



Grower Summary

PO BOF 002a

The National Cut-flower Trials
Centre Programme for 2013 -
2017

Annual 2015

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Project title: The National Cut-flower Trials Centre Programme for 2013 - 2017

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Report: Third Annual Report (2015)

Previous report: First Annual Report (2013)
Second Annual Report (2014)

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Date project commenced: 01 January 2013

**Date project completed
(or expected completion date):** 31 December 2017

GROWER SUMMARY

Headline

- Garden varieties of alstroemeria perform well as a natural-season tunnel crop. With several cultivars in Spanish tunnels and outside beds, high yields can be obtained over a five-month period.
- Growing in a permanent tunnel or under cold glass, *Aster ericoides* can produce two flushes in a year using blackout covers to advance flower initiation.
- As a high-quality protected crop in tunnels, newer cultivars of ornamental brassicas offer an alternative to the familiar 'Crane' series.
- Box-grown lilies in Spanish tunnels grow as well in peat mixed with up to 60% of anaerobic digestate, as they do in plain peat; they also grow well in 100% coir or coir and peat mixes. Care should be taken over the source and analysis of anaerobic digestate.
- *Ammi*, *Anethum*, *Anthriscus*, *Bupleurum* and *Euphorbia* show promise as direct-drilled, tunnel- and outdoor-grown fillers.
- Tracheliums show great potential as a crop for Spanish tunnels.

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 £125m to around £550m. Over the same period the value of UK-grown cut-flowers remained static at around £50m *per annum*. This shortage of enterprise was attributed to (1) a lack of 'know-how' and (2) a reluctance to challenge the Dutch flower export market. The Cut-flower Trials Centre (CFC) project was set up in 2007, largely with funding from the HDC (now AHDB Horticulture), and is currently funded by AHDB Horticulture until the end of 2017. The immediate aim of the project is to provide information on producing a wider range of cut-flowers outdoors and, taking advantage of the increased availability of low-cost Spanish tunnels, under protection ('*crop information*'). The longer-term aim is to stimulate the UK grower's interest in developing and commercialising novel cut-flowers ('*crop introduction*') while continuing to improve the quality of the more traditional products ('*crop improvement*'). In the context of the project the term 'novel cut-flowers' is interpreted widely: it could include a species completely new to production horticulture, or might simply indicate a crop or cultivar with which UK growers or customers are unfamiliar at the present time.

Summary

Crop information

Trials are underpinned by the reports produced by the CFC including:-

- A database of firms supplying seeds and planting material for cut-flower production (updated in 2015)
- The report on research on new cut-flower crops and cut-flower trials programmes (also updated in 2015)
- A new report compiled on the statistics of production and trends in the cut-flower trade worldwide

This information would also be of value to growers planning their own new product development and are available from the AHDB Horticulture and CFC websites.

Crop improvement

Alstroemeria – garden cultivars (Alstroemeria cultivars)

Commercial alstroemeria cut-flower production involves contemporary, high-quality cultivars grown as glasshouse crops. The availability of Spanish tunnels, however, raises the possibility of growing a cheap, seasonal crop of the older, garden cultivars (to which no royalties are attached). A feasibility trial was set up in 2014 with cultivars 'Apollo', 'Avanti', 'Bonanza', 'Candy', 'Dana', 'Flaming Star', 'Friendship', 'Golden Delight', 'Nina', 'Orange Supreme', 'Pink Sensation' and 'Tanya' grown in a Spanish tunnel or outside beds. After the first short stems were discarded, marketable flowers were produced in the tunnel from week 31 onwards and outside from week 33. Under protection the plants were very vigorous, producing strong stems that some growers considered better than the typical glasshouse crop. The outside crop was poorer. Picking continued to week 43, when it was brought to an end to allow the tunnel to be de-skinned for winter.

After overwintering the tunnel crop started shooting once the tunnel was covered (week 17), yielding good, marketable stems from week 23 onwards; the outside crop started producing marketable stems from week 26. In round terms the tunnel crops produced twice the yield of outside crops in 2014, improving to three-times the yield in 2015, the productivity of the outside crops having fallen in its second year. Marketable flowers were still being produced when cropping ceased with the de-skinning of the tunnel (week 44). Overall, cultivar 'Nina' was most productive, with 259 and 331 marketable stems/m² in the tunnel in year 1 and 2, respectively, and corresponding figures of 131 and 191 in outside plots. However, tunnel-grown 'Flaming Star' and 'Friendship' both achieved 400 stems/m² in the second year. In the tunnel, 'Orange Supreme' produce low yields in both years, 130 and 203 stems/m², but other cultivars that

gave low yields in year 1 made up for this in year 2 ('Apollo' and 'Golden Delight'). Grown outside, 'Dana' was most productive, with 188 and 105 stems/m² in year 1 and 2, though 'Candy' in year 1 produced 162, and 'Tanya' in year 2, 149 stems/m². 'Apollo', 'Avanti', 'Flaming Star', 'Friendship', 'Golden Delight' and 'Orange Supreme' gave relatively poor stem yields outside, but still on the whole produced an acceptable number of stems overall. With this combination of 12 cultivars in tunnel and outside plots, the supply of flowers was reasonably consistent over a 5-month period – it would have been longer had it been feasible to leave the cover on the Spanish tunnel. A selection of cultivars was sampled for vase-life (VL) testing and gave a satisfactory average VL of 12 days. It appeared important to allow the flowers to show good colour before picking, as this made the product more attractive and did not appear to detract from its VL. This growing system appears to have good potential, and the productivity, VL and costings of the crop will be assessed again in 2016.

Aster, September-flowering (Aster ericoides cultivars)

Aster ericoides, mainly the single-flowered 'Monte Casino' type, is imported as a relatively cheap filler, but the introduction of new, double-flowering lines could open up a new market. Previous CFC trials in 2010–2012 demonstrated there was market interest in the double cultivars as a pinched crop flowering in Spanish tunnels in September and October. Growers expressed interest in the possibility of season extension. As a short-day plant, under long-days blacking-out *A. ericoides* for part of the day will advance floral initiation. The 2012 plantings of cultivars 'Blue Tail', 'Capetown', 'Cassandra', 'Cassy', 'Chicago', 'Cirina Dark', 'Double Fun Blue', 'Double Fun Pink Dark', 'Double Fun White', 'Linda' and 'Pretty Wendy' in the Spanish tunnel and outside were overwintered and the protected crop used in 2013 to investigate the use of blackout covers. The covers were placed over the plots overnight for 13 hours each day from week 22 (when stems were 60cm tall), and by week 31 this short-day treatment had produced plants with large buds nearly showing colour, so blacking-out was discontinued. Flower cropping was mainly in weeks 32-33, somewhat later and with longer stems than required, but otherwise its quality was superb. A second flush in early-November was too short to be marketable. In comparison, the outdoor crops gave a single flush over weeks 37-43. It was likely that better timing of the short-day treatment could have been achieved by starting it sooner.

In 2014 rooted cuttings of 'Cairo', 'Cape Town', 'Cassy' and 'Chicago' were pinched in week 16 and transplanted to a Spanish tunnel in week 18. The blackout treatment as above was started in week 25 (with stems 50cm tall) and stopped in week 30. In 'Cairo' and 'Cassy' the buds started to develop in week 30 and went on to produce high-quality stems with high yield and no premature budding. 'Cape Town' and 'Chicago', on the other hand, had earlier, premature bud development resulting in poorer quality and lower yield. Stems of all four

cultivars were sampled for VL testing and demonstrated an acceptable average VL of 8–9 days. After the first flush the plants under protection were cut-back hard, and a second flush grew well in all cultivars and was on the way to producing a marketable crop when the tunnel had to be de-skinned (week 43). For comparison, the outside plots (left from the 2012 planting) cropped around week 42. The tunnel crops were grown-on to 2015 with the intention of determining how early a short-day crop might be produced. The black-out treatment was started in week 22, 3 weeks earlier than before, but, because of the cold spring and early summer, the plants grew very slowly with many breaks: as a result the plants became unmanageable and the trial was halted.

It seems that trying to get two flushes per year of *A. ericoides* is pushing the crop to the limit in the restricted growing period available in a Spanish tunnel, although it would be achievable if growing under glass or perhaps in a fixed tunnel. It may be worth starting the plants in pots and transplanting pinched plants, with side-shoots already present, in order to reduce growing time. Because of Plant Breeders Rights the cost of this type of planting material is high, meaning production costs have to be kept to a minimum, and at present there is little take-up in the industry.

Brassica, ornamental (Brassica oleracea cultivars)

Several demonstrations and trials of ornamental brassicas have been carried out in earlier CFC trials (2008–2012) and grower interest continues to be high, despite uncertainties about some aspects of husbandry and which cultivars to grow. To address the latter issue for the high-quality protected crop, a range of cultivars was compared in 2015: 'Agathana', 'Anthonia', 'Bogdana', 'Bright Wine', 'Condor Early White', 'Condor Pure White', 'Crane Bicolour', 'Crane Queen', 'Crane Pink', 'Crane Red', 'Crane Rose', 'Crane White', 'First Lady', 'Galina', 'Katya', 'Ksenia', 'Kysia', 'Olga', 'Svetlana', 'Varvara' and 'Vera'. All plantings established well and grew-away with negligible losses. Only 'Kysia' failed to colour-up as required. Some cultivars produced heavier stems ('Bright Wine' and 'Olga') or lighter stems ('Bogdana', 'Crane Queen' and 'Katya') compared with the trial average, or larger heads ('Anthonia') or smaller heads ('Agathana', 'Crane White', 'Olga' and 'Varvara') than average. The heads were of a high quality, and a number of the less familiar cultivars showed real promise and generated market interest exceeding that of the more familiar 'Crane' series. The VL of the cultivars tested was between 10 and 17 days. Despite this, there is an impression that many growers and pack-houses would prefer to stay with the well-tried 'Crane' series until more experience with alternative cultivars has been obtained. To this end a select range of 'Crane' and other cultivars will be further investigated in 2016.

Eryngium (sea holly) (Eryngium cultivars)

With their spiky flower-heads and attractive colouration, sea hollies remain popular. Responding to grower requests, small demonstration plots of eryngium cultivars were grown at the CFC in 2007–2008, and in 2011 a selection of cultivars - 'Arabian Dawn', 'Blue Bell', 'Deep Blue', 'Magical Blue Falls', 'Magical Cloud', 'Magical Purple Falls' and 'Marbella' - was planted in a Spanish tunnel and outside to assess their potential as a crop for the UK. In the first years few marketable flowers were produced, while there have been on-going plant losses due to the cold winters of 2011/2012 and 2012/2013 and the wet summer/autumn of 2012. Samples gave an adequate VL of 7 days in standard testing, and stems shown to potential buyers evoked keen interest. By 2013 the tunnel-grown plants had become over-vigorous and were grubbed-up. In the outside plots many plants had not survived the winter. By this time the outstanding cultivars were 'Blue Bell' and 'Deep Blue', which appeared to be hardy and produced 56 and 113 stems/m², respectively, the other cultivars having plant survival rates between 43 and 69% and producing between 28 ('Marbella') and 88 ('Magical Purple Falls') stems/m². In 2013 necrotic, black spots appeared on the foliage of 'Arabian Dawn' and 'Marbella' and were identified as symptoms of *Alternaria*. Further VL testing confirmed the earlier result, with stems of 'Blue Bell', 'Magical Blue', 'Magical Cloud' and 'Marbella' all having an acceptable VL of 8 to 9 days. The stem yields recorded in 2015 showed that 'Arabian Dawn' had more than doubled its yield, to 93 stems/m² and that the yield of 'Deep Blue' had fallen slightly (to 94/m²); the yields of the other five cultivars had fallen to between 5 and 33/m². These figures reflect hardiness as well as flower production. The trial has provided growers with information on the performance and hardiness of a range of cultivars, and no further trials are planned, although the plots will be left down as a demonstration, new varieties being added as they become available.

Lily (Lilium cultivars)

Lilies remain hugely popular with UK customers and UK production of cut-flowers from imported bulbs has been very successful. To avoid the soil-borne pathogens common in glasshouse soil, lilies are generally grown in crates of growing medium. For many years peat has been used, so there is obviously interest from growers to discover suitable alternatives or diluents for peat, and trials of alternative substrates have been carried out by the CFC since 2013. In the first trial a selection of newer cultivars was assessed for the suitability of a green-waste substrate in two separate trials. Bulbs were grown in 100% peat, 100% green-waste or a 50:50 v/v mixture. Stems were longest when grown in peat, shorter in the mixture and shortest in green-waste, though the tallest and shortest average length for a cultivar varied by only 20 to 25cm. There were no differences in bud count between growing media. Apart from

the shortness of affected stems, quality was superb in all three media, and subsequently the work was scaled-up on a commercial site.

In 2014, in the first of two trials using cultivar 'Dynamite', bulbs were planted in 100% peat, 100% coir, 100% 'Forest Gold' (a wood-derived 'potting compost') or mixtures of peat with coir (50:50 v/v), with anaerobic digestate (80:20 and 60:40 v/v) or with re-cycled green-waste (50:50 v/v). There were insignificant differences in stem length and weight between the growing media. Growing in peat + anaerobic digestate mixes gave better leaf colour than growing in peat alone, while growing in peat + green-waste delayed picking by a week and gave some stunted stems with chlorotic leaves, slightly reducing the yield of marketable stems. In trial 2, 100% 'green compost' was substituted for 'Forest Gold' and the range of peat + anaerobic digestate mixes expanded (80:20, 60:40 and 40:60 v/v). As in trial 1 the differences between growing media in average stem length and weight were insignificant, there were no between-media differences in cropping date, and no visual differences between plants grown in different media.

In 2015 trials were conducted with cultivars 'Alma Ata' and 'Capistrano' planted in 100% peat, 100% coir, 100% anaerobic digestate and the mixes peat + anaerobic digestate (60:40, 40:60 and 20:80 v/v) and coir + anaerobic digestate (33:67 v/v). Plants grown in 100% anaerobic digestate were stunted, chlorotic and distorted and those from peat + anaerobic digestate (20:80 v/v) only marginally better. Lilies grown in anaerobic digestate + coir, despite making a good height, had chlorotic, mottled foliage. Plants grown in 100% peat, 100% coir or the 'weaker' mixes of peat + anaerobic digestate (40:60 and 60:40 v/v) were all normal and marketable. Stems were tallest grown in peat, significantly shorter in 100% anaerobic digestate and slightly shorter in the anaerobic digestate mixes. Stems were heaviest grown in peat + anaerobic digestate (40 and 60% anaerobic digestate) and lightest in 100% anaerobic digestate. There were some points of difference in the chemical analysis of the anaerobic digestate used each year. The nitrogen concentration of the 2014 sample was higher than in 2015, perhaps accounting for the better foliage colour in lilies grown in anaerobic digestate in 2014. The poorer performance of lilies in anaerobic digestate or anaerobic digestate-rich mixes may have been attributable to the high conductivities and pH of anaerobic digestate. In conclusion, green-waste or green-compost may have a role in lily growing, but would need to be of a more consistent quality. Anaerobic digestate appears suitable to use mixed with peat at up to 60% anaerobic digestate. Lilies also performed well when grown in 100% coir, which should also be considered as a peat alternative or diluent. Before growers adopt green-waste or anaerobic digestate as materials for growing lilies, more needs to be known of their analysis and standardisation.

Herbicide trials

Parts of an AHDB Horticulture project seeking alternative herbicide treatments, HNS PO 192a, was carried out at the CFC site, using drilled China asters, larkspur, sweet William and wallflowers. It was found that 'Stomp Aqua' + 'Gamit 36 CS', applied post-drilling, pre-emergence, was safe and effective for use on drilled China aster. This treatment could be followed up with a post-emergence application of 'Shark' if required. The tank-mix 'Stomp Aqua' + 'Goltix 70 CS' provided the best weed control and was the safest option in sweet William trials. In the drilled wallflower trial 'Butisan S', 'Gamit 36 CS' and 'Wing-P' at the lower rate appeared safe when applied at drilling. 'Wing-P' (at the lower rate) + 'Gamit 36 CS' also appeared to be safe on wallflowers as a tank-mix. 'Benfluralin' was safe as a pre-drilling incorporated treatment on wallflower and could be combined with some of the post-drilling treatments. The drilled larkspur trial proved challenging because of the slow emergence and growth of the crop, combined with phytotoxic effects from the herbicides used; nevertheless the trial gave some pointers to investigate in later trials. The full report, especially its information on the approval status of the herbicides mentioned, should be consulted before considering their use.

Crop introduction

Novel crops were introduced into the project in 2013 and 2014. Some of these proved unsuitable and have either been dropped from the programme or trials suspended until more suitable material is available. The reasons for rejecting or postponing further trialling included a short VL (basil, lupin, physostegia), lack of hardiness (lupin), difficulties in handling or scheduling for the UK (leonotis, ornamental pepper) and difficulties obtaining suitable materials or cultivars (gentian, bleeding heart).

Trials on carthamus, cosmos, trachelium and zinnia and a range of seed-raised fillers, and on new cultivars of pinks, delphinium and leucanthemum showed more potential.

Carthamus (Carthamus tinctorius cultivars)

Carthamus has attracted much attention as an unusual, thistle-like filler. A cultivar demonstration was carried out in 2014, with cultivars 'Kinko', 'Nemo' and 'Shiro' sown in outside beds (week 25) and in a Spanish tunnel (weeks 27 and 30). Germination was satisfactory and plants budded-up quickly, but subsequent development was slow. Picking dates from the first two sowings, weeks 25–27, covered weeks 35–37, with plants from the week 30 tunnel sowing failing to produce marketable stems before the tunnel was de-skinned in week 43. A second trial with the same cultivars was set up in 2015, starting with earlier sowing dates. Sowings over weeks 17 to 28 in the tunnel and in week 24 outside, the picking period covered weeks 29–40, while a later tunnel sowing, week 31, again failed to crop before de-skinning. Stem quality was spoiled by the brown-tipping of bracts and leaf mottling, which

also marred VL tests which otherwise showed an adequate VL of 7 days. *Carthamus* produces reliable, strong and sturdy stems that are now being used successfully in bouquet work. Maintaining bract quality is an issue that may need to be resolved at some point.

Cosmos (Cosmos bipinnatus cultivars)

Cosmos are well known garden plants, producing masses of bright flowers and feathery foliage. Some cultivars have given good results elsewhere as a cut-flower, and they could have potential as a 'short-season filler' in the UK. In 2013, 15 cultivars from the 'Razzmatazz', 'Sonata' and 'Sensation' series were demonstrated in tunnel and outside beds at the CFC. They were vigorous in growth – too vigorous and unmanageable in the tunnel – and flowered slowly and unevenly but, eventually, prolifically. In 2014 cultivars 'Double Click Cranberries', 'Fizzy Rose Picotee', 'Psyche White', 'Rubenza', 'Sensation Antiquity', 'Sensation Dazzler', 'Sensation Purity', 'Sonata Pink', 'Sonata Premium Mix' and 'Sonata White' were sown in weeks 21 and 25 in outside beds, and in weeks 27 and 30 in the tunnel. Again, despite a good start, flowers were slow to develop and flowering was uneven. The best performer was the 'Double Click' series grown in the tunnel, this cultivar also producing stems of substantial length and weight when grown outside. The picking period was week 30 to 41, though stems from the last sowing were too short to be marketable. The bunched stems were surprisingly substantial and there was considered to be scope for further development work that would need to address ways of improving VL (currently a very short 1 to 3 days).

In 2015 cosmos were sown in weeks 21 and 25 in outside beds and weeks 27 and 30 in a Spanish tunnel, primarily for providing material for VL testing. The cultivars grown were 'Antiquity', 'Candy Stripe', 'Double Click Cranberries', 'Fizzy Rose Picotee', 'Psyche White', 'Purity', 'Rubenza', 'Sensation Dazzler', 'Sonata White' and 'Sonata Pink'. Despite the flowers being slow and uneven in development, some growth was so vigorous as to result in lodging, but in the last sowing stems were too short to be marketable. Stem samples were harvested with two or three open flowers for VL tests in which the effects of three conditioning solutions were compared. Only stems treated with 'Chrysal RVB Clear Intensive' (1ml/L) achieved a VL of 5 days, the other conditioner being 'Chrysal CVBN' used at 1 tablet per 1 or 2L water. The differences between conditioner treatments suggests further work to improve VL may be worthwhile. The crop might also be improved via disbudding: the lead bud develops and opens some time before the subordinate buds, so it may be practical to remove the lead bud.

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

Delphinium have previously been trialled quite extensively at the CFC, but there is continuing 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 were

included in the programme in 2014. Tissue-culture derived plugs of the three cultivars were transplanted into a Spanish tunnel in week 22. They produced attractive flowers and were very productive, potentially giving three flushes in a year. The 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. Growing-on to the second year they produced dense growth and productive flushes in mid- to late-June and mid- to late-August with a weak flush on October. The information gained is known to have helped the industry to explore new cultivars, and while those tested received a positive response from the market they are unfortunately unlikely to command the price required to justify the purchase of expensive tissue-cultured plants.

Dianthus (pinks/carnations) – new cultivars (Dianthus cultivars)

Spray dianthus cultivars have previously been trialled extensively at the Centre, but in 2014 and 2015 some newer cultivars were available from HilverdaKooij and Whetman Pinks. Some were strikingly different to familiar types and were deemed worthy of growing in demonstration plots. Rooted cuttings, derived from tissue culture, were potted-on before transplanting to beds in a Spanish tunnel.

'Tiara Coral Pink' and 'Tiara Lilac' (Hilverdakooij) were planted in week 22, 2014. The plants were slow growing but produced strong stems. The central bud developed well before any others and needed to be pinched-out to preserve the remaining spray, though this was a tricky, labour-intensive task. The stems, however, were attractive and growers appreciated them, so they were left *in situ* for a second year, when both cultivars produced a good second-year flush. They appeared to be susceptible to thrips damage, with white flecking on the flowers, but once damage had been seen the interval between insecticide sprays was reduced, which controlled the problem effectively: it would probably be routinely required. Stems of 'Coral Pink' were sampled for VL testing and gave a just-acceptable VL of 7 days.

'Green Magma', 'Green Trick' and 'Green Wicky' (Hilverkooij) were planted week 20, 2015. These unusual green dianthus were in full flower by week 29, with the flowers holding for several weeks. They were considered a very good product. As with the 'Tiara' series, the issue is one of economics and obtaining a reasonable return for the high outlay.

'Cherry Daiquiri', 'Cosmopolitan', 'Mojito', 'Shirley Temple' and 'Tequila Sunrise' are new dianthus from Whetman Pinks. They were planted in week 24, 2015 and were in full flower in week 31. They need to be grown-on to a second year to assess their potential.

Fillers, seed-raised

Recent years have seen an increase in growers' interest in producing cheap, seed-raised fillers, either in tunnels or outside. A range of fillers was demonstrated in 2014–2015, namely *Ammi majus*, *A. visnaga*, *Anethum graveolens* (dill), *Anthriscus sylvestris* 'Ravenswing',

Bupleurum rotundiflorum 'Griffithii', *Euphorbia oblongata* and *Ridolfia segetum*. Following encouraging results in 2014, in the 2015 trial seed was sown directly into beds in a Spanish tunnel or outside in succession between weeks 17 and 31, except for anthriscus and euphorbia which were grown-on from the previous year's plots.

In the 2014 demonstration *Ammi visnaga* germination and plant growth were slow, and, perhaps due to the consequent wide spacings, the stems were too large and branching for use as a filler. 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). In the 2015 trial *A. visnaga* was slower to mature, probably due to the cold spring and early summer. It seems unlikely that two rounds could be produced annually by growing in a tunnel. However, *A. visnaga* may be a suitable filler for the larger bouquet. As an alternative, *A. majus* was tested in 2015. It too was slow growing, but produced marketable, more compact stems from the later sowings, indoors and out. *A. visnaga* should be drilled at a higher density to reduce plant size, or might be better raised from plugs. Both species had a long VL, 17 and 22 days, in VL tests conducted in 2015.

Dill (*Anethum graveolens*) was quick to germinate and fast growing in both years of the trial. In 2014 picking started in weeks 29, 32, 34 and 39 from week 21, 25, 27 and 30 sowings, respectively, and in 2015 the equivalent dates were weeks 32, 34 and 41 from week 24, 28 and 31 tunnel sowings. Dill produced some secondary stems after the main stems had been cut. Post-harvest tests showed that anethum had a consistently satisfactory VL of 11 days. There was substantial post-harvest stem extension (elongation by up to 90%) in VL tests carried out in 2014, and this should be followed-up in 2016 to see if post-harvest extension growth can be restricted.

In 2014 seed of *Anthriscus sylvestris* 'Ravenswing' failed to germinate following direct-drilling, and plugs were planted as replacements. The plugs established quickly but produced only a handful of flowers, and in outside plots they were seriously damaged by two-spotted spider mite. The plants were left *in situ* and produced a good crop in early-May 2015. Treating it as a perennial, it will be grown again in 2016,.

In both years *Bupleurum rotundiflorum* 'Griffithii' was slow to germinate and grow but eventually produced long, strong stems. Both years the tunnel crop had some plants with leaf scorch, which needs to be investigated - it may 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. There was renewed grower interest in bupleurum as it is easy to grow and pick, but regular production would require weekly sowings and seasonal extension is desirable.

In 2014 *Euphorbia oblongata* was slow to germinate and grow and produced stems too short for cutting. Part of the crop was kept and transplanted for observations in 2015. It produced a good flush of long stems in late-May to early-June and then continued steady production of shorter stems (40–50cm) through to autumn. The VL was a long 14 days. As the latex produced from the ends of cut stems might cause skin irritation, euphorbias might cause problems for workers and consumers - a risk assessment is needed. Further, it would be necessary to test euphorbia in mixed vases to determine whether its sap had any inimical effects on other cut-flowers.

Ridolfia segetum is similar to anethum but slower germinating and growing. In 2014 it 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. In 2015 stems from the week 24 sowings were ready to pick by week 35 from the outside sowing and by week 36 from the tunnel sowing. After cutting the main stem, secondary stems were produced. It was thought that anethum could be a better option.

Further work on these and other fillers is planned for 2016: improving establishment is one concern, so that they could be reliably scheduled over a relatively short period of continuity as a summer crop. The CFC has been asked to look at additional fillers in 2016: *Orlaya*, *Atriplex* and *Daucus*.

Leucanthemum (Leucanthemum x superbum cultivars)

This crop was included in 2014 to demonstrate a new range of cut-flower leucanthemum from Realflo. Pinched plants of cultivars 'Real Fancy', 'Real Fizzy' and 'Real Frilly', having many breaks, were transplanted to beds in a Spanish tunnel in week 17, 2014. They grew away well but 'Real Frilly' started to bud prematurely and then flowered on short stems. The plants were mulched with peat and over-wintered for further assessment, but there were >50% plant losses and flower stems were again short. These cultivars do not appear suitable for growing in a Spanish tunnel.

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. Plug-plants of 'Corine Purple' were transplanted to a Spanish tunnel, where they grew well and produced 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.

In 2014 plugs of 'Corine Purple' and of the 'Lake Michigan' series ('White', 'Blue' and 'Purple') were transplanted in weeks 22 and 27 to a Spanish tunnel. Initial growth appeared weak and budding-up occurred early, but the stems lengthened and strengthened and 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 after trimming between 23 and 32g. In testing they had an average VL of 8 to 9 days. Flowering continued well into September and October, though the later planting of 'Lake Michigan Purple' produced short stems. Trachelium again seemed 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 - with a warmer-than-usual summer - were not atypical.

In 2015 plug-plants of 'Lake Michigan' series 'Blue', 'Purple', 'White' and 'Wine Red' and of 'Lake Forrest' series 'Blue', 'Purple' and 'White' were transplanted in weeks 18, 22 and 25 into beds in a Spanish tunnel. Half the plants were pinched to four or five leaves 14 days after planting, the other half remaining intact. As in 2014 initial growth was weak and budding-up premature, though the plants strengthened later and produced large numbers of marketable stems. Stem length was satisfactory, varying only between 62 and 71cm in the different treatments. For three cultivars - 'Lake Forrest Purple', 'Lake Michigan Purple' and 'Lake Michigan White' - stems from single-stemmed plants were taller than their pinched equivalents, effects largely due to cultivar differences, the effect of pinching treatment being weak. Trimmed stem weight also varied little between the treatments (between 16 and 22g). The single-stem plants grew so vigorously as to produce at least one or two side-shoots. Overall, stem yields were quite variable, with mean numbers of marketable stems per plot of between 133 (for pinched 'Lake Forrest Blue') and 273 (for single-stem 'Lake Forrest White'). Single-stemmed plants gave significantly more stems than pinched plants, and cropped around 10 days before their pinched equivalents.

The potential for tunnel-raised tracheliums grown in the UK suggests that trials should be continued. It has been reported that the CFC product is seen as superior to imported stems in its appearance – it is much 'fresher'-looking with no browning of the flowers - and length; the imported product may have damaged the product's reputation. It would be worthwhile to compare a single-stem crop with one that has been pinched and counted down to three stems to see if all are marketable.

Zinnia (Zinnia elegans cultivars)

Unlike most species in the 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 as cut-flowers, so trials were put on hold until better cultivars became available. A very different conclusion had been reached in the USA, where some 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, with some interesting flower colours and forms 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 CFC. 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 7 days in the vase, despite testing 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, as the use of a 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 '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 4-day retail store phase. This seems to have been due to adverse effects of the cool chain resulting in the early dehydration of the flowers, suggesting zinnia as a good candidate for ambient-temperature direct-sales. Chrysal UK consultants have suggested there may be treatments that could avoid this damage and so VL was examined further in 2015.

In 2015 further 'Benary Giant' cultivars were grown to provide fresh-cut stems for a VL study commissioned by Chrysal UK with ADAS. The aim was to assess the effects of post-harvest conditioning treatments on VL once they had reached the final, consumer phase. Plugs of

'Benary Giant' cultivars 'Bright Pink', 'Carmine', 'Coral', 'Dahlia Mix', 'Deep Red', 'Gold Yellow', 'Lilac', 'Orange', 'Purple', 'Salmon Rose', 'Scarlet', 'White' and 'Wine' were transplanted to a Spanish tunnel in week 18. As in previous years the crop grew well, starting to produce marketable flowers by week 28. Stems of zinnia (mixed cultivars) were picked on 1 September 2015 (week 36), choosing equal numbers of stems with un-opened flowers, almost fully open flowers and flowers at an intermediate stage. They were cold-stored overnight in water with added conditioning solution, either 'Chrysal Clear RVB Clear Intensive' (1ml/L) or 'Chrysal Clear CVBN' (1 tablet/L or 1 tablet/2L) and transferred to water with added shipping treatment and kept in the VL room until 4 September when the test was set-up using a standard flower food. Overall they performed reasonably well, with most stems lasting beyond the guarantee day, day 5, but between vase-days 5 and 10 they failed quickly. Reasons for failing including botrytis in the bud, bending of the neck and, mainly, discolouration around the petal edges. Stems harvested at the early stage with apparently weak necks, appeared to become firmer in the neck rather than bending as had been expected. VL was not obviously shorter for the most advanced stems, compared with those cropped at earlier stages. This suggested that the bending of the neck occurs when stems are picked at an over-mature stage, and that otherwise the developmental stage at picking is of little importance. No consistent differences were found between the three conditioning treatments, though there were large differences in VL between cultivars, between 6.3 and 9.9 days. Further post-harvest studies will be undertaken in 2016 when access to a new VL test facility should be available.

Summary of the Centre's work

The Centre continues to develop its role as an information hub and cohesive voice for the UK cut-flower industry, as demonstrated by the high turnout at the Open Days in August 2014 and 2015. The CFC has been successful in developing benefits over and above the core AHDB Horticulture-funded project by facilitating and hosting AHDB Horticulture-funded herbicide trials, undertaking trials looking at alternative growing media for boxed lilies (partially funded by Bulrush Horticulture) and developing a standalone AHDB Horticulture-funded trial to investigate the hydroponic production of cut-flowers.

Over recent years a number of crops trialled at the Centre have attracted enough attention for commercial production to be started, including sedum, hardy foliage, antirrhinum, bupleurum and lisianthus. A number of crops from the 2015 trials are generating market interest too, including direct-seeded fillers, seasonal alstroemeria, trachelium and 'alternative' varieties of ornamental brassicas, all of which will be the subject of further trials in 2016.

Financial Benefits

Anecdotal evidence has indicated that a number of crops has 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, *Symphoricarpos* (snowberries) and spirea. 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 1.0ha with a farm-gate value of £115,000; the value was similar in 2014 and 2015.
- Lisianthus: amount extra grown in 2013 approximately 0.5ha with a farm-gate value of £70,000; in 2014 the estimate was approximately 1.0ha with a farm-gate value of about £140,000. The figure for 2015 is thought to be similar to 2014.
- Hardy perennials: amount extra grown in 2013 approximately 2.5ha 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 3.5ha with a farm-gate value of about £109,000. This crop continues to expand and is now probably close to 5.5ha, but as much of this is new plantings it will at present have a farm-gate value similar to 2013, i.e. £78,000 per ha, making a total value of around £429,000 in 2015.

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 €90 per 1,000 (dependent on variety) plus delivery.
- Hardy perennials, using *Symphoricarpos* (snowberries) as an example: planting density around 1.3/m², 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 or two additional side-shoots; the plant cost is approximately €70 per 1,000 plus delivery.

Action Points

- Tunnel-grown trachelium cultivars have continued to show their worth and should be considered as a potential UK crop.
- As economic, direct-drilled fillers, *Ammi visnaga*, *Ammi majus*, *Anethum graveolens* (dill) and *Bupleurum rotundiflorum* showed promise as vigorous tunnel or outside crops. Cartamus cultivars could be used in a similar way.
- Garden cultivars of alstroemeria performed well and could be considered as a natural-season tunnel crop and have the advantage of lower plant costs compared with varieties still protected by plant breeders' rights.
- *Aster ericoides* cultivars 'Cairo' and 'Cassy' responded to summer blackout treatment with earlier floral initiation, going on to produce two flushes. The second flush was too late for cropping from a Spanish tunnel, but growing in a permanent tunnel or cold glasshouse should be effective.
- Alternative growing media trials of tunnel-grown, crated lilies showed that flowers of equal or better quality to those grown in peat could be obtained using 100% coir, 100% 'Forest Gold' (a wood-derived potting compost), peat + coir (50:50) or peat + anaerobic digestate (80:20, 60:40 or 40:60). Growers should consider adopting these materials in place of peat or as a peat diluent. Care should be exercised using green-waste/green compost materials because of possible variations in composition. Care should be exercised in adding large amounts of anaerobic digestate to peat because more needs to be known of the nutrient composition of anaerobic digestate.
- Cultivars of ornamental brassicas that could challenge the familiar 'Crane' series have been grown as a tunnel crop, and should be considered by growers.