied as necessary; no PGRs were applied to avoid confounding the effects of the treatments.

The response of plants to spectral films varied with species and film. Plant quality was generally good (score >7, commercially acceptable), with lower scores due to uneven plant height and spent flowers; this was most evident in *Cyclamen* as their production cycle was earlier than the other species examined. Lower quality was recorded in the two light diffusing treatments (Luminance and Lumisol) relative to the other treatments for the *Cyclamen*, but this trend was not evident across all species. SunSmart Blue improved quality in five of the eight species tested, Luminance in four and Lumisol in two.

Many of the flowering differences seen in this trial were varietal, i.e. were due to differences in the natural flowering periods. Compared with the untreated glass, Luminance appeared to advance flowering in *Bellis, Cheiranthus,* pansy and primrose; Lumisol in *Cyclamen,* pansy and primrose; and SunSmart Blue in *Cyclamen,* pansy and primrose.

There was no single treatment where plants of all varieties were more compact than the other treatments (**Table 2**). Compared with untreated glass, Lumisol resulted in more compact plants than the other treatments for four species (*Cheiranthus, Cineraria, Cyclamen* and *Viola)*, and SunSmart Blue in one species (*Cheiranthus*). None of the films improved the compactness or quality of the *Bellis*. Growth was generally more compact under the new SunSmart Blue tunnel than the old SunSmart Blue tunnel, except for the *Cheiranthus* and Primrose.

The variable response of the different species to the treatments is demonstrated by these results, for example growth of *Bellis* 'Medici' was more compact under the untreated glass than the new SunSmart Blue treatment, whilst the converse was true for the *Cheiranthus*.

Table 2. Observed effect of four polythene films on plant height (H) and quality (Q) of some autumn flowering ornamentals, compared with growth under glass – 17 November 2016

Variety	Film and assessment							
	Luminance		Lumisol		SunSmart Blue – New		SunSmart Blue - Old	
	H	Q	H	Q	H	Q	H	Q
Bellis 'Medici'	↑	↔	↔	↔	↑	↔	↑	↔
Cheiranthus 'Sugar Rush'	↔	↑	↓	↔	↓	↑	↓	↑
Cineraria 'Silver Dust'	↔	↑	↓	↔	↔	↑	↔	↑
Cyclamen 'Metis'	↔	↓	↓	↓	↔	↔	↔	↔
Pansy 'Matrix'	↑	↔	↔	↔	↑	↑	↑	↑
Polyanthus 'Piano'	↑	↑	↔	↑	↑	↔	↑	↔
Primrose 'Bonneli'	↑	↑	↔	↑	↑	↑	↑	↔
Viola 'Sorbet'	↔	↔	↓	↔	↔	↑	↔	↑

Key: ↑ - increased; ↓ - decreased; ↔ - no change. Treatments which increased plant quality and improved compactness are highlighted in red.

Objective 5: Pre-Christmas production of hellebore

The market for hellebore as pot plants has increased over the last five years as new seed and micro propagated varieties have become available. Although white varieties are marketed in flower before Christmas, this trial was established to determine if cold treatments can be used to manipulate the new coloured varieties to flower in time for Christmas marketing.

The work was carried out between March and December 2016. Six micro-propagated hellebore varieties ('Anna's Red', 'Molly's White' 'Penny's Pink' - Exceptio bv; 'HGC Madame Lemonnier' and 'Paradenia' – Heuger; and 'Royal Emma' - Beekenkamp Plants bv) were grown outdoors under shade (1.5 L pots). They were subjected to six weeks cold store treatment (2°C, 12 hour day / night, 100 watt incandescent light) in two batches from 24 August (CS1) and 21 September (CS2). A cold store malfunction occurred on two occasions when the temperature fell below 0°C for 16.5 hours and 8 hours respectively, reaching -12°C and -14°C. 'Anna's Red' 'Molly's White' and 'Penny's Pink' were the most cold sensitive varieties, with fewest surviving plants. 'Royal Emma' was least sensitive to the cold, and was the only variety with flowers opening (three plants, treatment CS1) by week 46; flowers on 'Paradenia' were open in week 49 (CS2b). Due to the cold store malfunction this trial will be repeated in 2017.

Objective 6: To advance the marketing period of perennials by overwintering under glass and polythene

There is an increasing trend, and interest among growers, to extend the herbaceous perennial season and product range so as to provide more flowering plants by late March ready for impulse sales. In previous work (PC 247 and PC 267), a range of seed and cutting raised perennials were grown under protection with the use of heat and light to force them for early spring marketing. The objective in this trial was to identify perennials that may be produced successfully under protection with minimal energy inputs, aiming to advance the natural marketing window. Nine species chosen by the project steering group were examined under both glass and polythene tunnel protected environments.

Seeds of nine perennial species (*Campanula glomerata* 'Acaulis', *Campanula persicifolia* 'Takion Blue', *Coreopsis grandiflora* 'Presto', *Echinacea* 'Cheyenne Spirit', *Gaura lindheimeri* 'Sparkle White', *Prunella grandiflora* 'Freelander Blue', *Scabiosa japonica* var. *alpina* 'Ritz Blue', *Silene alpestris* 'Starry Dreams' and *Verbena rigida* (syn. *V. venosa*) were sown into 104-cell trays in two batches (weeks 27 and 29), transplanted into jumbo 6-packs and 1 L pots (week 40) and set down under glass and within a polythene tunnel. Young plants from the second sowing (week 29) were transplanted for all species except *Campanula persicifolia* 'Takion Blue', for which plants from the first sowing (week 27) were used. *Gaura lindheimeri* 'Sparkle White' was trimmed prior to transplant. The glasshouse trial was heated from 24 March 2017 (week 12).

Plants were monitored throughout the winter and assessed for number in flower, quality and height in week 13/14, the target marketing date.

None of the species examined reached the target marketing criterion (90% of plants with fully open flowers) by late March in either the glasshouse or polythene tunnel environment. Five species (*Campanula glomerata* 'Acaulis, *Campanula persicifolia* 'Takion Blue', *Prunella grandiflora* 'Freelander Blue', *Scabiosa japonica* var. *alpina* 'Ritz Blue' and *Silene alpestris* 'Starry Dreams') had buds and / or were just beginning to flower. *Gaura lindheimeri* 'Sparkle White' and *Verbena rigida* in particular suffered cold damage in the glasshouse and polythene tunnel environments following sub-zero temperatures (-4.4˚C and -3.7˚C respectively); the cold damage was first observed in March 2017. Plant quality in late March was good for glasshouse grown *Campanula persicifolia* 'Takion Blue' and Silene *alpestris* 'Starry Dreams', and for the latter species grown in the polythene tunnel. The mean plant quality for the other species was poor. There was greater than 50% plant death of *Echinacea* 'Cheyenne Spirit' (packs) and *Gaura lindheimeri* 'Sparkle White' (pots) in the polythene tunnel. Survival was generally greater in packs than pots in the polythene tunnel, with the converse in the glasshouse. It was concluded that for the nine species examined production of flowering plants by late March will generally require more than two weeks of heat at 15˚C in March as used in this work.

Financial benefits

Objective 1: Improving cutting success

The benefits of this work are directly linked to reduced waste and quicker throughput of product. The farmgate value to growers of geraniums produced from cuttings in 10.5 cm or 1 L pots or jumbo 6-packs is estimated at 80-90p, £1.40 - £1.50 or £2.80 – £2.90 per unit respectively. Treatments costs are provided in **Table 3**.

Cuttings that are unusable due to a delay in transit may be replaced by the supplier, which would delay the finished product, or the supplier may not be able to provide replacements. In either case it may be necessary to purchase replacement plants from an alternative supplier. The cost of plants sourced from surplus lists is likely to be 10-20% higher than the grower's sale price to his client, excluding labour, labelling, input or transport costs.

Any gaps in supply can jeopardise client relationships with the potential for penalties to be applied under some contracts. Sourcing plants from an alternative supplier's surplus list increases the risk of supplying inferior quality plants, the plants may be a different variety or quantity and there may be insufficient to fill the gap in the production programme.

Table 3. Improving cutting success: costing

Item	£/unit + VAT	Rate	**Cost / treatment (1000 cuttings) SPRAY & QUICK DIP	**Cost / treatment (1000 cuttings) LONG DIP
Geranium 'Bianca'*	0.08-0.1p each plus 0.036p royalty			
Serenade ASO	£124.74 / 10L	10 L/ha	24.95 ml = £0.31	1000 ml = £12.47
Signum	£161.70 / 2.5 kg	1.35 kg/ha	3.37 g = £0.22	135 g = £8.73
Fructose	£4.70 / 100 g	2 L/ha	5 g = £0.24	200 g = £9.40
Rhizopon	£21.00 / 20 tablets	0.06 kg/ha	3 tablets = £3.15	120 tablets = £126
Omex SW7	£54.76 / L	0.5 L / ha	1.25 ml = £0.07	50 ml = £2.74

*unrooted cuttings. ** excluding labour costs

Potential financial benefits will be achieved through energy savings due to faster root development and reduced crop throughput time. The energy cost to increase glasshouse temperature by 1˚C compared with the outside temperature will vary depending on a number of factors, including the heating system, glasshouse size, infrastructure (screened or unscreened), and fuel used.

As an example (**Table 4**), the energy cost to heat a glasshouse (one acre) to 18 ˚C (outside temperature 5˚C) using an air heater fuelled by gas oil is estimated at £327.25/day. The energy cost is calculated in two stages: 1) the energy requirement to increase the glasshouse temperature by 13˚C, and 2) the cost to provide the required energy.

Note that this example assumes an air heater that is 100% efficient in energy delivery is used. Cabinet heaters and boiler systems are estimated at 95% and 85% efficient in energy delivery. For an 80% efficient boiler, adjust the calculation: energy requirement in glasshouse / 0.8 kWh (i.e. 10098/0.8 = 12,623 kWh).

Table 4. Parameters for example energy cost calculation

Example	Temperature (˚C)			Heat loss from a screened or unscreened glasshouse due to the difference between the glasshouse and outside temperatures ($W/m^2/˚C$)
	Glasshouse set	Outside	Difference	
Unscreened glasshouse	18	5	13	8
Screened glasshouse	18	5	13	6

1. The energy requirement to increase glasshouse temperature by 13 ˚C

$$Energy\ requirement\ (\mathrm{kWh})\ to\ heat\ the\ glasshouse\ by\ 13\ ^\circ\mathrm{C}$$
$$= \text{heat loss x acre x temperature difference x 24hrs/1000}$$

For this example, the calculation is as follows:

$$Energy\ requirement\ (\mathrm{kWh})\ to\ heat\ the\ glasshouse\ by\ 13\ ^\circ\mathrm{C}\ = 8\ x\ 4046\ x\ 13\ x\ \frac{24}{1000}$$
$$= \mathbf{10,098}\ \boldsymbol{kWh}$$

Where: heat loss = heat lost from a screened or unscreened glasshouse due to the temperature difference between the glasshouse and outside; acre is the conversion factor from m^2 to acres (1 acre = 4046 m^2); temperature difference = the difference between the glasshouse temperature and outside temperature (˚C); 24 hrs converts the calculation from hours to days; and 1000 converts from Wh to kWh.

2. The cost to increase the glasshouse temperature by 13˚C

The cost to heat the glasshouse by 13˚C = volume of fuel [heat requirement / energy content of fuel (kWh/L)] x fuel cost.

$$Cost\ to\ heat\ a\ glasshouse\ by\ 13^{\circ}\mathrm{C}\ = \frac{energy\ requirement}{fuel\ energy\ content}\ x\ fuel\ cost$$

For this example:

$$Cost\ to\ heat\ a\ glasshouse\ by\ 13^{\circ}\mathrm{C}\ = \frac{10{,}098}{10.8}\ x\ 0.35 = £\mathbf{327.25}\ \boldsymbol{per\ acre\ per\ day}$$

Where: energy content of gas oil = 10.8 kWh/L; fuel cost = 35p/L (45p minus horticultural fuel duty rebate).

Objective 2: Verbena leaf spot and chlorosis

The incidence of marginal leaf chlorosis and necrotic spotting symptoms vary from year to year, ranging from one or two varieties up to 60% of varieties in some years; the problem can affect 100% of the crop. While the value of *Verbena* to the horticulture sector is not known, grower feedback suggests that 5-6% of spring bedding sales can be affected. To put this into context, many nurseries consider 3% waste as the upper acceptable limit and above this would stop producing a particular crop or variety. Symptoms have been reported on many nurseries across the sector.

As an example, the turnover associated with a batch of 100,000 *Verbena* (double 6-pack, 12 plants) is estimated at £22,000 to the grower. Where 60% of the crop is affected, the value of this wastage is estimated at £13,200.

Objective 3: Spectral filters (glass coatings)

These measurements will aid growers to make informed decisions when they choose which glass coating to use on their glasshouse through understanding the effects of the products on the growing environment, plant quality and worker comfort. The data will help growers not only to select a coating that meets their needs but to also compare the products produced by different manufacturers (**Table 5**). Application rates will be dependent on the product used and the effect required and will depend on the nursery location, and growers should follow manufacturers' guidelines. For shade loving ornamental plants the need for spectral filters or shade coatings is vital to prevent leaf and flower scorch (and loss of quality) on bright, hot days. For non-shade loving ornamental plants the direct financial benefits are less defined and include improvements in plant habit, size and quality and working environment.

Table 5. Glass coatings: costing*

Manufacturer	Product	Cost (£ + VAT)	Unit (kg)	Manufacturers' application guidelines. Cans/ha	Cost / ha (£ + VAT)
	Horticultural glass	6.00	m^2	-	-

	Diffused glass	12.00	m²	-	-
Hermadix	D-Fuse Floriculture	90.00	15	13	1170
	D-Fuse Vegetable	90.00	15	13	1170
	DeGree	120.00	15	13	1560
	Q-Heat	120.00	15	22-44	2640 - 5280
	Q3	45.00	20	13-34	585 - 1530
	Q4	54.00	20	10-34	540 - 1836
Mardenkro	Redusol	62.70	20	10-33	627 - 2069
	Redufuse	125.70	15	12-20	1508 - 2514
	Redufuse IR	131.10	15	18-22	2378 - 2884
	Reduheat	155.90	15	21-30	3274 - 4677
Sudlac	Optifuse	117.40	15	13	1526
	Optifuse IR	120.40	15	17-22	2047 - 2649
	Optimix RB	126.02	15	17	
	Transpar	120.30	15	20-30	2406 - 3609
	Eclipse LD	59.26	20	10-30	590-1778

*Costs provided are undiscounted for trade or quantity and do not include application or removal costs

Objective 4: Spectral filters (films)

Spectral filters can help to reduce inputs e.g. plant growth regulators, and reduce waste.

A polythene tunnel clad with SunSmart Blue polythene can provide growers with additional production flexibility when used to hold plants back to meet marketing deadlines. This helps to ensure that orders are filled without loss of quality and avoids or reduces the waste usually associated with delayed marketing or plants that reach marketing stage ahead of schedule. As an example, the value associated with a standard single span polythene tunnel (4 m x 20 m) of mixed bedding in standard double 6-packs (dimensions 0.082 m^2) that would otherwise be wasted is estimated at £2,341, assuming all plants are sold.

The cost to cover a polythene tunnel (4 m x 20 m) skinned with Lumisol or SunSmart Blue covers is provided in **Table 6**. Luminance has been superseded by Lumisol and is no longer produced by BPI Visqueen.

Table 6. Polythene cost (material only)

Product*	Cost / m^2 + VAT (£)	Tunnel cover cost + VAT (£)***
Lumisol	1.11*	265
SunSmart Blue	0.88**	209

*LBS, **XL horticulture. *** Cost to cover a 4 m x 20 m tunnel, with the polythene trenched into the ground; excluding labour and fittings

Although plant growth regulators were not used in this trial, the treatment costs for a single application of Bonzi (at 1.25 ml/L) to hold plants back at dispatch in a 4 m x 20 m tunnel (requiring 20 ml of Bonzi) equates to £1.90 (per application) plus the cost of the labour and equipment to apply it.

Objective 5: Pre-Christmas production of hellebore

This work with hellebores will potentially broaden the range of plants in flower for the pre-Christmas marketing window to compliment poinsettia, given appropriate variety selection for key house plant attributes (such as flowers facing upwards and attractive foliage as well as flowers). Consumers have the option to purchase hellebore during this period, display them as a house plant and then subsequently plant them in the garden rather than disposing of them at the end of the season (as they would for poinsettia).

Sold as pot plants in flower, some hellebore varieties can demand high retail prices with a 10% premium over green plants. Current retail prices for some of the varieties used in this trial include: *Helleborus* 'Emma' and *H*. 'Penny's Pink', £13.50 (1.5 L); *H.* 'Anna's Red' £12.49 – £19.99 (1.5 L); *H*. 'Madame Lemonnier', £14.44 (2 L), from various outlets.

Based on the retail price range for *H*. 'Anna's Red' in a 1.5 L pot, the grower could receive in the region of £5.20 to £8.33 per plant in the natural flowering season. By marketing this product in flower before Christmas it is considered that a premium of 10% may be achievable. This would be a new product line, and a hypothetical market value of 50,000 plants would be estimated at £286,000 to £458,150.

Hellebore growers would need to set the projected extra income against the associated costs of operating their own cold room at 2˚C for two weeks at today's energy costs, and would need to include associated costs such as the labour cost to transfer plants to and from the cold store.

To help put this into context, we can use data from the AHDB publication 'HNS Cold Storage – a Grower Guide' as guidance. It was calculated that for nursery stock plants in 3 L pots, stacked on Danish trolleys with 4 to 5 shelves per trolley, the break even yield would be 9.66 to 7.72%; i.e. the benefit exceeds the cost when 9.66% to 7.72% more product is sold (**Table 7**). The break even yield would be reduced to 5.52% for plants in 9 cm pots, therefore the 1.5 L pots used in this trial falls between the two. This is based on a nursery output of £55.28 /m^2 and a cold store cost of £21.35 /m^2 (the cold store cost is the average annual cost to build and run a cold store when spread over a ten year pay-back period and excludes costs associated with any building the store may be situated within). Assumptions were made for this 2009 industry-wide cost:benefit analysis, and it was calculated as the average cost for facilities ranging from relatively low cost refrigerated lorry backs to large, purpose built cold stores.

Table 7. Break even yields for cold storage use

Pot size	Number of layers on Danish trolley	Cost of cold storage/m^2 (£)	Nursery output* (£)	Break even yield (%)

3 L	4	21.35	221.12	9.66
3 L	5	21.35	276.40	7.22
9 cm	7	21.35	386.96	5.52
*Nursery output assumed to be £55.28/m^2				

Objective 6: Overwintered perennials

The objective of this trial was to advance flowering in a range of perennials for impulse purchases in early spring. This has the potential to increase sales opportunities during a marketing window traditionally filled with species such as *Primula* and *Viola*, and more recently with Senetti. First marketed in Europe in 2001, Senetti is a prime example of a new crop that has been brought to market that flowers at a time of year when there are fewer products available in flower and that now commands strong consumer demand each year.

It is estimated that for sales of perennials in flower in early spring, the trade price would be in the region of £1.00 to £1.25 (1 L pot), for comparison, perennials sold without flower may command £0.85 each, but demand would be lower as they would not have the visual impact of plants in flower.

Action points

1. *Improving cutting success*

- Consider using Omex SW7 and Rhizopon as pre-sticking quick dip treatments to improve success of geranium rooting, particularly when cuttings have been delayed in transit.

2. *Verbena leaf spot and chlorosis*

- Conditions that cause these symptoms have not yet been identified. As a general measure, it is recommended that growers ensure healthy root development in *Verbena* through careful application of water; over application of water so that growing media is continually very wet will limit root development and impair nutrient uptake.

3. *Spectral filters (glass coatings)*

- Consider use of appropriate glass coatings (Redufuse, D-fuse and Optifuse) to improve crop quality and working environment (to diffuse light, reduce light intensity and reduce solar heating), adjusting application rates to achieve the required effect and duration.
- To reduce the effect of solar heating and maintain a cooler environment consider using products such as DeGree, Q Heat, Redufuse IR and ReduHeat, Optifuse IR or TransPAR.

- Closely monitor crop performance under treated glass. Account for associated application and removal costs in budget projections.

4. Spectral filters (films)

- Consider the use of SunSmart Blue film to hold batches of plants back.
- Light diffusing films such as Lumisol can be used to improve plant habit and quality and can be particularly useful for shade loving crops to prevent scorch.

5. Overwintered perennials

- There appears to be potential to force certain herbaceous species into flower with additional heat only. To determine such responsive species, trials should be carried out using different species (which ideally should be short-day or day neutral in their flowering response) and temperature regimes on growers' own holdings prior to any large scale production.