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Project leader:	Lyndon Mason (Director, The Cut Flower Centre Ltd)
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The results and conclusions in this report are based on investigations conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

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

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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 (Alstromeria 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/m^2 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/m^2 in the second year. In the tunnel, 'Orange Supreme' produce low yields in both years, 130 and 203 stems/m^2, 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/m^2 in year 1 and 2, though ‘Candy’ in year 1 produced 162, and ‘Tanya’ in year 2, 149 stems/m^2. ‘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/m^2, respectively, the other cultivars having plant survival rates between 43 and 69% and producing between 28 ('Marbella') and 88 ('Magical Purple Falls') stems/m^2. 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/m^2 and that the yield of 'Deep Blue' had fallen slightly (to 94/m^2); the yields of the other five cultivars had fallen to between 5 and 33/m^2. 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 for 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, *g*reen-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* × *superbum* cultivars)

This crop was included in 2014 to demonstrate a new range of cut-flower leucanthemum from Realflor. 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/m^2 for 'Corine Purple' to 158/m^2 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/m^2 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/m^2 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/m^2, 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/m^2 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.

SCIENCE SECTION

Introduction

The cut-flower trials programme described in this series of reports was set up in response to increasing *per capita* purchases of cut-flowers in the UK. This might have been expected to stimulate production by UK growers, but has instead resulted in greatly increased imports, while UK production remained more or less static. These issues were described in greater detail in earlier project reports.[1]

The practical aim of the programme is to provide (a) improvements in the growing of established cut-flower crops, and (b) information to encourage the introduction and production of new or alternative cut-flower products, primarily grown in Spanish tunnels or outdoors. The underlying aim is to stimulate UK cut-flower growers to develop and commercialise new and alternative cut-flowers for the benefit of consumers and producers. In the project the term 'new crops' is interpreted very widely – it could include a species completely new to production horticulture, or may simply indicate a crop with which UK growers are currently unfamiliar or for which improvements to husbandry or quality are needed. The types of trial carried out are varied and depend on the present understanding of a particular crop, and include (a) simple demonstration plots, (b) cultivar trials, (c) trials to develop a production protocol, (d) trouble-shooting experiments, (e) larger-scale commercial evaluations and (f) collaborative R&D on themes identified by AHDB Horticulture. As well as carrying out practical trials, the programme includes information gathering and technology transfer roles and a remit to identify gaps in knowledge and encourage the submission of concept notes to address them.

This report describes the work carried out in 2015, the third year of project PO BOF 002a. It gives a brief review of the information gathering work (fully described elsewhere), detailed reports of the 2015 trials (with summaries of previous CFC trials) and an inventory of technology transfer activities. An index to the cut-flowers trialled by the CFC since 2007 is included at the end of this report.

As often stated, the Project Leader and Management Group (MG) would welcome comments and suggestions from growers and the industry at large for future projects.

[1] The cut-flower trials project was proposed by industry representatives and funded by the HDC (now AHDB Horticulture) starting in 2007. The initial project (PC/BOF 268, 2007-2008) was jointly funded by the HDC and the Lincolnshire Fenlands LEADER+ programme. This was followed by projects PC/BOF 268a (2009), PC BOF 002 (2010-2012) and, currently, PC BOF 002a (2013-2017). Copies of earlier project reports are available from both the CFC and the AHDB Horticulture websites.

Crop information

Gathering information about cut-flower crops made use of both Internet sources and CABI's '*Horticultural Abstracts*' ('*HA*') database, a compilation of all significant research on horticultural crops worldwide. The information was summarised into the databases and reviews listed below, which are available from the AHDB Horticulture and CFC websites.

Database of seed and planting material suppliers

A database of companies supplying seeds and planting material for cut-flower production was compiled in 2013 using Internet and other resources. It was up-dated in 2015.

Review of new cut-flower crops and 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. Also included are reviews of overseas cut-flower trials, and internet sources of information for growers. The initial (2013) review was updated in 2015.

Production levels and trends in the cut-flower trade

International statistics on the world production and trade in cut-flowers was reviewed in 2015. The main source of information used is the annual *International Statistics, Plants and Flowers* from AIPH.

Experimental programme: Materials and Methods

Demonstrations, trials, experiments and commercial evaluations

As in previous years, the 2015 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. Several 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 are given in the 'Results' section, only the more general methods being described in this section. As appropriate to the practical nature of the project, demonstration plots were not usually replicated, but in other cases appropriate replication and randomisation were used where practicable.

Protocols and facilities at the Centre

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 constituted as The Cut Flower Centre Ltd with project leader Lyndon Mason as Director; it is managed by a Management Group (MG) comprising representatives of growers, packers, retailers and the AHDB Horticulture. The programme is formulated each year by the MG, taking into account comments received from growers and others through the year.

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

The facility at Rookery Farm, Holbeach St John, Spalding, Lincolnshire comprises a single-span 'Haygrove' tunnel[2] (7.9m wide × 38.1m long), a triple-span 'Pro-Tech' tunnel[3] (overall 22.7m wide × 38.0m long) and an adjacent area of outdoor beds of 600m^2. The growing area is provided with anti-rabbit fencing. Since it is an exposed site, wind-breaks of 2.5m-high polypropylene netting are provided at each end of the 'Pro-Tech' tunnel. The polythene covers

[2] http://www.Haygrove.co.uk/
[3] http://www.Pro-Tech-marketing.co.uk/

are removed for the winter in late-October in order to protect the structures; in some cases this will have brought crops to a forced end. Typical of the area, the soil is deep alluvium drained by ditches and pumps.[4]

Site preparation

The growing areas were sterilised as required by the year's trials programme. For the 2015 season the 'Haygrove' tunnel and 'Pro-Tech' tunnel bays 2 and 3 were sterilised with Basamid on 20 October 2014 and the polythene sheets left down until the next April. 'Pro-Tech' tunnel bay 1 remained planted with perennials.

Each year in April soil samples were taken across the trials site for standard glasshouse soil analysis. 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. In April 2015 100g/m^2 sulphate of potash was applied to all beds, and additionally 30g/m^2 'Nitram' (ammonium nitrate) to the outside beds.

Plant material

Most plants were obtained as plug-plants or seeds, some as rooted or un-rooted cuttings, liners or bulbs. Seeds were either germinated in plugs and transplanted, or direct-drilled. Details, and any special treatments, are described under 'Results'.

Crop husbandry – planting

Most plants were transplanted into labelled plots along the 1m-wide beds at the specified density. Individual plot lengths were dependent on the trial, and wherever practical 0.5m-long unplanted 'guard areas' were left between plots and at the ends of the beds, to guard against shading and 'end effects'. Up to and including 2014, the beds were generally covered with 1.2m-wide, 120-gauge, micro-perforated black polythene film and planting was through the film, otherwise planting was directly into the border soil. In 2015 planting was made directly into the border soil, little advantage being seen in using a film mulch in this context. Crops were watered with a hand-lance immediately after planting and then to ensure establishment. More details and any exceptions are given under 'Results'.

Crop husbandry – post-planting

Once plants were established most water was applied as needed through the lay-flat irrigation lines, though if required a hand-lance would also be used. 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

[4] *Soils of England and Wales*, Soil Survey of England and Wales

N:P:K:MgO with trace elements; Everris International). Beds were provided with one or more layers of support netting if required by the crop, the netting being raised with the growth of the crop. In some cases side-support wires were also provided because of the crop's vigour (*A. ericoides*). Sometimes plants were stopped (pinched) or other treatments were applied, and details are given under 'Results'.

Pesticide applications

The pesticides applied in 2015 were as detailed below.

- For powdery mildew, sulphur (as 'Thiovit Jet') to all asters and delphiniums, weeks 18 and 25
- For powdery mildew, myclobutanil (as 'Systhane 20EW') to all asters and delphiniums, weeks 21 and 27
- For powdery mildew, cyflufenamid (as 'Takumi 5C') to all asters and delphiniums, week 24
- For aphid, pymetrozine (as 'Chess WG') to all asters and delphiniums, week 24
- For thrips, spinosad (as 'Tracer') to all chrysanthemums and trachelium, week 26
- For greenfly, pymetrozine (as 'Chess WG') to all zinnias, week 27
- For pests, cypermethrin (as 'Permasect C') to wallflowers, weeks 31, 33 and 34
- For pests, cypermethrin (as 'Toppel 100 EC') to all brassicas and zinnias, weeks 33 and 35
- For growth regulation, daminozide (as 'B-Nine SG') to tunnel-grown zinnias, weeks 33 and 34
- For pests, spirotetramat (as 'Movento') to all brassicas and zinnias and outdoor crops, week 33
- For foliar diseases, azoxystrobin (as 'Amistar)' to brassicas, week 41

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 m^2), 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 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 2015 the trials on growing media for lilies were carried out at EM Cole (Farms), West Pinchbeck, Spalding, Lincolnshire and Smith & Munson, Gedney, Spalding, Lincolnshire.

Vase-life testing

Vase-life (VL) testing is an essential component of any cut-flower trials programme. There is a shortage of test facilities and the CFC has been unable to use a single, dedicated VL room, so the facilities and protocols have varied over time. Typically, VL testing includes some simulation of the treatment and storage of the cut-stems in the production, transport, storage and retail phase, ending with the actual VL tests under simulated domestic conditions. The VL quoted refers to the number of days in the vase only, not including the preparatory stages. Assessment involves determining not only the longevity of the product in an acceptable state, but also flower and leaf quality throughout VL, the clarity of vase water, and the 'throw-out' criteria. The conditions for the VL test have generally become standardised at 20°C under lighting of 1,000lux for 12h/day; many other factors are also important, including how the stems are cut/re-cut, the cleanliness of the vases, and water quality.

In 2015 VL tests on zinnia and cosmos were arranged by Chrysal UK and carried out at ADAS Boxworth. Because methods varied between tests, specific details are given under the individual crops. Other VL tests in 2015 – on ornamental brassica, ammi, euphorbia, dill and trachelium - were carried out by Jayne Winter (Superflora UK). Stems were picked into water and delivered to the depot where they were placed in water with added 'Chrysal Clear New Generation Professional 2 T bags'. After being held for 5d in a cold store to simulate the storage and transport phase, they were then transferred to vases containing water with a universal flower food and placed in the VL room. There were generally two replicate vases and five to ten stems in each vase. The VL, until half of the flowers in a vase had failed, was recorded.

Experimental programme: Results

In describing the results, the trials involving *Crop Improvement* – 'new ways with old crops' - are described first, followed by trials involving *Crop Introduction* – 'novel crops for the UK'. Within these sections the crops are described in alphabetical order.

Crop improvement

Alstroemeria – garden cultivars (Alstroemeria cultivars)

Alstroemeria, more familiar as a glasshouse crop using modern high-quality cultivars, had not previously been included in the Centre's work. But the availability of Spanish tunnels raises the possibility of growing a cheap, seasonal crop, and the more so if older cultivars - with no royalties attached - could be used. A feasibility trial was set up in 2014 and will be grown through to 2016 (**Error! Reference source not found.**).

Table 1. Details of 2014–2016 alstroemeria garden cultivars feasibility study

Site	Rookery Farm, in beds in 'Pro-Tech' tunnel bay 1 and outside
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, 2014 (tunnel) Week 23, 2014 (outside)
Plant spacing(s)	5/m^2
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
Post-planting treatment(s)	One layer of support netting in 2014, increased to three layers in 2015 Weak or short stems initially removed to encourage stronger growth Removed flower-heads until stems started to reach specification (60cm-long)
Pests, diseases and disorders	None evident
Picking stage(s) and market specification(s)	Buds just starting to show colour Stem length 60cm
Picking and recording date(s)	2014: week 30 to week 44 (in tunnel) or week 45 (outside) 2015: in tunnel week 23 to week 44 when the tunnel was de-skinned (still cropping); outside, week 26 to week 41 Picking half-weekly, weekly or fortnightly according to the state of the crop
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 of 2014 (tested by Butters Group)

Plant establishment in 2014 was very good. As the first stems produced were short, they were cut and discarded until marketable flowers were produced in week 31 in the tunnel (Figure 1). Outside, stems were slow to get going and the first stems were picked in week 33. Plants were very vigorous under protection, producing good, strong stems that some visiting growers thought were better than glasshouse crops, while outside stems were not as numerous (Figure 2). In both the tunnel and outside picking continued to weeks 43 when picking was brought to an end to allow the tunnel to be de-skinned.

Figure 1. 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 2. Alstroemeria garden cultivars trial: left and middle, tunnel-grown plots; right, outside plots (all on 7 August 2014, week 32)

The tunnel crop overwintered well, and started to produce shoots as soon as the tunnel was covered in week 17. Growth was slower and poorer in the outside crops. In 2015 stem quality was good, especially in the tunnel-grown plots. Yields and harvesting periods are summarised

for both years in Table 1. In 2015 the yield from outside beds fell slightly compared with 2014; in round terms tunnel-grown crops produced about twice the yield of outside beds in 2014 and this improved to over three-times the yield in 2015. There were marked differences between cultivars in performance: overall 'Nina' was the highest yielder, followed by 'Dana', the latter cultivar doing particularly well in the first crop year and in outside beds. 'Tanya' produced high yields in 2015, and 'Friendship' in the tunnel. Some cultivars consistently gave relatively low yields, notably 'Apollo', 'Bonanza', 'Golden Delight' and 'Orange Supreme'.

In 2014 marketable stems were picked from the tunnels starting week 31, but they were earlier in 2015, from week 23 onwards. Outside, picking began later, week 33 in 2014 and week 26 in 2015. In both years marketable flowers were still being produced when cropping ceased with the de-skinning of the tunnels in week 43 or 44.

Table 1. Stem yields and picking dates for 12 alstroemeria cultivars grown 2014–2015 in tunnel or outside beds

Measurement and cultivar	Tunnel		Outside		Overall total
	2014	2015	2014	2015	
Total marketable stems/m^2					
Apollo	113	327	42	65	547
Avanti	204	296	73	81	654
Bonanza	224	162	154	47	587
Candy	201	276	162	108	747
Dana	218	315	188	105	825
Flaming Star	151	400	57	58	666
Friendship	215	400	82	52	748
Golden Delight	117	351	29	95	592
Nina	259	331	131	191	911
Orange Supreme	130	203	49	53	435
Pink Sensation	187	278	120	35	619
Tanya	210	343	103	149	804
Average of above	185	307	99	87	678
Picking period (week no.)					
from	31	23–26	33–34	26–28	
to	44	44	45	41	

Profiles of flower picking are given in Figure 3 (totals across all cultivars) and Figure 4 (for individual cultivars). With the combination of 12 cultivars in tunnel and outside plots, the supply of flowers was remarkably consistent and occurred over a long, 5-month period (which would have been longer had the cover been left on). In the year of planting there was a slow build-

up of flowers, with most cropping in the second half of the season, while in the second year the build-up to the main picking period was rapid. Most cultivars appeared to crop over the whole cropping period to some extent (Figure 4). The plots are illustrated in Figure 5 and Figure 6.

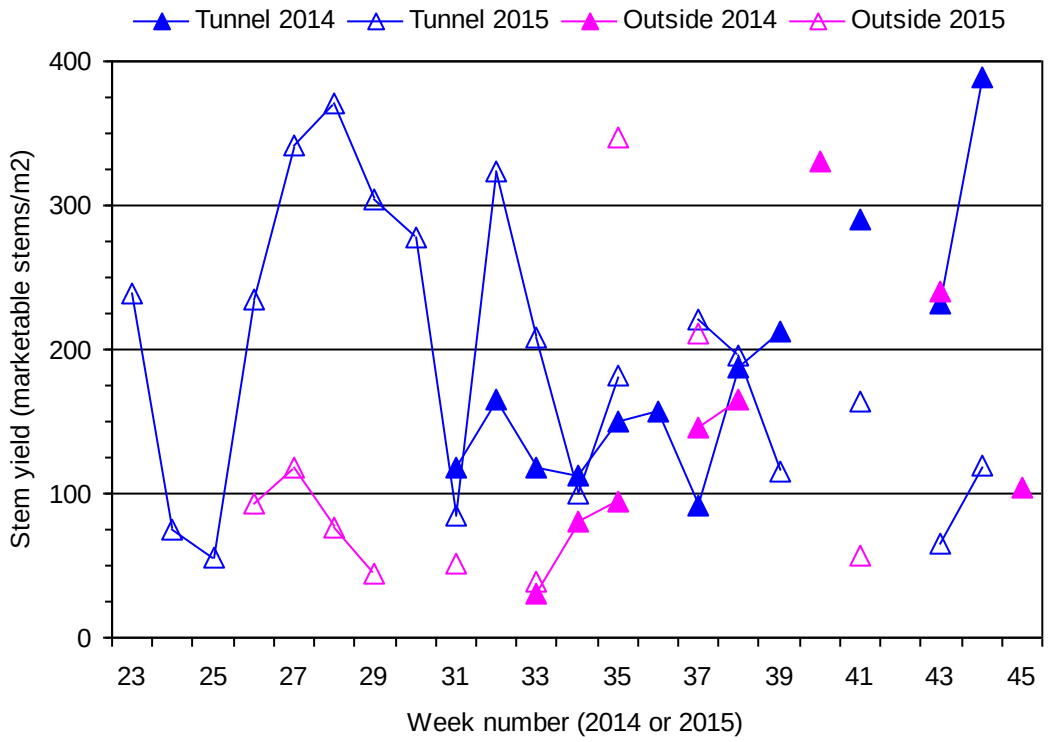

Figure 3. Total weekly stem yield across 12 alstroemeria cultivars (1m^2 of each) grown in a tunnel and outside in 2014 and 2015

In 2014 stems of eight cultivars were sampled for VL testing. It appears to be important to allow the flowers to show good colour before picking, as this makes them much more attractive and does not appear to shorten their VL. 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.

Growing older cultivars in Spanish tunnels appears to have strong potential, though the economics of the crop will be crucial. Further data will be collected in the crop's third year.

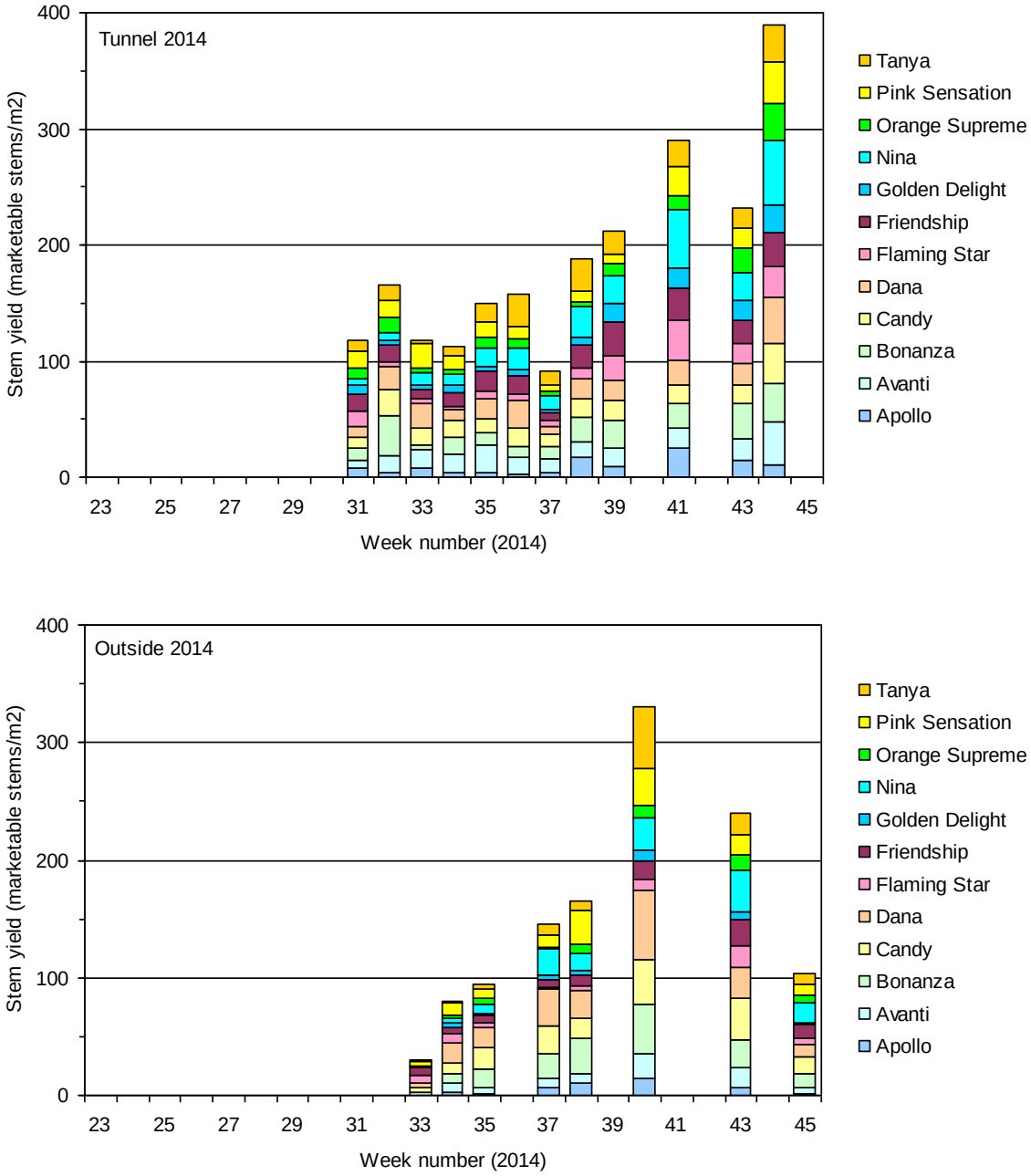

Figure 4. Weekly stem yields of alstroemeria cultivars (1m^2 of each) grown in (above) a tunnel and (bottom) outside in (this page) 2014 and (next page) 2015 (weeks with zero flowers recorded were due to picking being deferred in weeks when flowers were sparse; all x-axes drawn to same scale to aid comparison of time-lines) **Continued on next page**

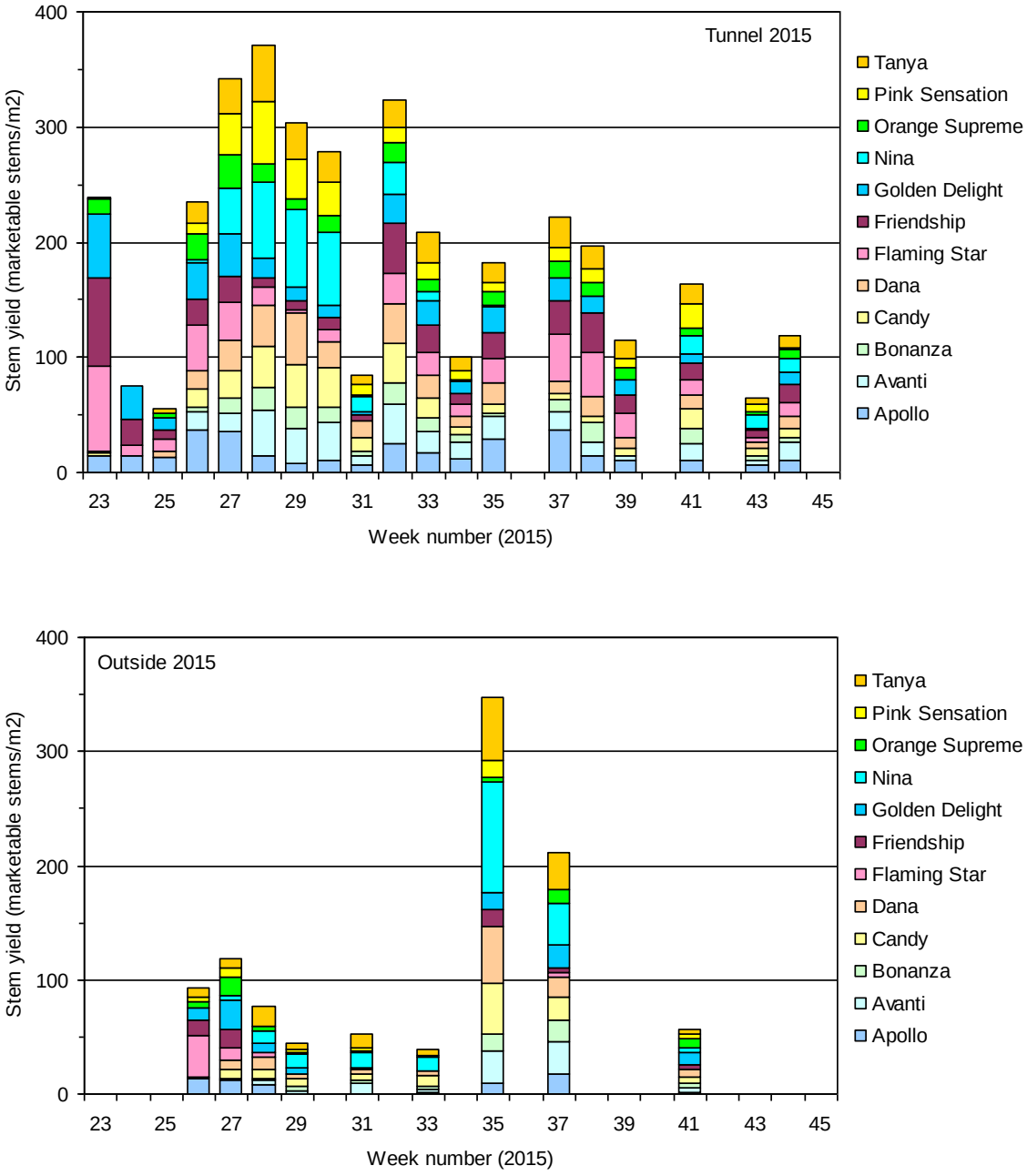

Figure 4 (continued). Weekly stem yields of alstroemeria cultivars (1m^2 of each) grown in (above) a tunnel and (below) outside in (previous page) 2014 and (this page) 2015

Figure 5 (next three pages). The 12 tunnel-grown cultivars from the alstroemeria garden varieties trial, photographed on 8 October 2015 (week 41)

‘Apollo’

‘Avanti’

‘Bonanza’

‘Candy’

‘Dana’

‘Flaming Star’

‘Friendship’

‘Golden Delight’

‘Nina’

‘Orange Supreme’

‘Pink Sensation’

‘Tanya’

Figure 6. The outside beds of alstroemeria garden varieties trial photographed on 25 September 2015 (week 39)

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 Plant Breeders Rights the high cost of planting material would mean production costs would have to be kept low.

Previous trials. Trials 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 (SD) 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 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 13h/d. By week 31 this SD 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.

2014–2015 trial. In 2014 a further blackout experiment was carried out. The blackout was applied at an earlier stage of growth than in the previous year, when stems were 50cm-tall (week 25) (Table 2).

Table 2. Details of 2014–2015 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, 2014) Potted to 1L-pots (week 14, 2014) Pinched (in the pot) (week 16, 2014) The plants from the 2012 planting outside were maintained for use as natural-season comparisons.
Planting or sowing	Transplanted
Planting or sowing date(s)	Week 18, 2014
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 in 2014 and week 22 to week 28 in 2015 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
Picking and recording date(s)	In 2014, week 32, except 'Cassy' (week 33) Not suitable for picking in 2015 (see text)
Records taken	Picking dates Number of marketable stems (in 2014)
VL testing	Sampled week 32 in 2014 (tested by Butters Group)

In 2014 the plants were already breaking when the black-out treatment was due to begin. Plant establishment was good in ‘Cairo’ and ‘Cassy’, with buds starting to develop in week 30 when the blackout was removed (week 30) and resulting in high quality stems with no premature budding and high yields (Figure 7 and Table **3**). However, in ‘Cape Town’ and ‘Chicago’ bud development had occurred about a month earlier, with much premature budding and consequently 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 8.

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

Stems of the four cultivars from the blackout trial in 2014 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; the condition of the foliage remained good.

Table 3. 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)				

A commercial aster grower requested that the 2014 planting be left *in situ* for another year to see how early a blacked-out crop can be produced. The black-out treatment was started in week 22, 3 weeks earlier than before. However, because of the cold spring and early summer, the plants grew very slowly and with a very large number of breaks which should, in retrospect, have been thinned. As a result the plants were more-or-less unmanageable and the trial was stopped.

These trials showed that blackout covers could be used in summer to advance floral initiation in some cultivars, thereby giving two flushes a year. However, to harvest the second flush – in October – the crop would need to be grown in a permanent tunnel or in cold glass. Samples taken to potential customers have been well received.

Given some market interest, it may be worth looking at starting the plants in pots and planting pinched plants with side-shoots already present in order to reduce the growing time, but at present there is little take-up in the industry.

Figure 8. *Aster ericoides* planted in 2012 and flowering in 2014 in the natural season (17 October 2014, week 42

Brassicas, ornamental (Brassica cultivars)

Although several demonstrations and trials of ornamental brassicas were carried out in earlier CFC projects between 2008 and 2012, grower interest in the crop continues to be high - despite uncertainties about some aspects of husbandry and the best cultivars to grow. To address the latter issue for the protected crop, in 2015 a wide range of cultivars was sourced from the main propagators and compared. Details of the demonstration are given in Table **4**, while Figure 9 illustrates the growing crop.

Table 4. Details of 2015 ornamental brassica cultivar demonstration

Site	Rookery Farm
Varieties	'Agathana', 'Anthonia', 'Bright Wine', 'Condor Early White', 'Condor Pure White', 'Crane Bicolour', 'Crane Queen', 'Crane Pink', 'Crane Red', 'Crane Rose', 'Crane White', 'First Lady', 'Ksenia', 'Kysia' and 'Varvara' (Florensis) 'Agathana', 'Bogdana', 'Condor Early White', 'Condor Pure White', 'Crane Bicolor', 'Crane Red', 'Crane Rose', 'Crane White', 'Galina', 'Katya', 'Olga', 'Svetlana' and 'Vera' (Noordam)
Format(s) and supplier(s)	Plug-plants (Florensis and Noordam)
Propagation and pre-planting treatment(s)	None
Planting or sowing	Transplanted
Planting or sowing date(s)	Noordam plugs: week 29 Florensis plugs: week 30 except 'Bright Wine', 'Ksenia', 'Kysia' and 'Varvara' planted week 31 (late delivery)
Plant spacing(s)	64/m^2
Layout	Duplicate 1.5m-long plots in separate beds
Post-planting treatment(s)	One layer of support net provided
Planting/housing site(s)	Beds in 'Haygrove' tunnel
Pests, diseases and disorders	Plugs received week 31 were leggy but grew away without problems Some mild leaf-spot noted
Picking stage(s) and market specification(s)	Heart developed and coloured-up, stem length 60cm
Picking and recording date(s)	Week 42
Records taken	Stem weight after trimming to 60cm-length, and head diameter, for random sample of ten stems per cultivar
VL testing	Samples of 'Condor Early White' and 'Katya' were taken on 12 October 2015 for testing (tested by SuperFlora UK)

Figure 9. Views of the 2015 brassica demonstration at (left to right) growing crop, 8 August (week 32); colouring-up, 18 September (week 38); harvesting, 12 October (week 42)

All plantings established well and grew-away with negligible losses. 'Kysia' heads failed to show any signs of colouring-up and were not cropped. Average trimmed stem weights and head sizes are given in Table 5. As can be seen, some cultivars produced heavier ('Bright Wine' and 'Olga') or lighter ('Bogdana', 'Crane Queen' and 'Katya') stems than the norm, or larger ('Anthonia') or smaller ('Agathana', 'Crane White', 'Olga' and 'Varvara') heads than the norm. Overall, the heads were of 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 (Figure 10). Samples of 'Katya' and 'Condor Early White' were taken for VL testing and gave very good results – VL of 10 and 17d, respectively.

Numerous samples from the trial were sent to potential customers and growers and some of the less familiar cultivars clearly impressed. However, there is an impression that many would prefer to stick with the well-tried 'Crane' series until more experience with the alternative cultivars has been gained. Alternative cultivars appear to need more exposure in the industry before they are adopted – it is still 'early days'. The new cultivars will need to show clear, economic advantages. 'Crane' cultivars do not always colour–up in mild weather, as found in some commercial crops in 2015, and this is an important factor in assessing alternative cultivars. It would not be surprising if different cultivars possessed different cold requirements. In the 2015 trial some of the newer cultivars produced lighter or smaller heads (others might be considered too heavy or large), which suggests manipulation via changing planting density. Growers are keen to see further demonstrations of newer cultivars alongside established types, and to see how well new cultivars perform in the open. Further work on some of these topics will be carried out in 2016

Table 5. Trimmed weights and head diameters for brassicas in the 2015 cultivars demonstration; figures are means, standard deviations (SD) and range of values

	Trimmed weight (g)		Head diameter (cm)	
	Mean (SD)	Range	Mean (SD)	Range
Agathana	118.1 (29.93)	66-163	9.2 (0.63)	8-10
Anthonia	117.6 (34.63)	78-170	12.5 (1.84)	9-15
Bogdana	103.8 (32.69)	64-171	10.0 (0.67)	9-11
Bright Wine	160.4 (30.19)	119-203	10.6 (0.52)	10-11
Condor Early White	135.3 (43.56)	83-203	10.2 (0.92)	9-12
Crane Bicolour	130.5 (26.53)	83-171	11.1 (0.74)	10-12
Crane Pink	139.5 (18.73)	115-165	10.8 (0.79)	10-12
Crane Queen	106.3 (17.46)	81-135	10.5 (0.53)	10-11
Crane Red	140.5 (19.78)	112-183	11.3 (0.48)	11-12
Crane Rose	140.6 (22.79)	107-177	10.4 (0.52)	10-11
Crane White	124.0 (20.97)	97-167	9.9 (0.57)	9-11
First Lady	124.7 (30.94)	87-189	10.6 (0.52)	10-11

Katya	93.8 (20.96)	73-126	10.5 (0.53)	10-11
Ksenia	111.8 (12.89)	83-126	11.0 (0.00)	11-11
Kysia[1]	-	-	-	-
Olga	157.0 (23.53)	113-194	9.9 (1.10)	8-12
Svetlana	151.3 (23.97)	98-185	10.1 (0.57)	9-11
Varvara	142.5 (34.71)	80-200	9.9 (0.32)	9-10
Vera	153.4 (28.07)	119-203	11.0 (0.67)	10-12
Overall means	130.6		10.5	
[1] Not recorded, heads failed to colour-up				

.

← ‘Agathana’

→ ‘Anthonia’

← ‘Bogdana’

→ ‘Bright Wine’

← ‘Condor Early White’

→ ‘Condor Pure White’

← ‘Crane Bicolour’

→ ‘Crane Pink’

← ‘Crane Queen’

→ ‘Crane Red’

← ‘Crane Rose’

→ ‘Crane White’

← ‘First Lady’

→ ‘Galina’

← ‘Katya’

→ ‘Ksenia’

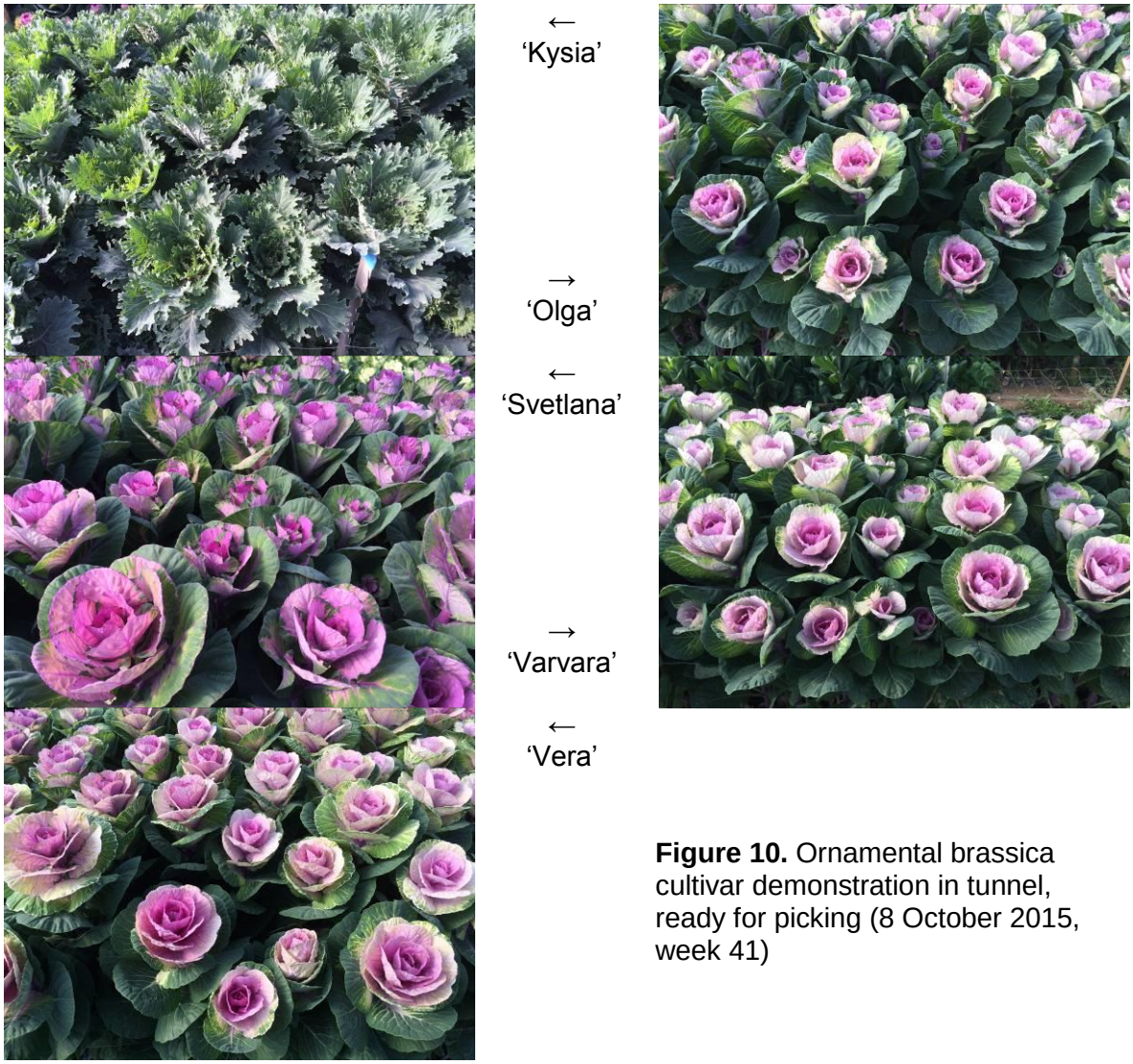

Figure 10. Ornamental brassica cultivar demonstration in tunnel, ready for picking (8 October 2015, week 41)

Eryngium (sea holly) (Eryngium cultivars)

Responding to grower requests, small demonstration plots of eryngium cultivars were grown at the Centre in 2007 and 2008. In 2011 plug-plants of a selection of cultivars - 'Arabian Dawn', 'Blue Bell', 'Deep Blue', 'Magical Blue Falls', 'Magical Cloud', 'Magical Purple Falls' and 'Marbella' - was planted at 12/m^2 in *ca* 3m-long plots in a tunnel and outside to assess their potential as a crop for the UK. Few marketable flowers were produced in their first year, but more in the second (2012), despite some plant losses due to a cold winter 2011/2012 and wet weather summer/autumn 2012. Samples gave an adequate VL of 7d in standard testing and stems shown to potential buyers evoked keen interest. In 2013 plants in the tunnel became over-vigorous and were grubbed-up, and again many in the outside plots did not survive the severe winter of 2012/2013. At this stage 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 m^2, while the other cultivars produced between 28 (‘Marbella’) and 88 (‘Magical Purple Falls’) stems/m^2 (Table **6**).

In 2013 necrotic, black spots appeared on the foliage of ‘Arabian Dawn’ and ‘Marbella’ and were identified as due to *Alternaria*, subsequently confirmed by the Stockbridge Technology Centre (STC) Plant Clinic (**Error! Reference source not found.**). *Alternaria* had been reported on eryngium previously. Stems of cultivars ‘Blue Bell’, ‘Magical Blue’, ‘Magical Cloud’ and ‘Marbella’ were sampled for VL testing in week 27. They had an adequate VL of 8–9d, confirming the earlier results and exceeding the usual number of ‘guaranteed’ days. In testing, stems of ‘Blue Bell’ showed 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.

The numbers of stems obtained per plot in 2015, and their picking dates, are shown in Table **6**. Compared with the yields two years earlier, ‘Deep Blue’ maintained its performance and ‘Arabian Dawn’ increased its yield, but the other cultivars showed falling yields to varying extents. These figures reflect the cultivars’ hardiness as well as productivity over the 2011-2015 period. The trial on eryngium has provided growers with information on the performance and hardiness of a range of cultivars. No further trials are planned, but the current plots will be left down as a demonstration and new cultivars will be added as they become available.

Table 6. Stem yields in 2013 and 2015 for outdoor eryngium cultivars planted in 2011

Cultivar	Yield (stems/m^2)		Main picking period 2015 (week numbers)
	2013	2015	
'Arabian Dawn'	40	93	25–30
'Blue Bell'	56	16	28–30
'Deep Blue'	113	94	28–31
'Magical Blue Falls'	44	5	28–30
'Magical Cloud'	53	33	29–30
'Magical Purple Falls'	88	21	30
'Marbella'	28	23	27–28

Figure 11. Foliar symptoms of *Alternaria* infection on eryngium 'Arabian Dawn' at the Centre in 2013.

Lily (Lilium cultivars)

Bulbous ornamentals were included in CFC trials for the first time with the start of the current project (PO BOF 002a). Lilies remain hugely popular with UK customers, and generally the bulbs are grown in crates of growing media in order to avoid soil-borne pathogens common in glasshouse soil. For many years peat has been used as the growing medium, so there is obviously interest from growers in discovering suitable alternatives or diluents for peat.

2013 trials. In 2013 the trial aimed to test how a selection of new lily cultivars reacted to crate-growing in green-waste. In week 17 bulbs of 16 cultivars[5] were planted in standard lily crates (58 × 29 × 20cm) in 100% peat (using a typical peat used in the UK for commercial lily growing), 100% green-waste[6] or a 50:50 v/v mixture of the two. Fifteen to 18 bulbs were planted in each crate, proportional to the bulb grade of the different cultivars which varied from 14-16 to 18-20cm (circumference). One crate of each combination was moved to the 'Haygrove' tunnel at Rookery Farm on the same day, while the second was cold-stored at 9°C

[5] 'Adelante' (OT), 'Burlesca' (OH), 'Carolyn'(OH), 'Crystal Blanca' (OH), 'Hacienda' (OT), 'Hypnose' (OT), 'Oberto' (OH) and 'Ovatie' (OT) (Nord Lommerse Flower Bulb Group, Hillegom, The Netherlands), 'Castille' (LA), 'Fiction' (OH), 'Pintado' (OH), 'Profundo' (OT) and 'Tupelo' (OH) (PF Onings, Poeldijk, The Netherlands) and 'Beau Soleil' (LA), 'Mandaro' (OH) and 'Sambuca' (OH) (VWS Flowerbulbs, Broek op Langedijk, The Netherlands) (OT = Oriental × Trumpet Hybrid group, OH = Oriental Hybrid group, LA = Longiflorum × Asiatic Hybrid group).

[6] Donarbon, Waterbeach, Cambridgeshire, UK

and moved to the tunnel in week 21. At a commercial picking stage with the buds starting to show colour the overall stem length and bud count were recorded for six stems per crate. Overall, the main flowering period ran from week 29 to week 33.

In the first batch, with minor exceptions, stems were longest when grown in peat (overall average 101cm), shorter in the mixture (97cm) and shortest in green-waste (86cm). The effects of both cultivar and growing medium were statistically significant at $P<0.001$. There was no relationship between bud count and growing medium (overall average, 4.9 buds/stem), though differences between the cultivars were again statistically significant at $P<0.001$. Apart from the shortness of affected stems, quality was considered superb in other respects for all three growing media. Some growers commented that stem quality was unnecessarily high - more 'ordinary' cultivars should be used in future trials! The promising results with green-waste decided that trials with such alternative growing media should be continued.

For the second, cold-stored batch, results were similar, with the same levels of statistical significance and - if the shortness of affected stems was ignored - very good stem quality. Overall average stem length in the three growing media was 111, 101 and 89cm, respectively, slightly longer than before, and average bud count overall was 5.2/stem; further analysis on the complete dataset showed that there were no statistically significant differences between the two housing dates.

2014 trials. There were two trials in 2014, both grown at EM Cole (Farms), West Pinchbeck, Lincolnshire. In trial 1, 14-16cm grade bulbs of lily 'Dynamite'[7] (Oriental Hybrid group) were planted in week 21 in crates in either 100% peat (as before, a typical peat used in commercial lily growing in the UK), 100% coir, 100% 'Forest Gold' (a wood-derived commercial potting medium),[8] or mixtures of the peat with coir (50:50 v/v), with anaerobic digestate (AD)[9] (80:20 and 60:40 v/v), and with re-cycled green-waste[10] (50:50 v/v). Each crate was planted with 18 bulbs and there were three replicate crates of each growing medium. The crates were placed in a cold-store for 3 weeks then moved to a heated glasshouse (week 24). In week 34 (exceptionally week 35 for the peat + green-waste medium), when the buds started to show colour, they were picked and overall stem length and (after trimming to 63cm-long) weight were recorded for a random sample of 50 stems for each growing medium.

Average stem length in 100% peat was 76cm, and in the alternative media varied only slightly, between 72cm (in peat + green-waste) and 81cm (coir). The average trimmed weight in peat was 78g, and in the other growing media between 74g (peat + green-waste) and 100g (peat

[7] GAV Lilies, Noordwijkerhout, The Netherlands
[8] Bulrush Horticulture, Magherafelt, Co. Londonderry, UK
[9] Supplied by Staples Vegetables, Wrangle, Lincolnshire, UK and blended by Bulrush Horticulture
[10] Donarbon, Waterbeach, Cambridgeshire, UK

+ AD in either ratio). Growing in peat + AD and in ‘Forest Gold’ resulted in heavier stems than growing in the standard peat, though these differences were slight and commercially insignificant. Growing in peat + AD mixtures produced plants with better leaf colour compared with peat alone, possibly due to the base dressing added at blending. In contrast, growing in peat + green-waste resulted in some stunted stems with chlorotic leaves and slightly reduced the yield of marketable stems compared with the other growing media, and plants in this treatment were a week later to pick. Examples of lilies in bud in each growing medium are shown in Figure 12.

Figure 12. Examples of lilies from 2014 lily trial 1, growing in (top-row L) peat (100%); (R) peat + coir (50:50); (2nd row L) coir (100%); (R) peat + AD (80:20); (3rd row L) peat + AD (60:40); (R) 'Forest Gold' (100%); (4th row) peat + green-waste (50:50), close-up on R (15 August 2015, week 33)

The second 2014 trial served to explore further the use of peat + AD mixtures. Otherwise using the same methods as for trial 1, bulbs were planted in week 28 in 100% peat, 100% coir, 100% green compost11 or mixtures of peat + coir (50:50 v/v) and peat + AD (80:20, 60:40 and 40:60 v/v), with five replicate crates for each growing medium. The crates were placed in a cold-store (9°C) for 2 weeks and then housed. In week 41, when the buds started to show colour in all treatments, they were picked and stem length and trimmed weight recorded as before for a random samples of 30 stems.

Stem length averaged 78cm when grown in peat and was hardly changed in the other growing media (averages varied between 77 and 84cm). Average trimmed stem weight in peat was 87g, with lighter stems in peat + coir (69g) and heavier stems in peat + AD (80:20 v/v) (96g). With the exception of the lighter stems produced in peat + coir, compared with all other growing media, the differences were probably commercially insignificant. Unlike the first trial there were no obvious visual differences between plants growing in the different media.

2015 trials. To compare further the results of growing lilies in peat and alternative growing media – in this case mainly mixtures of peat or coir with AD - two trials were carried out in 2015. The experimental details, similar to those previously used, are summarised in

[11] Bettaland Products, Crowland, Lincolnshire, UK

Table **7**. Chemical analyses of the growing media are shown in **Error! Reference source not found.**.

Table 7. Details of two 2015 alternative growing media trials for lily production in crates

Site	Trial 1: EM Cole (Farms), West Pinchbeck, Spalding, Lincolnshire Trial 2: Smith & Munson, Gedney, Spalding, Lincolnshire
Varieties	Trial 1: 'Capistrano' (Oriental Hybrid group) Trial 2 'Alma Ata' (Oriental Hybrid group cultivars)
Format(s) and supplier(s)	14-16cm grade bulbs Trial 1: GAV Lilies, Noordwijkerhout, The Netherlands Trial 2: P Aker Flowerbulbs, Venhuizen, The Netherlands
Propagation and pre-planting treatment(s)	None
Planting or sowing	Planted in standard lily crates using the following growing media: 1. Peat (100%) 2. Peat + AD (60:40 v/v) 3. Peat + AD (40:60 v/v) 4. Peat + AD (20:80 v/v) 5. Coir (100%) (trial 2 only) 6. Coir + AD (33:67 v/v) 7. AD (100%) The peat used was a typical peat used in commercial lily growing in the UK. AD was supplied by Staples Vegetables, Wrangle, Lincolnshire, UK and blended by Bulrush Horticulture, Magherafelt, Co. Londonderry, UK. For trial 2 the nursery's standard practice was to place a layer of newspaper in bottom of the crate, cover with a 5–7cm deep layer of re-used peat, then top-up with the test growing medium. In other trials in this series crates were filled solely with the test growing media.
Planting or sowing date(s)	Trial 1: Week 20 Trial 2: Week 22
Plant spacing(s)	Bulbs planted at 15/crate
Layout	Three replicate crates per growing medium (but only one, observational crate for treatment 3 in trial 2); the three replicates were placed in different positions across the glasshouse.
Post-planting treatment(s)	Crates placed in cold-store (9°C) for 3 weeks after planting One layer of support net provided Liquid feed regimes were according to each site's standard protocol
Planting/housing site(s)	Crates moved to glasshouse week 23 (trial 1) or week 25 (trial 2)
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 (both trials)
Records taken	Total stem length and stem weight after trimming to 70cm (random sample of 15 stems per pick)

VL testing	No

In both trials conducted in 2015 lilies grown in 100% AD were stunted, chlorotic and distorted and therefore unmarketable. Stems from peat + AD 20:80 mix were only marginally better. Lilies grown in AD + coir, despite making a good height, had chlorotic, mottled foliage. Plants grown in 100% peat, 100% coir or the 'weaker' mixes of peat + AD (40:60 and 60:40 v/v) were normal and marketable.

Stem lengths and trimmed stem weights are summarised for trial 1 in Figure 13, with statistical analyses in **Error! Reference source not found.** and Table 8. In trial 1 'stems grown in peat averaged 93cm in total length and 110g in trimmed weight. In all other growing media stem lengths were shorter (75cm in AD and varying only between 85 and 89cm in the AD mixtures). Compared with growing in peat, trimmed stem weights were lighter AD (87g), similar to peat in coir + AD and peat + AD (80% AD) (112–115g), but heavier in peat + AD when more AD was added (40 and 60% AD) (128g). Analysis of variance showed that the effects of growing medium on both length and weight were statistically significant at P<0.001***.

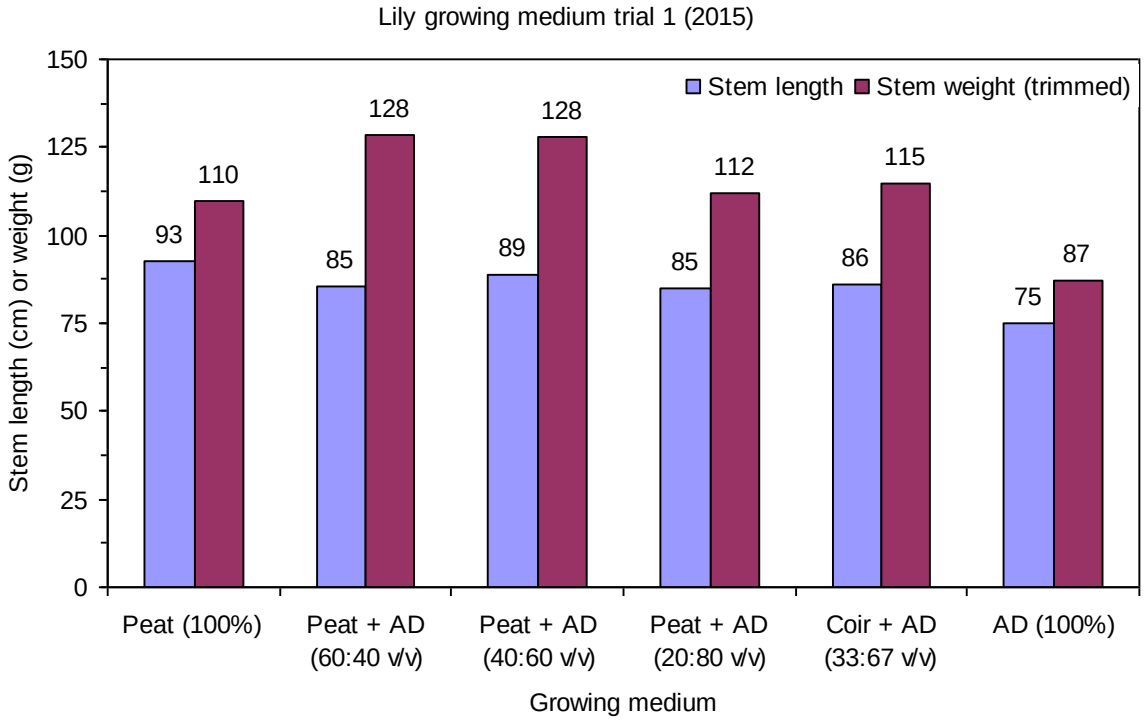

Figure 13. Stem lengths and trimmed weights of lily 'Capistrano' produced in six growing media, 2015 trial 1 (LSD (5%) for length = 3.2 and for weight = 8.8)

Table 9. Analysis of variance1 for the stem length data of Figure 13.

Source of variation	SS	DF	MS	F	P	
Growing medium	531.346	5	106.269	16.448	<0.001	***
Residual	77.529	12	6.461			
Total	608.875	17				

[1] In analysis of variance tables the value of P (probability) indicates the statistical significance of the source of variation (in this case growing medium). In analysis of variance tables *, ** and *** indicate significance at the 0.05, 0.01 and 0.001 levels of probability, i.e. that the result obtained could be expected to have occurred by chance in one in 20, one in 100 or 1 in 1000 instances, respectively, and NS indicates not significant (i.e. P>0.05)

Table 8. Analysis of variance[1] for the stem weight data of Figure 13.

Source of variation	SS	DF	MS	F	P	
Growing medium	3374.310	5	674.862	13.758	<0.001	***
Residual	588.634	12	49.053			
Total	3962.944	17				

[1] See footnote to **Error! Reference source not found.**

For trial 2 stem lengths and weights are summarised in Figure 14, with statistical analysis in Table **9** and Table 10. In this trial stems grown in peat averaged 73cm in length and 94g in trimmed weight. Again, stems from AD-grown lilies were both shorter and lighter (64cm and 69g). Lilies grown in coir, or in peat + AD mixes with 40 or 60% AD, performed in a similar way to those grown in peat, with averages of 73–79cm and 92–96g. Using AD mixed with coir or 20% peat only slightly reduced length and weight compared with plain peat. Analysis of variance showed that the effects of growing medium on length and weight were statistically significant at P<0.001 and P<0.05, respectively. On this basis growing lilies in 100% AD would not be advised, whereas 40 to 60% AD might be mixed with peat to reduce peat use without detrimental effects on stem length or weight or, in some cases, with heavier stems. Although growing in AD + coir (67:33 v/v) did not adversely affect stem height or weight, the plants in these trials had chlorotic foliage, though AD + coir mixtures might be usable if the proportion of AD was reduced or if remedial feed were applied.

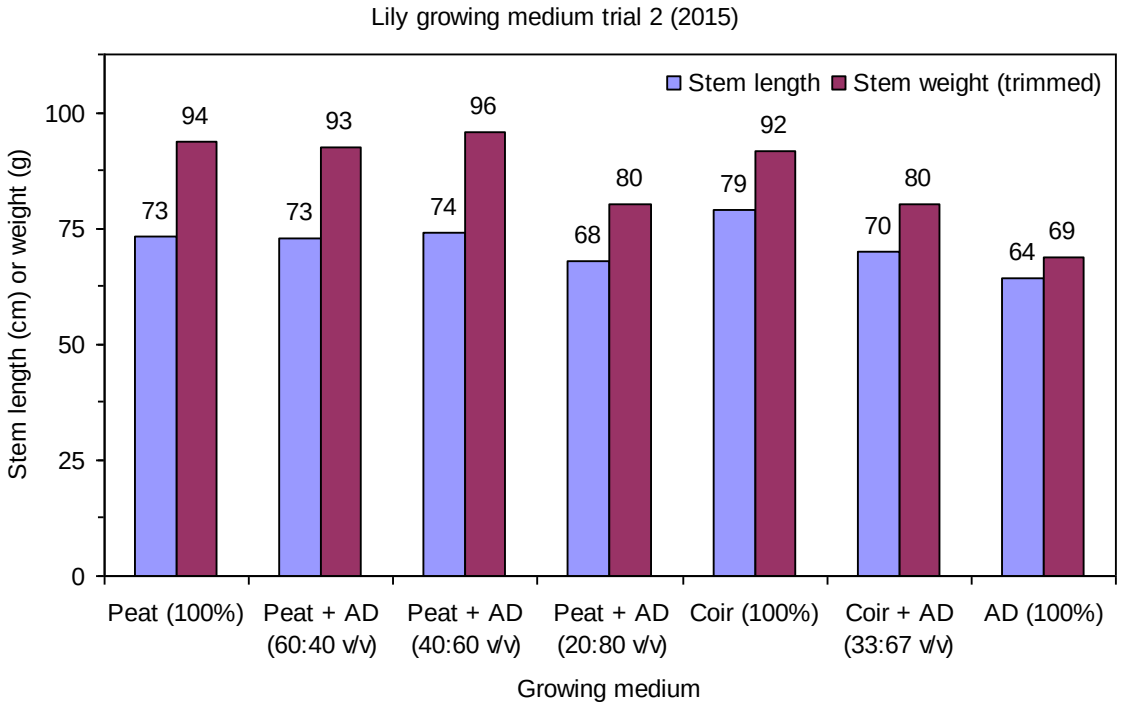

Figure 14. Stem lengths and trimmed weights of lily 'Alma Ata' produced in seven growing media, 2015 trial 2 (LSD (5%) for length = 5.4 and for weight = 7.0)

Table 9. Analysis of variance[1] for the stem length data[2] of Figure 14

Source of variation	SS	DF	MS	F	P	
Growing medium	216.058	5	43.212	14.266	<0.001	***
Residual	36.347	12	3.029			
Total	252.404	17				
[1] See footnote to **Error! Reference source not found.** [2] Excluding the data for AD (100%) which was included as a non-replicated check						

Table 10. Analysis of variance[1] for the stem weight data[2] of Figure 14

Source of variation	SS	DF	MS	F	P	
Growing medium	723.617	5	144.723	4.686	<0.05	*
Residual	370.575	12	30.881			
Total	1094.192	17				
[1] See footnotes to **Error! Reference source not found.**						

Nutrient analysis of growing media. Analyses were obtained of the AD used in 2014 and of AD and other growing media in 2015 (**Error! Reference source not found.**). Several points of difference were evident between the AD used in each year. Most notably, the concentrations of N were lower in 2015 than in 2014, while especially P, but also K and Mg, concentrations were higher in 2015. It is suggested that the better leaf colour seen in plants growing in AD in 2014 may have been due to the higher N level in that material. The poorer performance of lilies grown in 100% AD or AD-rich mixtures might be attributable to the high conductivities and pH of AD (>1300µS/cm and pH >8) that are probably excessive for lilies. AD also provided high concentrations of chlorine (>400mg/L). On the other hand lilies would benefit from appropriate calcium concentrations.

Conclusions. In the trials reported lily cut-flower production was entirely satisfactory when growing in the industry's standard growing medium, peat; peat's disadvantages are environmental ones. 'Green-waste' products were tested in three trials. In 2013 lilies were grown in peat, green-waste or a 50:50 mix of the two. Compared with growing in peat, stem length was shorter – though <10% shorter – in the mix, and was further reduced by growing in green-waste alone; otherwise stem quality was unaffected. In trial 1 of 2014 the same peat + green waste mix hardly affected average stem length and weight compared with using peat alone, but it led to chlorotic foliage, slightly delayed picking, and stunting in some plants, reducing marketable yield. However, in trial 2 lilies were grown in a 'green compost', and performance was not dissimilar to that in peat. Green waste or compost may have a role in lily growing, but it would need to be of a more advanced and consistent quality.

AD was investigated in four trials. Growing lilies in 100% AD (only tested in 2015) proved inappropriate, for as well as being shorter and lighter the stems were stunted and the foliage chlorotic and distorted; in the 2015 trials adding 20% peat only slightly improved quality, though this effect was not seen in the 2014 trials where, in fact, leaf colour in peat + AD mixtures was enhanced, perhaps due to base dressing added at mixing. Notably, peat + AD mixes with 40 or 60% AD resulted in heavier stems, a potentially useful effect. There would be obvious benefits in developing AD as a peat diluent in lily growing.

Growing lilies in coir or a 50:50 peat + coir mix resulted in somewhat lighter stems (compared with peat) in one out of three trials in which it was included, but had no other detrimental effects. In the 2015 trials a coir + AD (67:33 v/v) mix was included, but resulted in chlorotic, mottled foliage. Further development of coir mixtures for lily growing could be useful, and coir in its own right appeared to be a good growing medium for lilies too.

Growing in a wood-derived commercial potting medium ('Forest Gold') was tested in only one trial: lily production was similar to that in peat though stems were heavier. Further development of wood-based alternatives for lily growing could also be useful.

Table 13. Analysis of growing media used in 2014 and 2015 trials (all values are given in mg/L except density (g/L), pH and conductivity (µS/cm), analysis provided by Bulrush Horticulture)

	Density	**pH**	**Cond.**	**NH_4-N**	**NO_3-N**	**Total N**	**P**	**K**	**Mg**
2015									
Peat (100%)	429	5.6	59	12.1	3.2	15.2	2.4	5	2.4
Peat + AD (60:40)	416	6.4	287	60.1	5.8	65.9	111.3	237	6.9
Peat + AD (40:60)	400	7.8	594	117.0	<0.6	117.0	185.1	689	19.9
Peat + AD (20:80)	374	7.9	708	63.2	<0.6	63.2	175.5	981	32.6
Coir + AD (33:67)	396	8.3	810	121.7	<0.6	121.7	136.8	1032	27.5
AD (100%)	422	8.7	1365	363.0	<0.6	363.0	138.2	1467	40.3
2014									
AD (100%)	442	8.9	1352	511.7	1.0	512.7	67.1	1331	25.2

	C	**Ca**	**Na**	**Fe**	**Cu**	**Mn**	**Zn**	**B**	**SO_4**
2015									
Peat (100%)	19.5	4.2	16.4	0.36	<0.01	<0.01	0.14	0.07	26.4
Peat + AD (60:40)	163.5	12.5	25.6	0.77	0.03	0.04	0.19	0.19	105.1
Peat + AD (40:60)	375.8	38.0	35.9	2.38	0.07	0.27	0.47	0.34	172.1
Peat + AD (20:80)	422.3	55.2	39.6	2.52	0.10	0.35	0.41	0.52	247.1
Coir + AD (33:67)	421.3	52.3	56.1	2.95	0.12	0.32	0.54	0.44	199.6
AD (100%)	515.5	77.2	49.5	3.67	0.16	0.38	0.92	1.01	212.8
2014									
AD (100%)	420.8	57.6	47.3	5.43	0.12	0.47	0.30	0.26	236.0

General topic: Herbicide screening

We are grateful to John Atwood, project leader of AHDB project HNS PO 192a, and his colleagues Chloe Whiteside and Emma Worrall for providing a report on herbicide screening carried out at the CFC site in 2015. Their findings are summarised below.

There are few label recommended herbicides available for growers of ornamentals, which in many cases means growers have to rely on hand-weeding and cultivation - expensive and difficult in wet conditions - or off-label usage through EAMUs. With the loss of key active ingredients such as oxadiazon (as in 'Ronstar Liquid'), chlorthal-dimethyl (as in 'Dacthal-W75') and propachlor (as in 'Ramrod') it is necessary to find further options for growers. During 2014, as part of AHDB-funded project HNS PO 192, a range of herbicides was tested for crop safety on four key cut-flower crops and wallflowers grown at the CFC (see CFC Annual Report for 2014) and that highlighted some promising new treatments that were further tested in 2015. Trials on drilled China aster, larkspur, sweet Williams and wallflowers were carried out at the CFC site and are summarised here. Additional trials were carried out on transplanted China aster, drilled sweet Williams and newly planted peony on commercial nurseries in order to refine the treatments.[12]

Drilled China aster trial. Benfluralin (as 2kg 'Benfluralin'/ha) was applied pre-drilling and incorporated, and clomazone (as 0.05–0.25L 'Gamit 36 CS'/ha), propyzamide (as 3.75L 'Kerb Flo 400'/ha), pendimethalin with imazamox (as 3.0–4.5L 'Nirvana'/ha), pendimethalin (as 2.0L 'Stomp Aqua'/ha) and s-metalochlor (as 0.78L 'Dual Gold'/ha) post-drilling; carfentrazone ethyl (as 0.33–0.66L 'Shark'/ha) was applied post-emergence. As well as straight (single herbicide) treatments, combinations of herbicides were tested as tank-mixes (indicated by '+') or by sequential applications.

'Stomp Aqua' + the highest rate of 'Gamit 36 CS' resulted in slightly lower emergence, while 'Nirvana' gave the best weed control but the higher rate caused moderate yellowing and stunting. 'Shark' (both rates) initially scorched the crop, but it recovered. Weed control was good in all treatments except when 'Benfluralin' was followed by 'Gamit 36 CS' at 0.125L/ha. By 10 weeks after application all the treatments except the higher rate of 'Nirvana' gave plants of commercially acceptable quality.

For a commercial treatment 'Stomp Aqua' (2.0L/ha) + 'Gamit 36 CS' (0.125L/ha) could be recommended, followed (if required) by 'Shark' (0.33 L/ha) applied to the young plant.

Drilled larkspur trial. The herbicide treatments were pre-drilling incorporated benfuralin (as 2.0kg 'Benfuralin'/ha) and post-drilling prosulfocarb (as 4.0L 'Defy'/ha), s-metolachlor (as 0.78L 'Dual Gold'/ha), clomazone (as 0.25L 'Gamit 36 CS'/ha), pendimethalin (as 2.0L 'Stomp Aqua'/ha) and pendimethalin with dimethenamid-p (as 1.75 'Wing-P'/ha). As for the China aster trial, both straight herbicide treatments and combination treatments (tank-mixes or sequential applications) were tested.

[12] The report on project HNS PO 192a, Herbicide screening for ornamental plant production (nursery stock, cut flowers and wallflowers), will be available from the AHDB in 2016.

The crop was slow to germinate and emergence was patchy even in untreated plots, so the results should be treated with caution. ‘Stomp Aqua’ + ‘Defy’ and ‘Wing-P’ treatments resulted in phytotoxic effects (stunting and foliar distortion). The treatments gave good weed control, the most effective being ‘Stomp Aqua’ + ‘Gamit 36 CS’.

The treatment of ‘Stomp Aqua’ + ‘Gamit 36 CS’ should be developed further. Treatments with ‘Defy’ and ‘Wing-P’ should be ruled out.

Drilled sweet William trial. The treatments were benfuralin (as 2.0kg ‘Benfluralin’/ha) incorporated pre-sowing, post-sowing prosulfocarb (as 1.0–2.0L ‘Defy’/ha), metamitron (as 1.0–2.0L ‘Goltix 70 SC’/ha and pendimethalin (as 0.75–2.0L ‘Stomp Aqua’/ha), and, post-emergence at the four true-leaf stage, carfentrazone ethyl (as 0.33L ‘Shark’/ha). As for the previous trials, both straight herbicide treatments and combination treatments (tank-mixes or sequential applications) were tested.

The emergence of sweet Williams was reduced by ‘Benfluralin’ when followed by the higher rate of ‘Defy’. Emergence was adequate following the higher rate of ‘Goltix 70 CS’ as a straight treatment and with ‘Stomp Aqua’ up to 0.75L/ha or ‘Defy’ up to 1.0L/ha. However, later trials (on the commercial farms) showed ‘Goltix’ to be a safer treatment than ‘Defy’, either alone or mixed with ‘Stomp Aqua’. The higher rate of ‘Goltix’ (2.0L/ha) + ‘Stomp Aqua’ (0.75L/ha) gave the best weed control and were crop-safe, though on light soils the lower rate (1.0L/ha) of ‘Goltix 70 CS’ may be advisable. Except for the higher rates of ‘Stomp Aqua’ + ‘Defy’, all treatments appeared safe six weeks after treatment. ‘Shark’ at the lower rate had scorched the crop by one week after treatment, but it had recovered by four weeks later.

For a commercial treatment applied at drilling, ‘Stomp Aqua’ (0.75L/ha) + ‘Goltix 70 CS’ (1.0L/ha) is the safest option, with ‘Stomp Aqua’ (0.75L/ha) + ‘Goltix 70 CS’ (2.0L/ha) or ‘Stomp Aqua’ (0.75L/ha) + ‘Defy’ (1.0L/ha) possible at some sites. The lower rate of ‘Shark’ is a possible post-emergence treatment.

Drilled wallflower trial. Benfluralin (as 2.0kg ‘Benfluralin/ha) was used as a pre-drilling treatment and other treatments were applied post-drilling: metazachlor (as 1.0L ‘Butisan S’ /ha), clomazone (as 0.05–0.33L ‘Gamit 36 CS’/ha), pendimethalin (as 2.0–2.9L ‘Stomp Aqua’/ha) and pendimethalin with dimethenamid-p (as 1.75–3.5L ‘Wing-P’/ha). As for the previous trials, both straight herbicide treatments and combination treatments (tank-mixes or sequential applications) were tested.

The higher rate of ‘Wing-P’ (3.5L/ha) reduced emergence, while ‘Benfluralin’, ‘Butisan S’ and ‘Gamit 36 CS’ all caused slight phytotoxicity though reducing weeds effectively. Six weeks after treatment the worst damage – yellowing - was caused by ‘Wing P’ at the higher rate (3.5L/ha) + ‘Gamit 36 CS’ (0.125L/ha). However, all crops had recovered by 10 weeks after

treatment, although the high rate of 'Wing-P' (3.5L/ha) + 'Gamit 36 CS' (0.125L/ha) reduced emergence.

Overall there were some promising results. 'Butisan S' (1.0L/ha), 'Gamit 36 CS' (0.125 L/ha) and 'Wing-P' (1.75L/ha) appear safe when applied at drilling. The tank-mix 'Wing-P' (1.75 L/ha) + 'Gamit 36 CS' (0.125L/ha) also appear safe. 'Benfluralin' was safe as a pre-drilling incorporated treatment and could be followed by some post-drilling treatment, but is not yet available in the UK.

Conclusions. Work carried out at the CFC found 'Stomp Aqua' + 'Gamit 36 CS', post-drilling, pre-emergence to be safe and effective for use on drilled China aster. This could then be followed up with a post-emergence application of 'Shark' if required. In other trials this treatment was also found to be the best on transplanted China aster when applied pre-planting. 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 as a tank-mix. Benfluralin was also safe as a pre-drilling incorporated treatment on wallflower and could be combined with some of the post-drilling treatments (it is not yet available in the UK). 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. Although not part of the trials at the CFC site, in the peony trial 'Stomp Aqua' + 'Butisan S' was safe and effective when used post-planting.

Crop introduction

On the basis of the new crops and trials programmes review[13], suggestions from growers, and information from seed and young-plant suppliers, several novel 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 this section trials carried out in 2013 and 2014 are summarised (further details can be found in the 2013 and 2014 annual reports) and full details are given of the work carried out in 2015.

In 2013 the crops selected were basil, cosmos, gentian, Lion's ear (*Leonotis leonurus*), lupin, trachelium and zinnia. For various reasons, the trials on basil, gentian, lupin and lion's ear have now finished or been suspended:

[13] http://www.thecutflowercentre.co.uk/wp-content/uploads/2013/11/Cut-Flower-Review-Final.pdf

- 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, so no further trials were carried out.

- 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 trials with cosmos, lion’s ear, lupin, trachelium and zinnia showed some potential for the crop and are described below.

- For lupins a trial started in 2013 with ‘Gallery’ and ‘Russell’ cultivars in the tunnel and outside. The plants established slowly but well. 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, however, would limit their potential as cut-flowers in the UK. Trials will continue only 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.

- 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 to come to fruition. Other cultivars trialled in 2014 varied in stature, with none as vigorous as ‘Staircase’. Since it has not yet been possible to pick a stem, we cannot judge the potential for 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. *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. No further trials took place in 2015 and the crop will be re-assessed.

The trials on trachelium and zinnia are on-going and are fully described below in the section beginning ‘Carthamus’.

Further novel crops were selected for trialling in 2014: bleeding heart (*Dicentra spectabilis*), carthamus (*Carthamus tinctorius*), cosmos (*Cosmos bipinnatus*), a range of seed-raised fillers (*Ammi majus*, *A. visnaga*, *Anethum graveolens*, *Anthriscus sylvestris*, *Bupleurum rotundiflorum*, *Euphorbia oblongata* and *Ridolfia segetum*), ornamental peppers (Capsicum annuum cultivars) and physostegia (*Physostegia virginianum* cultivars). In addition some new cultivars of pinks, delphinium, gypsophila and leucanthemum were made available for demonstration. For various reasons, the trials on bleeding heart, gypsophila ‘Zinzi’ series, ornamental peppers and physostegia have now finished or been suspended:

- Bleeding heart 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 on bleeding heart was deferred until the germination issue can be resolved, which could mean switching to plug-plants or bare-root divisions.
- ‘Zinzi Discovery’ and ‘Zinzi Tyree’ are new cultivars of *Gypsophila paniculata* from HilverdaKooij that may be considered superior to other gypsophila on the market in terms of stem and flower quality. Following late delivery, however, they produced a poor flower crop and the trial was discontinued.
- Ornamental peppers proved successful novelties in trials in the USA, and cultivars ‘Black Pearl’ and ‘Masquerade’ were included in a demonstration at the Centre in 2014. They were slow-growing but eventually produced large, strong plants, and while some fruits were visible on both cultivars by week 36, thereafter they remained more or less static without growing or ripening until the tunnel was due to be de-skinned. Issues with seed availability prevented further trials in 2015, but can hopefully be resolved in time for the 2016 season.
- Physostegia was shown to be a potentially useful cut-flower in ASCFG trials. A small number of cultivars is available, and one, ‘Crystal’, was included in an initial demonstration at the Centre in 2014. It proved to be rather short and late, and since VL testing showed the stems failed on vase-day 2, they are probably unsuitable for further trialling.

The trials on carthamus, cosmos, a range of seed-raised fillers and new cultivars of dianthus, delphinium and leucanthemum are on-going and are fully described below in the section beginning ‘Carthamus’.

Demonstration plots of further introductions were planned for 2016 but were prevented through difficulties in sourcing material in time and because of a shortage of space in the Spanish

tunnels (several introductions from earlier years were still being assessed, including several species of seed-raised fillers).

Carthamus (Carthamus tinctorius and cultivars)

Carthamus has attracted much attention as an unusual, thistle-like filler. A cultivar demonstration was carried out in 2014: cultivars 'Kinko', 'Nemo' and 'Shiro' were sown in week 25 in outside beds and weeks 27 and 30 in tunnels. Although germination was satisfactory and the plants budded-up quickly - starting in week 30 in the outside plots – subsequent development was slow. Picking dates from the first two sowings covered weeks 35–37, with plants from the 30-week tunnel sowing failing to produce marketable stems before the tunnel had to be de-skinned (week 43). Stems were sampled for VL testing which was adequate at 7d, though quality was spoiled by bract-tipping. With both potential and problems highlighted by these results, a further demonstration to gain more information was justified in 2015, and the details are given in **Error! Reference source not found.**.

Table 11. Details of 2015 carthamus demonstration

Varieties	*Carthamus tinctorius* '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)	Sown in beds outside in week 24 and in beds in tunnel weeks 17, 20, 24, 28 and 31
Planting site(s)	3m-long plots
Planting/housing site(s)	Outside beds and beds in 'Pro-tech' tunnel bay 3, except that the late (week 31) sowing was into the 'Haygrove' tunnel
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 Rodent damage
Picking stage(s) and market specification(s)	Centre bud open and two side buds showing colour
Picking and recording date(s)	Weeks 29, 31, 35 and 40 respectively for the 17-, 20-, 24- and 28-week sowings in tunnels, and week 38 for the outdoor sowing in week 24 Plants from the week-31 sowing failed to produce marketable stems by week 43 when the tunnel was de-skinned
Records taken	Picking dates
VL testing	No

Germination was good and plant growth vigorous. With sowing dates in the tunnel from week 17 to week 28, the picking period covered weeks 29–40; the plots sown in the tunnel in week 31 failed to produce marketable stems before week 44 when the tunnel was de-skinned. The outdoor sowing, week 24, cropped in week 38. Hence earlier sowing than in 2014 was successful in gaining earlier picking. Stem quality was marred by the brown-tipping of bracts and leaf mottling, as previously noted in the growing crop and in VL testing. The protected and outdoor crops are shown in Figure 15 and Figure 16.

Carthamus is a crop which produces a reliable, strong sturdy stem, and is already being grown and used successfully as a bouquet filler. Sufficient trials have probably been done for the size of the market. Bract quality can be an issue, a topic that could be returned to later if necessary.

Figure 15. 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 16. Outdoor carthamus 'Nemo' (front), 'Shiro' (middle) and 'Kinko' (back) on 1 September 2014 (week 36) (left) and 11 September 2014 (week 37) (right)

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. In 2013, 15 cultivars from the 'Razzmatazz', 'Sonata' and 'Sensation' series were demonstrated in tunnel and outside beds at the Centre. They were vigorous in growth – too vigorous and unmanageable in the tunnel – and flowered slowly and unevenly but, eventually, prolifically.

2014 trials summary. In 2014 the cultivars grown were 'Double Click Cranberries', 'Fizzy Rose Picotee', 'Psyche White', 'Rubenza', 'Sensation Antiquity', 'Sensation Dazzler', 'Sensation Purity', 'Sonata Pink', 'Sonata Premium Mix' and 'Sonata White'. They were sown in weeks 21 and 25 in outside beds, and in weeks 27 and 30 in the tunnel. Germination was good and they grew vigorously, though flowers were slow to develop and flowering was uneven (Figure 17, Figure 19). The best performer was 'Double Click' grown in the tunnel, which produced stems of substantial length and weight even grown outside. The picking period covered weeks 30–41, though stems from the last sowing were *ca* 40cm long, too short to be marketable. However, the bunched stems were substantial, despite the initial impression of the plant's wispiness (Figure 18). The lead bud developed and opened some time before the subordinate

buds, so picking when the first bud is open gave disappointing results. It may be possible to remove the lead bud, but this is a time-consuming job for such a low-value crop and is unlikely to extend VL to an acceptable extent. Four cultivars were sampled for VL testing, but had a very short VL of 1 to 3d, with stems visibly breaking-down during this time.

Figure 17. 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 18. Typical bunches of tunnel-grown cosmos from the demonstration plots 2014 (1 September, week 36)

Figure 19. Outside cosmos cultivar trial 2014: left, on 1 September and right, on 24 September, both from week 25 sowing

2015 trials. From the results described, further development work was evidently required on issues such as scheduling, cultivar choice, stem strength and, particularly, post-harvest longevity. In 2015 cosmos were sown in weeks 21 and 25 in outside beds, and in weeks 27 and 30 in tunnel beds. One aim was to provide material for VL testing. Trial details for 2015 are given in Table 12.

Table 12. Details of 2015 cosmos demonstration

Varieties	*Cosmos bipinnatus* 'Antiquity', 'Candy Stripe' (not week 17), 'Double Click Cranberries', 'Fizzy Rose Picotee' (tunnel week 17 and outside week 24 only), 'Psyche White', 'Purity', 'Rubenza' (outside only), 'Sensation Dazzler' (outside only), 'Sonata White' (outside only) and 'Sonata Pink'
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)	Sown in beds outside in week 24 and in beds in tunnel weeks 17, 20, 24 and 28
Planting site(s)	3m-long plots
Planting/housing site(s)	Outside beds and beds in 'Pro-tech' tunnel bay 3
Layout	Un-replicated demonstration plots
Plant spacing(s)	Seedlings not thinned
Post-planting treatment(s)	None
Pests, diseases and disorders	None evident, other than lodging in the most vigorous plots
Picking stage(s) and market specification(s)	As a tentative picking stage, one flower fully open, but further investigation needed

Picking and recording date(s)	Onwards from weeks 29, 32, 36 and 41 respectively for the 17-, 20-, 24- and 28-week sowings in tunnels, and week 37 for the outdoor sowing in week 24
Records taken	Picking dates
VL testing	1 September 2015 (tested by ADAS Boxworth)

Figure 20. Cosmos cultivars grown for VL testing in 2015 (1 September 2015, week 36)

As in the previous trial germination and plant establishment were good but the flowers were slow and uneven in development. Some growth was so vigorous as to result in lodging, but in the last sowing stems were only *ca* 30cm-long, too short to be marketable. Stems of three cultivars of cosmos were harvested with two or three open flowers on 1 September 2015 (

Figure **20**) and cold-stored overnight in clean auction buckets in water with added conditioning solution, either (1) 'Chrysal RVB Clear Intensive' at 1ml/L, (2) 'Chrysal CVBN' at 1 tablet/2L or (3) 'Chrysal CVBN' at 1 tablet/L, before delivery to ADAS Boxworth. The cut-stems were transferred to buckets of water with added shipping treatment ('Chrysal Clear Professional 2 T-Bag') and kept in the VL room until 4 September when the VL test was set-up. The stems were de-sleeved, re-cut and placed in vases containing 1L of water with added flower food ('Chrysal Clear Liquid Universal'; all products from Chrysal UK). Three replicate vases, each containing two stems of each of three cultivars, were set up using stems from each of the three conditioning treatments. The vases were randomised in a VL room, in which the conditions were 20°C and 60% RH, with light at 1,000lux for 12h/day. The stems were assessed daily using as the write-off criterion when >50% of the flowers on a stem had wilted or dropped. Water clarity was monitored and the first day of clouding was recorded. Flower and leaf quality and water clarity were assessed on vase-day 7, each using a one-to-five scale (Table 13).

Table 13. Quality scores used in VL assessment

Score	Flower and leaf quality	Water clarity
1	Very poor quality, all consumers would discard	Very cloudy, hand barely visible through water
2	Poor quality, most consumers would discard	Cloudy, hand visible through water
3	Reasonable quality, most consumers would not discard	Moderately cloudy, hand visible through water
4	Good quality, all consumers would not discard	Good clarity, hand clearly visible through water
5	Very good quality	Completely clear

The flowers started wilting and showing some petal discolouration even during the store phase, with symptoms being worse in conditioning treatment 2 than in the other treatments. Stem failures were recorded as early as vase-day 3, and on average only conditioning treatment 1 achieved an average VL of 5 days and had more than 50% of stems still alive on day 5 (Table 14).

Table 14. VL and flower and water clarity of cosmos following three conditioning treatments

Conditioning treatments	First failure (day)	VL (days)[1]	% stems remaining		Quality score		Clarity score day 10	Day clouding 1st seen
			VL day 5	VL day 10	VL day 5	VL day 10		
1. 'RVB Clear Intensive' 1ml/L	4.0	5.0	67	33	3.0	3.0	4.3	6.6
2. 'CVBN' 1 tablet/2L	3.0	4.5	44	0	2.0	1.3	4.3	7.3
3. 'CVBN' 1 tablet/L	4.3	4.5	33	0	2.3	2.0	3.6	6.0
[1] excluding losses due to botrytis								

Overall flower quality was poor from the beginning of the trial, due to wilting and petal browning, and these symptoms were worse in conditioning treatment 2 (Figure 21). Conditioning treatment 1 - 'RVB Clear Intensive' - showed the best overall quality. No obvious differences were seen in leaf quality score. Differences in water clarity were observed between the treatments, the most noticeable differences being seen after vase-day 5: conditioning treatment 2 - 'CVBN' at 1 tablet/2L - had least clouding, with a decline in clarity seen on average around vase-day 7, other treatments clouding at around day 6. Treatments 1 and 2 maintained their water clarity score at 4.3 until the end of the trial, whereas in treatment 3 clarity continued to decline, with a final average score of 3.6 on day 10.

Overall it would appear that the short VL rules out cosmos as a supermarket flower, but it would have a place for direct sales where a shorter VL can the tolerated. There is a huge range of cultivars to choose from, that will achieve an adequate stem length while providing a wide range of colours and flower forms. Nevertheless, further post-harvest studies that had been proposed had to be delayed until 2016 when it is anticipated that access to a new VL test facility will be available.

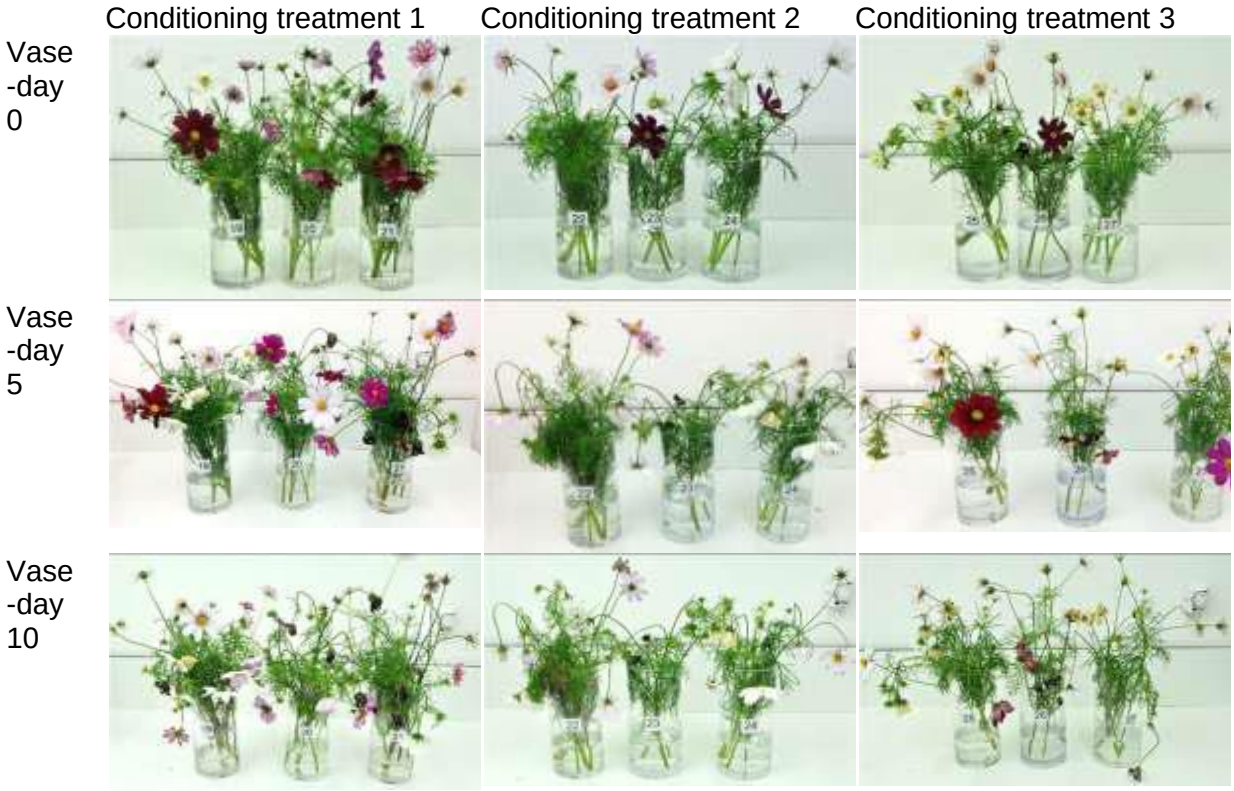

Figure 21. Three replicate vases of cosmos from three conditioning treatments, photographed on vase-days 1, 5 and 10

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 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 15.

Table 15. Details of 2014–2015 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 Grown-on to second year.
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 23), potentially giving three flushes in a year (Figure 22). 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 were grown-on to the second year, when they produced dense growth and productive flushes in mid- to late-June (

Figure **24**) and mid- to late-August and a weak flush on October. It is considered that there is little more the Centre can investigate with delphiniums. The information gained is known to have helped the industry to explore new cultivars, and while these 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.

Figure 22. Delphinium cultivars after cutting-back (11 September 2014, week 37) and giving third flush (17 October 2014, week 42)

Figure 23. 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 24. Delphinium plots in their second year (photographed 9 June, week 24)

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

Spray carnation cultivars have previously been trialled extensively at the Centre, but in 2014 and 2015 newer cultivars from HilverdaKooij and Whetman Pinks, some quite strikingly different to the familiar types, were deemed worthy of testing and were grown in demonstration plots. Details are given in Table 16.

Table 16. Details of 2014–2015 demonstration of newer cultivars of pinks

Varieties	(a) (2014) 'Tiara' series 'Coral Pink' and 'Lilac' (b) (2015) 'Green Magma', 'Green Trick' and 'Green Wicky'` (c) (2015) 'Cherry Daiquiri', 'Cosmopolitan', 'Mojito', 'Shirley Temple' and 'Tequila Sunrise'
Format(s) and supplier(s)	Rooted cuttings (a) and (b) HilverdaKooij

	(c) Whetman Pinks
Propagation and pre-planting treatment(s)	(a) Cuttings potted to 9cm-diameter pots week 14 and pinched week 17 (b) Cuttings potted to 9cm-diameter pots week 17 and pinched (c) Planted-on direct from plugs
Planting or sowing	Transplanted
Planting or sowing date(s)	(a) Week 22 2014 (b) Week 20 and (c) week 24 2015
Planting site(s)	Beds in 'Pro-Tech' tunnel bay 1 (a) 4m-long plots (b) and (c) 1.5m-long plots
Layout	Un-replicated demonstration plots
Plant spacing(s)	25 plants/m^2
Post-planting treatment(s)	One layer of support netting (a) 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 (white flecking of flowers) Flowers of 'Lilac' faded very quickly
Picking stage(s) and market specification(s)	Once two or more buds showing good colour, or (b) when the flower has formed a ball
Picking and recording date(s)	Main picking dates (a) week 36 for 'Coral Pink' and week 37 for 'Lilac' in 2014; week 30 for 'Coral Pink' and week 31 for 'Lilac' in 2015 (b) Week 29 and (c) week 31 2015
Records taken	Observations only
VL testing	'Coral Pink' sampled week 35 2014 (tested by Butters Group)

The 'Tiara' series planted in 2014 were clearly very susceptible to thrips damage, with white flecking on the flowers. Once damage was seen, the interval between insecticide sprays was reduced and this controlled the problem effectively and would be routinely necessary. These cultivars were slow growing but produced some strong stems. The central bud developed well before any others, and so needs to be pinched-out to preserve the remaining spray, though this is tricky to do properly, and labour-intensive. Stems of cultivar 'Coral Pink' were sampled for VL testing, giving an average VL of 7d and hence just achieving the usual 'guaranteed days'. By vase-day 7 the flower-heads were starting to breakdown; damage from thrips also detracted from their appearance. Despite these issues, the stems were attractive and growers appreciated them, so they were left *in situ* for a further year's growth, when both cultivars produced a good second-year flush (Figure 25).

Figure 25. Hilverdakooij ‘Tiara’ series spray carnations in demonstration plots at the Centre: left, ‘Lilac’ and right, ‘Coral Pink’ (top and middle, 11 September 2014, week 37; bottom, 22 July 2015, week 30)

The Whetman cultivars (planted in 2015) started producing flowers by week 29 with the main flush in week 31. However, the stems were rather weak and short: the plots will need to be grown on for assessment in 2016 (Figure 26).

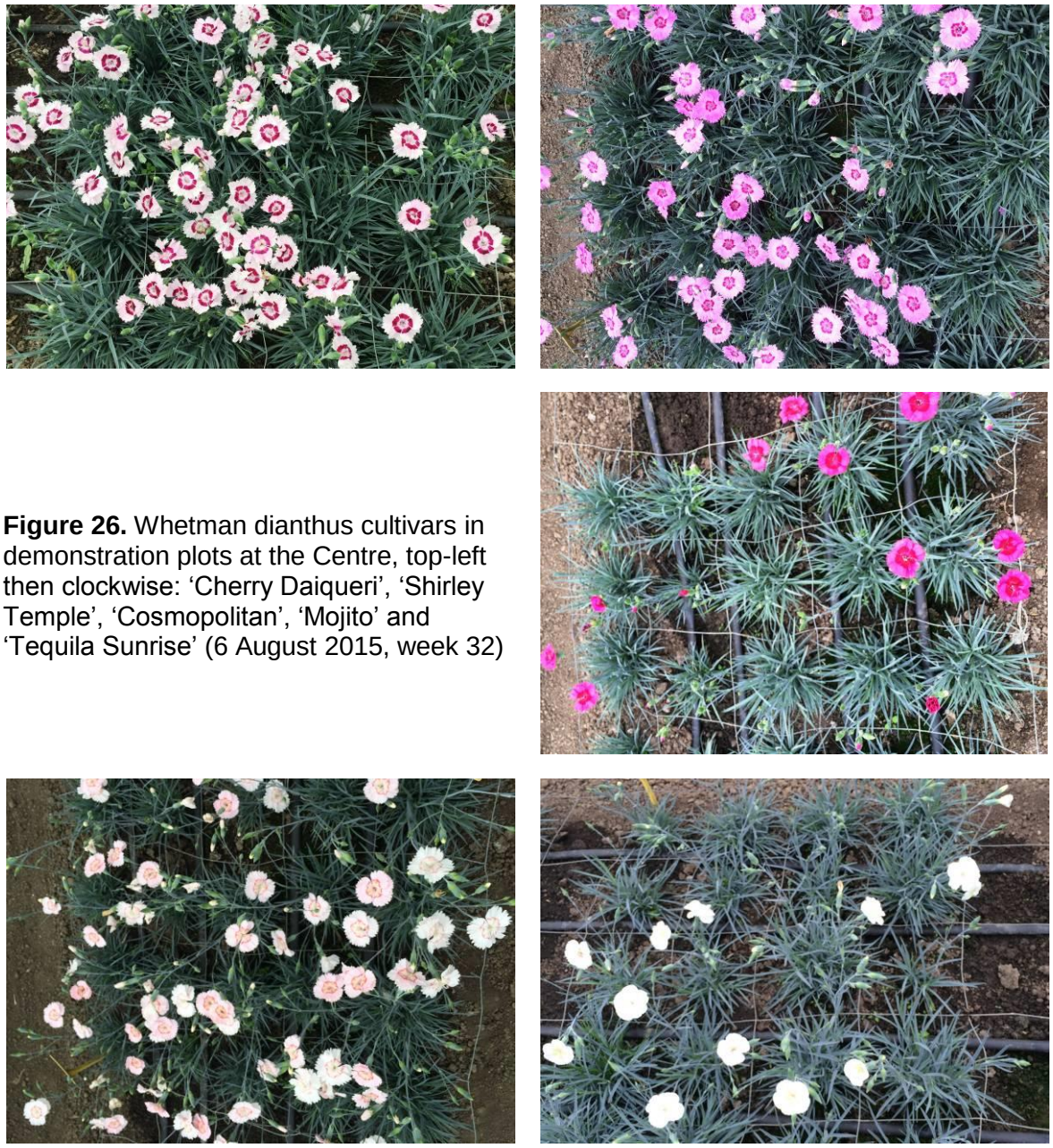

Figure 26. Whetman dianthus cultivars in demonstration plots at the Centre, top-left then clockwise: ‘Cherry Daiqueri’, ‘Shirley Temple’, ‘Cosmopolitan’, ‘Mojito’ and ‘Tequila Sunrise’ (6 August 2015, week 32)

In 2015 the new green cultivars were in full flower by week 29 and the flowers held for several weeks (Figure 27); stem length was *ca* 25cm. The green cultivars were considered a very good product, while the other new dianthus cultivars need further assessment. While in general all the new cultivars were well liked by the market, it seems they are unlikely to command the price required to justify the purchase of expensive tissue-cultured plants.

Figure 27. Hilverdakooij green dianthus cultivars in demonstration plots at the Centre: top, 'Green Wicky'; middle, 'Green Magma'; bottom, 'Green Trick' (6 August 2015, week 32)

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*.

2014 trial. In 2014 seed were direct-drilled in outside and tunnel plots, although the anthriscus seed failed and was replaced with plug-plants; full details are available in the 2014 Annual Report. Examples of the plots are shown in Figure 28.

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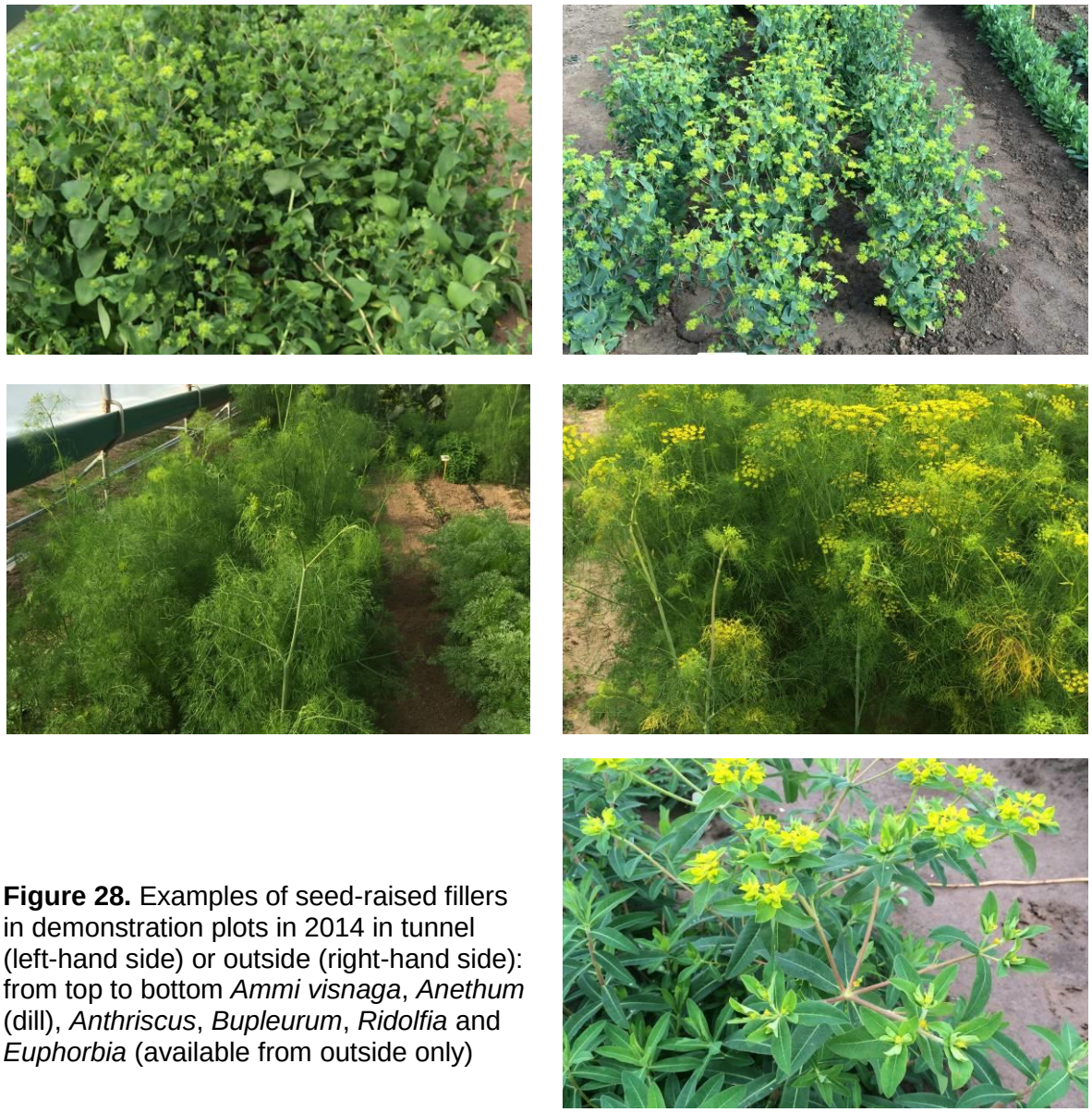


Figure 28. Examples of seed-raised fillers in demonstration plots in 2014 in tunnel (left-hand side) or outside (right-hand side): from top to bottom *Ammi visnaga*, *Anethum* (dill), *Anthriscus*, *Bupleurum*, *Ridolfia* and *Euphorbia* (available from outside only)

2015 trial. The results of this first round of trials were encouraging, though many issues had been raised, so further investigations were set up in 2015. The practical details are given in **Table 17** and then the results are summarised species-by-species.

Table 17. Details of 2015 demonstration of seed-raised fillers

Varieties	New plots drilled 2015: Ammi majus A. visnaga Anethum graveolens Bupleurum rotundiflorum 'Griffithii' Ridolfia segetum 2014 plots grown-on: Anthriscus sylvestris 'Ravenswing' Euphorbia oblongata
Format(s) and supplier(s)	Seed (Moles Seed) Euphorbia: not sown again in 2015 but at the end of the growing season plants from the 2014's tunnel plots were transplanted to new plots Anthriscus: planted as plugs in 2014 and left down for 2015
Propagation and pre-planting treatment(s)	None
Planting or sowing	Seed direct-drilled by hand in three rows along the bed Euphorbia (2014 sowing) transplanted for growing-on in 2015
Planting or sowing date(s)	Ammi species and ridolfia: beds in tunnel weeks 17, 20, 24 and 28, beds outside week 24 Anethum and bupleurum: beds in tunnel weeks 17, 20, 24, 28 and 31, beds outside week 24
Planting site(s)	3m-long plots
Planting/housing site(s)	Outside beds and beds in 'Pro-tech' tunnel bay 3, except that the late (week 31) sowings of anethum and bupleurum were into the 'Haygrove' tunnel Euphorbia sown 2014 was transplanted into 'Pro-Tech' tunnel bay 1 for the 2015 season Anthriscus had been planted as plugs in 'Pro-Tech' tunnel bay 1 and was grown-on for the 2015 season
Layout	Un-replicated demonstration plots
Plant spacing(s)	Ammi, anethum, bupleurum and ridolfia: seedlings not thinned but ended up at about 5cm spacings in the row
Post-planting treatment(s)	None
Pests, diseases and disorders	Ammi, anethum and ridolfia: first two sowings were sick and unproductive, possibly a result of residues from a herbicide trial the previous year Bupleurum: sun scorch was seen in tunnel-grown plants in

	both years, though it was not extensive (Figure 29) Anthriscus: two-spotted spider mite (Figure 30) and powdery mildew were problems in 2014; in 2015 appropriate pesticide applications overcame this problem Bupleurum: some caterpillar damage, also botrytis was seen where leaf scorch was evident in 2014: again this was not an issue in 2015 probably due to the use of more appropriate spray treatments
Picking stage(s) and market specification(s)	Ammi species and bupleurum: when the florets are showing colour Anethum, anthriscus and ridolfia: just before the florets open
Picking and recording date(s)	See Table 18
Records taken	Observations and picking dates
VL testing	*Ammi visnaga* and *A. majus* (tunnel): sampled 12 October 2015 Anethum sampled 11 August 2015 (outside) and 12 October 2015 (tunnel) Euphorbia (tunnel and outside) sampled 11 August 2015 (tested by Superflora UK)

Figure 29. Tunnel-grown bupleurum with leaf scorch (26 September 2014, week 39)

Figure 30. Outside-grown anthriscus showing damage due to two-spotted spider mite (1 September 2014, week 36)

Ammi majus and A. visnaga. In the 2014 demonstration *Ammi visnaga* had been 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. 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). These results suggested that *A. visnaga* might be drilled at a higher density to reduce plant size, might be grown more reliably from plugs, and that the more robust *A. majus* might be grown instead.

In 2015 *A. visnaga* was much slower to mature than in the previous year, probably due to the very cold spring and early summer. It seems unlikely that two rounds could be produced annually by growing in a tunnel. It was unfortunate that the first two sowings were virtually lost, possibly due to herbicide residues in the soil, but the later sowings were satisfactory. *A. visnaga* may be a suitable filler for the larger, more expensive bouquets. *A. majus* was also slow to mature in 2015, but produced marketable stems from the later sowings, both indoors and outdoors. As can be seem from the photographs *A. majus* has a totally different flower form and growth habit to *A. visnaga* (Figure 31). In testing in 2015, samples of *A. visnaga* and *A. majus* both achieved a very long VL: 17 and 22d, respectively. There has been interest in ammi from customers and growers, but preferences for one or the other vary. The industry is interested in the CFC trialling ammi again in 2016.

Figure 31. Typical plots of (left) *Ammi majus* and (right) *Ammi visnaga* growing in tunnels, 6 August 2015 (week 32)

Dill (Anethum graveolens). Anethum was quick to germinate and fast growing in both years. 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. In both years dill produced some secondary stems after the main stems had been cut.

Post-harvest tests in 2014 showed that anethum stems had a satisfactory 11 day VL, though there was substantial growth post-harvest that may be disadvantageous - stems elongating by up to 90% in length. Similar VL were obtained in 2015, with 15d for an outside sample (11 August) and 11d for a tunnel sample (12 October). Initially the stems had become flaccid, but regained turgor within two days. The promising VL of dill should be followed-up to see if its excessive post-harvest growth can be restricted, but the lack of facilities made this impractical in 2015.

Anthriscus sylvestris 'Ravenswing'. In 2014 seed of anthriscus did not germinate following direct-drilling, and replacement plugs were planted. These established quickly but produced only a handful of flowers. 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 (Figure 32). The planned VL testing was not possible because of the lack of facilities. *Anthriscus* 'Ravenswing' will be grown again in 2016, treating it as a perennial.

Figure 32. Anthriscus overwintered in tunnel and flowering 5 May 2015 (week 19)

Bupleurum rotundiflorum 'Griffithii'. In both years bupleurum was slow to germinate and grow, appeared to bud-up early, but did eventually produce long, strong stems. In both years the tunnel crop had some plants with leaf scorch, which needs to be investigated; it was 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. 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. A further trial is being considered for 2016.

Euphorbia oblongata. In 2014 euphorbia had been very slow to germinate and grow, and produced stems that were too short for cutting, about 20cm long. At the end of the growing season part of the crop was transplanted to 'Pro-Tech' tunnel bay 1 for observations in 2015. As the latex produced from the ends of cut stems can cause skin irritation, it would be necessary to test it in mixed vases to determine whether it had any inimical effects on other cut-flowers. Possibly the latex could cause problems for workers and consumers and a full risk assessment would need to be undertaken.

The transplanted euphorbia produced a good flush of long stems in late-May / early-June. It then continued steadily producing shorter stems (40–50cm) through to autumn. Samples cropped from tunnel and outside plots became limp soon after harvest, but recovered overnight in a cold store, thereafter having a long VL of 14d. Its overall look was well liked, with good bulk and zesty green colour, but euphorbia freely exudes milky sap when cut, making for messy handling and possibly a risk of skin irritation. These factors will be considered in 2016.

Ridolfia segetum. Ridolfia was 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 when the tunnel was de-skinned. 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 considered that anethum could be a better option.

The sowing and picking dates (excluding anthriscus and euphorbia) are summarised in Table 18. For the successful crops, the time from sowing to picking averaged 11.1 weeks. Reliable crop establishment and growth appears to be more of a problem than scheduling them over a relatively short period of continuity as a summer crop.

Table 18. Sowing and picking dates for seed-raised filler demonstrations in 2014 and 2015

Species	Year	Sowing week	Site	Picking week	Time to crop (weeks)	Notes
Ammi majus	2015	17	Tunnel	-	-	Crop failed[1]
		20	Tunnel	-	-	Crop failed
		24	Tunnel	37	13	-
		24	Outside	41	17	-
		28	Tunnel	>44	>16	Late crop[2]
Ammi visnaga	2014	21	Outside	33	12	-
		25	Outside	38	14	-
		27	Tunnel	42	15	-
		30	Tunnel	>43	>13	Late crop
	2015	17	Tunnel	-	-	Crop failed
		20	Tunnel	-	-	Crop failed

		24	Tunnel	40	16	-
		24	Outside	41	17	-
		28	Tunnel	>44	>16	Late crop
Anethum	2014	21	Outside	29	8	-
		25	Outside	32	7	-
		27	Tunnel	34	7	-
		30	Tunnel	39	9	-
	2015	17	Tunnel	-	-	Crop failed
		20	Tunnel	-	-	Crop failed
		24	Tunnel	32	8	-
		24	Outside	34	10	-
		28	Tunnel	34	6	-
		31	Tunnel	41	10	-
Bupleurum	2014	21	Outside	31	10	
		25	Outside	36	11	
		27	Tunnel	39	12	
		30	Tunnel	>43	>13	Late crop
	2015	17	Tunnel	29	12	
		20	Tunnel	31	11	
		24	Tunnel	35	11	
		24	Outside	37	13	
		28	Tunnel	>44	>16	Late crop
		31	Tunnel	>44	>13	Late crop
Ridolfia	2014	21	Outside	30	9	-
		25	Outside	35	10	-
		27	Tunnel	36	9	-
		30	Tunnel	>43	>13	Late crop
	2015	17	Tunnel	-	-	Crop failed
		20	Tunnel	-	-	Crop failed
		24	Tunnel	36	12	-
		24	Outside	35	11	-
		28	Tunnel	>44	>16	Late crop

[1] 'Crop failed' indicates failure probably caused by herbicide residues
[2] 'Late crop' indicates the crop failed to flower before the tunnels were de-skinned in week 43 or 44

Leucanthemum (Leucanthemum × superbum cultivars)

This crop has not been previously tried at the Centre and was included in 2014 to demonstrate a new range of cut-flower leucanthemum from Realflor. Details of the demonstration are given in Table 19.

Table 19. Details of 2014–2015 leucanthemum demonstration

Varieties	'Real Fancy', 'Real Fizzy' and 'Real Frilly'
Format(s) and supplier(s)	Pinched 9cm liners (Realflor)
Propagation and pre-planting treatment(s)	None
Planting or sowing	Transplanted
Planting or sowing date(s)	Week 17 2014
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)	Mulched with peat and over-wintered to 2015
Pests, diseases and disorders	None evident
Picking stage(s) and market specification(s)	Buds showing colour Stem length 60cm
Picking and recording date(s)	2014: 'Real Frilly' week 25; 'Real Fancy' and 'Real Fizzy' week 28
Records taken	Picking dates
VL testing	No

The plants as supplied had been pinched and had many breaks, and they grew away well. However, 'Real Frilly' started to bud prematurely (week 22) and then flowered on short stems (Figure 33). The three cultivars in flower are shown in Figure 34.

The plots were over-wintered for assessment in a second year, but there were >50% plant losses and flower stems were short. These cultivars do not appear suitable for growing in a Spanish tunnel.

Figure 33. Leucanthemum cultivars in the tunnel, front to back: 'Real Fancy' (in bud), 'Real Frilly' and 'Real Fizzy' (in bud) (23 June 2014, week 26)

Figure 34. 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)

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 many of the well-know seed houses and several series are available, including the 'Lake Collection' (Kieft Seeds) which is marketed as a cut-flower trachelium. Trachelium' seemed well worth testing.

2013 and 2014 trials. 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 are indicated in the seed catalogues consulted. However, discussions with other growers and propagators in the UK and the Netherlands 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/m^2 to a 2m-long plot in 'Pro-Tech' tunnel bay 1. The plants grew well and produced an attractive display that started 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 20).

Table 20. 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, minimum head diameter 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 and stem weight after trimming to 55cm (sample of 22 lead stems per plot)
VL testing	Sampled week 32 (not 'Lake Michigan Purple') (tested by Butters Group)

In 2014 the initial growth appeared weak and budding-up occurred early. However, the stems lengthened and strengthened as the plants matured (Figure 35). Each plant produced at least one heavy lead stem and a number of marketable side-shoots. Colours were impressive (Figure 36). Total yield of marketable stems ranged from 86/m^2 for 'Corine Purple' to 158/m^2 for 'Lake Michigan Blue' (Figure 37). For the lead stems, average lengths varied between 57 and 66cm and average weights (once trimmed to 55cm) from 23g ('Lake Michigan White') to 32g ('Corinne Purple') (Figure 37). The late, week 27 planting of 'Lake Michigan Purple' produced short stems, so this planting date was too late to achieve natural season flowering (Figure 38).

Figure 35. 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’

Stems of ‘Corine 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. The demonstration needed to be repeated in a further year before definite conclusions were drawn.

Figure 36. 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

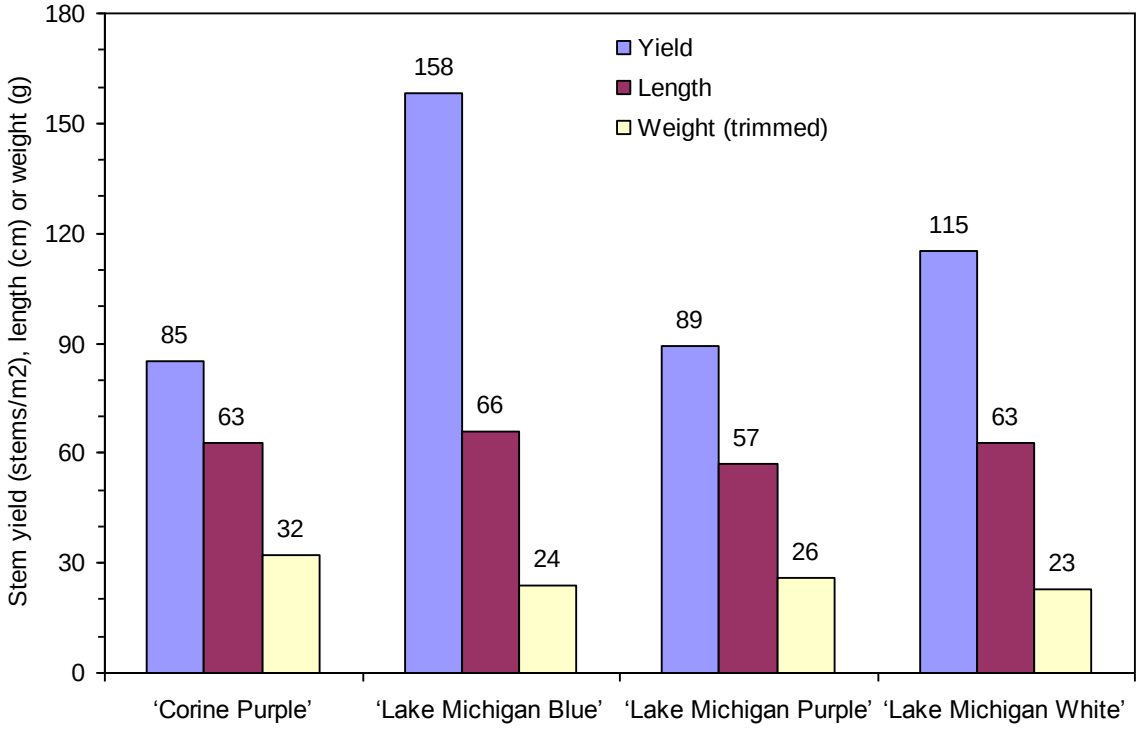


Figure 37. Stem yield, stem length and trimmed stem weight for four cultivars of trachelium planted week 22 in demonstration plots in 2014

Figure 38. Late-planted (week 27) 'Lake Michigan Purple' (17 October 2014, week 42)

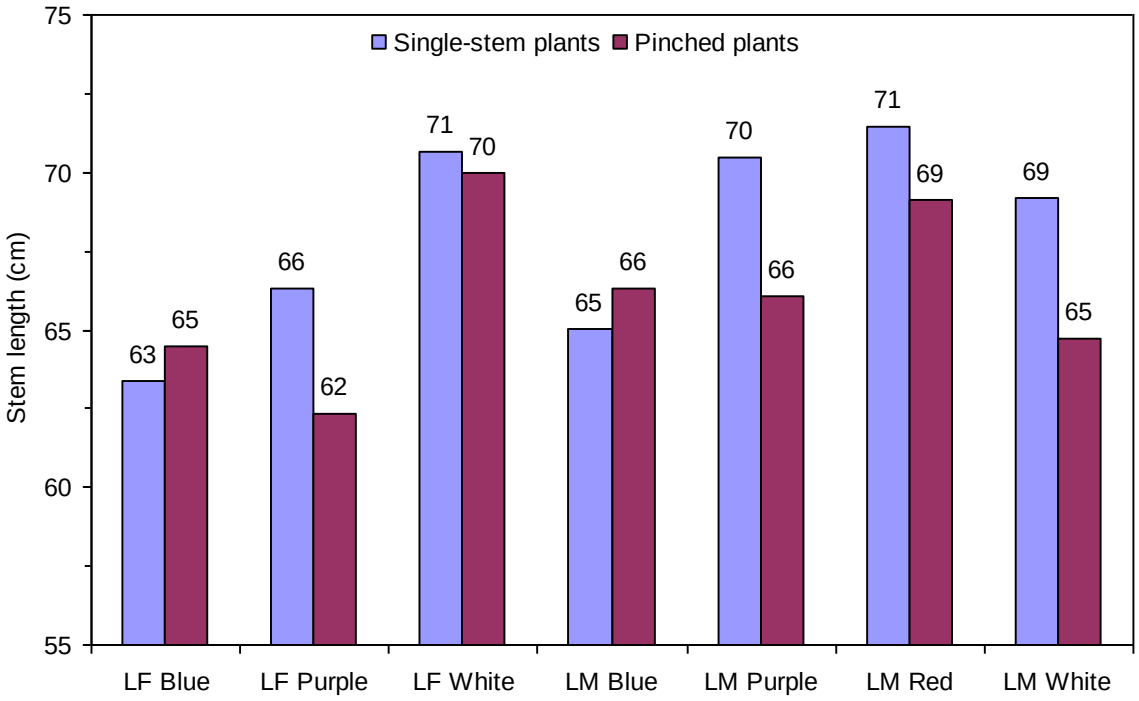
2015 trial. Following the successful trial in 2014 a second trial was set up to investigate transplanting dates further and compare pinched and non-pinched crops (Table 21).

Table 21. Details of 2015 trachelium trial

Site	Rookery Farm
Varieties	'Lake Michigan' series 'Blue', 'Purple', 'White' and 'Wine Red' 'Lake Forrest' series 'Blue', Purple' and 'White'
Format(s) and supplier(s)	Plug-plants (Florensis)
Propagation and pre-planting treatment(s)	None
Planting or sowing	Transplanted
Planting or sowing date(s)	Weeks 18, 22 and 25
Plant spacing(s)	64/m^2 (single-stem plots) 25/m^2 (pinched plots)
Layout	Weeks 18 and 25: un-replicated 2.5m-long plots Week 22: 3 replicate plots (0.8m-long) per treatment × cultivar combination
Post-planting treatment(s)	Treatment 1: pinched to 4 or 5 leaves 14 days after planting Treatment 2: not pinched One layer of support net provided
Planting/housing site(s)	Beds in 'Pro-Tech' tunnel bay 2
Pests, diseases and disorders	Scattered plant failures (average of 2/plot)
Picking stage(s) and market specification(s)	Florets just starting to open Stem length 60cm Minimum floret diameter 8cm
Picking and recording date(s)	Single-stem, week 18: weeks 30-31 Pinched crop, week 18: weeks 31-32 Single-stem, week 22: see results Pinched crop, week 22: see results Single-stem crop, week 25: weeks 35-36 Pinched crop, week 25: weeks 37-38
Records taken	Picking date Total number stems picked Stem length and (after trimming to 50-60cm-long) weight for random samples of 10 stems
VL testing	Sampled 11 August and 21 September 2015 (tested by Superflora UK)

As found in 2014, initially growth was weak and budding-up premature, though the plants strengthened later, producing large numbers of marketable stems. Stem length was satisfactory (Figure 39), averaging between 62 and 71cm in the different treatments, largely due to cultivar effects (significant at P<0.001***): overall, 'LF White' and 'LM Red' produced the tallest stems (70cm) and 'LF Blue' and 'LF Purple' the shortest (64cm). For three cultivars - 'LF Purple', 'LM Purple' and 'LM White' - the stems from single-stemmed plants were significantly taller than their pinched equivalents, though this is likely to have been largely due to chance than to an interaction between cultivar and pinching treatments (the cultivar effect

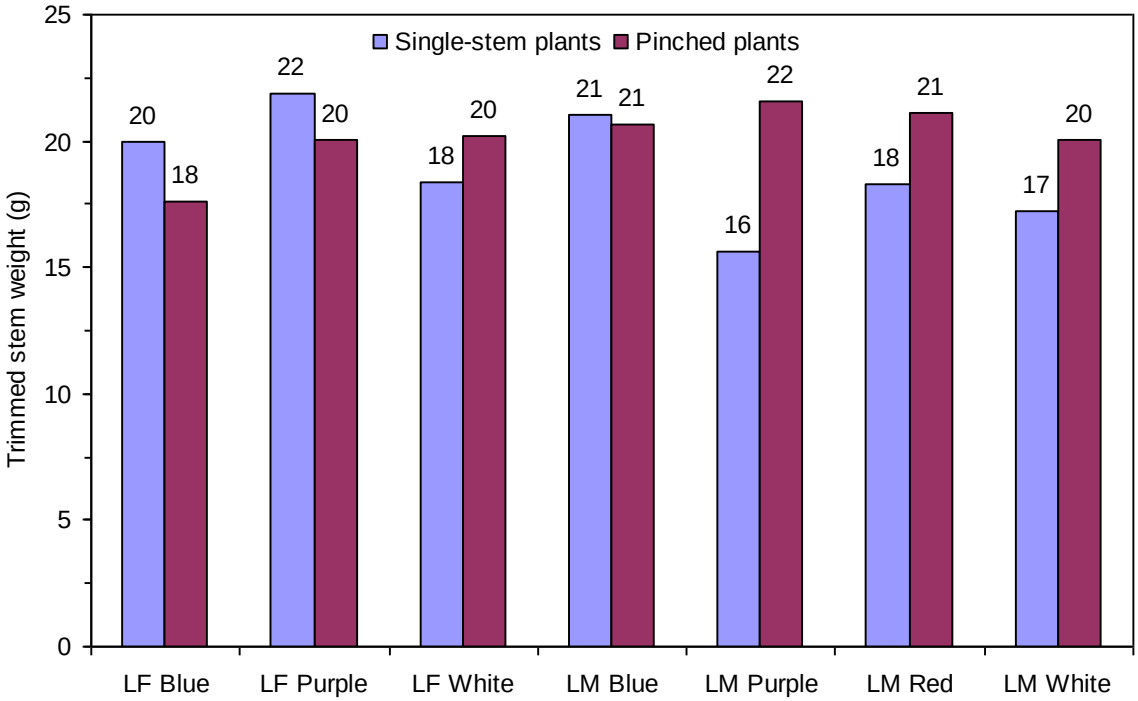
was statistically significant, but at P<0.05* only and the interaction was not significant). As shown by Figure 40, trimmed stem weight varied little between the treatments, the treatment means ranging from 16 to 22g. Effects due to pinching treatment, cultivar and the interaction between them were all non-significant.



Analysis of variance[1]						
Source of variation	SS	DF	MS	F	P	
Pinched/single stem	38.4771	1	38.4771	5.5234	0.026	*
Cultivar	249.0890	6	41.5148	5.9595	<0.001	***
Interaction	56.8195	6	9.4699	1.3594	0.265	NS
Residual	195.0533	28	6.9662			
Total	539.4390	41				

[1] In analysis of variance tables the value of P (probability) indicates the statistical significance of the sources of variation (in this case pinching, cultivar and the interaction between them). In analysis of variance tables *, ** and *** indicate significance at the 0.05, 0.01 and 0.001 levels of probability, i.e. that the result obtained could be expected to have occurred by chance in one in 20, one in 100 or 1 in 1000 instances, respectively, and NS indicates not significant (i.e. P>0.05)

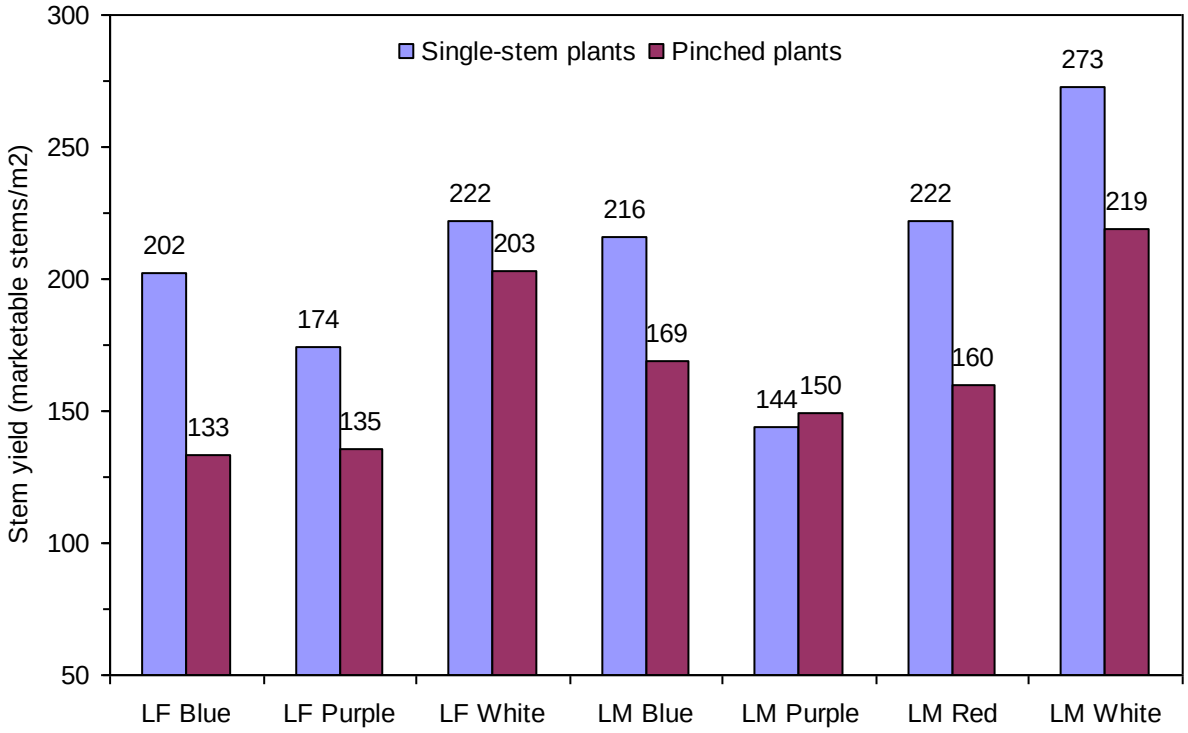
Figure 39. Average stem length for the replicated plots (planted week 22) (LSD (5%) between treatment means = 2.89) with analysis of variance for single-stemmed or pinched trachelium cultivars, 2015 trial



Analysis of variance[1]						
Source of variation	SS	DF	MS	F	P	
Pinched/single stem	17.2288	1	17.2288	1.7615	0.195	NS
Cultivar	36.2362	6	6.0394	0.6175	0.714	NS
Interaction	78.5762	6	13.0960	1.3390	0.273	NS
Residual	273.8600	28	9.7807			
Total	405.9012	41				
[1] See footnote to Figure 39						

Figure 40. Average trimmed stem weight for the replicated plots (planted week 22) (LSD (5%) between treatment means = 3.4) with analysis of variance for single-stemmed or pinched trachelium cultivars, 2015 trial

It was curious that 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/m^2 of between 133 (for pinched 'LF Blue') and 273 (for single-stem 'LM White') (Figure 41). Single-stemmed plants gave more stems than pinched plants (with marginal means of 207 and 167/m^2 , respectively), an effect significant at P<0.05*, and there was a similarly significant effect of cultivar, the marginal means ranging from 147 for 'LM Purple' to 246 for 'LM White'. Again, the interaction between pinching treatment and cultivar was not statistically significant. Single-stemmed plants cropped around 10 days before their pinched equivalents, a statistically significant effect (P<0.001***), any effects of cultivar and the interaction being non-significant (Figure 42).

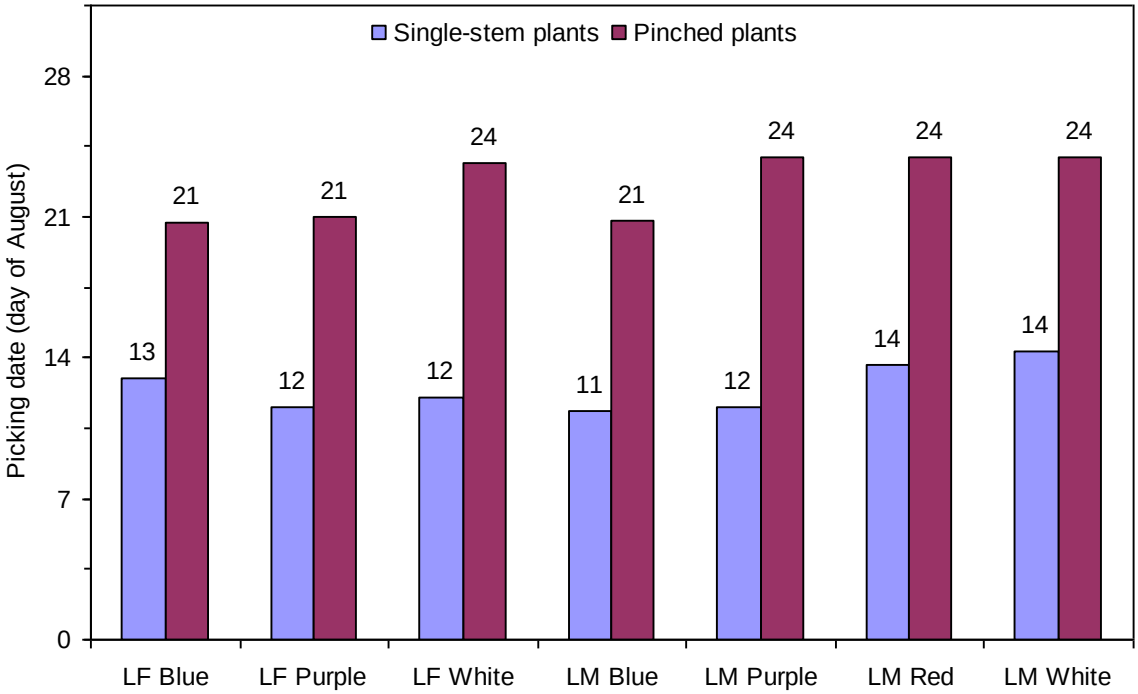


Analysis of variance[1]						
Source of variation	SS	DF	MS	F	P	
Pinched/single stem	17151.823	1	17151.823	5.8473	0.022	*
Cultivar	43141.518	6	7190.253	2.4513	0.049	*
Interaction	6176.042	6	1029.340	0.3509	0.903	NS
Residual	82132.292	28	2933.296			
Total	148601.674	41				
[1] See footnote to Figure 39						

Figure 41. Average marketable stem yield/m^2 for the replicated plots (planted week 22) (LSD (5%) between treatment means = 59.3) with analysis of variance for single-stemmed or pinched trachelium cultivars, 2015 trial

Samples of each cultivar were taken for VL testing on 11 August and 21 September 2015. VL was excellent: the average VL for the cultivars ranged from 13.7 to 17.0d, with an overall average of 14.8d. There was no substantial difference in VL between the August and September samples: 15.1 and 14.3d, respectively.

There appears to be very good potential for growing tunnel-raised tracheliums in the UK. Tracheliums have had a poor reputation in the past because of browning and the low weight of imported stems: the UK product seems much better – greener, taller and heavier. Trials will be continued in 2016. 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. Presently the high cost of plants is deterring growers from trying trachelium, and this would reduce costs.



Analysis of variance[1]						
Source of variation	SS	DF	MS	F	P	
Pinched/single stem	1070.9183	1	1070.9183	144.6775	<0.001	***
Cultivar	52.3838	6	8.7306	1.1795	0.345	NS
Interaction	21.7960	6	3.6327	0.4908	0.810	NS
Residual	207.2590	28	7.4021			
Total	1352.3572	41				
[1] See footnote to Figure 39						

Figure 42. Average picking date for the replicated plots (planted week 22) (LSD (5%) between treatment means = 3.0) with analysis of variance for single-stemmed or pinched trachelium cultivars, 2015 trial

Zinnia (*Zinnia elegans*)

Unlike the other species in the novel crops section, zinnias have been grown previously at the CFC, 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.

2013 trial. In 2013, seed of seven varieties of the ‘Oklahoma’ series and of thirteen varieties of the ‘Benary’s Giant’ series were germinated in plugs 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, 2013), 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).

2014 trial. In 2014 a selection of cultivars was tunnel-grown specifically to provide material for VL testing. ‘Benary Giant’ cultivars ‘Coral’, ‘Wine’, ‘Purple’, ‘Deep Red’, ‘Golden Yellow’, ‘Scarlet’, ‘Salmon Rose’, ‘White’, ‘Lime’, ‘Orange’, ‘Bright Pink ’and ‘Lilac’, and ‘Oklahoma’ cultivars ‘Pink’, ‘White’, ‘Salmon’, ‘Scarlet’, ‘Ivory’ and ‘Carmine’ were sown in module trays in weeks 13 and 17 and transplanted in weeks 18 and 22 respectively. Establishment was good and buds were visible within three or four weeks of transplanting (though stems were too short at that stage) and growth was prolific (Figure 43) until bacterial blight (*Xanthomonas campestris*) appeared. Once the disease had been treated by pruning-out the affected foliage and spraying the crop with Amistar, the crop grew away vigorously and continued producing flowers in abundance until well into October (Figure 44).

Figure 43. ‘Benary Giant’ and ‘Oklahoma’ zinnia cultivars in 2014 demonstration plots (7 August 2014, week 32)

Figure 44. Zinnia demonstration plots at the end of the season (17 October 2014, week 42)

The crop provided plenty of stems for VL testing, but post-harvest quality was unsatisfactory, with stems failing to last to the end of the 4d retail store phase. This seemed to have been due to adverse effects of the cool-chain, resulting in early dehydration of the flowers. Further VL work is desirable (using the taller ‘Benary’s Giant’ series). Consultants from Chrysal UK suggested there may be treatments available that could avoid such damage and further work was planned for 2015. There was a need 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 these shortfalls, with current knowledge zinnia appears to be a good candidate for ambient direct sales such as mail-order work.

2015 trial. 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. Details of the crop are given in Table 22 and it is shown in

Figure **45**.

Table 22. Details of 2015 zinnia production for VL testing

Site	Rookery Farm
Varieties	'Benary Giant' cultivars 'Bright Pink', 'Carmine', 'Coral', 'Dahlia Mix', 'Deep Red', 'Gold Yellow', 'Lilac', 'Orange', 'Purple', 'Salmon Rose', 'Scarlet', 'White' and 'Wine'
Format(s) and supplier(s)	Seed (Benary)
Propagation and pre-planting treatment(s)	None
Planting or sowing	Sown into module trays week 14
Planting or sowing date(s)	Transplanted week 19
Plant spacing(s)	25/m^2
Layout	3m-long plots
Post-planting treatment(s)	One layer of support net provided
Planting/housing site(s)	Beds in 'Haygrove' tunnel
Pests, diseases and disorders	Occasional aphids and caterpillars No problem with bacterial blight this year
Picking stage(s) and market specification(s)	Picked at a range of stages (see text)
Picking and recording date(s)	Week 28 onwards
Records taken	Observations only
VL testing	Sampled week 36 (tested by ADAS Boxworth)

Figure 45. Zinnia cultivars grown for VL testing in 2015 (photographed 22 July, week 30)

As in previous years the crop grew well, starting to produce marketable flowers by week 28. Because of the unavailability of a VL test room earlier in the season, stems of zinnia (mixed

cultivars) were picked on 1 September 2015 (week 36). Equal numbers of stems were sampled with un-opened flowers, almost fully open flowers (open stamens and disc florets) and flowers at an intermediate stage. They were cold-stored overnight in clean auction buckets in water with added conditioning solution, either (1) 'Chrysal Clear RVB Clear Intensive' at 1ml/L, (2) 'Chrysal Clear CVBN' at 1 tablet/2L or (3) 'Chrysal Clear CVBN' at 1 tablet/L before delivery to ADAS Boxworth. The cut-stems were transferred to buckets of water with added shipping treatment ('Chrysal Clear Professional 2 T-Bags') and kept in the VL room until 4 September when the VL test was set-up. The stems were de-sleeved, re-cut and placed in vases containing 1L of water with added flower food ('Chrysal Clear Liquid Universal'). With three conditioning treatments and using three mixtures of cultivars there were nine treatment combinations, each with two replicate vases (18 vases) containing six stems each (108 stems). The vases were randomised in the VL room, in which the conditions were 20°C and 60% RH, with light at 1,000lux for 12h/day.

The stems were assessed daily using the following write-off criteria: >90° bending of the stem or >75% of the petals wilted or showing signs of discolouration. Water clarity was monitored and the first day of clouding was recorded. Flower and leaf quality and water clarity were assessed on vase-day 7 using one-to-five scales (Table 13). The trial was completed on vase-day 10 with any stems not yet written-off being assessed a VL of up to 12 days.

Overall the zinnias performed reasonably well in the VL trial, most stems lasting beyond the guarantee day, day 5 (Table 23; Figure 46). But between vase-days 5 and 10 they failed quickly and on average <50% survived beyond vase-day 10. Stems failed for a variety of reasons, including botrytis in the bud and bending of the neck, but mainly for discolouration around the edges of the petals (Figure 47). Interestingly, stems harvested at the early stage with apparently weak necks, appeared to become firmer in the neck rather than bending, as had been expected from earlier trials. Also, VL was not obviously shorter for the most advanced stems, compared with those cropped at an earlier stage. Technologists have suggested that the bending of the neck only occurs when stems are picked at an over-mature stage, and that otherwise the developmental stage at picking is of little importance (Tracey Thomas, personal communication, 2015; Claire Strait, personal communication, 2015). No consistent differences in these metrics were found between the three conditioning treatments. There did, however, appear to be large differences in performance between cultivars: at the extremes 'green' had the longest average VL (9.9 days) and stems remaining at vase-day 10 (94%), whereas 'white' had the poorest responses (6.3 days and 25%).

There were some differences in flower quality scores between conditioner treatments, 'CVBN' treatments resulting in marginally better scores. The leaf quality score remained at 5

throughout. Water quality was good across the trial, with very little clouding seen until after vase-day 5 (Table 23).

Further post-harvest studies had been proposed, but had to be delayed until 2016, when it is anticipated that access to a new VL test facility will be available. The crop will only be grown in 2016 once the availability of this new facility is confirmed.

Figure 46. Zinnia cultivars from three conditioner treatments pictured on vase-days 5 and 10 (2015 VL trial)

Figure 47. Typical examples of stem failure in 2015 zinnia VL trial: (left) petal discolouration and (right) botrytis damage

Table 23. Average VL, flower quality and water clarity scores of zinnias with three conditioning treatments in 2015[1]

Cultivar combination	Conditioning treatments	First failure (day)	VL (days)[2]	% stems remaining		Flower quality score		Water clarity score VL day 10[3]	First day clouding observed
				VL day 5	VL day 10	VL day 5	VL day 10		
Pink & green	1. 'RVB Clear Intensive' 1ml/L	6.0	7.1	100	50	3.0	2.5	4.5	9.5
	2. 'CVBN' 1 tablet/2L	5.0	7.1	75	33	4.0	2.0	2.5	7.5
	3. 'CVBN' 1 tablet/L	6.0	8.0	100	83	4.0	3.5	3.5	8.0
Purple & white	1. 'RVB Clear Intensive' 1ml/L	5.0	6.5	75	33	4.0	2.5	4.5	9.5
	2. 'CVBN' 1 tablet/2L	5.5	8.4	83	58	4.0	3.0	4.5	9.5
	3. 'CVBN' 1 tablet/L	4.5	5.9	87	37	4.0	2.5	4.5	9.5
Red & yellow	1. 'RVB Clear Intensive' 1ml/L	6.0	7.8	100	58	3.5	3.0	5.0	10.0
	2. 'CVBN' 1 tablet/2L	6.0	7.2	100	75	4.0	3.5	4.0	9.0
	3. 'CVBN' 1 tablet/L	7.0	7.8	100	42	4.0	2.5	5.0	10.0
Marginal means for all cultivars	1. 'RVB Clear Intensive' 1ml/L	5.7	7.2	92	47	3.5	2.7	4.7	9.7
	2. 'CVBN' 1 tablet/2L	5.5	7.6	86	56	4.0	2.8	3.7	8.7
	3. 'CVBN' 1 tablet/L	5.8	7.2	96	54	4.0	2.8	4.3	9.2

[1] leaf quality scores were 5.0 throughout
[2] excluding losses due to botrytis
[3] water clarity scores on vase-day 5 were 5.0 throughout

Discussion

A review of the global cut-flower trade, carried out as part of this project, showed that production horticulture businesses across western Europe and North America are seeking novel cut-flower crops to develop as production of the traditional mass-market species – rose, carnation, chrysanthemum and lily – is taken up by emerging producers in Africa and Central and South America. Business will become even more competitive for UK cut-flower growers, who nevertheless have the considerable advantage of expertise in dealing with supermarkets and demanding legislation – amongst European countries the UK sees by far the greater proportion of its cut-flowers sold through supermarkets rather than smaller, more traditional outlets.

Among the more familiar cut-flowers trialled in 2015, the new approaches tried with alstroemeria, *Aster ericoides*, ornamental brassicas and lilies seemed most successful. Trials with **alstroemeria** showed that a familiar crop can sometimes be grown in a new way. Production costs were reduced by growing older garden cultivars – cheaper because they are free of plant variety rights - in Spanish tunnels rather than in the usual well controlled glass. Planting at 5/m^2 in week 22, flowers were cropped between weeks 30 and 44 in the first year and between weeks 23 and 44 in their second year. Using several cultivars and having some planted in outside beds, enable reasonably consistent cropping over a 5-month period, stopped in this case only because it was necessary to de-skin the tunnel in readiness for winter. Against expectations perhaps, the quality of the tunnel-grown stems was highly rated by the industry in both years, aided by a VL of about 12 days if cut at the right stage. The economics of the operation will be the key to success, and costings will be carried out after a third year's crop in 2016. There would be several disincentives to be overcome, mainly the labour-intensive, long-term nature of the crop, and the long-term agreements of UK supermarkets with overseas growers.

September–flowering ***Aster ericoides*** is a familiar and relatively cheap filler, but the advent of new double-flowered lines raised the possibility of a better quality product, perhaps suitable as a straight line. Interest was expressed by growers in seasonal extension for the new lines, which could be achieved in this short-day plant by using summer black-out covers. The crop was blacked-out overnight for 13h/d between weeks 22 and 31, producing tall, high-quality flowers in weeks 32-33 (first-half August) and a second flush in week 45 (October-November), though the latter were too short to be marketable. For comparison plants kept under natural day-lengths outdoors flowered around week 40 (September-October). In 2014 a fresh crop was similarly treated, SD covers being applied in weeks 25-30, and resulting in a high-quality crop in weeks 32-33 for two of the four cultivars tested, and a second flush around week 43

(the time when the tunnel was de-skinned). VL was typically 8-9d, acceptable but not exceptional. The other cultivars had premature budding and poor quality and yield. It seems that trying to get two flushes of *A. ericoides* is pushing the crop to the limit in the restricted growing period available in a Spanish tunnel before de-skinning, whereas it should be achievable when growing under glass or possibly in a fixed tunnel. Given some market interest, it might be worth looking at starting the plants in pots and planting pinched plants with side-shoots already present in order to reduce the growing time: but at present there is little take-up in the industry.

The CFC has carried out a number of trials on ornamental ***brassicas***, both in Spanish tunnels and in the field. In 2015 a selection of newer cultivars was grown in a tunnel alongside cultivars of the familiar 'Crane' series. While cultivar selection is of concern, so are issues like the failure of the heads to colour in mild conditions and the management of head size. The alternative cultivars grown included several with well coloured pink heads, as well as cream and pink/cream/green heads and dissected leaves as well as solid leaves. The uncertainties of growing ornamental brassicas in the UK seem to mean that growers are unwilling to take on alternative cultivars at this time – they would need to show clear economic advantage over the established 'Crane' cultivars. The quality of the tunnel-grown heads in 2015 probably surpassed other previously grown at the CFC.

*Crate-grown **lilies** remain an important cut-flower in the UK. They are routinely grown in peat – usually producing excellent results but, of course, raising the familiar concerns. Substitutes or diluents for peat have been evaluated as growing media since at least the 1980s, but more recently green-waste products and anaerobic digestate (AD) have become available: these have been evaluated in lily growing by the CFC over the last three years. Results with green-waste-derived materials varied, probably reflecting the varied origins and nutrient contents of the different products. In the best case lily growth and cut-flower quality in a 100% 'green compost' was as good as in a standard peat, while with other materials growing in a 50:50 (v/v) mix of peat and green-waste resulted in stems up to 10% shorter than in peat alone or, in another case, marketable yield was reduced through chlorotic foliage and stunting. Growing in peat + AD mixtures, results varied according to the source or prior treatment of the AD: in some cases chlorosis and stunting occurred in AD-rich mixtures, but in the best case growing in* peat + AD mixes containing 40 or 60% AD produced high-quality and heavier stems. In other treatments, lily quality was similar to that obtained in peat when grown in a wood-derived commercial potting medium*, in coir and in* a 50:50 peat + coir mix, but growing in a coir + AD (67:33) mix resulted in chlorotic, mottled foliage. There is clearly further scope for working on the composition of green-waste-derived, AD and wood-based materials with a view to their use as peat substitutes or as diluents for peat, coir or other growing media.

Amongst the more novel crops evaluated, trachelium was considered the most attractive proposition, and trials with seed-raised fillers and carthamus were also promising. ***Trachelium*** show real potential for cut-flower production in Spanish tunnels. Cultivars from the 'Lake Michigan' and 'Lake Forrest' series were evaluated in 2014 and produced impressive crops. Since 2014 was a warm summer, probably favourable to tracheliums, a further trial was carried out in 2015: it gave equally good results. In 2014 plugs had been planted at a density of 65/m^2 in week 22, each producing a lead flower and a number of marketable side-stems. Lead stems achieved up to 66cm length and 32g weight, with up to 158stems/m^2. and a main cropping period in weeks 32-34. In 2015 plugs were planted in weeks 18, 22 and 25 and either planted at 25/m^2 and left to grow as one main stem, or at 64/m^2 and pinched. The overall picking period was from week 30 to week 38. For the middle planting date, stems were up to 71cm in length and 22g in weight, with up to 219 stems/m^2 for pinched plants and up to 273 stems/m^2 for single-stem plants. Single-stemmed plants cropped around 10d before their pinched equivalents. Their VL was reported to be much better than in imported flowers. The potential of the tunnel crop for the UK is promising and suggests trials should be continued. In particular 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. Presently the high cost of plants is deterring growers from trying trachelium, and this would reduce costs.

Recent years have seen greater interest in producing cheap, seed-raised ***fillers***, in tunnels or outside, and over the last two years the CFC evaluated *Ammi majus, A. visnaga*, *Anethum graveolens*, *Anthriscus sylvestris*, *Bupleurum rotundiflorum*, *Euphorbia oblongata* and *Ridolfia segetum*. *Ammi visnaga* germination and growth were slow, and consequently the unintentionally wide spacings produced stems too large as a conventional filler but possibly useful in the larger bouquets. *Ammi majus* was also slow growing but produced more compact stems from the later sowings, indoors and out. *Anethum graveolens* (dill) was quick to germinate and fast-growing. Sown from week 21 to 31, picking covered the period week 29 to week 41. Anthriscus sylvestris seed failed to germinate following direct-drilling and plugs were planted as replacements, though they produced only a handful of flowers and were damaged by two-spotted spider mite. However, the plants were left *in situ* and produced a good crop in early-May, and it will be treated it as a perennial. *Bupleurum rotundiflorum* was another filler that was slow to germinate, but eventually produced vigorous stems. The CFC tunnel crop suffered some leaf scorch, possibly leading to damage from botrytis. Another filler slow to germinate was Euphorbia oblongata, and it produced short stems unsuitable for cutting. Plants transplanted and grown-on, however, produced a good flush of long stems in late-May/early-June the next year, continuing with a steady flush of stems 40–50cm long through to autumn. *Ridolfia segetum* was slow to germinate, but sowing from week 21 to 30 stems were ready for

picking starting week 30 on onwards to the onset of winter. After cutting the main stem, secondary stems were produced. It should be possible to improve germination and establishment of some of these species and schedule them over a relatively short period as a summer crop. Growers have expressed interest in developing this work in 2016, and *Orlaya*, *Atriplex* and *Daucus* have been suggested as additional subjects.

Carthamus is well liked as an unusual, thistle-like filler. Three cultivars were sown in a tunnel and outdoors over week 25 to 30, and although plant development was initially rapid it later slowed and crops from the earlier sowings were ready to pick at weeks 35-37, though the late sowing had not been picked by the onset of winter. The next year sowing started earlier, from week 17 and extending to week 31; they cropped mainly over the period week 29 to 40, though the later plantings were not ready for picking by the onset of winter. Samples taken for post-harvest testing had a just-adequate VL of 7d, but quality was spoiled by bract-tipping. Carthamus is a crop which produces a reliable strong sturdy stem, but maintaining bract quality is an issue that should need to be resolved. With limited industry interest in expanding the crop, further work is hard to justify.

Other novel cut-flowers tested showed many positive features but were handicapped by more generic issues. One recurring issue in the UK cut-flower business concerns the poor returns obtainable from supermarkets. Many of the exciting cultivars of cut-flowers now being produced, which might otherwise be seen as ideal for UK growers, are supplied as tissue-cultured plants or cuttings that also incur the costs associated with plant variety rights. Amongst the crops tested at the CFC in 2015 to which this applies, were new cultivars of double ***Aster ericoides, delphiniums*** ('Waltz' and 'Tango' series), various types of ***pinks*** ('Tiara' series, a range of green flowers such as 'Green Trick' and Whetman Pinks exemplified by 'Cherry Daiquiri'), and ***leucanthemum*** from the 'Real' series. All these attracted the interest of the cut-flower business, but the economics of UK horticulture mean that growers need better returns in order to justify growing crops having expensive plant material.

Many attractive flowers fail to make it as commercial cut-flowers because of poor post-harvest quality, primarily short VL. It is likely that advances in post-harvest treatments – conditioners and flower-foods – will eventually extend further the range of species that can be held in good condition by the consumer for one to two weeks. For the present the lack of post-harvest research is a critical restraint on expansion of the range. One reason is the virtual absence of VL-test facilities available for near-market research, and this held back work planned for 2015 on ***cosmos*** and ***zinnia***, which otherwise have been shown in CFC trials to have potential for commercialisation as cut-flowers. Cosmos have very short VL, while in zinnia the hollow stem is prone to collapse just below the inflorescence. It is anticipated that a VL test-room will become available in the area in 2016.

The tentative ***plan for trials in 2016***, based on the results to date and the findings of the new products review, includes the following:

- Seed-raised fillers: demonstrate as many cultivars as practical of *Ammi*, *Anthriscus*, *Atriplex*, *Daucus*, *Euphorbia* (overwintered) and *Orlaya*
- Zinnia: grow plants for further VL tests
- Trachelium: investigate the economics of production of pinched crops compared with traditional single-stem production
- Lilies: continue trial on alternative growing media including new AD materials
- Alstroemeria: continue trial for a further year
- Pinks: continue trials of novel pinks for a further year
- Sunflowers: evaluate dwarf and new cultivars
- Herbicides: herbicide trials mainly seeking a replacement for 'Ronstar'
- Column stocks: investigate the potential of SHDI fungicides to control fusarium (pot trial)
- Ornamental grasses: investigate a range of seed- and plug-raised grasses in tunnels and outdoors
- Novel product demonstrations (ornamental grasses): *Eragrostis*, *Miscanthus*, *Panicum*, millet, *Miliaceum*, *Bromus*, *Setaria*, *Sorghum*, *Stipa*, maize, *Nassella* and *Chasmanthium*
- Ornamental brassicas: continue to evaluate alternatives to 'Crane' cultivars in tunnels and outdoors
- Novel product demonstrations (annuals): lobelia, campanula, cleome, craspedia, gomphrena and scabious
- Novel product demonstration (perennials): ranunculus, hellebore, tuberose and eremurus
- Novel product demonstration (ornamental fruits): solanum, 'pumpkin-on-a-stick', peppers
- Novel product demonstration: evaluate new cultivars of basil
- Novel product demonstration: evaluate new cultivars of delphinium
- Additional shrubs for foliage or flowering branches: *Caryopteris* 'Longwood Blue', *Hydrangea* 'Everlasting' series 'Hamburg' and 'Limelight', *Ilex verticilliata* 'Winter Red', *Physocarpus* 'Coppertina', *Symphoricarpos* 'Amethyst' and *Viburnum* 'Wentworth' and 'Snowball'
- Requests have also been received to demonstrate: seed heads as autumn fillers (poppy, echinacea, crocosmia), herbs (mint, lavender), foxgloves and hardy eucalyptus

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 (now AHDB Horticulture) since the formation of the CFC.

How the objectives were achieved: the CFC 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 The project continues to produce appropriate technical literature, including a review of cut-flower research and trials worldwide, a review of the statistics of cut-flower production worldwide, and leaflets/factsheets summarising the Centre's trials on specific crops. A number of crops that have been trialled at the Centre have now been planted commercially, including antirrhinum, sedum, hardy foliage, a summer spot-crop of lisianthus, alstroemeria in a Spanish tunnel and seed-raised fillers. 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 and initial investigations into growing cut-flowers (particularly column stocks) in a hydroponic system. The CFC (and the wider industry) has participated in discussions with the British Growers Association to investigate any promotional activities or funding that may be open to the industry; at present this is unlikely to go ahead, however, due to financial constraints in the cut-flower industry.

Knowledge and Technology Transfer

Events

Handouts for CFC events are available from http://www.thecutflowercentre.co.uk/ or from AHDB Horticulture.

- National Cut Flower Centre Open Day, JA Collison & Sons, Perch Holme Nursery, Market Lane, Walpole St Andrew, Wisbech, Cambridgeshire and Rookery Farm, Holbeach St John, Lincolnshire, 5 August 2015. The Open Day attracted over 90 attendees. The event included viewing the deep pool hydroponics trial at JA Collison & Sons and tours of the CFC trials and ADAS herbicide trials at Rookery Farm. At Rookery Farm there were presentations on 'Promotional activities' (Jack Ward, British Growers), 'Developments in the global market for cut-flowers' (Gordon Hanks, Horticultural Consultant), 'New

developments within horticultural lighting and spectral coatings' (Dr Simon Pearson, Frieston Associates), a 'CFC trials overview' (Lyndon Mason, CFC) and 'Herbicide trials' (Chloe Whiteside, ADAS).

Website

The Centre's website was kept updated during 2015. 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 2015:

- Mason, L (2015). New crops, new techniques. *HDC News*, no. 212, p. 15-17
- Atwood, J & Whiteside, C (2015). Flowers find their herbicide partners. *HDC News*, no. 213, p.22-23
- Anon. (2015). Investigating the shifts in flower production. *AHDB Horticulture Grower*, no. 215, p.18-19
- Shaddick, C (2015). New technique floated at Cut Flower Centre. *AHDB Horticulture Grower*, no.216, p.28-30.
- Mason, L (2015). Working it out with water. *AHDB Horticulture Grower*, no.219, p.19-21.

Reports and databases

Copies are available from http://www.thecutflowercentre.co.uk/ or from AHDB Horticulture:

- Cut flower seed and young plant suppliers' directory. Revised June 2015. Compiled by Gordon Hanks.
- Field- and tunnel-grown cut-flowers with potential for UK exploitation: A review of trials programmes and research on 'novel subjects. Revised September 2015. Compiled by Gordon Hanks.
- A review of production statistics for the cut-flower and foliage sector. 2015. Compiled by Gordon Hanks.

Leaflets

Copies will be available from http://www.thecutflowercentre.co.uk/ or from AHDB Horticulture:

- Delphinium as a cut-flower grown in tunnels. Information Sheet, National Cut-Flower Centre/AHDB Horticulture. Gordon Hanks and CFC MG (in press)
- Woody foliage production. Information Sheet, National Cut-Flower Centre/AHDB Horticulture. Gordon Hanks and CFC MG (in press)

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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Particular thanks are due to Sue Lamb for her vigorous promotion of the Centre and especially her work in ensuring a large number of cut-flower samples have been made available to the trade.

Index to crops in CFC reports

Key: grey cells = not trialled. White cells = results to come, cells with diagonal lines are for 'cross reference' rows (e.g. 'CAPSICUM see pepper...').

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
GENERAL TOPICS (various species)											
Anaerobic digestate, green-waste, etc							‘13				
Herbicides								‘14	‘15		
Spectral filters							‘13				
ALPHABETICAL INDEX											
Ageratum (*Ageratum houstonianum*)	‘07										
Alstroemeria (*Alstromeria* cultivars)								‘14	‘15		
Amaranthus (*Amaranthus caudatus*)		‘08			‘11	‘12					
Ammi (*Ammi* spp.)								‘14	‘15		
Anethium (*Anethium graveolens*)								‘14	‘15		
Anthriscus (*Anthriscus sylvestris*)								‘14	‘15		
Antirrhinum (*Antirrhinum majus*)		‘08	‘09	‘10	‘11	‘12					
Aster (*Aster pringlei*)		‘08									
Aster, September-flowering (*Aster ericoides*)	‘07			‘10	‘11	‘12	‘13	‘14	‘15		
Basil (*Ocimum basilicum)*							‘13				
Brassica, ornamental (*Brassica oleracea*)		‘08	‘09	‘10	‘11	‘12			‘15		
Bupleurum (*Bupleurum rotundifolia*)								‘14	‘15		
Campanula (*Campanula* spp.)						‘12					
Capsicum SEE Pepper, ornamental											
Carnation and pinks (all types) (*Dianthus* spp.)	’07	‘08	’09			‘12	‘13	‘14	‘15		
Carthamus (*Carthamus tinctorius*)								‘14	‘15		
Caryopteris (*Caryopteris* x *clandonensis*)		‘08									
Celosia (Celosia cristata)						‘12					
Chasmanthium spp. SEE Grasses, Ornamental											
China aster (*Callistephus chinensis*),	’07	‘08	‘09	‘10	‘11	‘12	‘13				
Clarkia grandiflora SEE Godetia											
Column stocks SEE Stocks, column											

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Consolida ajacis SEE Larkspur											
Cosmos (*Cosmos bipinnatus)*							‘13	‘14	‘15		
Cynara (*Cynara cardunculatus*)	‘07	‘08									
Dahlia (*Dahlia hortensis*)			‘09	‘10		‘12	‘13				
Delphinium (*Delphinium elatum*)	‘07	‘08				‘12		‘14	‘15		
Delphinium consolida SEE Larkspur											
Dianthus, annual SEE Carnations and pinks (all types)											
Dianthus barbatus SEE Carnations and pinks (all types)											
Dianthus caryophyllus SEE Carnations and pinks (all types)											
Dill SEE Anethium											
Echinops (*Echinops* spp.)	‘07	‘08									
Eryngium (*Eryngium* spp.)	‘07	‘08			‘11	‘12	‘13	‘14	‘15		
Euphorbia *(*Euphorbia oblongata*)*								‘14	‘15		
Eustoma SEE Lisianthus											
Fillers, seed-raised SEE under individual species											
Foliage SEE Hardy foliage											
‘German’ asters SEE China aster											
Godetia (*Godetia grandiflora*)	‘07	‘08									
Grasses, ornamental (various species)	‘07	‘08									
Gypsophila (*Gypsophila paniculata*)								‘14			
Hardy foliage (various species)				‘10	‘11	‘12	‘13	‘14			
Heath aster SEE Aster, September-flowering											
Helianthus annuus SEE Sunflower											
Larkspur (*Consolida ajacis*)	‘07	‘08									
Lathryus odoratus SEE Sweet pea											
Leonotis SEE Lion’s ear											
Leucanthemum (*Leucanthemum* x *superbum*)								‘14	‘15		
Lion’s ear (*Leonotis leonurus)*							‘13	‘14			

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Lily (*Lilium* hybrids)							‘13	‘14	‘15		
Lisianthus (*Eustoma grandiflorum*)				‘10	‘11	‘12					
Love-lies-bleeding SEE *Amaranthus*											
Lupin (*Lupinus* hybrids)							‘13	‘14			
Lupinus SEE Lupin											
Lychnis (*Lychnis chalcedonica*)		‘08									
Matthiola incana SEE Stocks, column											
Miscanthus SEE Grasses, ornamental											
‘Monte Cassino' aster SEE Aster (*Aster pringlei*)											
Ocimum SEE Basil											
Ornamental brassica, ornamental cabbage SEE Brassicas, ornamental											
Ornamental grasses SEE Grasses, ornamental											
Panicum spp. SEE Grasses, ornamental											
Pepper, ornamental (*Capsicum annuum*)								‘14			
Phlox (*Phlox paniculata*)	‘07	‘08	‘09	‘10	‘11	‘12					
Physostegia (*Physostegia virginianum*)								‘14			
Pinks SEE Carnations and pinks (all types)											
Ridolfia (*Ridolfia segetum*)								‘14	‘15		
Rudbeckia (*Rudbeckia hirta*)					‘11	‘12	‘13				
Sedum (*Sedum* spp.)		‘08	‘09	‘10	‘11	‘12	‘13	‘14			
Setaria italica SEE Grasses, ornamental											
Snapdragons SEE Antirrhinums											
Solidago (*Solidago media*)		‘08									
Spray carnation SEE Carnations and pinks (all types)											
Stock, column (*Matthiola incana*)			‘09		‘11	‘12	‘13	‘14			
Sunflower (*Helianthus annuus*)				‘10	‘11	‘12	‘13	‘14			
Sweet pea (*Lathyrus odoratus*)					‘11	‘12					
Trachelium (*Trachelium caerulum*)							‘13	‘14	‘15		

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
'Trumpet' antirrhinums SEE Antirrhinums											
Veronica (*Veronica* spp.)	'07										
Zinnia (*Zinnia elegans*)	'07	'08					'13	'14	'15		