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AUTHENTICATION

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

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GROWER SUMMARY

Headline

- Garden varieties of alstroemeria perform well as a natural-season tunnel crop.
- Tunnel-grown *Aster ericoides* 'Cairo' and 'Cassy' produce a first flush of flowers in early-August, and a second flush in October, using blackout covers to advance flower initiation.
- Zinnia continue to show promise, mainly for sale through short, ambient-temperature supply chains such as mail order.
- Tunnel-grown tracheliums impress with vigorous growth and quality stems.
- *Ammi*, *Anethum* and *Bupleurum* show promise as direct-drilled, tunnel- and outdoor-grown fillers.
- Tunnel-grown lily 'Dynamite' planted in alternative growing media – such as peat and aerobic digestate - produce flowers of equal or better quality than using standard lily peat.
- Sedum and a number of other hardy perennial crops have now been planted on a commercial scale.

Background

For a long time the UK had a relatively low *per capita* consumption of cut-flowers compared with other western European countries, but between the late-1980s and early-2000s the UK's annual imports of cut-flowers rose from some £125 m to around £550 m. Perhaps surprisingly, this appeared to have resulted in no incentive for UK cut-flower growers to expand production: over the same period the value of UK-grown cut-flowers remained static at around £50 m *per annum*. This lack of enterprise was attributed to a lack of 'know-how' and a reluctance to challenge the Dutch flower export market. The Cut-flower Trials Centre project was set up in 2007, largely with funding from the HDC, and is currently funded by the HDC until the end of 2017. The immediate aim of the programme was, and remains, to provide information on the production of a wider range of cut-flowers outdoors or (taking advantage of the increased availability of low-cost Spanish tunnels) under protection. The longer-term aim is to stimulate UK grower interest in developing and commercialising novel cut-flowers and continuing to improve the quality of the more traditional products (here referred to as 'crop introduction' and 'crop improvement'). In the context of the project and its outputs the description 'novel' is interpreted very widely: it could include a species completely new to production horticulture, or might simply indicate a crop with which UK growers are currently unfamiliar.

Summary

Crop information

A database of companies supplying seeds and planting material for cut-flower production was compiled. Research on new cut-flower crops and programmes of cut-flower trials worldwide were reviewed. Internet sources of information on cut-flower production were compiled, along with statistics of production levels and trends in the cut-flower trade. This information was used to build a programme of novel crop testing and will be available on the Centre's website <http://www.thecutflowercentre.co.uk/>

Crop introduction

Basil, cosmos, lion's ear (*Leonotis leonurus*), lupin, trachelium and zinnia were selected as novel crops for growing in demonstration plots in 2013, and carthamus, leucanthemum, ornamental pepper, physostegia and a range of seed-raised fillers in 2014. These were chosen from a large number of possible candidates on the basis of a review of the new crops and trials programmes, suggestions from growers and information from seed and young-plant suppliers. In addition, examples of new lines of some old favourites were made available for demonstration in 2014, from the 'Tiara' series of spray carnation, the 'Waltz' and 'Tango' series of delphinium and the 'Zinzi' series of gypsophila. Gentian and bleeding heart have also been identified worthy of testing in future years.

Basil (*Ocimum basilicum* cultivars)

In 2013 basil cultivars 'Dark Red Opal', 'Floral Spires Lavender', 'Floral Spires White' and 'Sweet Dani Lemon' made good growth in tunnel plantings, some having attractive, fragrant foliage with potential use as a filler. However, in tests its vase-life (VL) was poor (less than five days). Any further demonstration of basil was therefore deferred until better cultivars (such as 'Aramato' and 'Cardinal') and more information on post-harvest treatment can be obtained.

Carnation, spray, 'Tiara' series (*Dianthus caryophyllus* cultivars)

Spray carnation cultivars have previously been trialled extensively at the Centre, but the 'Tiara' series is a new type with a unique flower form that was available from HilverdaKooij in 2014 and was deemed worthy of testing.

'Tiara Coral Pink' and 'Tiara Lilac' were obtained as rooted cuttings, potted-up in week 14, pinched in week 17 and transplanted when well branched to tunnel plots in week 22. The cultivars were slow growing but threw some strong stems, of which the central bud developed first, well before the others, and consequently needed to be pinched-out to preserve the remaining spray, though this is hard to do as well as labour-intensive. The main picking dates were week 36 for 'Tiara Coral Pink' and week 37 for 'Tiara Lilac'. The

plants were very susceptible to thrips damage, with white flecking appearing in the flowers, and a prophylactic spray programme would be needed. They were attractive and appreciated by growers. Stems of cultivar 'Tiara Coral Pink' were sampled for testing and had an average VL of seven days, just adequate. Damage due to thrips also detracted from their appearance in the vase.

New colours will be available from HilverdaKooij in 2015, so the current plots have been left down for 2015 and will be augmented by further varieties. VL and thrips control will need to be optimised.

Carthamus (*Carthamus tinctorius* and cultivars)

Carthamus attracts attention as an unusual 'thistle-like' filler, and cultivars 'Kinko', 'Nemo' and 'Shiro' were tested in 2014. Seed was direct-drilled into outside plots in week 25 and tunnel plots in weeks 27 and 30. The three cultivars germinated well but once budded-up - starting week 30 in outside plots - were slow to develop but eventually grew vigorously. Picking dates were condensed relative to the spread of sowing: weeks 35-36 from week 25 sowings and week 37 from week 27 sowings, while plants from the week 30 sowing were not ready by week 43 when the tunnel was de-skinned. 'Kinko' and 'Nemo' were very similar orange-flowered types, while 'Shiro' was cream-flowered. In VL testing they showed a consistent average VL of seven days, just sufficient. Brown-tipping of the bracts was evident during production and in testing and detracted from their appearance. Carthamus seems to be a suitable subject for future trials, if bract-tipping can be prevented.

Cosmos (*Cosmos bipinnatus* and cultivars)

Fifteen cultivars from the 'Razzmatazz', 'Sonata' and 'Sensation' series were demonstrated in tunnel and outside plots in 2013. They were vigorous, possibly over-vigorous and unmanageable under protection, but flowered prolifically and produced unexpectedly robust stems with potential as a 'short-season filler' that would introduce seasonal variety to bouquets.

Having shown some promise, a further demonstration and cultivar trial was planted in 2014, using 'Double Click Cranberries', 'Fizzy Rose Picotee', 'Psyche White', 'Rubenza', 'Sensation Antiquity', 'Sensation Dazzler', 'Sensation Purity', 'Sonata Pink', 'Sonata Premium Mix' and 'Sonata White'. After direct drilling they germinated well and grew vigorously, though flowers were slow to develop and flowering was uneven. The best performer was the tunnel-grown 'Double Click' series, which even in outside plots produced stems of substantial length and weight. Stems from the last sowing (week 30), however, were short compared with earlier sowings (weeks 21, 25 and 27). Cosmos made a

floriferous late-season crop through September and October, producing substantial stems. However, when samples were tested they exhibited a very short VL (one to three days).

Cosmos appears to have potential for development as a cheap, drilled outside crop, if appropriate post-harvest treatments can be established. As practised here, picking when the first bud had opened can give disappointing results, and there is a case for investigating disbudding - a reasonably quick, easy task in this species - to get a better display from the side-shoots. A further series of cosmos, 'QIS', with larger flowers on longer, stronger stems and marketed as a cut-flower type, should be investigated.

Delphinium 'Waltz' and 'Tango' series (*Delphinium elatum* cultivars)

Delphinium cultivars have previously been trialled quite extensively at the Centre, but growers and others continue to debate whether more of their potential might be realised. 'Sea Waltz', 'Sky Waltz' and 'Tango Dark Blue' are examples of new series from HilverdaKooij and were deemed worthy of including in the programme. These are tissue-cultured cultivars that produce interesting flower spikes, included following a suggestion from a grower. In 2014 plugs of the three cultivars were transplanted in week 22 into tunnel plots. They produced attractive flowers and were very productive, potentially giving three flushes in a year. A second flush had ended by late-July, and, following cutting-back, a further flush was developing before the plants were damaged by gales in late-October. They are being grown-on to a second year to assess their full potential.

The new delphinium cultivars were liked by growers because of their flower form and stem quality, however the early indications are that supermarkets would not be prepared to pay a premium price to justify the extra planting costs associated with tissue-cultured plants.

Gypsophila 'Zinzi' series (*Gypsophila paniculata* cultivars)

'Zinzi Discovery' and 'Zinzi Tyree' are brand new cultivars from HilverdaKooij that were considered worthy of inclusion in demonstration plots at the Centre in 2014. Plugs of both cultivars were transplanted to tunnel and outside plots in week 27, which was apparently too late in the season to produce a reasonable flower crops. These plants are and being grown-on to 2015 for assessment. It is claimed that the 'Zinzi' series is superior to other gypsophila on the market in terms of stem and flower quality, and the trial will allow the industry to make its own independent assessment.

Leucanthemum 'Real' series (*Leucanthemum × superbum* cultivars)

This crop was included to demonstrate a new range of cut-flower leucanthemum from Realflo. Pinched liners of cultivars 'Real Fancy', 'Real Fizzy' and 'Real Frilly' were transplanted in week 17 to tunnel and outside plots. As supplied, the plants had been well pinched with many breaks, and they grew away well. However, 'Real Frilly' started to bud

prematurely in week 22 and then flowered on very short stems in week 25. 'Real Fancy' and 'Real Fizzy' were harvested in week 28. A second year's growth is required to see their full potential and economic viability. Further work could be undertaken to attempt to improve VL, either by changing husbandry, picking stage or post-harvest treatment.

Lion's ear (*Leonotis leonurus* and other species and cultivars)

Leonotis is a South African plant currently being introduced to cultivation, and there have been promising indications from research in Poland, Israel, Italy and elsewhere. In 2013 seed of *Leonotis* 'Staircase' were grown as plug-plants and transplanted to a tunnel. They grew vigorously, almost reaching the top of the tunnel by week 40-41 when the buds began to open, though it was by then too late to achieve a commercial harvest.

While *Leonotis* in this form would be difficult to manage, it was considered worthy of further investigation. In 2014 *Leonotis leonurus* 'Alba' and 'Staircase' and, *L. mollis* and 'Wild Dagga' were grown. All established well and grew away quickly and were less vigorous than 'Staircase' had been in 2013. Compared with the others, *L. mollis* was relatively compact. By week 43 'Staircase' was in bud, but gales in late-October damaged the plants before any flowers opened. None of the other *Leonotis* had reached a visible bud stage. As a truly novel crop, there is much to learn about the cultural requirements of lion's ear and, although the potential for lion's ear in the UK is unknown at present, work should be extended to 2015. Earlier plantings and control of two-spotted spider mite by prophylactic applications will need to be addressed.

Lupin (*Lupinus* species and cultivars)

Due to their familiarity in the garden, lupins may not seem a likely choice as a commercial cut-flower for the UK. However, in the USA *Lupinus harvardii* (big bend bluebonnet), a native of Texas that produces attractive, tall blue flowers is being investigated for its potential as a new specialty cut-flower, two lines, 'Texas Ice' and 'Texas Sapphire', having been released. Although it was not possible to gain access to this material, perhaps because of commercial sensitivity, the popularity of lupins as garden plants means many cultivars are widely available, mainly from the 'Gallery' and 'Russell' series (*L. polyphyllus*, big leaf lupin).

In 2013 seed of 'Gallery' cultivars ('Gallery Blue', 'Pink', 'Red' and 'White') and 'Russell' cultivars ('Band of Nobles', 'Chandelier', 'Noble Maiden', 'My Castle', 'The Chantelaine', 'The Governor' and 'The Pages') were germinated in plugs and transplanted to outside and tunnel plots. After initially weak growth the plants recovered and established well. Flowering started in week 32 and they continued to produce reasonable numbers of stems over a long period. Plants of the 'Gallery' series were shorter (though not excessively so) than the

'Russell' series, though still acceptable, while the outdoor plants produced much shorter stems than those under protection. In both series the stems were of a high quality and there was a striking range of colours. They were left *in situ* for further assessment in 2014, but many plants failed to survive the winter. In combination with a short VL, the potential of 'Russell' and 'Gallery' lupins as cut-flowers appears limited.

Lupin trials should continue only if new lines and cultivars such as those mentioned above can be sourced, along with *L. densiflorus* 'Aureus' (golden lupin) and *L. x regalis* 'Morello Cherry' (probably the cultivar 'Morello' mentioned as performing well in the US Association of Specialty Cut Flowers Growers (ASCFG) trials, tall and quick-flowering) that are available from specialist suppliers.

Pepper, ornamental (*Capsicum annuum* cultivars)

Ornamental peppers proved to be successful novelties in US trials, and two cultivars were included in a demonstration at the Centre in 2014. Seed of cultivars 'Black Pearl' and 'Masquerade' were sown in 104-module trays in week 20 and transplanted to tunnel plots in weeks 25 and 27. They were slow-growing but eventually produced large, strong plants, and some fruits were visible on each cultivar by week 36 – however, thereafter they remained more or less static without growing or ripening until the tunnel was de-skinned in week 43. It is too early to speculate on their potential for UK growers, 'Black Pearl' and 'Masquerade' should be grown again in 2015, sowing and transplanting earlier. Several other attractive cultivars are available, and enquiries will be made as to whether any are earlier-maturing than 'Black Pearl' and 'Masquerade'.

Physostegia (*Physostegia virginianum* cultivars)

Physostegia was shown to be a potentially useful cut-flower in trials in the USA. A small number of cultivars is available, and one, 'Crystal', was included in an initial demonstration at the Centre in 2014. Seed were sown in 104-module trays in week 20 and transplanted to tunnel plots in week 26. The plants were rather short and late-flowering, and in VL testing stems failed on day two in the vase. The plots need to be grown-on to a second year to assess its full potential. Some other cultivars are available and could be added in 2015, particularly to see if earlier flowering and better keeping quality can be obtained.

Seed-raised fillers (various species)

There has been an increase in grower interest in producing cheap, seed-raised fillers in tunnels or outside. A range of such fillers was demonstrated in 2014: *Ammi visnaga*, *Anethum graveolens* (dill), *Anthriscus sylvestris* 'Ravenswing', *Bupleurum rotundiflorum* 'Griffithii', *Euphorbia oblongata* and *Ridolfia segetum*. Seed of all six plants were direct-drilled in outside plots (in weeks 21 and 25) and in tunnel plots (in weeks 27 and 30). The

anthriscus failed to germinate and was replaced with plug-plants that were transplanted in week 25.

Ammi visnaga was slow to germinate, germination was poor, and plant growth was slow. Possibly due to the consequent wide spacings, stems were too large and branching for use as a filler in this case. Ammi was ready for picking starting weeks 33, 38 and 42 from week 21, 25 and 27 sowings, respectively, while plants from the week 30 sowing were not ready by week 43 (when the tunnel was de-skinned). Stems had a barely acceptable VL of five days. Maybe *A. visnaga* should be drilled at a higher density to reduce plant size, or it could be grown more reliably from plugs; alternatively the more robust *A. majus* could be tested.

Anethum graveolens (dill) was quick to germinate and fast growing. Picking started in weeks 29, 32, 34 and 39 from week 21, 25, 27 and 30 sowings, respectively. The stems had a satisfactory 11 day VL, though there was substantial growth post-harvest with stems elongating by up to 90% in length. After the main stems had been picked the plants produced several secondary stems. Anethum is worth following up in 2015 to see if the excessive stem growth can be restricted.

Anthriscus sylvestris 'Ravenswing' did not germinate following direct-drilling. Replacement plug-plants established quickly, but produced only a handful of flowers. In outside plots they were seriously damaged by two-spotted spider mite. The plants have been left *in situ* to see how they perform in 2015.

Bupleurum rotundiflorum 'Griffithii' was slow to germinate and grow, appeared to bud-up early and eventually produced long, strong stems. In the tunnel crop some plants had leaf scorch, which needs to be investigated. There was renewed grower interest in bupleurum as it is easy to grow and pick, so further trials may be worthwhile, especially to investigate season extension. Regular production would require weekly sowings. Stems were sampled and had a barely acceptable VL of five days. Based on other experience such a short VL was unexpected, and it may have been due to picking at too mature a stage.

Euphorbia oblongata was very slow to germinate and grow and produced stems that were too short for cutting - about 20 cm in length. Part of the crop has been transplanted to the perennial tunnel for observations in 2015. It is possible that the latex produced from the ends of cut stems could cause skin irritation problems with workers and consumers. Before the product were recommended it would be necessary to test it in mixed vases to determine whether it had any inimical effects on other cut-flowers.

Ridolfia segetum was similar to anethum but slower germinating and growing. Ridolfia was ready for picking starting weeks 30, 35 and 36 from week 21, 25 and 27 sowings, respectively, while plants from the week 30 sowing were not ready for picking by week 43

when the tunnel was de-skinned. After cutting the main stem, secondary stems were produced. Anethum could be a better option.

In conclusion *Ammi majus* (or *A. visnaga*), *Anethum graveolens* and *Bupleurum rotundiflorum* appeared to be the most promising of these fillers for further trialling. Bupleurum grew well and the chief need is to optimise the seeding rate. For ammi and anethum poor germination, slow growth and late flowering are key problems that would merit further study, and approaches could include earlier planting dates, starting the season in a tunnel and using plug-plants. *Anthriscus sylvestris*, *Euphorbia oblongata* and *Ridolfia segetum* appeared to be less suitable.

Trachelium (*Trachelium caeruleum* cultivars)

Trachelium is not well known in the UK, although it is widely grown in the Netherlands and is produced in the USA. Several series are available, including the 'Lake Collection' which is marketed as a cut-flower trachelium, and this seemed worthy of testing. In 2013 seed of a selection of cultivars was sown in plug-trays but all failed to germinate. Subsequent discussions with growers and propagators revealed that germination had been an industry-wide issue in that year. Therefore plug-plants of 'Corine Purple' were transplanted to a tunnel plot where they grew well, producing an attractive display starting late-August. With its colour and form, trachelium could have potential for UK production and so the demonstration was repeated in 2014 using plug-plants.

Plugs of 'Corine Purple' and of the 'Lake Michigan' series ('White', 'Blue' and 'Purple') were transplanted in weeks 22 and 27. Initial growth appeared weak and budding-up occurred early, but the stems lengthened and strengthened as the plants matured, each plant producing at least one heavy lead stem and a number of marketable side-shoots. The colours were impressive. The yield of marketable stems ranged from 86/m² for 'Corine Purple' to 158/m² for 'Lake Michigan Blue'. For the lead stems, average lengths varied between 57 and 66 cm and average weights for stems trimmed to 55 cm from 23 g ('Lake Michigan White') to 32 g ('Corinne Purple'). They had an average VL of eight or nine days. Flowering continued well into September and October, though the later planting of 'Lake Michigan Purple' produced short stems, indicating that planting in week 27 was too late for natural-season flowering.

Trachelium seems to have real potential as a tunnel-grown flower for the UK, subject to testing in further years to ensure the results obtained in 2014 - in a warmer-than-usual summer - were not atypical. Growers have asked the CFC to address some specific questions earlier planting, the benefits of pinching, and cultivar comparisons covering a selection of the 'Corine', 'Lake' and 'Devotion' series including a red-flowered cultivar.

Zinnia (*Zinnia elegans* cultivars)

Unlike most species in this novel crops section, zinnia have been grown previously at the Centre (in 2007 and 2008), when the industry was enthusiastic about their wide range of bright colours. However, after picking, the hollow stems collapse and bend just below the flower-head, making them unusable, so trials were put on hold until better cultivars became available. A very different conclusion had been reached in the USA, where trials results rated zinnia as very dependable.

In 2013 seed of seven cultivars of the 'Oklahoma' series and of thirteen cultivars of the 'Benary's Giant' series were germinated in plug-trays and transplanted in weeks 22-23 to tunnel and outside plots. Shortly after planting premature buds were visible, and after pinching these out, the plants grew away vigorously. Some stems were ready for picking by mid-July, and some interesting flower colours and forms were evident. 'Benary's Giant' varieties were stronger and attracted more interest than the 'Oklahoma' series, but nevertheless the latter were considered far superior to any cultivars previously grown at the Centre. The tunnel crop was much more vigorous than the outside crop, with more and longer stems. Throughout summer, samples were taken for VL testing, but flower quality was unacceptable with a maximum of seven days in the vase, despite tests with different flower conditioners and foods. This was nevertheless a promising indication of potential, and it was suggested that they might benefit from earlier picking and treatment with flower food immediately after picking (use of an hydrating solution had been ineffective).

In 2014, a selection of cultivars was grown specifically to provide material for VL testing ('Benary Giant' series 'Bright Pink', 'Coral', 'Deep Red', 'Golden Yellow', 'Lime', 'Lilac', 'Orange', 'Purple', 'Salmon Rose', 'Scarlet', 'White' and 'Wine', and, and 'Oklahoma' series 'Carmine', 'Ivory', 'Pink', 'Salmon', 'Scarlet', and 'White'). Apart from some initial damage due to rabbits, establishment was good. Buds were visible within three or four weeks of transplanting. Plant growth was vigorous until bacterial blight (*Xanthomonas campestris*) symptoms appeared, although after treatment, the crop again grew away vigorously and continued producing flowers in abundance until well into October, providing plenty of stems for VL testing. However, post-harvest quality was unsatisfactory, with stems failing to last to the end of the four day retail store phase. This seems to have been due to adverse effects of the cool chain resulting in early dehydration of the flowers. Chrysal consultants have suggested that there may be treatments that could avoid this damage and so VL will be examined further in 2015 utilising new plantings of 'Benary's Giant' cultivars. With current knowledge zinnia appears to be a very good candidate for ambient-temperature direct-sales such as mail order work.

Crop improvement

Alstroemeria (*Alstromeria* cultivars): 2014 garden cultivars feasibility study

Alstroemeria are familiar as a cold glasshouse crop of high-quality, contemporary cultivars, and have not been included previously in the Centre's trials. However, the availability of Spanish tunnels raises the possibility of growing a cheap, seasonal crop. If older (garden) cultivars were used costs could be reduced as no royalties would be involved. Plug-plants of cultivars 'Apollo', 'Avanti', 'Bonanza', 'Candy', 'Dana', 'Flaming Star', 'Friendship', 'Golden Delight', 'Nina', 'Orange Supreme', 'Pink Sensation' and 'Tanya' were transplanted to beds in a tunnel (week 22) and outside (week 23). The first stems were short and were removed until marketable flowers were produced, about week 30 in the tunnel and week 33 outside. Under protection the plants were vigorous and picking peaked at the end of the season (weeks 41 to 44). Plants in outdoor plots were less vigorous, and picking was slow to begin, peaked in weeks 40 to 43 and continued to week 45. Some growers thought the stems were better than glasshouse crops. Stems of several cultivars were sampled and they had a consistent and satisfactory average VL of 12 days.

Aster, September-flowering (*Aster ericoides* cultivars): 2014 season extension trial

Aster ericoides is imported as a relatively cheap filler, usually the single-flowered 'Monte Casino' types. However, previous trials at the Centre (in 2010, 2011 and 2012) generated interest in a new range of double cultivars grown as a pinched crop for flowering in tunnels during September and October. This could potentially open up new markets, possibly as a straight line product, while growers have expressed an interest in season extension. As *A. ericoides* is a short-day plant, floral initiation under long days can be brought forward by blacking-out the crop for part of the day. In 2013 tunnel-grown plants were used to investigate the use of blackout covers for manipulating the flowering period, the covers being left in place overnight for 13 hours per day from week 22 (stems 60 cm tall) to week 31 (large buds nearly showing colour). Flowering occurred later than expected (mainly weeks 32-33) and on stems taller than required - perhaps because of a slow start following a late spring - but their quality was superb. A second flush in weeks 45-46 was too short to be marketable. The outdoor plots ('controls') produced a single flush in weeks 37-43.

From the 2013 results, it appears the blackout treatment should have been started earlier, before the stems were 60 cm tall. In 2014, a further experiment was carried out with the blackout applied when stems were 50 cm tall (week 25). Un-rooted cuttings of cultivars 'Cairo', 'Cape Town', 'Cassy' and 'Chicago' were rooted in 104-plug trays (week 11), potted-on (week 14), pinched (week 16) and transplanted to beds in a tunnel (week 18, when the plants were already breaking). The blackout cover was applied as before, but from week 25 to week 30. Plant establishment was good in 'Cairo' and 'Cassy', with buds starting to

develop in week 30 when the blackout was removed, producing high quality stems, high yield and no premature budding. However, with 'Cape Town' and 'Chicago' bud development had occurred about a month earlier, resulting in premature budding and poor quality and yield. Stems of the four cultivars were taken for testing and had an acceptable average VL of eight to nine days. After the first flush the plants were cut back almost to the ground. The natural season second flush grew-away well in all cultivars and would have made a marketable crop had it been in a glasshouse instead of a tunnel that had to be de-skinned because of an impending storm in week 43. For comparison the outdoor plots ('controls') cropped around week 42.

Eryngium (*Eryngium* cultivars): 2014 observations

Small demonstration plots of eryngium cultivars have been grown at the Centre for several years. In 2011, plantings were made of cultivars 'Arabian Dawn', 'Blue Bell', 'Deep Blue', 'Magical Blue Falls', 'Magical Cloud', 'Magical Purple Falls' and 'Marbella' outside and in tunnel beds. They were grown-on *in situ* for observations of hardiness and flowering. In 2014 samples of cultivars 'Blue Bell', 'Magical Blue', 'Magical Cloud' and 'Marbella' were sampled for VL testing. Their VL was satisfactory at eight or nine days.

Hardy foliage (various genera): 2014 observations

A wide range of hardy foliage plants was planted in outside beds in spring 2010 and 2011. Most have become well established and there has been distinct interest from the industry: it is known that substantial commercial plantings of *Hypericum*, *Symphoricarpos* and other hardy foliage plants have been made on local nurseries. All plantings were pruned back very hard in early-March 2014 and retained to provide samples and for demonstration purposes.

Lily (*Lilium* cultivars): 2014 alternative growing media trials

Lily production in crates of soil-less media has become a significant UK line and there is now more urgency in developing peat-free growing media. Trials in 2013 indicated the potential of green compost for at least partial peat substitution for lily production, with good quality stems produced using green compost either alone or in a mixture with peat. In 2014 this work was scaled-up on a commercial site with further growing media selections that were evaluated on two crops of lily 'Dynamite'.

In trial 1 bulbs were planted in crates of 100% peat, 100% coir or 100% 'Forest Gold' (a wood-derived commercial potting compost) or mixtures of peat with coir (50:50 v/v), peat with aerobic digestate (AD) (80:20 and 60:40 v/v) or peat with re-cycled green-waste (50:50 v/v). The planted crates were moved to a tunnel in week 24. Stems were cropped in week 34 except for the peat + green-waste treatment which cropped a week later. There were

only small differences in average length and weight between the growing media and these were unlikely to have been statistically significant. Growing in mixtures of peat + AD resulted in plants with better leaf colour than when growing in peat alone. Growing in peat + green-waste resulted in some stunted stems with chlorotic leaves, slightly reducing the yield of marketable stems compared with the other growing media.

In trial 2 bulbs were planted in crates of 100% peat, 100% coir or 100% green compost or mixtures of peat + coir (50:50 v/v) and peat + AD (80:20, 60:40 and 40:60 v/v) and the planted crates were moved to the tunnel in week 30. The picking period was week 41 in all treatments. As in trial 1 the differences in stem length and weight were small and probably statistically insignificant, although in this case there were no obvious visual differences between plants in different media.

Sedum (*Sedum* cultivars): 2014 observations

Since 2010, sedum cultivars have been grown in outside beds at the Centre as a demonstration. Once established, growth was vigorous. Stem counts, length and weight were impressive and as cut-flowers they had a VL of at least seven days. In 2012 the Centre's sedum plots probably generated more attention than any of the other crops. The numerous and substantial stems could be cropped at a range of stages, from relatively tight to wide-developed, and they have potential uses in a range of bouquets as well as straight lines. Numerous samples were made available to the industry for information and promotion, and it is known that, as a result, significant commercial plantings have been made. Since the interest from growers continues and commercial plantings have been made, no further trials are planned. The plots have been retained for demonstration and sample purposes.

Stocks, column (*Matthiola incana*): 2014 fusarium control experiment

Column stocks are a mainstay of UK protected cut-flower production and they have been the subject of several of the Centre's trials. The control of fusarium is an important issue for growers. In a related trial in 2013 under project PO 005, an error was made and Octave was applied at higher than the intended rate - which produced exceptional control of fusarium, indicating perhaps that prochloraz may still be providing some level of control at label recommended rates. This trial was therefore created to try and identify active ingredients which still have some activity against the pathogen (though not providing control individually) which could be used as part of an holistic control programme.

Plug-plants of column stock 'Centum Deep Blue' were transplanted to pots of growing media inoculated with fusarium. Fungicides were applied at 2x and 4x the usual rates as a growing medium drench, using thiophanate-methyl (as 4 and 8 g Cercobin/L), prochloraz

(as 4 and 8 g Octave/L), difenoconazole (as 2 and 4 ml Plover/L), boscalid + pyraclostrobin (as 3.4 and 6.8 g Signum/L) and fludioxonil + cyprodinil (as 1.6 and 3.2 g Switch/L). In addition there were controls (inoculated growing media but no fungicide treatment) and an un-inoculated comparison (no inoculum, no fungicide). The plants were grown-on in a tunnel and assessed at intervals. Judging by plant growth and survival, both rates of Cercobin, Octave and Signum increased growth and survival and reduced the appearance of fusarium symptoms to as large extent. Treatment with Plover and Switch initially appeared successful, but the plants mostly died within a month of application. These treatments are purely experimental and cannot be used commercially, but the results suggest that better control programmes for fusarium in stocks could be developed using these fungicides including the newer family of SDHI fungicides.

Sunflower (*Helianthus annuus* cultivars): 2014 demonstration of new sunflower cultivars for protected cultivation

Since sunflowers became a fashionable cut-flower in the early-2000s they have maintained their popularity despite a number of difficulties, and significant quantities are now field-grown in the UK. Sunflowers have been included in the Centre's trials since 2010. A major requirement is to reduce the resources needed in harvesting and handling, and one approach is to switch to new dwarf cultivars. In 2014 more information was sought on the protected cultivation of new cultivars, and plots of 'Galilee Orange', 'Happy Face', 'Helios Flame', 'Lemon Party', 'Rio Carnival', 'Solar Flash', 'Stellar Sun', 'Superted', 'Tabya', 'Tall Timber' and 'Tavor Flash' and of three numbered lines (PV174, PV197 and PV199) were direct-drilled in weeks 27 and 30.

For most cultivars the germination rates were high and growth was rapid. 'Solar Flash' and 'Carnival' are actually bedding varieties and were too short for cut-flower use, but all the others gave acceptable results. Stems of a selection of cultivars were sampled for VL testing and had a consistent average VL of seven days, thereby just attaining the usual number of 'guaranteed' days, although stems of 'Helios Flame' started to bend on vase-day three.

Herbicide trials

The availability and suitability of herbicides is a particular problem in the production of 'minor crops' such as cut-flowers because the size of the market is not sufficient to cover the costs incurred in the development of information for any on-label approval. Consequently few on-label approvals are available and growers are dependent on EAMUs (Extension of Authorisation for Minor Use) and the LTAEU (Long Term Arrangements for Extension of Use). HDC Project HNS PO 192 included herbicide trials on outdoor drilled and transplanted China aster, tunnel-grown lily and outdoor drilled sweet william, and these

were sited at the Centre in 2014. The results are summarised in this report and full details will be available in the Final Report of project HNS PO 192. In addition a separate herbicide trial on outdoor drilled sweet william was carried out at a commercial nursery as part of the CFC project.

From the initial trial 'Benfluralin' looked promising, with good crop emergence and little phytotoxicity on drilled crops or transplanted asters. 'Shark' seemed a possible selective contact treatment, with China aster and sweet william recovering from initial damage. 'Defy' alone or in combination with 1 L/ha 'Stomp' appeared safe on drilled sweet william on the silty soil at this nursery. The experimental formulation HDC H22 proved highly phytotoxic to drilled crops and reduced emergence, although it would be safer in transplanted crops. All treatments used on lily and transplanted China asters were safe and had minimal effect on stem length and weight. These are all trials results, not recommendations.

Summary of the Centre's work

The Centre has continued to develop its role as an information hub and cohesive voice for the UK cut-flower industry. This has been achieved by holding a number of grower events throughout the year and Open Days to examine trials on both commercial nurseries and the main site at Rookery Farm. The project continues to produce appropriate technical literature. Several crops trialled at the Centre have attracted enough attention to be planted commercially, including sedum, hardy foliage, antirrhinum and lisianthus. In addition the Centre, in its role as a crop association, has promoted other cut-flower R&D and encouraged the development of new projects such as herbicide trials and the hydroponic production of cut-flowers.

Financial Benefits

Anecdotal evidence has indicated that a number of crops have been trialled and grown commercially as a direct result of the CFC trials programme. Examples known to have been grown on a small-scale include the annual dianthus from Hilverda, *Aster ericoides*, carnation 'Solomio', dahlia 'Karma', phlox, scented pinks and zinnia. Others have been grown on a more commercial scale, the main ones being antirrhinum, a spot-crop of lisianthus and various hardy perennials including hypericum, salix, sedum and *Symphoricarpos* (snowberries). The following is an estimate of the area grown and farm-gate value of these products, the hardy perennials being included as single category:

- Antirrhinum: amount extra grown in 2013 approximately 1.0 ha with a farm-gate value of £115,000; the value was similar in 2014.

- Lisianthus: amount extra grown in 2013 approximately 0.5 ha with a farm-gate value of £70,000; in 2014 the estimate was approximately 1 ha with a farm-gate value of about £140,000.
- Hardy perennials: amount extra grown in 2013 approximately 2.5 ha with a farm-gate value of £78,000 (based on an average yield figure which takes into account that these are relatively new plantings and have not yet reached their maximum yield). In 2014 the area increased to approximately 3.5 ha with a farm-gate value of about £109,000.

To enable growers to undertake a basic assessment of the commercial potential of some of the most promising subjects, the following section includes some basic yields, planting density data and plant costs of the three subjects listed above, as well as of trachelium which showed great promise in the 2014 trials.

- Antirrhinum: planting density around 64 plants/m² of bed, with 80 to 95% of stems being harvested (one stem produced per plant); the plant cost is approximately €40 per 1,000 plus delivery.
- Lisianthus: planting density between 64 and 80 plants/m² of bed with 80 to 95% of stems being harvested (one stem produced per plant); the plant cost is approximately €53 to €78 per 1,000 (dependent on variety) plus delivery.
- Hardy perennials: using *Symphoricarpos* (snowberries) as an example planting density around 1.3/m², with a yield of around 20 stems per plant from year three onwards. The plant cost of hardy perennials varies with the subject, the cheapest being sedum at less than €1 per plant, then hypericum at about €1.5 per plant, and snowberries at about €1.75 per plant. The expected life of these crops would be between 10 and 20 years.
- Trachelium: planting density around 64 plants/m² of bed with at least one lead-stem harvested per plant and with some varieties in 2014 also producing one to two additional side-shoots; the plant cost is approximately €70 per 100 plus delivery.

Action Points

- Tunnel-grown trachelium cultivars continue to provide impressive stems with their length, weight and colour, and should be considered as a potentially valuable and vigorous UK crop, with the proviso that they may do less well in a cool summer.

- As cheap, direct-driller fillers, *Ammi majus*, *Anethum graveolens* (dill) and *Bupleurum rotundiflorum* showed promise as vigorous tunnel-raised crops and should be considered. *Anthriscus sylvestris*, *Euphorbia oblongata* and *Ridolfia segetum* seem less amenable.
- Relatively cheap, garden cultivars of alstroemeria performed well and could be considered as a natural-season tunnel crop.
- September-flowering tunnel-grown *Aster ericoides* cultivars 'Cairo' and 'Cassy' were amenable to seasonal extension when flower initiation was instigated using blackout covers giving 13 hour nights in June-July, a technique that could be considered to produce two flushes of flowers per year.
- Alternative growing medium trials of tunnel-grown, crated lily 'Dynamite' showed that flowers of equal or better quality to those grown in standard peat could be obtained using 100% coir, 100% 'Forest Gold' (a wood-derived potting compost), peat + coir (50:50) or peat + aerobic digestate (AD) (80:20, 60:40 or 40:60), showing that growers could adopt such materials in place of peat. Mixtures of peat + green-compost (50:50) produced some variable results, but this may be due to variations in the composition of the green compost.
- In trials, several other crops have shown potential for UK production in tunnels or outside, but, before recommendations are made, further investigations are required, (typically further cultivar screening, addressing cultural issues (such as planting schedules, pinching and controlling disorders) and the optimisation of post-harvest treatments). These include basil, carthamus, cosmos, leucanthemum, *Leonotis* (lion's ears), lupin, ornamental pepper, physostegia and zinnia, as well as new series of spray carnation ('Tiara'), delphinium ('Waltz' and 'Tango') and gypsophila ('Zinzi').

Science Section

Introduction

For a long time the UK had a relatively low *per capita* consumption of cut-flowers compared with other western European countries. This provided little incentive for UK cut-flower growers – other than the most driven of them - to expand production or hope to compete with the well-established Dutch export trade. Between the late-1980s and early-2000s, the UK's imports of cut-flowers rose from some £125m to around £550m. In stark contrast, over the same period the value of UK-grown cut-flowers has remained static at around £50m (farm-gate values for England & Wales), variously attributed to a lack of 'know-how' and a culture of buying-in from 'across the water'. The bulk of this UK production has been glasshouse alstromeria, chrysanthemum, column stock and lisianthus, forced daffodil, lily and tulip bulbs and field-grown daffodil, with a small amount (worth some £5m to £10m annually) of outdoor, non-bulbous crops such as natural-season chrysanthemum, sunflower and peony.

In the last 20 or so years several factors should have provided a stimulus to increase the UK production of cut-flowers in quantitative and qualitative terms.

- An increase in cut-flower purchases in the UK
- The avowed environmental interest of supermarket chains in home production (closeness to markets, fresher products, etc.) though the associated low margins and high specifications are a disincentive
- The perceived interest of supermarkets and consumers in a greater variety of products
- The success of relatively cheap Spanish tunnels in enabling season extension and weather protection for other crops
- The availability of more 'know-how' on cut-flower production in tunnels and outside as a result trials and research funded by the HDC and others

A cut-flower trials project was proposed by industry representatives and funded by the HDC, starting in 2007. The initial project (PC/BOF 268, 2007-2008)¹ was followed by projects PC/BOF 268a (2009), PC BOF 002 (2010-2012) and PC BOF 002a (2013-2017), for which all annual reports should be available from the HDC or the National Cut-Flower Trials Centre web-sites.² The immediate aim of the programme is to provide information on the production of alternative and novel cut-flowers outdoors or in tunnels. The underlying and

¹ In 2007 and 2008 the project was jointly funded by the HDC and the Lincolnshire Fenlands LEADER+ programme

² <http://www.hdc.org.uk/> and <http://www.thecutflowercentre.co.uk/>

longer-term aim, however, is to stimulate UK cut-flower growers to develop and commercialise new products to the benefit of the industry. In the context of this project and its outputs the term 'new crops' is interpreted very widely: it could include a species completely new to production horticulture, or might simply indicate a crop with which UK growers are currently unfamiliar.

The mechanics of running the project are as follows. By arrangement with David Robinson (Managing Director, R Robinson & Son Ltd), the trials programme is hosted at Rookery Farm, Holbeach St John, Spalding, Lincolnshire. The National Cut-Flower Trials Centre ('the Centre') is formally constituted as The Cut Flower Centre Ltd with project leader Lyndon Mason as a Director, and is managed by a Management Group (MG) comprising representatives of growers, packers, retailers and the HDC. The trials programme is formulated each year by the MG, taking into account comments received from growers and others through the year.

The types of trial carried out are varied: depending on the present state of understanding of a crop, different species might require:

- Simple demonstration plots (e.g. to gain an initial impression of the suitability of new cut-flowers);
- Cultivar trials (to identify the better cultivars);
- Trials to develop a production protocol (e.g. to investigate the effects of factors such as planting dates and plant density);
- Trouble-shooting experiments (e.g. to extend the growing season or control over-vigorous growth); and
- Larger-scale evaluations, if appropriate at a commercial nursery (e.g. to test a promising crop grown on a larger scale or under commercial conditions).

Each year some new crops will be assessed for their likely potential in UK production, deciding whether or not to take them forward for further testing. Over time, a new crop with demonstrated promise might go through all these stages.

With the start of new funding in 2013, the scope of the project was extended so as to make its role more comprehensive:

- An increased information gathering role, including reviewing other cut-flower trials programmes, new crop development, and trends in cut-flower production;
- An increased technology transfer role including holding key technical meetings as well as traditional Open Days, and with the Centre's web-site acting as a source of reports and reviews;
- A remit to include 'bulbous' ornamentals;

- A remit to include, where appropriate, production under glass as well as outdoors and in Spanish tunnels;
- An extension in the types of trials and experiments carried out, including collaborative research relating to major themes identified by the HDC such as herbicide replacement, spectral filters and sustainable pest and disease control; and
- A remit to identify knowledge gaps and encourage the submission of concept notes for new R&D projects, to develop contacts with education and training at all levels, and to take on 'Crop Association' role.

This report describes the work carried out in 2014, the second year of the enhanced project (PO/BOF 002a). It gives a brief review of the information gathering aspects, a detailed report of the 2014 trials (with a summary of previous trials at the Centre), and an inventory of technology transfer activities so far.

The project leader or members of the MG would welcome comments and suggestions for future projects.

Information gathering

Information gathering used both Internet sources and CABI's '*Horticultural Abstracts*' ('HA') database. 'HA' is a compilation of all significant research on horticultural crops worldwide, and at the time of the 2014 report a period from about 2000 to September 2014 had been covered. The information was summarised into databases or reviews under a number of headings.

Database of seed and planting material suppliers

A database of companies supplying seeds and planting material for cut-flower production was compiled in 2013 and up-dated in 2014, using Internet and other resources. It is available on the Centre web-site. As well as being a resource for the cut-flower industry, the database facilitates contacts by researchers with the seed/plant industry and helps in the identification and sourcing of new cut-flower species and hybrids for the trials programme. This exercise has helped to identify new sources of subjects for trialling. The database will be up-dated annually.



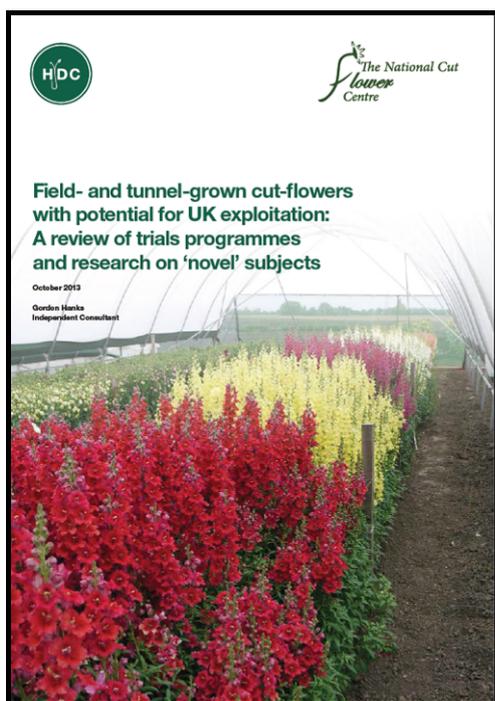
Review of new cut-flower crops and of cut-flower trials programmes

R&D on new cut-flower crops was largely reviewed through the world scientific literature using 'HA' (see above), and this is where information on species genuinely new to the cut-flower trade is to be found. The research identified is often at the level of collection of wild material, of its initial assessment as potential commercial crops, or breeding for improved cut-flower qualities. In some more advanced projects some progress may have been made in understanding the growth and development of the species and in developing appropriate protocols for growing a new commercial product.

Such 'new crop' projects often impinge on the cut-flower trials programmes that are carried on in horticulturally developed or developing countries; in the former, trials are likely to be funded partly through grower organisations and carried out by educational institutions, while in the latter they are often funded by government at government-funded institutes. In the

more developed countries trials may concentrate on the finer points of between-cultivar differences, while elsewhere there may be a wide range of species being assessed much more speculatively. Cut-flower trials programmes may be reported in the scientific press but are more likely to appear in the trade press or on web sites. In general the in-house trials and demonstrations carried out by seed houses, etc., are not covered.

The initial (2013) review of new crops and cut-flower trials programmes was published on the Centre's web-site in 2013.³ The review is being up-dated annually and the 2014 version will be made available on the Centre's website.



Sources of information on cut-flower production

Particularly in the USA, where several Land-Grant Universities are prominent in more technology-related subjects including horticultural production, there is a host of guidance for growers available as downloadable information-sheets on their web-sites. This information was placed on a database and a list is available as part of the new crops and cut-flower trials review (see above).

Production levels and trends in the cut-flower trade

Monitoring the production levels and prices for different products can provide an insight into trends of products in decline or coming into fashion. Unfortunately information is sparse other than from the Netherlands. These statistics are being collated and will be made available on the Centre's website.

³ <http://www.thecutflowercentre.co.uk/wp-content/uploads/2013/11/Cut-Flower-Review-Final.pdf>

Experimental programme: Materials and Methods

Demonstrations, trials, experiments and commercial evaluations

The 2014 experimental programme was developed by the MG, taking into account comments received from growers and others and information from the review of new crops and cut-flower trials. Depending on the present state of understanding of a crop, different species might require a simple demonstration plot, a comprehensive cultivar trial, the development of a production protocol or a trouble-shooting experiment (e.g. to develop seasonal extension or test pesticide effects), or a larger-scale evaluation at a commercial nursery. Included in this programme about five new crops are investigated each year, assessing their potential for UK production and deciding whether or not to take them forward for further testing.

The experimental programme consisted of many individual demonstrations, trials, experiments and evaluations on numerous species and cultivars, and the individual trial methods and results are provided in later sections of this report. As appropriate to the practical nature of the project, demonstration plots were not usually replicated, but in other cases, where practicable, appropriate replication and randomisation were used. The remainder of this section therefore describes the more overarching trial details.

Facilities and protocols at the Centre

The facility at Rookery Farm, Holbeach St John, Spalding, Lincolnshire comprises a single-span 'Haygrove' tunnel⁴ (7.9m wide × 38.1m long), a triple-span 'Pro-Tech' tunnel⁵ (overall 22.7m wide × 38.0m long) and an adjacent area of outdoor beds of about 600m². Since it is on an exposed site, wind-breaks of 2.5m-high polypropylene netting are provided at each end of the 'Pro-Tech' tunnel. Typical of the area, the soil is deep alluvium drained by ditches and pumps.⁶

Protocols were agreed between David Robinson of Rookery Farm and the Centre's MG, the aim being to achieve a good standard of commercial husbandry. Practices were adapted as necessary to suit small trial plots that might require frequent or detailed records to be kept and individual pesticide, irrigation and fertiliser treatments to be made.

Site preparation

The growing areas were sterilised as required by the year's trials programme. For the 2014 season the 'Haygrove' tunnel and 'Pro-Tech' tunnel bays 1 and 2 were steamed in late-

⁴ <http://www.Haygrove.co.uk/>

⁵ <http://www.Pro-Tech-marketing.co.uk/>

⁶ *Soils of England and Wales*, Soil Survey of England and Wales

October 2013 and the sheets left down over winter. 'Pro-Tech' tunnel bay 3 remained planted with perennials and so could not be sterilised.

Prior to the start of planting, soil samples were taken across the trials site for standard glasshouse soil analysis, with the results shown in Table 1. As it is not possible to give a base fertiliser recommendation for all minor cut-flower crops, the aim was to bring base fertiliser levels up to about those required for column stocks or chrysanthemums, that is indices of 2 for N, 5+ for P, and 4 each for K and Mg. The rates of fertilisers applied in April 2014 are in Table 2.

Table 1. Results of standard glasshouse soil analysis for the tunnels and outside beds (April 2014)

Site	pH	P		K		Mg		NO ₃		Conductivity	
		mg/L	Index	mg/L	Index	mg/L	Index	mg/L	Index	µS/cm	Index
'Haygrove' N	7.5	55	4	322	3	314	5	15	0	2422	2
'Haygrove' S	7.5	30	4	345	3	319	5	20	0	2478	2
'Pro-Tech' 1 N	nd ¹	-	-	-	-	-	-	-	-	-	-
'Pro-Tech' 1 S	7.6	54	4	367	3	353	6	21	0	2452	2
'Pro-Tech' 2 N	7.2	45	3	247	3	629	7	17	0	2380	1
'Pro-Tech' 2 S	7.4	42	3	299	3	540	6	16	0	2731	4
'Pro-Tech' 3	7.5	34	3	253	3	204	4	32	1	2316	1
Outside beds	7.6	19	2	146	2-	165	3	62	2	2334	1

¹ No sampling or fertiliser application, this area largely occupied by crops left down

Table 2. Rates of fertilisers applied to tunnel and outside beds in April 2014

Site	Application rates (g/m ²)		
	Triple superphosphate	Sulphate of potash	Ammonium nitrate
'Haygrove'	80	100	30
'Pro-Tech' 1 S	80	100	30
'Pro-Tech' 2	80	130	30
'Pro-Tech' 3	110	130	15
Outside beds	130	50	15

Plant material

Most plants were obtained as plug-plants or liners, some as un-rooted cuttings (*Aster ericoides*), rooted cuttings (spray carnation 'Tiara' series), potted plants (hardy foliage plants), bulbs (lily) or seeds. Seeds were germinated in plugs (for ease of management seed of novel crops were sown into 'Jiffy 104' preforma plugs and germinated on a heated floor), or direct-drilled in the case of cosmos, seed-raised fillers, sunflowers and sweet william.

Crop husbandry – planting

Most plants were transplanted into labelled plots along the 1m-wide beds at a specified density. Individual plot lengths were dependent on the trial, and 0.5m-long unplanted 'guard areas' were left between plots and at the ends of the beds to guard against shading and 'end' effects. Details are specified under 'Results'. Generally the beds were covered with 1.2m-wide, 120-gauge, micro-perforated black polythene film and planting was through the film; in a few cases planting was directly into the border soil (column stocks, sunflowers and the perennials in 'Pro-Tech' tunnel bay 3). Crops were watered with a hand-lance immediately after planting.

Crop husbandry – post-planting

Once plants were established (using a hand lance) most water was applied as needed through the lay-flat irrigation lines. If required (eg to bring any dry patches back up to the required moisture status) the hand lance would also be used during the main production period. Once in growth, plants received a weekly liquid feed, with applications increased as required to twice per week on vigorous crops later in the growing season. The liquid fertiliser used was 'Universol® Green' (23:6:10:2.7 N:P:K:MgO with trace elements; Everris International BV). Beds were provided with one or two layers of support netting if required by the crop, the netting being raised with the growth of the crop. In some cases, such as *A. ericoides*, side-support wires were also provided because of the crop's vigour. In some cases plants were stopped (pinched) or other treatments were applied, in which case the details are given under 'Results'.

In anticipation of stormy weather the 'Haygrove' tunnel and 'Pro-Tech' tunnel bay 1 and 3 were de-skinned in late-October 2014 and sterilised with Basamid, bringing to an end the trials sited there. 'Pro-Tech' tunnel bay 2 was initially left intact as protection for the perennial trial remaining there, but was de-skinned in mid-November.

Pesticide applications

Pesticide advice was given by a BASIS-qualified agronomist and pesticides were applied as needed and according to recommendations. The pesticides applied in 2014 were as detailed below.

- For aphid, deltamethrin (as 'Decis') to all lupins, week 14
- For powdery mildew, kresoxim-methyl (as 'Stroby WG') to tunnel asters, tunnel and outside lupins, and outdoor zinnias and delphiniums, week 24
- For aphid, spirotetramat (as 'Movento') to all crops, week 25 and 28
- For aphid, thiacloprid (as 'Calypso') to tunnel asters, tunnel and outside lupins, and outdoor zinnias and delphiniums, week 25, and to tunnel lupins week 29

- For powdery mildew, sulphur (as 'Thiovit Jet'), to tunnel asters, tunnel and outside lupins and outside zinnias and delphiniums, week 26 (with adjuvant), and to tunnel and outside lupins and asters and outdoor zinnias and delphiniums, week 31, and to tunnel and outside asters and delphiniums, weeks 34 and 40
- For aphid, pymetrozine (as 'Chess WG') to tunnel asters, tunnel and outside lupins, and outdoor zinnias and delphiniums, week 26
- For powdery mildew, myclobutanil (as 'Systhane 20EW') to tunnel asters, tunnel and outside lupins, and outdoor zinnias and delphiniums, week 27, and to tunnel and outside asters and delphiniums, and to outside anthriscus, week 38
- For powdery mildew, boscalid + pyraclostrobin (as 'Signum') to all crops, week 28
- For powdery mildew, cyflufenamid (as 'Takumi 5C') to tunnel lupins and delphiniums and tunnel and outside asters and bupleurum, week 29, and to tunnel and outside asters and delphiniums, and to outside anthriscus, weeks 37 and 41
- For bacterial blight, azoxystrobin (as 'Amistar') to zinnias, weeks 29 and 33
- For flea beetle, cypermethrin (as 'Permasect C') to outdoor wallflowers, weeks 30, 31, 33 and 34
- For two-spotted spider mite, abamectin (as 'Dynamec') to tunnel and outside asters, lupins and delphiniums and outdoor zinnias, bupleurum, stocks and wallflowers, week 31
- For rust, propiconazole (as 'Bumper 250EC') to outside hypericums, week 34

Crop assessments

Stems were picked at the appropriate commercial stage for each crop, wherever practicable taking samples close to the peak cropping date. Usually the number of marketable stems picked was recorded (and converted to numbers of stems per m²), along with (for an appropriate random sample of each plot) picking dates, lengths and weights of stems (either overall figures or after trimming to a specified length) and other measurements as appropriate (such as spike length or flower-head diameter). Other than as required by trimming, the stem lengths and weights quoted always refer to the total weights and lengths of the whole stem, including buds, flowers or inflorescences. Less formally, the plots were also assessed at intervals by the MG and others as appropriate, and in the case of preliminary demonstrations emphasis was placed on photographs and grower comments.

Protocols for trials at commercial nurseries

Some evaluations have been carried out at appropriate commercial nurseries, either because conditions at the Centre were unsuitable (e.g. the soil at Rookery Farm is

considered too heavy for growing ornamental brassicas), or in order to assess crops on a larger scale or on a more 'commercial' basis than would be practical at the Centre. Under these circumstances growers would be expected to apply their normal standards of cultural practices, project staff having less control than over trials at Rookery Farm. In 2014 the lily substrate trials and a herbicide trial on sweet Williams were carried out off-site.

Vase-life testing

In 2014, whenever practical, samples of cut-flowers were cropped at the appropriate picking stage and transported in buckets of water containing a storage and transport solution ('Clear 200 eZ Dose' sachets, FloraLife⁷) to Butters Group, Spalding, Lincolnshire for vase-life (VL) testing. On receipt the stems were checked for satisfactory quality (all samples were acceptable) and placed in buckets of water containing a processing solution ('Chrysal Clear Professional 2' 'T-bag', Chrysal⁸) and stored for 1d at 5°C (representing time at the depot) and 4d at 20±1°C (representing time in the retail store). The stems were then placed in water containing a universal flower food in vases at 20±1°C, representing time with the consumer. Usually, tests were based on three replicate vases of three stems each. Stems were examined daily and each vase was considered to have reached the end of its VL when half of its stems were failing, the way in which stems were failing being recorded. In general a guaranteed VL of 5 to 7d would be required. Details of sampling are given under the results for individual crops, where the VL quoted is the number of days in the vase, in the consumer phase.

⁷ <http://www.floralife.com/en-gb/>

⁸ <http://www.chrysal.co.uk/>

Experimental programme: Results

Crop introduction started 2013

On the basis of the new crops and trials programmes review (see Review of new cut-flower crops and of cut-flower trials programmes, above), suggestions from growers, and information from seed and young-plant suppliers, several crops were selected for testing each year. At the end of each year new crops showing promise for UK production, and those for which further information was needed before such a decision could be made, were taken forward for further testing.

In 2013 the selected crops were basil, cosmos, gentian, Lion's ear (*Leonotis leonurus*), lupin, trachelium and zinnia. More information on these can be found in the 'new crops review'.⁹ Information on these trials was given in the annual project report for 2013 and is updated here.

Basil (*Ocimum basilicum*) 'Dark Red Opal', 'Floral Spires Lavender', 'Floral Spires White' and 'Sweet Dani Lemon' made good growth in tunnel plantings, some cultivars having attractive foliage with potential use as a fragrant filler for mixed bunches and bouquets. However, its VL was poor, <5d.

In the case of gentian (*Gentiana* species) it proved impractical to obtain samples of the required new commercial lines produced in New Zealand or Japan. As an interim measure, seeds of taller garden types, *G. asclepiadeum* (and its cultivars) and *G. lutea* were obtained from specialist suppliers but failed to germinate under our conditions in either 2013 or 2014. Further tests with gentians were deferred until its germination has been researched and fresh approaches made to the owners of new lines.

The other candidates - cosmos, lion's ear, lupin, trachelium and zinnia - were all deemed worthy of further investigation in 2014, and a summary of these tests is given below.

⁹ <http://www.thecutflowercentre.co.uk/wp-content/uploads/2013/11/Cut-Flower-Review-Final.pdf>

Cosmos (Cosmos bipinnatus)

Cosmos are well known garden plants, producing masses of bright flowers and feathery foliage. Although they may appear too wispy to be adapted as a cut-flower, some cultivars have given good results in the ASCFG trials. Cosmos would seem to have potential as a 'short-season filler' used to introduce variety to bouquets through the year. Fifteen cultivars from the 'Razzmatazz', 'Sonata' and 'Sensation' series were demonstrated in tunnel and outside beds at the Centre in 2013. They were vigorous in growth – too vigorous and unmanageable in the tunnel – and flowered slowly and unevenly but, eventually, prolifically. They were deemed to have sufficient promise for a further demonstration and variety trial in 2014 (Table 3).

Table 3. Details of 2014 cosmos (a) demonstration and (b) variety trial

Varieties	(a) Cultivars 'Double Click Cranberries', 'Sensation Antiquity' and 'Sonata Pink' (b) Cultivars 'Double Click Cranberries', 'Fizzy Rose Picotee', 'Psyche White', 'Rubenza', 'Sensation Antiquity', 'Sensation Dazzler', 'Sensation Purity', 'Sonata Pink', 'Sonata Premium Mix' and 'Sonata White'
Format(s) and supplier(s)	Seed (Moles Seeds)
Propagation and pre-planting treatment(s)	None
Planting or sowing	Direct-drilled by hand in three rows along beds
Planting or sowing date(s)	Outside: weeks 21 and 25 Tunnel: weeks 27 and 30
Planting site(s)	(a) 3m-long plots in beds outside and in 'Haygrove' tunnel (b) 3m-long plots in beds outside
Layout	Un-replicated demonstration plots
Plant spacing(s)	Thinned to about 5cm apart in rows
Post-planting treatment(s)	None
Pests, diseases and disorders	No problems evident
Picking stage(s) and market specification(s)	As a tentative picking stage, one flower fully open, but further definition needed
Picking and recording date(s)	Week 21 outside: week 30 Week 25 outside: week 35 onwards Week 27 in tunnel: week 36 onwards Week 30 in tunnel: week 41 onwards
Records taken	Observations only
VL testing	Four cultivars sampled

Cosmos germinated well and grew vigorously, though flowers were slow to develop and flowering was uneven. 'Sensation Mix' is known to be a short-day plant that begins to flower in late-summer on large plants. The best performer was the 'Double Click' series grown in

the tunnel, which produced stems of substantial length and weight even grown outside. Stems from the last sowing (week 30) were short. Cosmos made a floriferous, late-season crop through September and October (Figure 1, Figure 3) and the bunched stems were substantial despite the initial impression of the plant's wispieness (Figure 2).

In these cultivars the lead bud developed and opened some time before the subordinate buds, so picking when the first bud is open can give disappointing results. Stems of the four cultivars were sampled for VL testing but showed a very short VL of 1 to 3d, with stems visibly breaking-down at this time.



Figure 1. Tunnel-grown cosmos demonstration plots 2014, from front to back 'Sonata Pink', 'Sensation Antiquity' and 'Double Click Cranberries': left, on 9 September (week 37) from week 27 sowing; middle, on 26 September (week 39) from week 27 sowing; and right, on 7 October (week 41) from week 30 sowing



Figure 2. Typical bunches of tunnel-grown cosmos from the demonstration plots 2014 (1 September, week 36)



Figure 3. Outside cosmos cultivar trial 2014: left, on 1 September and right, on 24 September, both from week 25 sowing

Lion's ear (*Leonotis leonurus*)

As reported in the previous annual project report and novel crops review,¹⁰ *Leonotis* is a South African plant being introduced to cultivation. It has attractive orange flowers, is aromatic, and is reputedly easy to grown in various regions. In field studies conducted in Poland it flowered from July to late-autumn, was tall (120-300cm) and produced dense inflorescences on long, upright stems. In Israel research led to an extended VL of 12d with fully open flowers. In studies in Italy rooted cuttings were pruned back at the end of December and moved to an unheated plastic glasshouse where flowering started in April and continued throughout summer, while plants kept outside flowered from June/July to late-October.

Several specialist seed suppliers list *Leonotis* 'Staircase', one giving a height of 180cm and stating that it is suitable for growing in 'deep' patio pots and in the border. Some suppliers list other cultivars and species, some (such as *L. mollis*) more dwarf than *L. leonurus*. In 2013 seed of *Leonotis* 'Staircase' were germinated in plugs and transplanted to a tunnel. The plants grew vigorously and almost reached the top of the tunnel by week 40-41 when the buds began to open. Previous findings and their relative ease of growth suggested further tests should take place in 2014 and new sowings were made (Table 4).

Table 4. Details of 2014 *Leonotis* demonstration

Varieties	<i>Leonotis leonurus</i> 'Staircase' and 'Alba', <i>L. mollis</i> and 'Wild Dagga'
Format(s) and supplier(s)	Seed (EconSeeds)
Propagation and pre-planting treatment(s)	Sown week 20 in '104' module trays
Planting or sowing	Transplanted
Planting or sowing date(s)	2014: week 27
Planting site(s)	1m-long plots in beds in 'Pro-Tech' tunnel bay 1
Layout	Un-replicated demonstration plots
Plant spacing(s)	24/m ²
Post-planting treatment(s)	One layer of support netting At end of growing season plants cut-back and left <i>in situ</i>
Pests, diseases and disorders	Two-spotted spider mite a serious problem
Picking stage(s) and market specification(s)	Not known, possibly first florets fully open
Picking and recording date(s)	Observations only
Records taken	Observations only
VL testing	No

¹⁰ <http://www.thecutflowercentre.co.uk/wp-content/uploads/2013/11/Cut-Flower-Review-Final.pdf>

All 2014 plantings established well and grew away quickly (Figure 4). 'Staircase' was again very vigorous, while, compared with the other examples, *L. mollis* was relatively compact. By week 43 'Staircase' was in bud, but gales in late-October flattened the plants before any flowers opened, but none of the other *Leonotis* plantings reached a visible bud stage. Two-spotted spider mite was a problem on *Leonotis* in 2014.



Figure 4. *Leonotis* planted in 2014: top, cultivar 'Staircase' (with inflorescences enlarged on right); bottom left, 'Staircase' on left and 'Alba' on right; bottom right, *Leonotis mollis* on left and 'wild dagga' on right (11 September 2014)

Lupin (*Lupinus* species)

From a UK viewpoint, the role of lupins in gardens may not make them a likely choice as a commercial cut-flower. However, *Lupinus harvardii* (big bend bluebonnet), a native of Texas, produces attractive, tall blue flowers with potential as a new specialty cut-flower. Research at Texas A&M and New Mexico State Universities led to limited commercial production, and 'Texas Sapphire' and 'Texas Ice' were subsequently released. Contact with researchers at Texas A&M University in 2013 failed to produce access to these new introductions, perhaps because of commercial sensitivity. On the basis of published results, they seem worthy of demonstrating at the Centre. In addition, lupin 'Morello' was among the plants tested in the ASCFG trials. The popularity of lupins as garden plants in the UK means that many cultivars are widely available, mainly from the 'Gallery' and 'Russell' series (*L. polyphyllus*, big leaf lupin), and in 2013 it was decided to demonstrate some of these cultivars pending sourcing the more advanced lines.

In 2013 seed of 'Gallery' and 'Russell' cultivars were germinated in plugs and transplanted to outside and tunnel beds. Initially growth was judged as weak, the plants recovered and established well, but were slow to begin flowering. Flowering started, albeit on only a handful of stems, in week 32, and they continued to produce reasonable numbers of stems over a long period. Although plants of the 'Gallery' series were shorter than the 'Russell' series, their length was adequate. Comparing protected and outdoor cultivation in the first year the outdoor flowers produced much shorter stems than those grown under protection. They were left *in situ* to over-winter and their potential as cut-flowers was further assessed in 2014 (Table 5).

Table 5. Details of 2013-2014 lupin demonstration

Varieties	'Gallery' cultivars 'Blue', 'Pink', 'Red' and 'White' 'Russell' cultivars 'Band of Nobles', 'Chandelier', 'Noble Maiden', 'My Castle', 'The Chantelaine', 'The Governor' and 'The Pages'
Format(s) and supplier(s)	Seed (EconSeeds and Ball Colegrave)
Propagation and pre-planting treatment(s)	Sown week 20, 2013 in '104' module trays
Planting or sowing	Transplanted
Planting or sowing date(s)	Week 26, 2013
Planting site(s)	2m-long plots in beds outside and in 'Pro-Tech' tunnel bay 1
Layout	Un-replicated demonstration plots
Plant spacing(s)	10 plants /m ²
Post-planting treatment(s)	Left down to over-winter 2013-2014
Pests, diseases and disorders	Lupin aphid (<i>Macrosiphum albifrons</i>) (see Figure 6)
Picking stage(s) and market specification(s)	One flower fully open (a tentative picking stage)
Picking and recording date(s)	Observations only
Records taken	Observations only
VL testing	No

Many plants failed to survive the winter, resulting in gappy plots. Nevertheless, Figure 5 shows the high quality and great range of colours amongst the cultivars of both series. The results confirmed the stems of 'Russell' lupins were taller than those of the 'Gallery' series, though the latter were still adequate. Outdoor plants were again shorter than those grown under protection. Because of their untidy appearance the plots were grubbed-up at the end of the main flowering season.



Figure 5. Tunnel-grown, 2013-planted 'Russell' and 'Gallery' lupins in demonstration plots on 16 May 2014, week 20



Figure 6. Lupin aphid can rapidly infest all aerial parts (taken on demonstration plots on 16 May 2014, week 20)

Trachelium (*Trachelium caeruleum*)

Trachelium is not well known in the UK, although it is widely grown in the Netherlands and has been trialled and grown in the USA. Seed is supplied by several of the well-know seed houses and several series are available, including the 'Lake Collection' (from Kieft Seeds) which is marketed as a cut-flower trachelium. It seemed well worth testing.

In 2013 seeds of a selection of cultivars were sown into plugs but all failed to germinate. Some reports state that germination is sometimes poor, though no unusual germination requirements were indicated in seed catalogues. However, discussions with other growers and propagators in the UK and Holland revealed that germination seemed to have been an industry-wide issue in 2013. Subsequently, plug-plants of cultivar 'Corine Purple' (Combinations Young Plants) were obtained and transplanted in week 23 at 64/m² to a 2m-long plot in 'Pro-Tech' tunnel bay 1. The plants grew well and produced an attractive display starting in late-August. With its colour and form trachelium may have potential for UK production, so the trial was repeated in 2014 using plug-plants (Table 6).

Table 6. Details of 2014 trachelium demonstration

Varieties	'Corine Purple' 'Lake Michigan' series 'White', 'Blue' and 'Purple'
Format(s) and supplier(s)	Plug-plants 'Corine Purple': Combinations/Noordam 'Lake Michigan' series: Florensis
Propagation and pre-planting treatment(s)	None
Planting or sowing	Transplanted
Planting or sowing date(s)	Week 22 (all cultivars) Week 27 ('Lake Michigan Purple' only)
Planting site(s)	3m-long plots in beds in 'Pro-Tech' tunnel bay 2 (4.5m-long for week 27)
Layout	Un-replicated demonstration plots
Plant spacing(s)	64/m ²
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	No problems evident
Picking stage(s) and market specification(s)	Florets just starting to open, stem length 55cm and minimum head diameter of 8cm
Picking and recording date(s)	First planting: weeks 32-34 Second planting ('Lake Michigan Purple'): week 42
Records taken	Total number of marketable stems Stem length before trimming (sample of 22 lead stems per plot) Stem weight after trimming to 55cm (sample of 22 lead stems per plot)
VL testing	Sampled week 32 (not 'Lake Michigan Purple')



Figure 7. Tracheliums in 2014 demonstration plots on 26 July, week 30: left, week 22 planting, from front to back, ‘Lake Michigan White’, Lake Michigan Blue’, ‘Lake Michigan Purple’ and ‘Corinne Purple’; right, week 27 planting of ‘Lake Michigan Purple’

In 2014 the initial growth appeared weak and budding-up occurred early. However, the stems lengthened and strengthened as the plants matured (Figure 7). Each plant produced at least one heavy lead stem and a number of marketable side-shoots. The colours were impressive (Figure 8). The total yield of marketable stems ranged from 86/m² for ‘Corinne Purple’ to 158/m² for ‘Lake Michigan Blue’ (**Figure 9**). For the lead stems, average lengths varied between 57 and 66cm and average weights for stems trimmed to 55cm from 23g (‘Lake Michigan White’) to 32g (‘Corinne Purple’) (**Figure 9**). The late, week 27 planting of ‘Lake Michigan Purple’ produced short stems, so this was a planting date too late to achieve natural season flowering (Figure 10).

Stems of ‘Corinne Purple’, ‘Lake Michigan Blue’ and ‘Lake Michigan White’ were sampled for VL testing. They had an average VL of 8 or 9d, thereby exceeding the usual number of ‘guaranteed’ days. By vase-day 9 or 10, however, the foliage was dehydrated.

Because of better-than-average summer weather in 2014, with good light levels and warm temperatures in June and July, these results may have been atypical, so the demonstration ought to be repeated in a further year before definite conclusions are drawn.



Figure 8. Tracheliums in 2014 demonstration plots (week 22 planting) on 7 August, week 32: top four clockwise from top-left: 'Lake Michigan White', Lake Michigan Blue', 'Corinne Purple' and 'Lake Michigan Purple'; bottom two: other views of the 'Lake Michigan' series

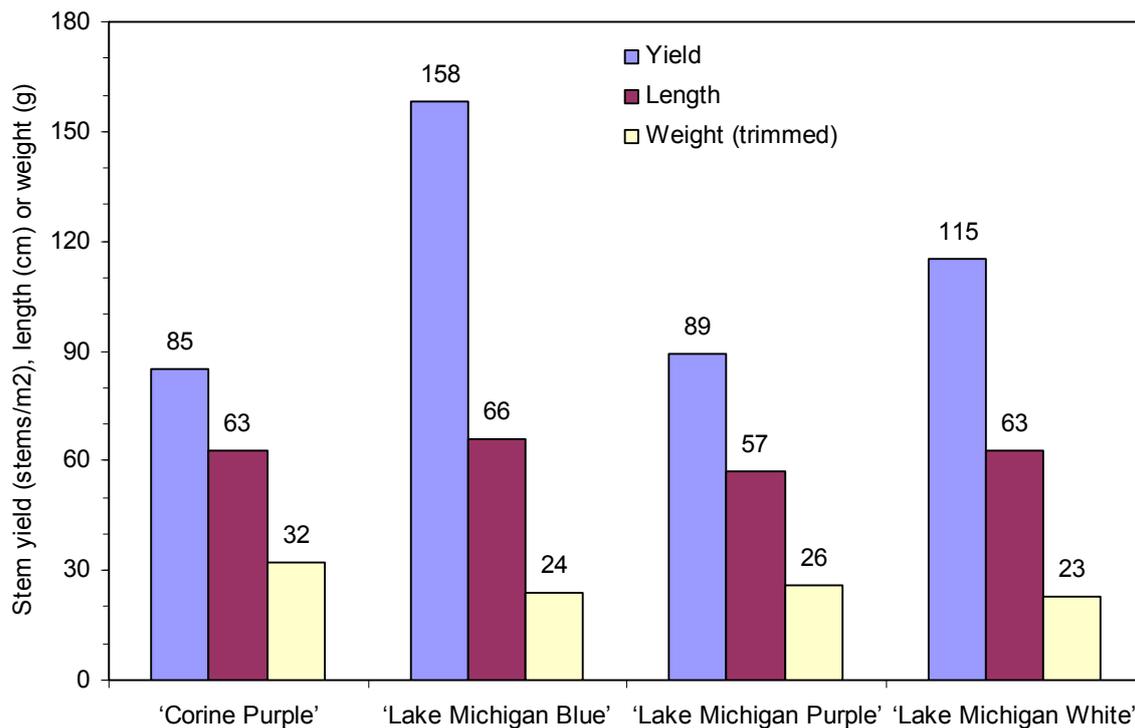


Figure 9. Stem yield, stem length and trimmed stem weight for four cultivars of trachelium planted week 22 in demonstration plots in 2014



Figure 10. Late-planted (week 27) 'Lake Michigan Purple' (17 October 2014, week 42)

Zinnia (*Zinnia elegans*)

Unlike the other species in this new crops section, zinnias have been grown previously at the Centre, in 2007 and 2008, when the industry was enthusiastic about their wide range of cheerful, vibrant colours. However, after picking, the hollow stems collapse and bend just below the flower-head, making them unusable. Trials with zinnia were put on hold until varieties with improved stem strength became available. Meanwhile, a different conclusion had been reached in trials in the USA. For example, in the Santa Rosa Specialty Cut Flower Trials zinnia were rated “the most dependable flower in the trial [with] continuous flowering on 18” [45cm] stems”, whilst admitting that “cultivar selection [was] critical.” In the 2010 ASCFG trials zinnias ‘Queen Red Lime’ and ‘Benary’s Giant Lime’ (from Benary) created most discussion with their colours, and ‘Benary’s Giant Lime’ made the ‘top-five’ in that year’s trials. It seemed appropriate to revive the Centre’s trials on zinnia.

In 2013, seed of seven varieties of the ‘Oklahoma’ series and of thirteen varieties of the ‘Benary’s Giant’ series (Benary) were germinated in plug and transplanted in weeks 22-23 to plots in tunnel and outside beds. Shortly after planting, when the plants were only a few inches high, premature buds became visible on all plants. Apparently this is a common occurrence (John Dole, personal communication), so they were pinched and then grew away vigorously. Some stems were ready for picking by mid-July, and some interesting flower colours and forms were evident. ‘Benary’s Giant’ varieties were stronger and attracted more interest than the ‘Oklahoma’ series, but nevertheless the latter were considered far superior to the cultivars previously grown at the Centre. Comparing plants grown under protection and outside, the tunnel crop was much more vigorous, with more and longer stems. Throughout summer samples were taken for standard VL testing, but flower quality was unacceptable with a maximum of 7d in the vase, despite tests with flower conditioners and foods. Bending of the neck had previously occurred soon after transfer to the vase, but in the 2013 tests it was apparent only once the flowers were almost dead. This was a promising indication of potential commercial use, and it was suggested that they might benefit from earlier picking and treatment with flower food immediately after picking (using a hydrating solution had been ineffective in retaining quality). Hence in 2014 a selection of cultivars was grown specifically to provide material for VL testing (Table 7).

Table 7. Details of 2014 zinnia demonstration

Varieties	‘Benary Giant’ series ‘Coral’, ‘Wine’, ‘Purple’, ‘Deep Red’, ‘Golden Yellow’, ‘Scarlet’, ‘Salmon Rose’, ‘White’, ‘Lime’, ‘Orange’, ‘Bright Pink’ and ‘Lilac’ ‘Oklahoma’ series ‘Pink’, ‘White’,
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	'Salmon', 'Scarlet', 'Ivory' and 'Carmine'
Format(s) and supplier(s)	Seed (Benary)
Propagation and pre-planting treatment(s)	Sown week 13 (first batch) and 17 (second batch) in '104' module trays
Planting or sowing	Transplanted
Planting or sowing date(s)	Week 18 (first batch) and 22 (second batch)
Planting site(s)	2m-long (first batch) or 1m-long (second batch) plots in beds in 'Pro-Tech' tunnel bay 2
Layout	Un-replicated demonstration plots
Plant spacing(s)	64/m ²
Post-planting treatment(s)	As in the 2013 planting premature budding occurred at an early stage. In 2014 they were not pinched and grew away just as vigorously as the pinched plants of 2013. One layer of support netting Cutting-back and spraying for bacterial blight (see below)
Pests, diseases and disorders	Some rabbit damage on second batch of transplants only <i>Xanthomonas campestris</i> bacterial blight symptoms appeared week 25; plants cut back to about 1.5m-high in week 29 and sprayed with azoxystrobin (as 'Amistar') which brought the infection under control. Some further infection towards the end of the season
Picking stage(s) and market specification(s)	Not yet defined. A range of picking stages was used in 2014 and the issue will be pursued by Chrysal in 2015
Picking and recording date(s)	Picking from week 26 to week 43
Records taken	Observations only
VL testing	Samples taken throughout summer



Figure 11. 'Benary Giant' and 'Oklahoma' zinnia cultivars in 2014 demonstration plots (7 August 2014, week 32)

Apart from some initial damage from rabbits, establishment was good. Buds were visible within three or four weeks of transplanting, though stems were too short at that stage. Plant

growth was prolific (Figure 11) until bacterial blight (*Xanthomonas campestris*) appeared (Figure 12). Its symptoms are varied and include scorch-like damage, angular black to reddish-brown lesions on the leaf, and necrosis of the stem or flower bud. After treatment, however, the crop grew away vigorously and continued producing flowers in abundance until well into October (Figure 13).

The crop provided plenty of stems for VL testing. However, post-harvest quality was unsatisfactory, with stems failing to last to the end of the 4d retail store phase. This seems to have been due to adverse effects of the cool chain resulting in early dehydration of the flowers. Consultants from Chrysal have suggested there may be treatments that could avoid such damage, and so VL will be examined further in 2015.



Figure 12. Examples of bacterial blight symptoms in zinnia demonstration plots in 2014: top, on 10 July 2014 (week 28); bottom, on 17 July 2014 (week 29)

Since industry's enthusiasm for zinnias remains, further VL work is desirable, using just the taller 'Benary's Giant' series. There are needs to mitigate the effects of the cool-chain and investigate the use of growth regulators to strengthen the neck. Further work on *Xanthomonas* may also be needed. Despite this, with current knowledge zinnia appears to be a very good candidate for ambient direct sales such as mail-order work.



Figure 13. Zinnia demonstration plots at the end of the season (17 October 2014, week 42)

Crop introduction started 2014

Further new crops were selected for testing starting in 2014: bleeding heart, ornamental pepper, physostegia and a range of seed-raised fillers. Some new lines of old favourites were also made available for demonstration: spray carnation 'Tiara' series, delphinium 'Waltz' and 'Tango' series, gypsophila 'Zinzi' series and leucanthemum 'Real' series.

Bleeding heart (*Dicentra spectabilis*) is a perennial with an unusual flower form that may have potential as an outdoor-raised cut-flower. It rated well in the ASCFG trials in the USA. In 2014 seeds were obtained but failed to germinate under our conditions. Further work was deferred until the germination issue can be resolved, and it could also mean switching to plug-plants or bare-root divisions.

Trials of the remaining species went to plan and are described below.

Delphinium ‘Waltz’ and ‘Tango’ series (*Delphinium elatum* cultivars)

Delphinium cultivars have previously been trialled quite extensively at the Centre, but growers and others continue to debate whether more of their potential might be realised. ‘Sea Waltz’, ‘Sky Waltz’ and ‘Tango Dark Blue’ are examples of the new ‘Waltz’ and ‘Tango’ series from HilverdaKooij and they were deemed worthy of including in the programme. These are tissue-cultured cultivars that produce interesting flower spikes that had been included following a suggestion from a grower. The trial is described in Table 8.

Table 8. Details of 2014 delphinium new cultivars demonstration

Varieties	‘Sea Waltz’, ‘Sky Waltz’ and ‘Tango Dark Blue’
Format(s) and supplier(s)	Plugs ex tissue culture (HilverdaKooij)
Propagation and pre-planting treatment(s)	None
Planting or sowing	Transplanted
Planting or sowing date(s)	Week 22
Planting site(s)	2m-long plots in beds in ‘Pro-Tech’ tunnel bay 1
Layout	Duplicate demonstration plots
Plant spacing(s)	9/m ²
Post-planting treatment(s)	One layer of support netting Cut back after first and second flushes
Pests, diseases and disorders	Susceptible to powdery mildew, but this was successfully controlled in 2014 through the spray programme.
Picking stage(s) and market specification(s)	Not yet defined
Picking and recording date(s)	Observations only
Records taken	Observations only
VL testing	No

These cultivars produced attractive flowers and were very productive (Figure 14), potentially giving three flushes in a year (Figure 15). A second flush had ended by late-July, and, following cutting-back, a further flush was developing before the plants were flattened by gales in late-October. They are being grown-on to a second year to assess their full potential.



Figure 14. New cultivars of delphinium in the demonstration: top, from left to right: 'Sky Waltz' (on 7 August 2014, week 32), (in mid-ground) 'Tango Dark Blue' and 'Sea Waltz' (on 27 July 2014, week 31), with close-ups below (taken on 7 August 2014, week 32)



Figure 15. Delphinium cultivars after cutting-back (11 September 2014, week 37) and giving third flush (17 October 2014, week 42)

Gypsophila Zinzi series (*Gypsophila paniculata* cultivars)

'Zinzi Discovery' and 'Zinzi Tyree' are brand new cultivars from HilverdaKooij that were considered worthy of demonstration plots at the Centre. It is claimed that the Zinzi series is superior to other gypsophila on the market in terms of stem and flower quality. The trial (Table 9) will allow the industry to make its own independent assessment.

Table 9. Details of 2014 gypsophila new cultivars demonstration

Varieties	'Zinzi Discovery' and 'Zinzi Tyree'
Format(s) and supplier(s)	Plug-plants (HilverdaKooij)
Propagation and pre-planting treatment(s)	None
Planting or sowing	Transplanted
Planting or sowing date(s)	Week 27
Planting site(s)	1m-long plots in beds in 'Pro-Tech' tunnel bay 1 and outside
Layout	Un-replicated demonstration plots
Plant spacing(s)	9 plants /m ²
Post-planting treatment(s)	One layer of support netting Cut-back end of October
Pests, diseases and disorders	No specific problems
Picking stage(s) and market specification(s)	Not yet defined
Picking and recording date(s)	Sparse crop, left down to 2015 for recording
Records taken	Observations only
VL testing	No

Typical plants are shown in Figure 16. Following very late planting they produced a poor flower crop, so they are being grown-on to 2015.



Figure 16. Gypsophila 'Zinzi Tyree' (at front) and 'Zinzi Discovery' (at back) in demonstration plots (7 October 2014, week 41)

Leucanthemum (*Leucanthemum* × *superbum* cultivars)

This crop has not been previously tried at the Centre but was included to demonstrate a new range of cut-flower leucanthemum from Realflo. Details of the demonstration are given in Table 10.

Table 10. Details of 2014 leucanthemum demonstration

Varieties	'Real Fancy', 'Real Fizzy' and 'Real Frilly'
Format(s) and supplier(s)	Pinched 9cm liners (Realflo)
Propagation and pre-planting treatment(s)	None
Planting or sowing	Transplanted
Planting or sowing date(s)	Week 17
Planting site(s)	1.1m-long plots in beds in 'Pro-Tech' tunnel bay 1
Layout	Un-replicated demonstration plots
Plant spacing(s)	16/m ²
Post-planting treatment(s)	None
Pests, diseases and disorders	None evident
Picking stage(s) and market specification(s)	Buds showing colour Stem length 60cm
Picking and recording date(s)	'Real Frilly' week 25 'Real Fancy' and 'Real Fizzy' week 28
Records taken	Picking dates
VL testing	No



Figure 17. Leucanthemum cultivars in the tunnel, front to back: 'Real Fancy' (in bud), 'Real Frilly' (in flower) and 'Real Fizzy' in bud (23 June 2014, week 26)

The plants as supplied had been well pinched with many breaks, and grew away well. However, 'Real Frilly' started to bud prematurely (week 22) and then flowered on short

stems (Figure 17). The three cultivars in flower are shown in Figure 18. A second year's growth is required to see their full potential - including VL - and their economic viability.



Figure 18. Leucanthemum cultivars (left to right) 'Real Fancy' (7 August 2014, week 32), Real Frilly' (17 July 2014, week 29) and 'Real Fizzy' (26 July 2014, week 30)

Ornamental pepper (*Capsicum annuum* cultivars)

Ornamental peppers proved successful novelties in the ASCFG trials in the USA, and two cultivars were included in a demonstration at the Centre (Table 11).

Table 11. Details of 2014 ornamental pepper demonstration

Varieties	'Black Pearl' and 'Masquerade'
Format(s) and supplier(s)	Seed (from Ball Colgrave)
Propagation and pre-planting treatment(s)	Sown week 20 in '104' module trays
Planting or sowing	Transplanted
Planting or sowing date(s)	Weeks 25 and 27
Planting site(s)	3m-long plots (first planting) and 1.5m-long plots (second planting) in beds in 'Pro-Tech' tunnel bay 2
Layout	Un-replicated demonstration plots
Plant spacing(s)	25/m ²
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	No specific problems
Picking stage(s) and market specification(s)	One flower fully open (a tentative picking stage)
Picking and recording date(s)	Fruits visible by week 36 but not ready by week 43 (when tunnel de-skinned)
Records taken	Observations only
VL testing	No

The ornamental peppers were slow-growing but eventually produced large, strong plants (Figure 19). Some fruits were visible on both cultivars by week 36 but thereafter remained more or less static without growing or ripening until the tunnel was de-skinned in week 43.



Figure 19. Ornamental peppers 'Masquerade' (top left) and 'Black Pearl' (top right) on 7 August 2014, with the same cultivars on 11 September 2014 (week 37) (bottom left) and close-up of flowers and young fruits on right

Physostegia (*Physostegia virginianum* cultivars)

Physostegia was shown to be a potentially useful cut-flower in the ASCFG trials. A small number of cultivars is available, and one, 'Crystal', was included in an initial demonstration at the Centre (Table 12).

Table 12. Details of 2014 physostegia demonstration

Varieties	'Crystal'
Format(s) and supplier(s)	Seed (from Ball Colgrave)
Propagation and pre-planting treatment(s)	Sown week 20 in '104' module trays
Planting or sowing	Transplanted
Planting or sowing date(s)	Week 26
Planting site(s)	3m-long plots in beds in 'Pro-Tech' tunnel bay 2
Layout	Un-replicated demonstration plots
Plant spacing(s)	25 plants /m ²
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	No problems evident
Picking stage(s) and market specification(s)	Six flowers fully open (a tentative picking stage)
Picking and recording date(s)	Observations only
Records taken	Observations only
VL testing	Sampled week 36



Figure 20. Physostegia 'Crystal' in flower (11 September 2014, week 37)

In the demonstration physostegia 'Crystal' was rather short and late (Figure 20) and needs to be grown-on to a second year to assess its potential fully. However, in VL testing the stems failed on day 2 in the vase, so they may be unsuitable for further trialling.

Carthamus (*Carthamus tinctorius* and cultivars)

Carthamus attracts attention as an unusual, thistle-like filler, and some cultivars were tested in 2014 (Table 13).

Table 13. Details of 2014 carthamus demonstration

Varieties	<i>Carthamus tinctorius</i> 'Kinko', 'Nemo' and 'Shiro'
Format(s) and supplier(s)	Seed (Moles Seed)
Propagation and pre-planting treatment(s)	None
Planting or sowing	Seed direct-drilled by hand in three rows along the bed
Planting or sowing date(s)	Seed: outside beds week 25 and tunnel weeks 27 and 30
Planting site(s)	3m-long plots
Layout	Un-replicated demonstration plots
Plant spacing(s)	Seedlings thinned to 5-6cm apart
Post-planting treatment(s)	None
Pests, diseases and disorders	Brown-tipping of bracts Leaf mottling Caterpillar damage
Picking stage(s) and market specification(s)	Centre bud open and two side buds showing colour
Picking and recording date(s)	Weeks 35-36 and 37 from week 25 and 27 sowings, respectively; plants from week 30 sowing were not ready by week 43 (when the tunnel was de-skinned)
Records taken	Picking dates
VL testing	Sampled week 35 and 36

Carthamus tinctorius 'Kinko', 'Nemo' and 'Shiro' showed good germination but once budded-up - starting week 30 in outside plots - they were slow to develop. Examples from the tunnel are shown in Figure 21 and from outside plots in Figure 22. Picking dates were concentrated compared with the extended range of sowing dates. 'Kinko' and 'Nemo', very similar orange-flowered cultivars, grew well. 'Shiro', cream-flowered, also grew well but as a cut-flower senesced quickly and may not be attractive to customers. Brown-tipping of the bracts occurred both outside and under protection.

Stems of the three cultivars were sampled for VL testing and showed a consistent average VL of 7d, thereby just attaining the usual number of 'guaranteed' days. All flowers opened satisfactorily, the stems using a relatively large amount of water, but some brown-tipping was evident throughout the test and was considered commercially unacceptable by vase-day 7.



Figure 21. Tunnel-grown carthamus in demonstration plots: top-left, 'Nemo'; top-middle, 'Kinko' and top-right, 'Shiro' (20 October 2014, week 43); bottom, 'Kinko' flower-heads (11 September 2014, week 37, from earlier sowing)



Figure 22. Outdoor carthamus 'Nemo' (front), 'Shiro' (middle) and 'Kinko' (back) on 1 September 2014 (week 36) (left) and 11 September 2014 (week 37) (right)

Seed-raised fillers (Ammi visnaga, Anethum graveolens, Anthriscus sylvestris, Bupleurum rotundiflorum, Euphorbia oblongata and Ridolfia segetum and their cultivars)

There has been an increase in grower interest in growing cheap, seed-raised fillers in tunnels or outside, and a range of them was demonstrated in 2014 (Table 14).

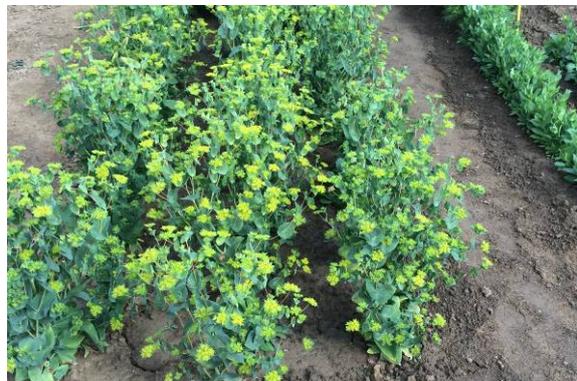
Table 14. Details of 2014 seed-raised fillers demonstration

Varieties	Ammi visnaga Anethum graveolens (dill) Anthriscus sylvestris 'Ravenswing' Bupleurum rotundiflorum 'Griffithii' Euphorbia oblongata Ridolfia segetum
Format(s) and supplier(s)	Seed (Moles Seed) Plug-plants of anthriscus (Rookery Farm), used as replacements for non-germinating seed
Propagation and pre-planting treatment(s)	None
Planting or sowing	All species: seed direct-drilled by hand in three rows along the bed
Planting or sowing date(s)	Seed: outside beds weeks 21 and 25 and tunnel weeks 27 and 30 Anthriscus plugs: transplanted to outside and tunnel week 25
Planting site(s)	3m-long plots
Layout	Un-replicated demonstration plots
Plant spacing(s)	Ammi, anethum, bupleurum, ridolfia: seedlings not thinned (spacing of ammi variable due to erratic germination) Euphorbia seedlings thinned to 5-6cm apart Anthriscus: seed did not germinate, plug-plants spaced at 64/m ²
Post-planting treatment(s)	None
Pests, diseases and disorders	Anthriscus: two-spotted spider mite (Figure 24) and powdery mildew were problems Bupleurum: Some caterpillar damage, also botrytis was seen where leaf scorch was evident (Figure 25) No other problems evident
Picking stage(s) and market specification(s)	Ammi: when the umbel is showing colour Anethum, anthriscus, ridolfia: suggest just before the florets are opening Bupleurum: when the flowers are showing colour Euphorbia: stems too short to pick
Picking and recording date(s)	Ammi: starting weeks 33, 38 and 42 from week 21, 25 and 27 sowings, respectively; plants from week 30 sowing

	were not ready by week 43 (when the tunnel was de-skinned) Anethum: starting weeks 29, 32, 34 and 39 from week 21, 25, 27 and 30 sowings Anthriscus (plug-plants): flowering sparse and plants too damaged by two-spotted spider mite for picking Bupleurum: starting weeks 31, 36 and 39 from week 21, 25 and 27 sowings, respectively; plants from week 30 sowing were not ready by week 43 (when the tunnel was de-skinned) Euphorbia: too short to pick, leave down to over-winter for 2015 Ridolfia: starting weeks 30, 35 and 36 from week 21, 25 and 27 sowings; plants from week 30 sowing were not ready by week 43 (when the tunnel was de-skinned)
Records taken	Picking dates
VL testing	Ammi: sampled week 34 Anethum: sampled week 29 Anthriscus: not sampled Bupleurum: sampled week 36 Euphorbia: not sampled Ridolfia: not sampled

Ammi visnaga was slow to germinate, germination was poor, and plant growth was slow (Figure 23). Possibly due to the poor germination and the consequent wide spacings, stems were too large and branching for use as a filler from this direct-drilled crop (it might be more suitable as a filler if drilled at a higher density). Stems were sampled for VL testing and had a VL of 5d, barely attaining the usual number of 'guaranteed' days. During testing the stems elongated by up to 20% in length. By day 5 the foliage was dehydrated; they had used a large amount of water. Maybe *A. visnaga* should be grown from plugs; alternatively the more robust species *A. majus* could be tested.

Anethum graveolens (dill) was quick to germinate and fast growing (Figure 23). The stems had an 11d VL, though there was substantial growth post-harvest. After the main stems were picked the plants produced several secondary stems. Stems were sampled for VL testing and had an average VL of 10d, thereby exceeding the usual number of 'guaranteed' days. During testing the stems elongated by up to 90% in length, and a large amount of vase-water was taken-up; by vase-day 10 the foliage was becoming dehydrated. Anethum is worth following up in 2015 to see if the stem stretching issue can be resolved.



Continued on next page

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Figure 23. Examples of seed-raised fillers in demonstration plots in 2014 in tunnel (left-hand side) or outside (right-hand side): from top to bottom ammi, anethum (dill), anthriscus, bupleurum, euphorbia (available outside only) and ridolfia

Anthriscus sylvestris ‘Ravenswing’ did not germinate following direct-drilling. Replacement plug-plants established quickly and grew very vigorously but produced only a handful of flowers (Figure 23). In the outside plots they were seriously damaged by two-spotted spider mite (Figure 24). The anthriscus are being left *in situ* to see how they perform in 2015.



Figure 24. Outside-grown anthriscus showing damage due to two-spotted spider mite (1 September 2014, week 36)

Bupleurum rotundiflorum ‘Griffithii’ was slow to germinate and grow, appeared to bud-up early but eventually produced long, strong stems (Figure 23). In the tunnel crop there was marked leaf scorch, thought to have been caused by growth being too soft following a period of high temperatures and light levels, subsequently allowing botrytis to colonise the

damaged tissue (Figure 25). There was renewed grower interest in bupleurum as it is easy to grow and pick, so further trials may be worthwhile, especially to investigate season extension. Regular production would require weekly sowings. Stems were sampled for VL testing and had a VL of 5d, barely attaining the usual number of 'guaranteed' days. By day 5 the umbel had started to discolour and by day 6 the foliage was dehydrated and browning, despite their having taken up a relatively large amount of water. Based on other experience such a short VL was unexpected, and it may have been due to picking at too mature a stage.



Figure 25. Tunnel-grown bupleurum with leaf scorch (26 September 2014, week 39)

Euphorbia oblongata was very slow to germinate and grow and produced stems that were too short for cutting - about 20cm long (Figure 23). Part of the crop is being transplanted to the perennial tunnel for observations in 2015. Possibly the latex could cause problems with workers and consumers.

Ridolfia segetum was similar to anethum but slower germinating and growing (Figure 23). After cutting the main stem, secondary stems were produced. Anethum could be a better option.

Ammi majus (or *Ammi visnaga*), *Anethum graveolens* and *Bupleurum rotundiflorum* appear to be the most promising of these fillers for further trialling. Bupleurum grew well and the chief need is to optimise the seedling rate. For ammi and anethum poor germination, slow growth and late flowering are key problems that would merit further study, and approaches could include earlier planting dates, starting the season in a tunnel and using plug-plants. *Anthriscus sylvestris*, *Euphorbia oblongata* and *Ridolfia segetum* appeared to be less suitable.

Spray carnation 'Tiara' series (*Dianthus caryophyllus* cultivars)

Spray carnation cultivars have previously been trialled extensively at the Centre. The 'Tiara' series is a new type of spray carnation from HilverdaKooij that has a unique flower form deemed worthy of testing (Table 15).

Table 15. Details of 2014 spray carnation 'Tiara' demonstration

Varieties	'Tiara' series 'Coral Pink' and 'Lilac'
Format(s) and supplier(s)	Rooted cuttings (HilverdaKooij)
Propagation and pre-planting treatment(s)	Cuttings potted into 9cm-diameter pots week 14 and pinched in the pot week 17
Planting or sowing	Transplanted
Planting or sowing date(s)	Week 22 (when well branched)
Planting site(s)	4m-long plots in beds in 'Pro-Tech' tunnel bay 1
Layout	Un-replicated demonstration plots
Plant spacing(s)	25 plants /m ²
Post-planting treatment(s)	One layer of support netting One bud per stem develops well before the remainder and needs to be removed to maintain a good appearance
Pests, diseases and disorders	Flowers very susceptible to thrips, causing white flecking in the flowers. Flowers of 'Lilac' faded very quickly
Picking stage(s) and market specification(s)	Once two or more buds are showing good colour
Picking and recording date(s)	Main picking dates week 36 for 'Coral Pink' and week 37 for 'Lilac'
Records taken	Observations only
VL testing	'Coral Pink' sampled for testing week 35

These plants were very susceptible to thrips damage, with white flecking appearing in the flowers. Once seen the spray interval between the application of thrips chemicals was reduced, and it would appear a prophylactic spray programme is needed. They were slow growing but threw some strong stems, of which the central bud develops first, well before the others, and consequently need to be pinched out to preserve the remaining spray, though this is hard to do as well as labour-intensive. They were attractive and appreciated by growers (Figure 26).

Stems of cultivar 'Coral Pink' were sampled for VL testing and had an average VL of 7d, just achieving the usual number of 'guaranteed' days. By vase-day 7 the flower-heads were starting to display some breakdown. Damage due to thrips also detracted from their appearance in the vase.

New colours will be available from HilverdaKooij in 2015, so the current plots have been left down for 2015 and will be augmented by further varieties. VL and thrips control will need to be optimised.



Figure 26. 'Tiara' series spray carnations in demonstration plots at the Centre: left, 'Lilac'; right, 'Coral Pink' (11 September 2014, week 37)

Crop improvement

Alstroemeria – garden cultivars (*Alstroemeria* cultivars)

Alstroemeria, more familiar as a glasshouse crop using contemporary, high-quality cultivars, has not been included in the Centre's trials previously. But the availability of Spanish tunnels raises the possibility of growing a cheap, seasonal crop, the more so if older cultivars - with no royalties attached - could be used. A feasibility trial was set up in 2014 (Table 16).

Table 16. Details of 2014 alstroemeria garden cultivars feasibility study

Varieties	'Apollo', 'Avanti', 'Bonanza', 'Candy', 'Dana', 'Flaming Star', 'Friendship', 'Golden Delight', 'Nina', 'Orange Supreme', 'Pink Sensation' and 'Tanya'
Format(s) and supplier(s)	7 and 9cm plug-plants (Parigo)
Propagation and pre-planting treatment(s)	None
Planting or sowing	Transplanted
Planting or sowing date(s)	Week 22 (tunnel) or 23 (outside)
Planting site(s)	2m-long plots in beds in 'Pro-Tech' tunnel bay 1 1m-long plots in beds outside
Layout	Un-replicated demonstration plots
Plant spacing(s)	5/m ²
Post-planting treatment(s)	One layer of support netting (but found two or three layers needed) Removed flower-heads until stems started to make the specification of 60cm-length
Pests, diseases and disorders	None evident
Picking stage(s) and market specification(s)	Buds just starting to show colour Stem length of 60cm
Picking and recording date(s)	Ongoing from week 30 to week 44 (in tunnel) or week 45 (outside)
Records taken	Picked to a minimum specification of 60cm, recording picking dates and number of stems picked each date
VL testing	Sampled for testing week 29

Plant establishment was very good. The first stems produced were short, so these were cut and discarded until marketable flowers were produced about week 30 in the tunnel and (in small numbers) week 33 outside (Figure 27). Under protection the plants were very vigorous - they produced good, strong stems that some growers thought were better than glasshouse crops - but outside very much less so (Figure 28). In the tunnel picking peaked at the end of the season (weeks 41 to 44); in outdoor plots picking was slower to begin, peaked in weeks 40 to 43, and continued to week 45 (**Error! Reference source not**

found.c). No obvious varietal effects were seen in the profile of picking (**Error! Reference source not found.a** and b).

Stems of eight cultivars were sampled for VL testing. They had a consistent average VL of 12d, thereby greatly exceeding the usual number of 'guaranteed' days. By vase-day 13 the petals were dropping and the foliage was senescing.



Figure 27. Alstroemeria garden cultivars trial, tunnel-grown plots: left, short stems at the start of the season (20 July 2014, week 30); right, later stems (26 July 2014, week 30)



Figure 28. Alstroemeria garden cultivars trial: left and middle, tunnel-grown plots; right, outside plots (all on 7 August 2014, week 32)

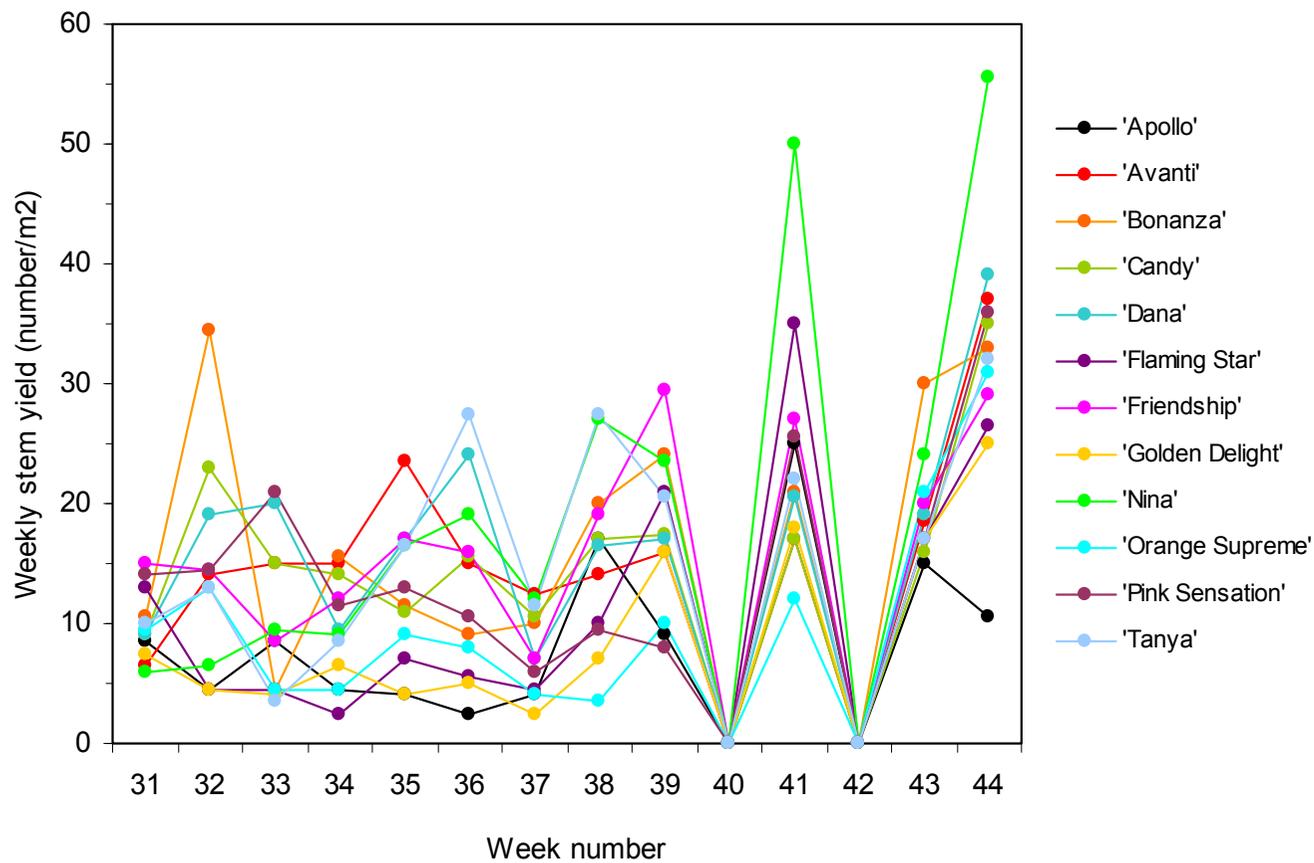


Figure 29 (a). Weekly stem yields of alstroemeria cultivars grown in a tunnel in the 2014 variety trial (weeks with zero flowers recorded were due to picking being deferred in weeks when flowers were sparse)

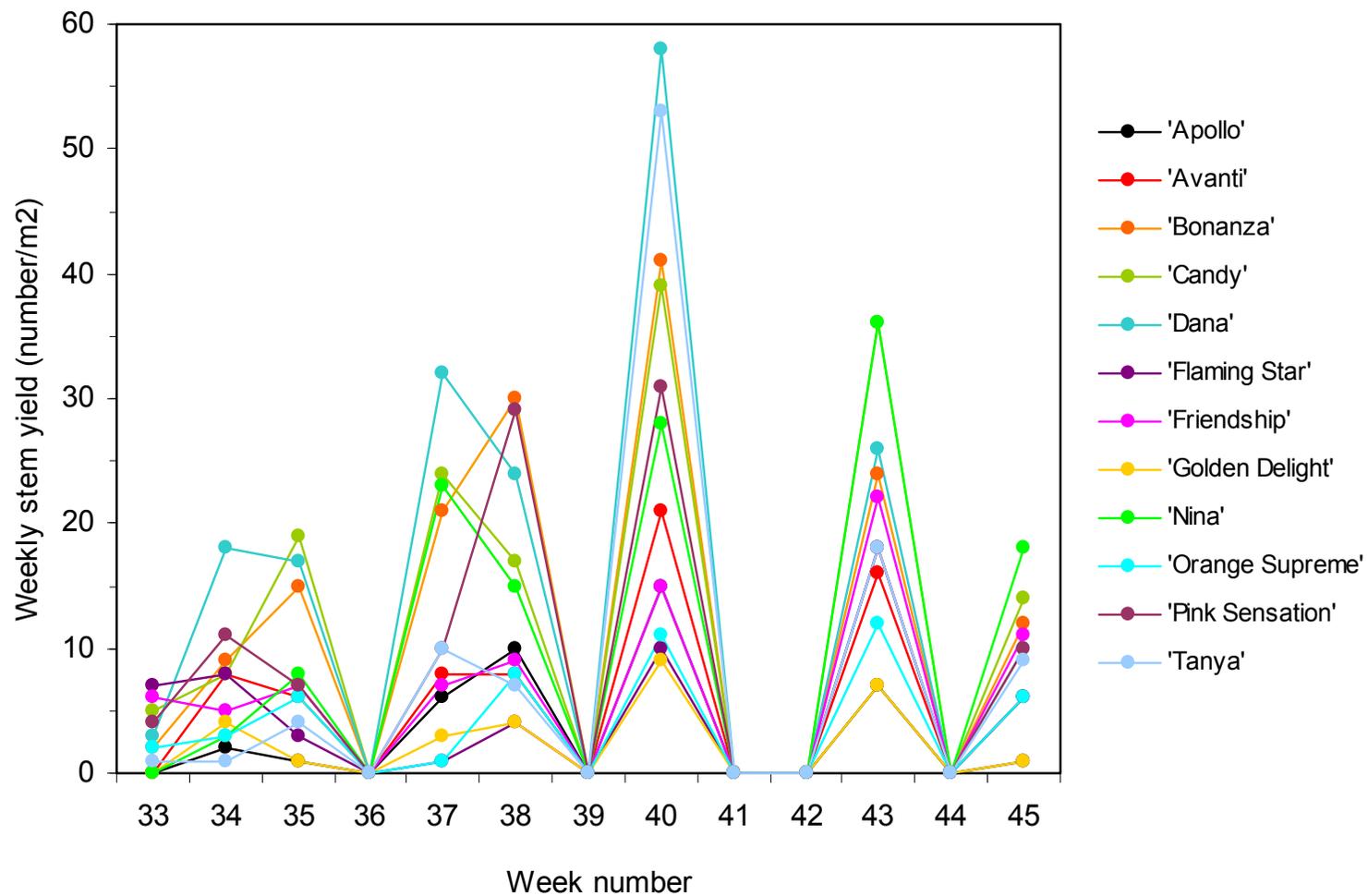


Figure 30 (b). Weekly stem yields of alstroemeria cultivars grown outside in the 2014 variety trial (weeks with zero flowers recorded were due to picking being deferred in weeks when flowers were sparse)

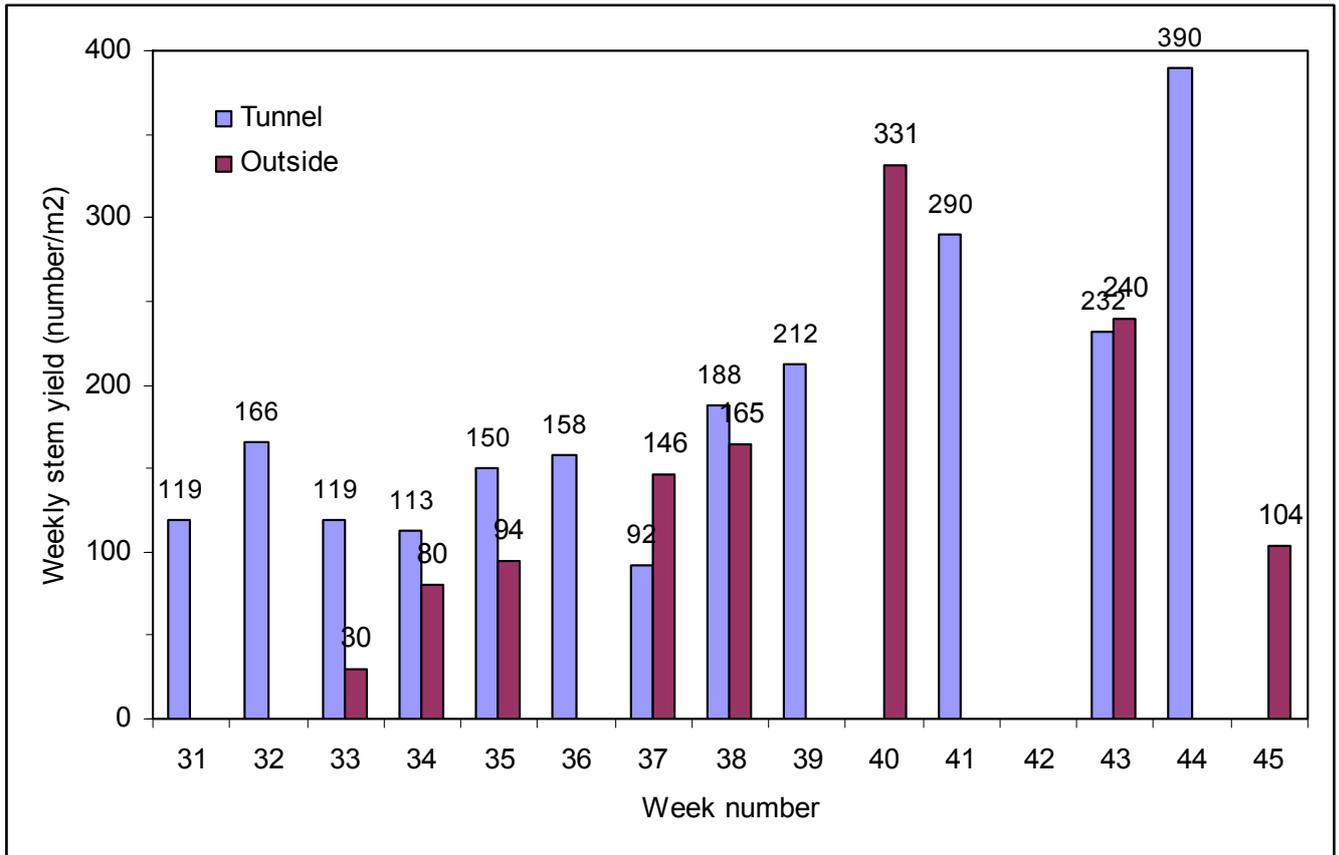


Figure 31 (c). Total weekly stem yields across all 12 cultivars of alstroemeria grown in a tunnel and outside in the 2014 variety trial (weeks with zero flowers recorded were due to picking being deferred in weeks when flowers were sparse)

Aster, September-flowering (*Aster ericoides*)

Aster ericoides is currently imported as a relatively cheap filler, mainly using the single-flowered 'Monte Casino' types. However, the introduction of new, double-flowering breeding lines could potentially open up a new market - possibly with straight lines. Because of PBR the high cost of planting material would mean production costs would have to be kept low.

Previous trials at the Centre (in 2010, 2011 and 2012) generated market interest in these double cultivars as a pinched crop for flowering in tunnels during September and October. Growers also expressed an interest in season extension. *A. ericoides* is a short-day plant, so in long days floral initiation can be brought forward by blacking-out the crop for part of the day. The plots set up in 2012 were left to over-winter *in situ* in 'Pro-Tech' tunnel bay 3 and outside, and the tunnel-grown plants were used in 2013 to investigate the use of blackout covers for manipulating the flowering period. The cultivars were 'Blue Tail', 'Capetown', 'Cassandra', 'Cassy', 'Chicago', 'Cirina Dark', 'Double Fun Blue', 'Double Fun Pink Dark', 'Double Fun White', 'Linda' and 'Pretty Wendy'. Blackout covers were placed over the tunnel-grown plots from week 22 (when stems were about 60cm tall) and left in place overnight for 13 hours per day. By week 31 this short-day regime had produced large buds nearly showing colour, so blacking-out was discontinued. Flowering occurred mainly in weeks 32-33, later than expected, and on stems taller than required - probably because of the slow start of growth following a late spring - but nevertheless the quality was superb. A second flush produced in early-November was too short to be marketable. To achieve a better timing the blackout should have been started before stems had reached 60cm. The outdoor crops produced a single flush in September-October.

In 2014 a further experiment was carried out, with the blackout applied at an earlier stage of growth than in the previous year, when stems were 50cm tall (week 25) (Table 17).

Table 17. Details of 2014 aster (*A. ericoides*) season extension trial

Varieties	'Cairo', 'Cape Town', 'Cassy' and 'Chicago'
Format(s) and supplier(s)	Un-rooted cuttings (Armada)
Propagation and pre-planting treatment(s)	Rooted in 104 plugs (week 11) Potted to 1L-pots (week 14) Pinched (in the pot) (week 16)
Planting or sowing	Transplanted
Planting or sowing date(s)	Week 18
Planting site(s)	4.5m-long plots in beds in 'Pro-Tech' tunnel bay 1
Layout	Un-replicated demonstration plots
Plant spacing(s)	15/m ²
Post-planting treatment(s)	One layer of support netting Blackout cover overnight weeks 25 to 30 After picking cut-back to about 2cm above ground and fed and watered well
Pests, diseases and disorders	None evident except for some caterpillar damage
Picking stage(s) and market specification(s)	Buds just starting to show colour Stem length of 70cm
Picking and recording date(s)	Week 32, except 'Cassy' (week 33)
Records taken	Picking dates Number of marketable stems
VL testing	Sampled week 32

By the time of transplanting the plants were already breaking. Plant establishment was good in 'Cairo' and 'Cassy', with buds starting to develop in week 30 when the blackout was removed and resulting in high quality stems with no premature budding and high yields (

Table 18 and Figure 32). However, in 'Cape Town' and 'Chicago' bud development had occurred about a month earlier, with much premature budding and consequent poor quality and yield. The second flush grew-away well in all cultivars and would have made a marketable crop had it been in a glasshouse instead of a tunnel that had to be de-skinned because of an impending storm. For comparison the asters from the 2012 planting that had been left *in situ* in outdoor beds to flower under natural-season conditions, are shown in Figure 33.

Table 18. Stem and bunch yields for the first flush of flowering in over-wintered, tunnel-grown, blackout-treated *A. ericoides* cultivars in 2014

Cultivar	Yield per plot		Yield/m ²	
	Stems	Bunches ¹	Stems	Bunches ¹
'Cairo'	240	51	53	11
'Cape Town'	169	35	38	8
'Cassy'	395	58	88	13
'Chicago'	186	25	41	6

¹ Number of full sleeves (hence the number of stems per bunch varies)

Stems of the four cultivars from the blackout trial were sampled for VL testing. They had an average VL of 8-9d, thereby exceeding the usual number of 'guaranteed' days. These were large bunches taking-up a large volume of water that needed to be replenished half-way through the test. By vase-day 8 or 9 the undersides of the flower-heads were showing slight dehydration, though the condition of the foliage remained good.

There is probably a limit as to how much further the Centre can take these trials. However, a commercial grower of the crop has requested that the 2014 planting be left *in situ* for another year to see how early a blacked-out crop can be produced in 2015.





Figure 32. *Aster ericoides* blackout trial 2014: top-left, blackout in place (1 July 2014, week 27); top-right, plants during the blackout period (27 June 2014, week 26); bottom pictures, examples from the blackout treatments flowering, left 'Cape Town', right 'Cairo' (7 August 2014, week 32)



Figure 33. *Aster ericoides* planted in 2012 and flowering in 2014 in the natural season (17 October 2014, week 42)

Eryngium (*Eryngium* cultivars)

Responding to grower requests, small demonstration plots of eryngium cultivars were grown at the Centre in 2007 and 2008. In 2011 a small selection of new cultivars - 'Arabian Dawn', 'Blue Bell', 'Deep Blue', 'Magical Blue Falls', 'Magical Cloud', 'Magical Purple Falls' and 'Marbella' - were planted at 12/m² in ca 3m-long plots in a Spanish tunnel and outside to assess their potential as a crop for the UK. Few flowers were produced in 2011 and the plants were grown-on for assessment in 2012. Some marketable stems were produced in this second year, having a 7-day VL in standard testing (see below for later VL testing). But owing to plant losses as result of the cold weather in winter 2011-2012 and the wet summer and autumn of 2012, these yields were not considered meaningful and the plants were grown-on to 2013.

In 2013 plants in the tunnel became over-vigorous and were grubbed-up, while many of the outside planting did not survive the severe winter of 2012-2013, the survivors producing variable numbers of stems. From these results the outstanding cultivars were 'Blue Bell' and 'Deep Blue', which appeared to be almost fully hardy (for the remaining five cultivars plant survival varied between 43 and 69%). Scaling-up these yields to the equivalent of 100% plant survival, 'Deep Blue' produced 113 and 'Blue Bell' 56 stems per m², while the other cultivars produced between 28 ('Marbella') and 88 ('Magical Purple Falls') stems per m². The plots were grown-on for further observations in 2014.

In 2013 necrotic, black spots appeared on, and devastated, the foliage of 'Arabian Dawn' and 'Marbella'. The lesions were identified as due to *Alternaria*, subsequently confirmed by the Stockbridge Technology Centre (STC) Plant Clinic, who informed that this pathogen has been previously reported on eryngium.

Stems of cultivars 'Blue Bell', 'Magical Blue', 'Magical Cloud' and 'Marbella' were sampled for VL testing in week 27. They had a good VL of 8 or 9d, confirming the earlier results and exceeding the usual number of 'guaranteed' days. Stems of 'Blue Bell' were showing signs of foliar dehydration by vase-day 8, and stems of the other cultivars had dehydrating flower-heads and yellowing or browning foliage by vase-day 10.

Hardy foliage (various genera)

A wide range of hardy foliage plants (from Kolster) was planted in outside beds in spring 2010 and (those marked *) in 2011:

- *Callicarpa bodiniera* 'Profusion'
- *Cornus alba* 'Flaviramea', 'Kesselringil' and 'Sibirica'
- *Corylus avellana contorta*
- *Cotinus* 'Magical Green Fountain' and 'Royal Purple'
- *Hedera helix arborescens*
- **Hypericum inodorum* 'Magical Green Fall', 'Magical Tropical Fall' and 'Magical White Fall'
- *Philadelphus* 'Snowbelle'
- *Photinia* 'Purple Peter' and 'Red Robin'
- *Quercus palustris* and *Q. rubra*
- *Salix alba* 'Darts Snake', *S. 'Caradoc'* and *S. udensis* 'Sekka'
- *Symphoricarpos* 'Bright Fantasy', 'Charm Fantasy' and 'Magical Pride'
- **Symphoricarpos* 'Magical Pride' and 'Magical Avalanche'
- *Viburnum opulus* 'Compactum' and 'Roseum', *V. tinus* and *V. tinus* 'Red Spirit'

Most of the plantings have become well established and there has been distinct interest from the industry (Figure 34). It is known that substantial commercial plantings of *Hypericum*, *Symphoricarpos* and other hardy foliage have been made on UK nurseries.



Figure 34. Part of the Centre's demonstration of woody foliage plants (7 August 2014, week 32)

In 2012 plants of *Cotinus*, *Hypericum* and *Symphoricarpos* were producing marketable stems which were sampled for VL testing. After simulated storage, etc., taking 5 days, the VL of *Cotinus* cultivars varied from 1 to 7 days, depending on the hydrating solution used. The VL of *Hypericum* cultivars also varied from 1 to 7 days, while *Symphoricarpos* cultivars

achieved 6 days. Considerable foliar wilting was seen during testing, so there appears to be a problem with water uptake, despite flower foods being used. As these results were so variable, they need to be repeated, especially as they conflicted with comments from local growers who considered *Hypericum*, but not *Cotinus*, to have a very good VL. More attention also needs to be paid to achieving uniform stems.

In 2013 the plants of *Hypericum* cultivars 'Magical Green Fall', 'Magical Tropical Fall' and 'Magical White Fall' (Figure 35) yielded between 20 and 25 stems per plant.

Most plantings established well and marketable stems have been cropped from 2012 onwards. All plantings were pruned back very hard in early-March 2014. The quality and yields of many of the subjects has been superb (examples in Figure 36).



Figure 35. *Hypericum* cultivars (left to right) 'Magical Green Fall', 'Magical Tropical Fall' and 'Magical White Fall' at the Centre (7 August 2014, week 32)



Figure 36. Further highly rated performers from the woody foliage plots planted 2010 and 2011: from top-left clockwise: *Cotinus* 'Royal Purple', *Cotinus* 'Magical Green Fountain', *Symphoricarpos* 'Magical Pride' and *Photinia* 'Red Robin' and (17 July 2014 (week 29) except *Symphoricarpos*, 7 October 2014 (week 41))

Lily (*Lilium* cultivars)

The remit of previous projects (up to and including PO BOF 002) did not cover bulbous ornamentals, but they have been included in the current project. Over the last 20 years lilies have become a major phenomenon of the UK cut-flower trade, with large quantities grown in the UK (from imported bulbs) in addition to the stems imported. Factors involved in this success include the dynamic hybridisation programmes in the Netherlands, the relative rapidity of bulking-up new cultivars, ability to provide AYR supplies, the avoidance of soil-borne diseases through the successful development of growing lilies in crates of soil-less media, their good post-harvest qualities – and the ‘wow factor’ that modern lily cultivars often evoke.

An initial trial in 2013 focussed on demonstrating new cultivars and investigating the use of green-waste in lily production in crates. Ironically, the quality of the lily cultivars in the trial was so high it was suggested more ‘ordinary’ cultivars should be used in future trials! The growing media tested were 100% standard commercial lily peat, 100% green-waste (Donarbon Ltd., Waterbeach, Cambridgeshire) and a 50:50 mixture of the two. Stem length was longest in plants grown in peat and shortest grown in green-waste. There was no obvious relationship between the number of buds per stem and the growing medium used. Ignoring stem length, the quality of the stems was very good in all three media. The results demonstrated a possible role for green-waste as a peat diluent or partial replacement, encouraging further work on the topic in 2014 when two trials were carried out.

Lilies also formed part of a series of herbicide trials for ornamentals, carried out at the Centre as part of HDC project HNS PO 192. The findings are summarised under ‘Herbicide trials’ (below).

Growing medium trial 1 was carried out at EM Cole (Farms) Ltd, West Pinchbeck, Lincolnshire. Bulbs of lily ‘Dynamite’ were planted in crates of 100% peat (the current industry standard), coir or ‘Forest Gold’ (a wood-derived commercial potting compost, Bulrush Horticulture Ltd, Magherafelt, Co. Londonderry) or mixtures of peat with coir (50:50 v/v), aerobic digestate (AD; supplied by Staples Vegetables Ltd, Wrangle, Lincolnshire and blended by Bulrush Horticulture) (80:20 and 60:40 v/v) or re-cycled green-waste (Donarbon Ltd, Waterbeach, Cambridgeshire) (50:50 v/v). Further details of the trial are in Table 19.

Table 19. Details of 2014 alternative growing media for boxed lily production, trial 1

Varieties	'Dynamite'
Format(s) and supplier(s)	14-16cm grade bulbs (GAV Lilies, Noordwijkerhout, The Netherlands)
Propagation and pre-planting treatment(s)	None
Planting or sowing	Planted in standard lily crates in the following growing media: 1. Peat (100%) 2. Peat + coir (50:50 v/v) 3. Coir (100%) 4. Peat + AD (80:20 v/v) 5. Peat + AD (60:40 v/v) 6. 'Forest Gold' (100%) 7. Peat + green-waste (50:50 v/v)
Planting or sowing date(s)	Week 21
Planting/housing site(s)	Crates moved to tunnel week 24
Layout	Three replicate crates per growing medium
Plant spacing(s)	Bulbs planted at 18/crate
Post-planting treatment(s)	Crates placed in cold-store for 3 weeks after planting
Pests, diseases and disorders	None evident
Picking stage(s) and market specification(s)	Buds starting to show colour
Picking and recording date(s)	Week 34 (week 35 for peat + green-waste treatment)
Records taken	Stem length (sample of 50 stems) Stem weight after trimming to 63cm-long (sample of 50 stems)
VL testing	No

Examples of plants in each growing medium are shown in Figure 37 and stem lengths and trimmed weights are summarised in Figure 38. The average stem length in the standard 100% peat growing medium was 76cm, and in the alternative media average length varied only slightly, between 72cm (peat + green-waste) and 81cm (coir). Average trimmed weight in peat was 78g and in the other media varied from 74g (peat + green-waste) and 100g (peat + AD). The addition of AD and using 'Forest Gold' both showed a tendency for a heavier stem, although the error bars (Figure 38) indicate that these differences in length and weight were probably not statistically significant.

Growing in peat + AD mixtures produced plants with better leaf colour compared with those in peat - though this may have been due to the base dressing added when the mixes were produced. Growing in peat + green-waste resulted in some stunted stems with chlorotic leaves (Figure 37), slightly reducing the yield of marketable stems compared with other growing media, and plants in this treatment were a week later to pick.



Figure 37. Examples from lily growing media trial 1, from top-row left, top-row right, next row down left to bottom-row left: peat (100%), peat + coir (50:50), coir (100%), peat + AD (80:20), peat + AD (60:40), 'Forest Gold' (100%) and peat + green-waste (50:50); bottom-right: chlorotic leaves in peat + green-waste (50:50) (15 August 2015, week 33)

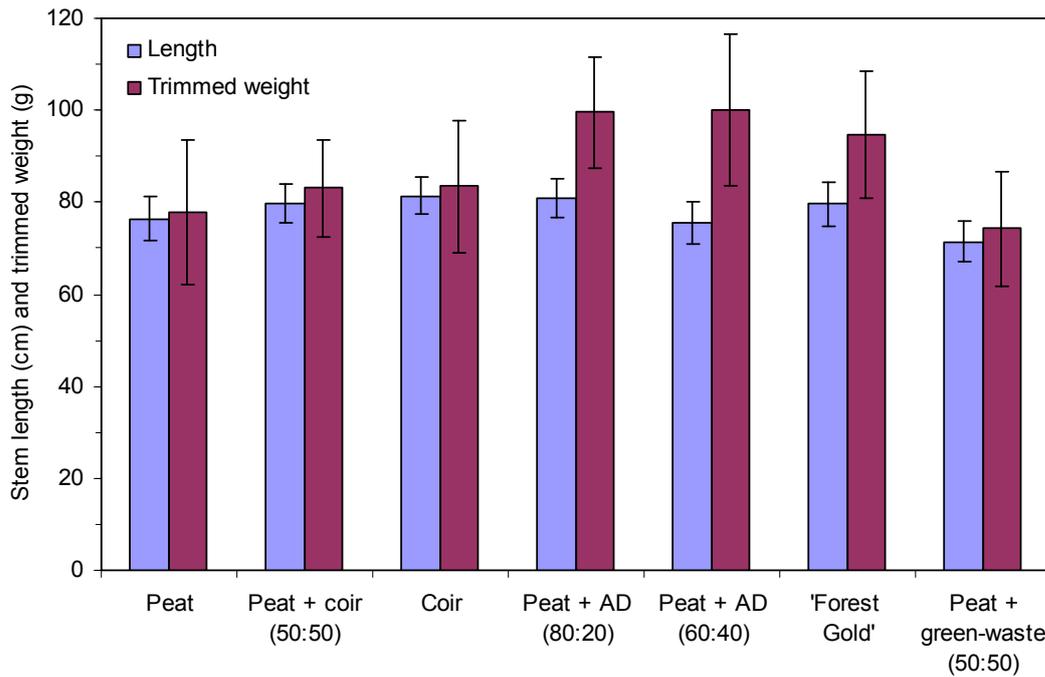


Figure 38. Stem lengths and trimmed weights of lily 'Dynamite' produced in a range of growing media, 2014 trial 1 (error bars represent \pm SD)

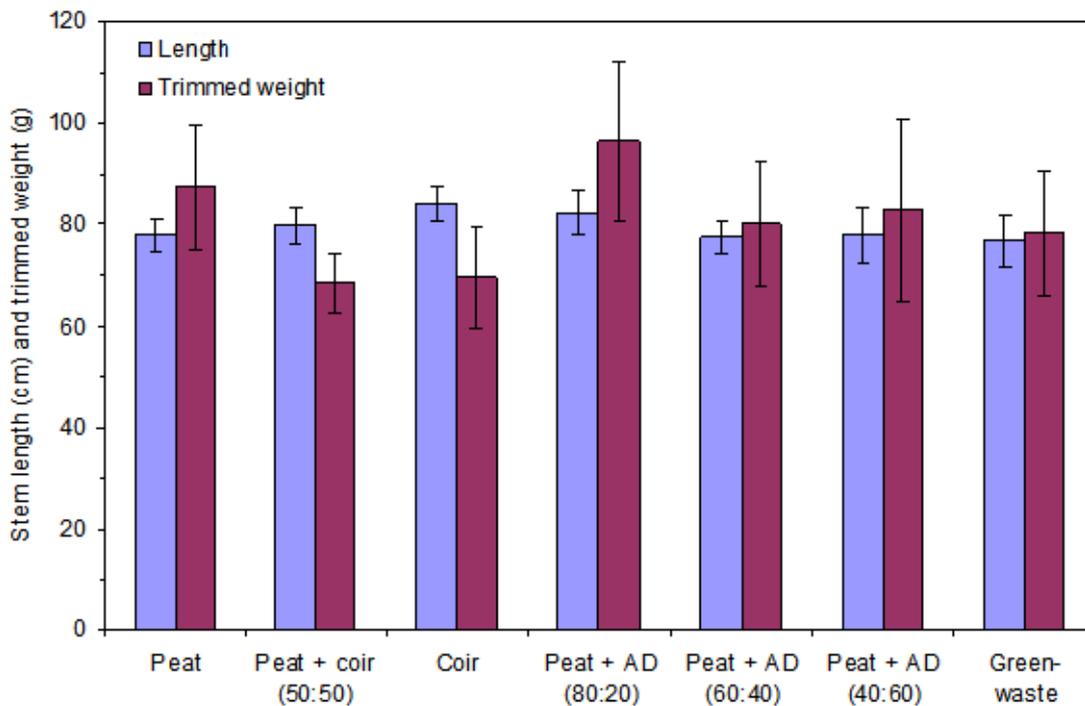


Figure 39. Stem lengths and trimmed weights of lily 'Dynamite' produced in a range of growing media, 2014 trial 2 (error bars represent \pm SD)

Growing medium trial 2 served to explore further the use of AD + peat mixtures. The growing media were as detailed in Table 19, except that the green-waste used was Bettaland 'green compost' (Bettaland Products Ltd., Crowland, Peterborough). Other details are shown in Table 20.

Table 20. Details of 2014 alternative growing media for boxed lily production, trial 2

Varieties	'Dynamite'
Format(s) and supplier(s)	14-16cm grade bulbs (GAV Lilies, Noordwijkerhout, The Netherlands)
Propagation and pre-planting treatment(s)	None
Planting or sowing	Planted in standard lily crates in the following growing media: 1. Peat (100%) 2. Peat + coir (50:50 v/v) 3. Coir (100%) 4. Peat + AD (80:20 v/v) 5. Peat + AD (60:40 v/v) 6. Peat + AD (40:60 v/v) 7. Green compost (100%)
Planting or sowing date(s)	Week 28
Planting/housing site(s)	Crates moved to tunnel week 30
Layout	Five replicate crates per growing medium
Plant spacing(s)	Bulbs planted at 18/crate
Post-planting treatment(s)	Crates placed in cold-store for 2 weeks after planting
Pests, diseases and disorders	None evident
Picking stage(s) and market specification(s)	Buds starting to show colour
Picking and recording date(s)	Week 41
Records taken	Stem length (sample of 30 stems) Stem weight after trimming to 63cm-long (sample of 30 stems)
VL testing	No

Stem lengths and weights are shown in Figure 39. Stem length averaged 78cm in the standard peat growing medium, and was hardly affected by the other media, the averages varying between 77 and 84cm. Average stem weight in peat was 87g, with lighter stems in coir and peat + coir, 69g, and heavier stems in peat + AD (80:20 v/v) at 96g. As for trial 1, the error bars on Figure 39 indicate that these differences in length and weight were probably not statistically significant, with the exception that the addition of coir tended to produce stems lighter in weight compared with the other growing media. The picking date was the same across all treatments.

In this trial no obvious visual differences were seen between plants growing in different media.

Sedum (Sedum cultivars)

In 2010 three sedum cultivars, *Sedum spectabile* 'Brilliant', 'Matrona' and 'Herbstfreude' (from Kolster) were planted as a demonstration in outside beds. Growth was weak in the first year, but once established subsequent growth was very vigorous, with impressive stem counts, length and weight and a demonstration of their quality as cut-flowers (with at least a 7-day VL) suggesting the demonstration should be extended. In 2011 plants of cultivars 'Mr Goodbud', 'Magical Bon Bon', 'Magical Lizzy' and 'Magical Twist' (Kolster; see Figure 40) were added. In 2012 the Centre's sedum plots probably generated more attention than any of the other crops. The numerous and substantial stems could be cropped at a range of stages, from relatively tight to wide-developed, and they have potential uses in a range of bouquets as well as straight lines. Numerous samples were been made available to the industry for information and promotion, and it is known that, as a result, significant commercial plantings have been made.



Figure 40. Examples of some sedum cultivars performing well at the Centre: from left to right, 'Magical Lizzy', 'Magical Bon Bon' and 'Mr Goodbud' (26 August 2014, week 35)

Since the interest from growers continues and commercial plantings have been made, no further trials are planned. The plots have been retained for demonstration purposes.

Stocks, column (*Matthiola incana*)

Column stocks are a mainstay of UK protected cut-flower production, so it is appropriate they have been the subject of several of the Centre's trials concerned with crop improvement. In 2009 and 2011 trials investigated the suggested advantage of using block-raised plants over plug-plants (there was none), the possibly adverse effects of using automated gapping-up (effects were minimal), the performance of a then new line, the 'Anytime' series (now well accepted within the industry and known to perform well during hot summers), and the use of the high temperature-resilient 'Katz' series ('Katz' was also suitable as a late-flowering crop in tunnels or minimally heated or unheated glass).

In 2012 the Centre undertook a variety trial of 48 lines, including cultivars from both standard and new series, grown in steamed and non-steamed soil in tunnels. As well as defining varietal differences, the results showed a strongly beneficial effect of steaming on stem weight but insignificant effects on stem and spike length. Due to ongoing interest in the 'Katz' series as a summer or late crop, several varieties were compared in 2013. For the 'Katz' lines growing at the Centre, stem strength was not as good as in previous years - possibly due to hot weather through most of the life of the crop - but their quality was far superior to that in the commercial glasshouse trial which was mostly un-marketable due to weak stems. On a commercial nursery the full range of Combinations Young Plants and Florensis Cut Flowers column stocks were (a) grown as a further cultivar trial and (b) planted under glass at a commercial nursery for testing for susceptibility to fusarium wilt (the glasshouse had a history of fusarium wilt). The hot weather brought plants on much quicker than anticipated and some of the 'Anytime' varieties and coded lines were ready for cropping in week 30. Despite the hot weather during this period, nearly all the varieties produced marketable stems. In the susceptibility trial the resilient and productive varieties were 'Fantasy Red Imp', 'Fantasy Red', 'Avalanche White', 'Phantom Cream Imp' and 'Phantom Red' in Combinations cultivars and, in the Florensis cultivars, 'Anytime' varieties 'Red', 'Pink', 'Sea Blue', 'White', 'Apple Blossom' and 'Yellow', 'Katz' varieties 'Pink', 'Bright Rose', 'Cherry Blossom', 'Light Lavender' and 'Yellow', 'Figaro Lavender' and some of the coded lines. In contrast, these properties were not shared by the 'Opera' series. This information can be found in more detail in the Centre's Information Sheet 4.

There has been increasing concern among growers about poor establishment and growth and lack of flower uniformity in column stocks. No single factor had been identified as responsible. As a result, separate HDC-funded projects (PO 005 and 005a) were carried out in 2013 to survey cultural practices and investigate the role of *Pythium* and *Fusarium* in these findings (PO 005) and to consider the possibly of remedial effects of soil amendments (PO 005a). Reports are available from the Centre and AHDB Horticulture websites.

In a related trial on stocks in 2013 under project PO 005, higher-than-usual rates of fungicides were used to discriminate between products that might give some control of the pathogens and products that were completely ineffective. This approach was examined in the experiment described in Table 21.

Table 21. Details of 2014 column stocks fusarium control experiment

Varieties	'Centum Deep Blue'
Format(s) and supplier(s)	Plug-plants (Florensis)
Propagation and pre-planting treatment(s)	Plant pots (22cm-diameter, 5L) were prepared on 9 July 2014 in readiness for planting. Except for the pots for un-inoculated controls, the growing medium ('John Innes' (JI) no.2 potting compost) was inoculated with fusarium using a rate of one macerated Petri dish of inoculum to 3L of JI compost.
Planting or sowing	Plug-plants planted in pots
Planting or sowing date(s)	10 July 2014
Planting site(s)	'Pro-Tech' tunnel bay 1
Layout	4 pots per treatment
Plant spacing(s)	3 plants/pot
Post-planting treatment(s)	After planting on 10 July 2014 fungicides were applied at 2x and 4x the usual rates as a growing medium drench: <ol style="list-style-type: none"> 1. Control (inoculated but no fungicide) 2. Thiophanate-methyl (as 4 and 8g Cercobin/L) 3. Prochloraz (as 4 and 8g Octave/L) 4. Difenoconazole (as 2 and 4ml Plover/L) 5. Boscalid + pyraclostrobin (as 3.4 and 6.8g Signum/L) 6. Fludioxonil + cyprodinil (as 1.6 and 3.2g Switch/L) 7. Un-inoculated (and no fungicide) for comparison <p>Due to a delay in obtaining Cercobin, all operations for this treatment were made 10 days later than for other treatments</p>
Pests, diseases and disorders	Fusarium wilt and flea beetle
Picking stage(s) and market specification(s)	Not applicable
Picking and recording date(s)	Not applicable
Records taken	Visual assessments of plant survival and quality at about weekly intervals from fungicide application to flowering
VL testing	Not applicable

The condition of the plants was recorded at intervals after fungicide application. The results 4 weeks after treatment are shown in Figure 41 (for controls and x2 rate of fungicides) and Figure 42 (for x2 and x4 rates of fungicides), and the same plants 6 weeks after treatment are shown in Figure 43 and **Figure 44**). The main findings were:

- The 'check plants' – planted into non-inoculated growing medium and receiving no fungicide – grew normally and appeared healthy, with the typical blue-green foliage of stocks
- Control plants - planted into inoculated growing medium and receiving no fungicide – half of the plants were dead by 7 August and all but one by 21 August
- Except for being paler and having blotchy foliage compared with other treatments, Cercobin-treated plants appeared healthy throughout (with no difference in appearance between the x2 and x4 rates of application); most Cercobin-treated plants survived through to flowering in late-September
- Octave-treated plants were smaller than the check plants but appeared healthy throughout (with no difference in appearance between the x2 and x4 rates)
- Plover-treated plants appeared healthy but smaller than check plants on 7 August but by 21 August the plants treated with the lower rate had mostly died while those treated with the higher rate had mostly survived - but had distorted foliage typical of fusarium infection
- Signum-treated plants appeared normal (like the check plants) on 7 August but by 21 August some were smaller and had distorted foliage typical of fusarium infection (the more so with the higher rate); many Signum-treated plants survived through to flowering in late-September
- Switch-treated plants appeared healthy though smaller than check plants on 7 August (less so for the higher rate) but by 21 August most plants were dead irrespective of the rate used.

Hence Cercobin, Octave and Signum (at either of these rates) appeared to give options for controlling fusarium. Plover and Switch appeared successful at controlling fusarium initially, but most plants had died by 21 August. Note that these conclusions are not a recommendation – at this stage the information presented is purely the report of an experiment and some usage does not conform to label requirements. With further investigations in 2015 it may be possible to optimise fusarium treatment and include the new succinate dehydrogenase inhibiting (SDHI) fungicides (such as boscalid, an a.i. of Signum).



Figure 41. 2014 Column stocks fusarium control experiment: top left, control (inoculated and no fungicide); top right, un-inoculated and no fungicide; lower five photographs from top left clockwise, all at x2 rate: Cercobin, Octave, Signum, Switch and Plover, shown 4 weeks after treatment (7 August 2014) (see also Figure 42)



Figure 42. 2014 Column stocks fusarium control experiment: from top to bottom in pairs, with x2 rate on left and x4 rate on right: Cercobin, Octave, Plover, Signum and Switch; shown 4 weeks after treatment (7 August 2014) (for controls see Figure 41)



Figure 43. 2014 Column stocks fusarium control experiment: top left, control (inoculated and no fungicide); top right, un-inoculated and no fungicide; lower five photographs from top left clockwise, all at x2 rate: Cercobin, Octave, Signum, Switch and Plover; shown 6 weeks after treatment (21 August 2014) (see also Figure 44)



Figure 44. 2014 Column stocks fusarium control experiment: from top to bottom in pairs, with x2 rate on left and x4 rate on right: Cercobin, Octave, Plover, Signum and Switch; shown 6 weeks after treatment (21 August 2014) (for controls see Figure 43)

Sunflower (*Helianthus annuus*)

Sunflowers became a fashionable cut-flower in the early-2000s, and this popularity has been maintained despite a number of problems – notably handling flowers of their size. Significant quantities are now field-grown in the UK. Sunflowers have been included in the Centre's trials since 2010. A major requirement is to reduce the resources needed in harvesting and handling, one approach being to switch to new dwarf cultivars or use plant growth regulators on standard cultivars.

Trials at the Centre also highlighted the difficulties of achieving a uniform plant stand from direct-drilling and of achieving satisfactory restriction of stem growth, especially under the ambient conditions of outdoor production. Of the cultivars tested, 'Dafna' looked very promising from the 2011 trials in terms of post-harvest quality and VL, while VV 10-4 from the 2012 trial showed potential as a truly dwarf variety for both outdoor and protected production.

In 2013 a range of cultivars and numbered lines were demonstrated. Despite the dry weather of 2013, some cultivars started to produce marketable stems from mid-June onwards, with a second planting coming into flower in early-August. The majority of the cultivars were 120 to 160cm-tall and large-headed. 'Galilee Miracle' and 'Tavor Lemon' were shorter (80 to 100cm-tall), though with normal-sized flower-heads, while 'Tanya' was short (about 100cm) and had smaller (3.5cm-diameter) flower-heads. Overall, growing in the tunnel produced much taller plants than growing outside, while in most cases flower-head diameters were smaller in the tunnel than outside. In 2014 more information was sought on the protected cultivation of new cultivars, including dwarf types (

Table 22).

Table 22. Details of 2014 demonstration of new sunflower cultivars for protected cultivation

Varieties	'Galilee Orange', 'Happy Face', 'Helios Flame', 'Lemon Party', 'Rio Carnival', 'Solar Flash', 'Stellar Sun', 'Superted', 'Tanya', 'Tall Timber' and 'Tavor Flash' Numbered lines PV174, PV197 and PV199
Format(s) and supplier(s)	Seed (ProVeg)
Propagation and pre-planting treatment(s)	None
Planting or sowing	Direct-drilled
Planting or sowing date(s)	Weeks 27 and 30
Planting site(s)	2m-long plots in beds in 'Haygrove' tunnel
Plant spacing(s)	4 rows along the bed, seed 10cm apart in the rows
Post-planting treatment(s)	None
Pests, diseases and disorders	None evident
Picking stage(s) and market specification(s)	Petals just starting to expand
Picking and recording date(s)	Weeks 35-37 for the week 27 sowing Weeks 39-40 for the week 30 sowing
Records taken	Observations only
VL testing	'Helios Flame', 'Tavor Flash' and the numbered lines sampled for testing week 32 onwards

For most cultivars the germination rates were high and growth was rapid. 'Solar Flash' and 'Carnival' are actually bedding varieties and were too short (65cm cut length), the overall

stem would need to be reliably longer than this to meet the appropriate specification in all weather.

Stems of five cultivars were sampled for VL testing. They had a consistent average VL of 7d, thereby just attaining the usual number of 'guaranteed' days. Some stems started to bend on vase-day 3 ('Helios Flame') or by days 5 and 7 (numbered lines). Tipping of the petals was slight from day 4 in 'Helios Flame' and PV197 and more progressive from day 3 in 'Tavor Flash'. Some flower-heads of PV197 and PV199 were breaking down by day 7.

Some of the cultivars are shown in Figure 45.



Figure 45. Some examples of cultivars and numbered lines from the 2014 cultivar demonstration: top row, L-R: PV174, PV197, PV199 and 'Tavor Flash'; bottom row, L-R: 'Helios Flame', 'Tanya', 'Lemon Party' and 'Superted' (20 August 2014)

Herbicide trials

The availability and suitability of herbicides is a particular problem in growing 'minor crops' such as cut-flowers because the size of the market is not compatible with the large development costs that would be incurred in development and testing by the agrochemicals industry. Consequently few full (on-label) approvals are available and growers are dependent on EAMUs and the LTAEU. As a result the HDC in particular has funded herbicide trials on a number of cut-flower crops, listed in the Final Report of project HNS PO 192.¹¹

Project HNS PO 192 included new herbicide trials - on outdoor drilled and transplanted China aster, tunnel-grown lily and outdoor drilled sweet william - that were sited at the Centre in 2014. The herbicides tested included products with appropriate EAMUs and products available under the LTAEU, all tested at the maximum approved rate of product or at lower rates where indicated by prior experience, as well as new (experimental) formulations coded by number. The emphasis of this work was to test these products for phytotoxicity, the spectrum of weed control for these products having previously been tested in other trials e.g. the Sceptre trials (HDC project CP 077¹²). With acknowledgements to John Atwood and Chloe Whiteside, the main findings are summarised below, though the report itself should be consulted for full details.

In addition, a separate herbicide trial on outdoor drilled sweet william was subsequently carried out at a commercial nursery, as part of the CFC project, in order to take advantage of the new findings.

Drilled China aster 'Matsumoto' Treatments were applied *post-drilling, pre-emergence unless otherwise stated*.

- Benfluralin (as 2kg 'Benfluralin'/ha, ***pre-drilling incorporation***) and propyzamide (as 4.25L 'Kerb Flo 400'/ha) gave best crop emergence and minimal phytotoxicity.
- Treatment with s-metolachlor (as 0.78L 'Dual Gold'/ha) gave least phytotoxicity on emerged seedlings and good weed control, although emergence was reduced compared with other treatments.
- Benfluralin and propyzamide treatments (both as above) and pendimethalin + imazamox (as 4.5L 'Nirvana'/ha) were acceptable treatments overall, although weed control was poorer with benfluralin alone.

¹¹ John Atwood (2014). Final Report, HDC project HNS PO 192, Herbicide screening for ornamental plant production (nursery stock, cut flowers and wallflowers).

¹² Tim O'Neill (2015). Final Report, HDC project CP 077, SCEPTRE: Sustainable Crop & Environment Protection - Targeted Research for Edibles.

- There was some initial damage from carfentrazone ethyl (as 0.33L 'Shark'/ha, **post-emergence**) but the crop grew away quickly, making this a possibility as a selective contact treatment.
- Pendimethalin + clomazone (as 2L 'Stomp Aqua' + 0.25L 'Gamit 36 CS'/ha), previously used on China aster in another HDC-funded trial¹³ and considered safe, led to reduced emergence in this trial, but as the crop looked healthy it is possible it should be considered at a reduced rate.
- The experimental formulation HDC H22 was the most phytotoxic treatment and emergence was greatly reduced.
- Other treatments tested, without notable effects, were prosulfocarb (as 5L 'Defy'/ha) and benfluralin followed by s-metolachlor (both as above).

Transplanted China aster 'Matsumoto' Treatments were applied **post-planting, pre-weed-emergence unless otherwise stated.**

- Little phytotoxicity was seen in any of the treatments.
- Some yellowing of foliage and stunting of plants was noted 2 weeks after treatment using prosulfocarb (as 5L 'Defy'/ha), benfluralin + s-metolachlor (as 2kg 'Benfluralin'/ha **pre-planting incorporation** followed by 0.78L 'Dual Gold'/ha) and 2L 'Venzar Flowable'/ha + s-metolachlor (as above), but the plants grew away from this damage.
- At picking stems from all treatments exceeded the 60cm height specification and there was very little difference in stem weight between any of the treatments. Using benfluralin + s-metolachlor (as above) produced both heaviest and shortest stems, meaning that less stems would be needed to produce a weighed bunch.
- Other treatments tested, without notable effects, were benfluralin (as 2kg 'Benfluralin'/ha **pre-planting incorporation**), propyzamide (as 4.25L 'Kerb Flo 400'/ha **pre-planting**), experimental formulation HDC H22, and pendimethalin (as 2L 'Stomp Aqua'/ha) alone or in combination with clomazone (as 0.25L 'Gamit 36 CS'/ha) or s-metolachlor (as 0.78L 'Dual Gold'/ha).

Tunnel-grown lilies 'White Triumph' and 'Dynamite' Treatments were applied **post-planting, pre-weed-emergence unless otherwise stated.**

- 'Dynamite' showed slight phytotoxicity from most treatments, but grew out of it by picking, while all treatments proved safe on 'White Triumph'.
- At picking 'Dynamite' stems were shorter and lighter than 'White Triumph', but there was little difference between treatments for the two varieties.

- Stem length and weight were reduced in both varieties by using napropamide (as 5L 'Devrinol'/ha, **pre-planting incorporation**) followed by isoxaben + metazachlor (as 2L 'Flexidor 125' + 1L 'Butisan S'/ha).
- The other treatments tested were napropamide (as 5L 'Devrinol'/ha, **pre-planting incorporation**) alone or followed by isoxaben (as 2L 'Flexidor 125'/ha); isoxaben + metazachlor (as 2L 'Flexidor 125' + 1L 'Butisan S'/ha); experimental formulation HDC H28 + pendimethalin (as 2L 'Stomp Aqua'/ha) alone or with experimental treatment HDC H31 or clomazone (as 0.25L 'Gamit 36 CS'/ha) or followed by bromoxynil (as 1L 'Butryflow'/ha); and experimental formulations HDC H24 + H31.

Drilled outdoor sweet william 'Messenger' - trial 1 at CFC. Treatments were applied **post-drilling, pre-emergence unless otherwise stated.**

- Prosulfocarb (as 5L 'Defy'/ha) and benfluralin (as 2kg 'Benfluralin'/ha, **pre-drilling incorporation**) were generally safe treatments with minimal effect on emergence, although with slight phytotoxicity from the former.
- Napropamide (as 5L 'Devrinol'/ha, **pre-drilling incorporation**) showed minimal phytotoxicity, although emergence was reduced. A subsequent small-scale trial confirmed the risk from this treatment (see below).
- There was some initial damage from carfentrazone-ethyl (as 0.33L 'Shark'/ha, **post-emergence treatment**), with scorching of leaves, but the crop recovered well, making this a possibility.
- The remaining treatments all reduced emergence and were phytotoxic to emerged plants: pendimethalin + imazamox (as 4.5L 'Nirvana'/ha), pendimethalin (as 2L 'Stomp Aqua'/ha), pendimethalin + clomazone (as 2L 'Stomp Aqua' + 0.05L 'Gamit 36 CS'/ha), pendimethalin + dimethenamid-p (as 3.5L 'Wing-P'/ha), and the experimental formulation HDC H22.

Drilled outdoor sweet william 'Messenger' - trial 2 at commercial nursery. The trial was conducted at a commercial nursery, Belmont Nursery, Terrington St Clement, King's Lynn, in order to build on the above results and gain further guidance for herbicide trials in 2015. Treatments comprised three application rates of pendimethalin ('Stomp') superimposed on napropamide ('Devrinol') and prosulfocarb ('Defy') applications using a row-and-column layout. There were two replicate blocks of plots 1m wide and 3m long, with guard areas between plots. The row treatments were pendimethalin as 1, 2 or 3L 'Stomp'/ha. The column treatments were napropamide as 2.5 or 5L 'Devrinol'/ha, prosulfocarb as 2, 3 or 5L 'Defy'/ha, and control (untreated) plots. All herbicides were applied by tractor-mounted spray boom at 400L/ha. For plots receiving 'Devrinol' the herbicide was applied then

incorporated by forming shallow beds, and the seed drilled, all in week 31, and for other treatments the seed was drilled in week 30 and herbicides applied in week 31.

A visual assessment of the crop was made on 22 January 2015:

- Sweet william germination was satisfactory in plots treated with 1L 'Stomp'/ha although subsequent growth was slightly retarded. Germination was much reduced where treated with 2 or 3L 'Stomp'/ha.
- Germination was also much reduced where treated with 'Devrinol' at 2.5 or 5L/ha, though this may have been a result of late drilling
- Sweet william germination and growth were satisfactory in plots treated with 2, 3 or 5L 'Defy'/ha alone (i.e. in the guard areas) or in combination with 1L 'Stomp'/ha.

General conclusions

Experimental formulation HDC H22 proved highly phytotoxic to drilled crops and reduced emergence, although it would be safer in transplanted crops. 'Benfluralin' looks promising, with good crop emergence and little phytotoxicity on drilled crops or transplanted asters. 'Shark' is a possible selective contact treatment, with China aster and sweet william recovering from initial damage. 'Defy' alone or in combination with 1L 'Stomp'/ha appeared safe on drilled sweet william on the silty soil at the nursery. All treatments used on lily and transplanted China asters were safe and had minimal effect on stem length and weight. These are all trials results, not recommendations.

Discussion

Reviewing the scientific and technical literature on new introductions of cut-flower crops and their commercialisation reveals a plethora of studies worldwide and a dizzying selection of species new to commercial horticulture, new cultivars of established crops, and means of improving crop production. In the current series of projects under the aegis of the HDC and the National Cut-flower Trials Centre, the aim has been to use this information to identify novel opportunities for UK cut-flower growers, largely making use of Spanish tunnels. As a result, several crops have been introduced or re-packaged to the industry and it is known that significant areas of these are now being grown, among them September-flowering asters (*Aster ericoides*), new cultivars of China asters (*Callistephus chinensis*), antirrhinums (*Antirrhinum majus*), lisianthus (*Eustoma grandiflorum*), sedum (*Sedum spectabilis*) and woody foliage such as *Hypericum inodorum*, *Symphoricarpos* cultivars and *Salix*.

Crop introduction

In 2013 and 2014 19 new crops were demonstrated at the Centre, including new series of old favourites made available for demonstration (spray carnation, delphinium, gypsophila and leucanthemum).

Basil (*Ocimum basilicum*)

Basil cultivars grew well in a trial in 2013 but the stems had too short a VL. Further trials should be carried out if better cultivars ('Aramato' and 'Cardinal' performed well in trials in the USA) and information on more appropriate post-harvest treatments can be obtained. At present its potential for production as a cut-flower in the UK is undecided.

Carthamus (*Carthamus tinctorius* and cultivars)

The unusual, thistle-like flowers of carthamus suggest value as a filler, and three cultivars were trialled in 2014. Carthamus seems to have good potential for commercial uptake, though the bract-tipping seen in both outside and tunnel-grown crops was considered detrimental. This is an important issue to investigate in 2015.

Cosmos (*Cosmos bipinnatus*)

In trials in 2013 and 2014 cosmos cultivars produced stems of substantial length and weight through September and October whether grown in a tunnel or outside, but their VL was very short. Under protection they were very vigorous and may need growth control. The 'QIS' series has larger flowers on longer, stronger stems and is marketed as a cut-flower type, so should also be tested. Hence the potential for production of cosmos as a cut-flower in the UK is undecided, with a number of issues left to resolve. If successful, the best cultivars of cosmos might be developed as a cheap, drilled outside crop.

Since the lead bud developed some time before the subordinate buds, picking when the first bud was open gave disappointing results and there is a case for investigating the disbudding of the central bud (a reasonably quick task in this species) to get a better display from the side-shoots.

Delphinium 'Waltz' and 'Tango' series (*Delphinium elatum* cultivars)

Delphinium cultivars have previously been trialled extensively at the Centre and growers continue to debate whether more of their potential might be realised. 'Sea Waltz', 'Sky Waltz' and 'Tango Dark Blue' are examples of new series from HilverdaKooij and were made available for testing in 2014. They were liked by growers because of their flower form and stem quality, but supermarkets may not be prepared to pay a premium price to justify the extra planting costs associated with these tissue-cultured plants. They are being grown-on to a second year to assess their full potential.

Gypsophila 'Zinzi' series (*Gypsophila paniculata* cultivars)

'Zinzi Discovery' and 'Zinzi Tyree' are new cultivars from HilverdaKooij that were made available for testing at the Centre in 2014. The 'Zinzi' series is said to be superior to other gypsophila in terms of stem and flower quality and the trial will allow the industry to make its independent assessment. Following very late planting in 2014 they produced a poor flower crop and are being grown-on to 2015 to assess their full potential.

Leucanthemum (*Leucanthemum* × *superbum* cultivars)

This crop has not been previously tried at the Centre but was included to demonstrate a new range of cut-flower leucanthemum made available in 2014 by Realflor. The plants grew away well though 'Real Frilly' budded prematurely and flowered on short stems. A second year's growth is required to see their full potential, test their VL and establish their economic viability.

Lion's ear (*Leonotis leonurus*)

In 2013 and 2014 trials *Leonotis* 'Staircase' grew vigorously and almost reached the top of the tunnel by weeks 40-43, when its buds began to open, too close to the end of the season. Other types trialled in 2014 varied in stature, with none as vigorous as 'Staircase'. It has not yet been possible for us to pick a stem, so we cannot judge the potential of a tunnel crop in the UK. As a truly novel crop, there is much to learn about the cultural requirements of lion's ear, but its flower is unusual and it has been seen growing at one UK commercial nursery in early-October 2013 where it was being used in florist's bouquets. Although the potential for lion's ear in the UK is unknown at present, work should be extended to 2015. *Leonotis* 'Staircase' in this form would be difficult to handle, but research in Italy showed that if the plants were cut-back for over-wintering more manageable growth and a useful

crop of flowers may result. Results so far indicate that earlier planting and two-spotted spider mite control will need to be addressed.

Lupin (*Lupinus* species)

Starting a trial in 2013 'Gallery' and 'Russell' cultivars established slowly but well in the tunnel and outside. Numerous plants failed to over-winter to 2014 but those that did produced high-quality stems with flowers in a superb range of colours. Their lack of winter hardiness, damage from aphids and short VL would limit their potential as cut-flowers in the UK. Trials should continue if superior types such as *Lupinus harvardii* (big bend bluebonnet) 'Texas Sapphire' and 'Texas Ice', *L. densiflorus* 'Aureus' (golden lupin) and *L. × regalis* 'Morello Cherry' can be obtained.

Ornamental pepper (*Capsicum annuum* cultivars)

Following a trial in 2014 it is still too early to speculate on the potential of ornamental peppers for UK growers. 'Black Pearl' and 'Masquerade' will be tested again in 2015, sowing and transplanting earlier to achieve a timely pick. Other attractive cultivars are available and should be investigated to see if they are early-maturing.

Physostegia (*Physostegia virginianum* cultivars)

Shown to be a potentially useful cut-flower in trials in the USA and 'Crystal' was included in an initial demonstration at the Centre in 2014. It was rather short and late and showed a short VL, so needs to be grown-on to a second year to assess its potential fully. Other cultivars are available and could be added to see if earlier flowering can be obtained.

Seed-raised fillers (*Ammi visnaga*, *Anethum graveolens*, *Anthriscus sylvestris*, *Bupleurum rotundiflorum*, *Euphorbia oblongata* and *Ridolfia segetum*)

There is more interest now in growing cheap, seed-raised fillers in tunnels or outside. The six species listed were trialled in outside and tunnel plots in 2015. *Ammi majus* (or *Ammi visnaga* as an alternative), *Anethum graveolens* and *Bupleurum rotundiflorum* appeared to be the most promising for further trialling. For bupleurum the chief need is to optimise the seedling rate. For ammi and anethum poor germination, slow growth and late flowering are key problems meriting further study: approaches could include earlier planting dates, starting the season in a tunnel and using plug-plants.

Anthriscus sylvestris (with seed germination problems and issues with lack of flowers), *Euphorbia oblongata* (with slow germination and short stems) and *Ridolfia segetum* (slow germination and growing) appeared to be less suitable, but are being grown-on to 2015 to assess their potential further.

Spray carnation 'Tiara' series (*Dianthus caryophyllus* cultivars)

Spray carnation cultivars have previously been trialled extensively at the Centre. The 'Tiara' series is a new type of spray carnation from HilverdaKooij that has a unique flower form and was made available for trialling in 2014. The central bud may need to be pinched to allow better spray development, potentially a labour-intensive task. They appear susceptible to thrips damage. New colours will be available from HilverdaKooij in 2015, so the current plots have been left down for 2015 and will be augmented by further varieties.

Trachelium (*Trachelium caeruleum*)

Trachelium is not well known in the UK, although it is widely grown in the Netherlands. In plug-plant trials in 2013 and 2014 trachelium grew well and produced high yields of long stems with dense heads of attractive colours. Its VL was satisfactory. Because of better-than-average summer weather in 2014, with good light levels and warm temperatures in June and July, these results may have been atypical, so the demonstration ought to be repeated in a further year before definite conclusions are drawn. Although not an issue to growers using plug-plants, germination of trachelium can be poor in some years, and this should be researched. There are some other issues that growers have asked the Centre to address: slightly earlier planting should be tested, the possible benefits of pinching should be investigated and a cultivar trial is needed covering a selection of the 'Corine', 'Lake' and 'Devotion' series including a red-flowered cultivar.

Zinnia (*Zinnia elegans*)

In earlier (2007 and 2008) trials the flowers were well liked by growers and potential customers, but after picking the hollow stems collapsed and soon bent just below the flower-head, making them unusable. Trials in the USA, however, had rated zinnias as very dependable, and so the Centre's trials on zinnia were revived in 2013 to resolve differences over post-harvest quality. Through summer 2013 VL was a maximum of 7d in the vase, despite investigating the use of flower conditioners and foods, though bending of the neck was apparent only once the flowers were almost dead, rather than immediately after picking as previously noted. An earlier picking stage was suggested. However, in the 2014 trial post-harvest quality was unsatisfactory, with stems failing to last to the end of the 4d retail store phase. This seems to have been due to adverse effects of the cool chain resulting in early dehydration of the flowers. The different finding in the USA and the UK may be due to different marketing chains and conditions; with current knowledge zinnia appears to be a very good candidate for ambient direct sales such as mail-order work.

Consultants from Chrysal have suggested there may be treatments that could avoid such damage, and so VL will be examined further in 2015, since industry's enthusiasm for zinnias remains. The effects of the cool-chain needs to be mitigated and the use of growth

regulators to strengthen the neck investigated. The trials in 2014 were affected by bacterial blight (caused by *Xanthomonas campestris*), so preventative sprays will be needed.

Crop improvement

Alstroemeria – garden cultivars (*Alstroemeria* cultivars)

Trialling this crop was suggested by the use of low cost of older cultivars. Crop performance and yield was excellent in the tunnel with good, strong stems some growers thought were better than glasshouse crops. Growth was less good outside. VL was also satisfactory, so the crop appears to have good potential for UK uptake. Trials should continue.

Aster, September-flowering (*Aster ericoides* cultivars)

Previous trials had confirmed the possibility of bringing forward flower initiation through using a blackout cover to provide short days in summer. In a 2014 trial cultivars 'Cairo' and 'Cassy' produced high-quality blooms under this regime, with no premature budding and high yields. In 'Cape Town' and 'Chicago' however bud development occurred a month earlier, producing premature budding and consequent poor quality and yield. The second flush grew-away well in all cultivars. Stems of the four cultivars had a satisfactory VL. There is probably a limit how much further the Centre can take these trials, but at a grower's request the crop has been left *in situ* for another year to see how early a blacked-out crop can be produced in 2015. The responses of other cultivars could be studied.

Eryngium (*Eryngium* cultivars)

Eryngium have been tested in previous trials at the Centre. Stems tested in 2014 showed they have a satisfactory VL. The outside plots will be grown-on to 2015 in order to clarify winter hardiness. There appear to be good prospects for eryngium as a UK commercial crop. An issue to watch is the necrotic, black spots due to *Alternaria*.

Hardy foliage (various genera)

Plots of a range of species are maintained at the Centre for demonstration purposes, with *Cotinus*, *Hypericum* and *Symphoricarpos* particularly favoured and now being grown commercially. There appear to be discrepancies in VL between samples. More attention needs to be paid to achieving uniform stems.

Lily (*Lilium* cultivars)

In 2014 trials of alternative growing media showed there are good prospects for lily production in tunnels in crates of reduced-peat or non-peat media. Using cultivar 'Dynamite' flowers of equal or better quality to those grown in standard peat could be obtained using 100% coir, 100% 'Forest Gold' (a wood-derived potting compost), peat + coir (50:50) or peat + aerobic digestate (AD) (80:20, 60:40 or 40:60). Using mixtures of peat + green-waste

(50:50) produced some variable results, but this may be due to variations in the composition of the green-waste. It would be advisable to check the responses of other cultivars to peat + AD and to define the optimal ratio of the mixture.

Sedum (*Sedum* cultivars)

Since the interest from growers continues and commercial plantings have been made, no further trials are planned. The plots have been retained for demonstration purposes.

Stocks, column (*Matthiola incana* cultivars)

Separate HDC-funded projects in 2013 investigated the role of *Fusarium* in poor quality column stocks. In 2014 stocks were planted in pots of growing medium inoculated with fusarium and drenched two days later with a range of fungicides. Cercobin, Octave and Signum appeared to be useful treatments for controlling fusarium. Plover and Switch were less successful. With further investigations in 2015 it may be possible to optimise this fusarium treatment.

Sunflower (*Helianthus annuus*)

Significant quantities of sunflowers for cutting are now field-grown in the UK. One approach to the high labour requirements associated with handling sunflowers is to switch to new dwarf cultivars or use plant growth regulators on standard cultivars. In a tunnel-grown cultivar trial in 2014 it was shown that the 'dwarf' varieties 'Solar Flash' and 'Carnival' were too short for use as cut-flowers. Cultivar trials are likely to continue as further new lines are produced.

Herbicide trials

HDC Project HNS PO 192 included herbicide trials on outdoor drilled and transplanted China aster, tunnel-grown lily and outdoor drilled sweet william, and these were sited at the Centre in 2014. The results are summarised in this report and full details will be available in the Final Report of project HNS PO 192. In addition a separate herbicide trial on outdoor drilled sweet william was carried out at a commercial nursery as part of the CFC project.

Experimental formulation HDC H22 proved highly phytotoxic to drilled crops and reduced emergence, although it would be safer in transplanted crops. 'Benfluralin' looked promising, with good crop emergence and little phytotoxicity on drilled crops or transplanted asters. 'Shark' seems a possible selective contact treatment, with China aster and sweet william recovering from initial damage. 'Defy' alone or in combination with 1L 'Stomp'/ha appeared safe on outdoor drilled sweet william on the silt soil at this nursery. All treatments used on lily and transplanted China asters were safe and had minimal effect on stem length and weight. These are all trials results, not recommendations.

Note: the product names of herbicides currently reported as code numbers will be revealed as approvals are obtained and email alerts will be circulated to cut flower growers as these approvals are issued.

Knowledge and technology transfer

Knowledge and technology transfer are major objectives of this project, and while progress in these areas is covered below in a specific section, it is important to note that the demonstrations, trials and experiments reported above have hard-to-quantify outputs other than the data that have been reported. In particular, the Centre provides a point of contact and discussion around the opportunity to see a wide range of trials and plant material gathered at one site, in which not only growers, but also seed and plant suppliers, packers, technologists and retailers, participate. Further, substantial samples of cut-flowers have been made available to the industry at large, providing further stimulus to the UK industry to consider growing or sourcing a wider range of cut-flowers in the UK. The Centre also provides a focus for the industry to come together, enabling it to have a more cohesive voice especially in relation to R&D priorities. This is clearly reflected in the number of cut-flower R&D projects that have been funded by the HDC since the formation of the CFC.

How the objectives were achieved

The Centre has now successfully developed its role as an information hub and cohesive voice for the UK cut-flower industry. This has been achieved by holding a number of grower events throughout the year and Open Days to look at the CFC trials on both growers' holdings and the main site at Rookery Farm (see Knowledge and technology transfer, above). The project continues to produce appropriate technical literature including a review of cut-flower trials worldwide and a summary of the Centre's column stock fusarium wilt susceptibility variety trial. A number of crops that have been trialled at the Centre have now been planted commercially, including antirrhinum, sedum, hardy foliage and a summer spot-crop of lisianthus. In addition to the main trials, the Centre, in its role as a crop association and in liaison with AHDB Horticulture, has facilitated additional trials including herbicides on column stocks and sweet william as well as a review of hydroponic use for cut-flowers. The CFC (and the wider industry) is also participating in ongoing discussions with the British Growers Association to investigate any promotional activities or funding that may be open to the industry.

Conclusions

- Basil cultivars showed potential as a tunnel-raised aromatic filler. To realise this better cultivars would be needed along with the development of suitable post-harvest treatments to extend VL.
- The new spray carnation 'Tiara' series has a unique flower form and was appreciated by growers, but will need to have the leading bud pinched to maintain the spray structure and this is potentially labour-intensive. Trials will be continued and new colours tested in 2015.
- Carthamus is a valuable thistle-like filler, but in trials quality was downgraded due to bract-tipping. This disorder will need to be controlled for carthamus to realise its potential.
- Cosmos cultivars in tunnel and outside plots were vigorous and flowered prolifically with robust stems: a potential cheap, drilled 'short-season filler'. With a very short VL, improved post-harvest treatments need to be developed.
- Delphinium 'Waltz' and 'Tango' series produced attractive flowers and were very productive, potentially giving three flushes in a year. They are being grown-on to assess their full potential.
- Gypsophila 'Zinzi' series – potentially superior to other gypsophila on the market - produced a poor flower crop due to late planting and will be grown-on for further assessment.
- Leucanthemum 'Real' series grew away well but one cultivar out of three budded prematurely and flowered on very short stems. They will be further assessed in 2015.
- *Leonotis* is a South African plant currently being introduced to cultivation. In trials they grew vigorously but too late to achieve a commercial harvest. As a truly novel crop there is much to learn about their cultural requirements though good results are being had in other countries.
- Lupin (*Lupinus* species and cultivars) 'Gallery' and 'Russell' continued to produce reasonable numbers of stems over a long period, with stems of a high quality and a striking range of colours. Left *in situ* to overwinter, many plants failed to survive. In combination with a short VL, their potential as cut-flowers appears limited. Newer cultivars may have better potential.
- Ornamental peppers were included in trials but after producing strong plants, the fruits remained more or less static without growing or ripening. Earlier planting dates and other cultivars should be investigated.

- Physostegia 'Crystal' was rather short and late-flowering with a very short VL. Other cultivars should be tested for earlier flowering and better vase life.
- There is grower interest in producing cheap, seed-raised fillers in tunnels or outside. *Ammi visnaga*, *Anethum graveolens* (dill), *Anthriscus sylvestris* 'Ravenswing', *Bupleurum rotundiflorum* 'Griffithii', *Euphorbia oblongata* and *Ridolfia segetum* were trialled. *Ammi majus*, *Anethum graveolens* and *Bupleurum rotundiflorum* appeared to be the most promising.
- Trachelium seems to have real potential as a tunnel-grown flower for the UK, subject to testing in further years to ensure the results obtained in 2014 - in a warmer-than-usual summer - were not atypical.
- Zinnia have a wide range of bright colours but vase life still remains an issue. Trials have shown they may be sensitive to cool temperatures experienced in the post-harvest chain so may be suitable for ambient-temperature direct-sales such as mail order work.
- Using older garden cultivars alstroemeria produced a high-quality crop possibly better than some glasshouse crops. They will be further tested.
- September-flowering *Aster ericoides* is a short-day plant and floral initiation under long days can be brought forward by blacking-out the crop for 13h per day. Using a blackout from week 25 to week 30 'Cairo' and 'Cassy' started to develop when the blackout was removed, producing high quality stems, high yield and no premature budding.
- Demonstrations of eryngium and hardy woody foliage has resulted in interest from the industry and substantial commercial plantings of *Hypericum*, *Symphoricarpos*, *Sedum*, *Salix* and others have been made.
- Lily trials have shown that a product as good or better than those grown in standard lily peat may be obtained using peat-free and peat-reduced growing media such as, coir, a wood-derived commercial potting compost, or mixtures of peat with coir (50:50 v/v), aerobic digestate (AD) (80:20 and 60:40 v/v) or recycled green-waste (50:50 v/v).
- Sedum's numerous and substantial stems can be cropped at a range of stages, from relatively tight to wide-developed, and they have potential uses in a range of bouquets as well as straight lines.
- The control of fusarium in column stocks is an important issue for growers. Trials with high rates of Cercobin, Octave and Signum increased growth and survival and reduced the appearance of fusarium symptoms. This will be the subject of further trials and any legislative issues will need to be addressed before firm recommendations can be made.

- A wide range of sunflower cultivars, both standard and dwarf, have been demonstrated as suitable for quality production in tunnels.
- The availability and suitability of herbicides is a particular problem in growing 'minor crops' such as cut-flowers. Under HDC Project HNS PO 192 herbicide trials were carried out at the Centre on outdoor drilled and transplanted China aster, tunnel-grown lily and outdoor drilled sweet william. Some potentially new treatments were identified.

Knowledge and Technology Transfer

Events

Five events were held in 2013. Handouts are available from <http://www.thecutflowercentre.co.uk/> or from the HDC.

CFC/HDC Tulip Mechanisation Stock Study Tour, the Netherlands, 25-26 February 2014

CFC/HDC Dutch Lily and Column Stock Study Tour, the Netherlands, 14 May 2014

National Cut Flower Centre Open Day, EM Cole Farms Ltd, Terrington St Clement, Norfolk and Rookery Farm, Holbeach St John, Lincolnshire, 6 August 2014

HDC/CFC Field-grown sweet william herbicide trial viewing, Belmont Nurseries, Terrington St Clement, Norfolk, 24 September 2014

CFC/HDC Ornamental cut brassica production study tour, Multi Color Flowers, Takii Europe BV and grower visits, the Netherlands, 8-9 October 2014

The Open Day attracted over 80 attendees from all sectors of the industry, which meant that as well as the interest in the trials themselves, the format of the event again provided a significant opportunity for networking. This year the Open Day included a viewing of the alternative growing media for lily trials at the nursery of E M Cole (Farms) Ltd which demonstrated some very promising results. Presentations were also given to update growers on the MOPS project and also the ADAS herbicide trials looking at replacements for Ronstar.

Website

The Centre's website was kept updated during 2014. Annual project reports and the specialist reviews and leaflets cited in this section are available for downloading from the website, along with relevant EAMUs and Centre news.

Articles published

These articles on the Centre's work were published during 2014:

- Anon. (2013/2014). *World of flowers on trial*. HDC News, no. 199, p.22
- Brough, W (2014). *Forced through technology* [Study tour report, Dutch automated forced tulip production]. HDC News, no. 202, p.19-21
- Mason, L (2014). *Performance tested through to the vase*. HDC News, no. 202, p.22-23
- Brough, W (2014). *Opening doors in the Netherlands* [Study tour report, Dutch growing and breeding of lilies and column stocks]. HDC News, no.205, p.16-17
- Shaddick, C (2014). *A-Z at the CFC*. HDC News, no.206, p.28-30

- Brough, W (2014). *A bouquet of brassicas* [Study tour report, Dutch ornamental brassica production]. HDC News, no.208, p. 15

Reports and databases

Copies are available from <http://www.thecutflowercentre.co.uk/> or from the HDC:

- *A database of seed and young plant suppliers for the cut-flower industry.* National Cut-Flower Centre/HDC. Gordon Hanks (2014)

Leaflets

Copies will be available from <http://www.thecutflowercentre.co.uk/> or from the HDC:

- *The National Cut-Flower Trials Centre & UK Cut-flower Growers' Association.* Flyer, National Cut-Flower Centre/HDC. Lyndon Mason and Gordon Hanks (2014)
- *Snapdragons (including 'Trumpet' or peloric cultivars) as a cut-flower grown in tunnels.* Information Sheet, National Cut-Flower Centre/HDC. Gordon Hanks and CFC MG (2014)
- *Lisianthus as a cut-flower grown in tunnels.* Information Sheet, National Cut-Flower Centre/HDC. Gordon Hanks and CFC MG (2014)
- Delphinium as a cut-flower grown in tunnels (in preparation)
- Woody foliage production (in preparation)

Other examples of technology and knowledge transfer

The work of the Centre included a number of aspects of obvious value, but difficult to quantify. For example, samples of cut-flowers have always been made available from the trial plots for supply to packers and retailers as examples of the quality and variety of cut-flowers that can be grown in the UK. There is little doubt that this process stimulates ideas and a demand and desire for novel UK-grown produce alongside established products.

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