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The results and conclusions in this report are based on investigations conducted over a one-year (or other limited) period, on one site. 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

I/we declare that this work was done under my/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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Signature Date

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Grower Summary

Headline

- Fillers such as ammi, anethum, bupleurum and ornamental carrot are in demand and relatively easy to grow, but excessive vigour needs to be kept in check.
- Gomphrena is prolific, with red, pink and white flower spikes, the possibility of once-over cropping and good potential as a filler.
- Asclepias and echinacea cultivars are novel and attractive cut-flowers for the UK, but vase-life (VL) issues need to be addressed.
- Ornamental grasses generate much interest for use in fashionable mixed bouquets (*Panicum elegans* 'Sprinkles' and *P. miliaceum* 'Violaceum' are among the best).
- Scabious shows great promise for cut flower production in the UK, in tunnels and outdoors; modern cultivars have a good range of colours, high yields, good VL and potential for use in mixed bouquets.
- Craspedia is an unusual product with high yields of yellow, globe-shaped flowers on long, strong stems, with potential as fresh or dried flowers and as a filler in bouquets.
- Older cultivars of alstroemeria perform well as a natural-season tunnel crop; with several cultivars in tunnels and outside beds, high yields are obtained over a five-month period.
- Growing in a permanent tunnel or under cold glass, *Aster ericoides* produces two flushes in a year using blackout covers to advance flower initiation.
- As a high-quality crop in tunnels, newer cultivars of ornamental brassicas offer an alternative to the familiar 'Crane' series.
- Box-grown lilies in tunnels grow as well in peat mixed with up to 60% of anaerobic digestate, as they do in plain peat, and also grow well in 100% coir or coir and peat mixes.

Background

The UK had a relatively low *per capita* consumption of cut flowers compared with other western European countries, but between 1988 and 2016 its imports of cut flowers rose from some £122m to about £750m. This change in consumer spending, combined with the advent of relatively cheap ‘Spanish tunnels’ and environmental demands to cut ‘air miles’, should have provided cut flower growers with opportunities to expand production. That this did not happen is generally ascribed to (1) a lack of ‘know-how’ and (2) a culture of buying in from ‘across the water’. However, Brexit may now provide greater opportunities for UK growers, as has been seen in the short-term advantage created by the changes in the sterling exchange rate against both dollar and euro.

A national cut flower trials centre (CFC) was proposed by industry representatives and subsequently funded by the HDC (now AHDB Horticulture)¹, starting in 2007. Its short-term aim was to provide information on new product development, novel or alternative cut flowers for production outdoors or in tunnels in the UK. The longer-term strategy was to encourage the cut flower industry to develop new products and markets. Funding provided by AHDB Horticulture has since enabled the CFC to enhance its role by taking on a ‘crop association’ role, including developing a voice for the R&D needs of the sector, extending its work beyond new product development to the facilitation of trials on mainstream cut flower crops.

Summary of the project and main conclusions

In practical terms, the CFC collates ***crop information***, investigates ***crop introduction*** (new product development) and trials ***crop improvement***.

Crop information

The CFC’s trial work has been underpinned by reviewing the appropriate scientific

¹ Initially with part-funding from the Lincolnshire Fenlands LEADER+ programme

literature, technical information and websites. Reports on novel cut flower crops and trials, and on the global statistics and trends of cut flower production, were made available separately in 2015 and at the end of the project.

The CFC has continued to develop its role as an information hub and cohesive voice for the UK cut flower industry. There have been regular (and well attended) open days, and a series of study days and study tours. The CFC has been successful in developing assets over and above the core AHDB Horticulture-funded project by facilitating and hosting other AHDB Horticulture-funded herbicide trials, undertaking (with input from industry) trials on alternative growing media, integrating with research on fusarium, carrying out surveys of quality issues in column stocks and flower spotting problems in cut sunflower, and developing a standalone AHDB Horticulture-funded project investigating the hydroponic production of cut flowers.

Crop introduction

The bulk of the CFC's practical work has involved new product development, that is the demonstrations and trialling of cut flowers that are novel to, or alternatives for, UK growers. The term 'novel' has been used in a wide sense, to include crops that are new to cut flower growing, new or unfamiliar to UK cut flower growers, and new cultivars that could reinvigorate crops that are established in UK growing. The crops were included in demonstrations and trials on the basis of information from the new crops report and discussion with growers and the CFC's management group. Once trialled, novel crops may be eliminated if unsuitable, or, if suitable, taken on for further trialling. Over the five years of the project some novel crops have been introduced each year, so, inevitably, progressively more is known about those that have been in the project for longer.

Crops with first trials in 2017

- ***Asclepias curassavica*** and *A. incarnata* cultivars were grown in a tunnel and established well, flowering in their first year. *A. curassavica* 'Apollo Orange' produced

prolific, attractive, orange-red flowers on long stems, each plant having a strong leader plus five or six smaller but marketable side-shoots. Flowers of *A. incarnata* 'White' turned brown before reaching the picking stage. 'Apollo Orange' showed obvious potential as a novel commercial cut flower for the UK, subject to getting more data on cultivars, VL (including its poor post-harvest water uptake), hardiness and any issues with its sap.

- ***Echinacea purpurea*** and *E.* 'Yellow Cone' grew well in a tunnel and were free of obvious problems, though the flowers were rather late and sparse, sometimes not unexpected for a seed-raised perennial in its first year. *Echinacea* showed obvious potential as a UK crop, subject to trials to assess cultivars, VL, scheduling and tunnel/outside growing.
- **Helipterum** (*Rhodanthe chlorocephala* subsp. *rosea*) cultivars grown in a tunnel produced a large flush of flowers, but its stems were weak and short. Four weeks later they produced a second flush, but with thin stems and small flowers. The stems discounted helipterum as a cut flower crop, unless better cut flower cultivars become available.
- ***Lobelia*** 'Queen Victoria' and *Lobelia siphilitica*, grown in a tunnel produced few marketable flowers in their first year, but grew and flowered well in their second. 'Queen Victoria' produced attractive, bright red flowers on substantial, long stems, with a good VL (10 days). *L. siphilitica* produced striking, bright blue flowers. Both have potential as UK crops, subject to further trials on cultivars, VL, hardiness, longevity and any issues with its sap.
- ***Ranunculus*** 'Rococo' is a new series being promoted as a cut flower or garden plant. Planted in a tunnel in autumn 2016 they flowered over April to May 2017. They were productive, but the colour range available was limited, and it is not yet clear whether the stems are long enough for a cut flower (this might be affected

by its husbandry). More information is needed before these (or other) cultivars are taken forward.

Crops with trials ongoing in 2017

- **Annual dianthus (pinks)** (cultivars of *Dianthus barbatus*) were once a staple cut flower in the UK, but have been reduced to a small area in the south-west. They were included to allow the testing of new cultivars that might reinvigorate the UK crop. (1) At the start of the project (2013) a new series, 'Breanthus', was trialled in a tunnel. Its large flower heads found favour with the industry and made a case for further trials. Six 'Breanthus' cultivars were transplanted to a tunnel in two batches, with half of each batch pinched two weeks later (pinching reduces stem length and weight in vigorous cultivars). The earlier, non-pinched batch produced the best quality and yield, but left *in situ* they did not overwinter well. 'Breanthus' cultivars showed some issues with premature budding and leaf scorch. (2) 'Green Magma', 'Green Trick' and 'Green Wicky' were grown in a tunnel and their novel, bright green flower heads were well liked by the industry. By then similar dianthus were being imported from the Netherlands and there was little enthusiasm to grow them in the UK. (3) Plugs of 'Cocktail Pinks' cultivars were tested in a tunnel. It was evident that these were good cultivars for the garden, but too short stemmed for a commercial cut flower. (4) Cultivars of the 'Barberatus' series were grown in a tunnel and outside. They made much vegetative growth, the early flowers had short stems, but their length increased later in the season, especially in the tunnel. As with other trials of annual dianthus, these were generally appreciated by the industry, but at the current time the economics do not stack up for them as a supermarket product because the customer will not pay more than for a standard sweet william. A watching brief needs to be kept for other new series being released.
- ***Caryopteris*** 'Pagoda' cultivars were grown in a tunnel over two years and grew well in both years with prolific stems and no evident problems. Picking started in mid-September and continued well into October, and the stems were robust and of

suitable length and weight. There was interest from the trade – especially for ‘Pagoda Lagoon’ with its rich blue colour - but it was considered unlikely to attract a large demand under the current economics. Should interest be revived, more data on cultivars, VL and hardiness would be needed.

- **Delphinium** trials concentrated on assessing new series from the Belladonna Group, which have more delicate and elegant flowers than the traditional delphinium. (1) ‘Sea Waltz’, ‘Sky Waltz’ and ‘Tango Dark Blue’ were grown in a tunnel, produced elegant spikes in a wide colour range, with potentially three flushes a year. (2) ‘Trick Lilac’, ‘Trick Pink’ and ‘Trick Yellow’ were grown in a tunnel, producing two good flushes each year. While of good marketable quality, the stems were (as expected) lighter in weight than in the traditional product, and had a good VL (over eight days); an issue with virus-like symptoms remains unresolved. Both series were judged as good products for the UK market, held back only by economics.

- **Eremurus** rhizomes of three cultivars were grown in a tunnel for two years. Flowering in May 2016 was sparse but spectacular (1.2m+ tall stems), and in the following May 2017 the number of flowers increased appreciably. The cost of planting material is high and needs to be offset by an appropriate return. While probably suitable for the specialist grower, any larger-scale production would be dependent on bulking-up the rhizomes *in situ* in semi-permanent beds. If taken up, further data would be desirable on cultivars, VL and longevity.

Seed-raised **fillers** have seen increased interest from the industry in recent years. Several species were grown, usually by direct-drilling, in tunnels and outside. (1) ***Ammi majus*** and ***A. visnaga*** grew vigorously in tunnels, producing large flower heads suitable for use in the more expensive bouquets, smaller flower heads could be produced using higher planting densities or growing outside to reduce vigour to obtain a cheap filler. They had long VL (17 and 22 days respectively). Grower interest encouraged the trialling of a range of named cultivars, and although this was successful the cultivars were not very dissimilar. Grown in a tunnel they were rather

too vigorous, but this has to be balanced against the weather protection afforded by the tunnel. *A. majus* 'Queen of Africa' and 'Snowflake' and *A. visnaga* 'Green Mist' and 'Queen Anne's Lace' were selected for further trialling. (2) ***Anethum graveolens*** (dill) was fast-growing in a tunnel or outside. Its stems wilted after harvest but recovered to give a long VL (10–15 days) accompanied by substantial post-harvest stem elongation that might need to be managed. (3) ***Anthriscus sylvestris*** 'Ravenswing' seed failed to germinate, so plugs were planted and, although growth was weak in the first year, the second year produced a good crop, especially in a tunnel. Anthriscus may be better grown as a perennial. (4) ***Bupleurum rotundiflorum*** 'Griffithii' was slow to establish but eventually produced long, strong stems but with the minimum acceptable VL (five days) (which does not accord with other reports). Nevertheless there has been a revival of grower interest in bupleurum. Seed germination, sequential sowing, season extension and VL would need to be addressed. (5) ***Euphorbia oblongata*** was also slow to germinate, initially producing very short stems, but grown-on in a tunnel produced a good flush of long stems, freely produced into autumn. Euphorbia exude a milky sap, the significance of which should be identified. (6) **Ornamental carrot** (*Daucus carota*) generated much interest from growers despite its yield being relatively low and its flower head size variable. More research would be required to develop the crop. (7) ***Ridolfia segetum*** is similar in appearance to anethum; its germination and growth were slow, though secondary stems were produced after cutting the main stem. In all of the trials, fillers provoked considerable interest amongst the industry being judged to have very good potential as UK crops. Bupleurum has been grown commercially for two years, and a wide range of other fillers have been grown in small quantities by specialist growers. The industry is keen to see further demonstrations of ammi and some other fillers – *Atriplex*, *Orlaya* and cereals have been suggested. The common problem of poor germination and slow establishment may require changes to husbandry.

- **Gomphrena** is not well known in the UK, but its lively colours might have appeal as a filler. Nine cultivars were grown in tunnels in two batches and two planting densities. When flowering started the stems were too short for a cut flower, but after three to four weeks much longer stems were produced, and with a good VL (seven days). The following year four of these cultivars were grown in a tunnel, but stems of the 'Globosa' type were too short for cut flowers. Stem length of 'Haageana' cultivars increased through the season, with a high yield (340 marketable stems/m² over a picking period of eight weeks). With prolific, attractive flowers, long stems and good VL, gomphrena generated a lot of interest and it was considered to have good potential as a UK-grown filler. Once-over cropping should be investigated as a means of reducing labour costs, along with the causes of its inconsistent stem length and the properties of other cultivars.
- **Gypsophila** is already a staple filler, but the advent of novel cultivars may offer a number of advantages (including larger, whiter and pink flower heads) over older cultivars, reinvigorating the market. Grown in a tunnel the flower yield was low in the first summer but increased considerably in the second. They were considered to have very good potential as a UK-grown filler.
- Much interest has been shown recently in growing **ornamental grasses** as fillers. Numerous species are available, and a selection was trialled: *Bromus macrostachys*, *B. secalinus*, *Chasmanthium latifolium* (*Uniola latifolia*) (sea oats), *Eragrostis elegans*, *Panicum elegans* 'Sprinkles', *P. miliaceum* 'Violaceum', *Setaria italica* 'Max', *Setaria pumila glauca*, *Sorghum nigrum* and *Stipa capillata* 'Lace Veil'. In 2016 plug plants and direct-drilled seed were grown in a tunnel and outside. All established well in tunnels, direct-drilled plants flowering slightly later. There was huge variety in flower head form amongst the cultivars, and *Panicum elegans* 'Sprinkles', *P. miliaceum* 'Violaceum' and *Stipa capillata* 'Lace Veil' elicited most positive comments. Those grown outside early failed to thrive, having been severely

frosted soon after planting, but the crop would be very suitable for outside production from sequential sowings. In 2017 sequential sowing and transplanting monthly (weeks 21–30) gave picking over a long period (weeks 28–38). Crops from tunnels were taller and more vigorous than those outside, but, with better weather after planting this year, the majority of the latter were also of marketable quality. All plantings of *Bromus secalinus* were affected by powdery mildew. In testing, samples remained in an acceptable condition at vase-day seven, a good VL. There seem to be no reasons why the industry cannot take up the crop on a commercial scale, as a group ornamental grasses have very good prospects as UK crops. Discussions with some packers and growers have indicated that commercial quantities will be planted in 2018.

- The success of **scabious** as a cut flower abroad, and the availability of new cut flower cultivars, led to substantial trials. Plugs of seven ‘Scoop’ cultivars were transplanted under a tunnel and outside, pinched after three weeks, and grew vigorously, with prolific flowering continuing until the tunnel was de-skinned for winter. Stems long enough to be marketable stems (45cm+) comprised between 15–30% of the total stems in different cultivars. The outside crop also yielded well in spite of adverse weather. In testing, all samples had a good VL, remaining in acceptable condition by vase-day seven. Another trial, a year later, included seven ‘Scoop’ cultivars and ten other new cultivars. In this case high temperatures in June led to premature budding, and the crop was pinched three and again six weeks after transplanting. In contrast to the previous year, growth was poor and the flower stems, though prolific, were generally short (this was overcome by harvesting to the required stem length and then removing a side-shoot). The new cultivars, with an attractive range of colours, high yields and good VL, were well received by the industry, have potential for use in mixed bouquets, and are judged to have good prospects as a UK crop. There is scope for further research on the effect of high temperatures on premature budding, the high incidence of short stems and hardiness.

- **Solidago** is a well known filler supplied cheaply from imports. Earlier trials produced stems weighing 200–300g and >100cm in length, suitable only for bunch sales, for which there was no demand. To re-examine the prospects for solidago, five new cultivars from the ‘Glory’ series were grown in a tunnel or outside, all producing crops of high-quality stems. While the tunnel-grown stems were too heavy for current requirements, the outdoor-grown stems suited supermarket requirements; these new cultivars have very good prospects as a UK crop. It is understood that some commercial crops have been planted.
- **Trachelium** is not well known in the UK, but is widely grown in the Netherlands and has been trialled in the USA. ‘Corine Purple’ and cultivars of the ‘Lake Michigan’ series were trialled in a tunnel, and while initial growth appeared weak and budding-up occurred early, the stems lengthened as the plants matured, each producing at least one heavy lead stem and a number of marketable side-shoots, and the flower colours were impressive. In a further trial the planting date and effect of pinching ‘Lake Forrest’ and ‘Lake Michigan’ cultivars were investigated. Yields and stem length were satisfactory but showed large varietal differences. Non-pinched plants cropped 10 days earlier than pinched plants. Tests gave a long VL (14–17 days for cultivar averages). The greater number of stems/plant from pinched crops was further investigated with ‘Lake Michigan White’ and ‘Lake Forrest Blue’: pinched plants produced an average of just over 5 stems/plant, while non-pinched plants gave 3.5 stems/plant. Lastly, a novel, green-flowered cultivar, ‘Briba Green’, gave excellent results in trial plots. There appears to be very good potential for growing tracheliums in tunnels commercially in the UK. The UK product appears greener, taller and heavier than imported product. At present the high cost of plants is deterring growers from trying trachelium; further trialling may be needed, for example to understand how the number of marketable stems can be manipulated to increase income.

- **Veronica** 'Spark' cultivars had been trialled in an earlier project and, despite a good colour range, the lightweight stems and small production window made it unlikely to be economic to grow in the UK. Following a revival of interest, cultivars of the new 'Skyler' series were grown in a tunnel. The stems were of higher quality than the earlier trials, flowering was prolific, with straight stems and well coloured spikes. Overwintered, they flowered in two flushes the next year, but second flushes tended to be weaker. The window of production was rather short. Later the same cultivars were trialled outside as well, but outside plots suffered weather damage. 'Skyler' veronica seem to have good potential as a UK crop, subject to trials to extend the cropping period, ensure better quality second-flush stems and measure VL.
- **Woody foliage** can be produced from many hardy shrubs. To demonstrate the possibilities of cut foliage for UK growers, a selection of popular types was planted at the CFC in 2010 and maintained as a long-term crop with minimal maintenance. The plantings included calicarpa, cornus, corylus, cotinus, hедера, hypericum, philadelphus, photinia, quercus, salix, symphoricarpos and viburnum. All established well and marketable stems were cropped from 2012 onwards; hypericum, cotinus, photinia and symphoricarpos were considered particularly impressive. Substantial plantings of hypericum and symphoricarpos have been made and other species have been taken up by local growers. This is a crop with very good prospects for UK growers, and a huge range of species is available.
- **Zinnia** were trialled in an earlier project, when the industry was enthusiastic about their wide range of vibrant colours. But after picking the hollow stems can collapse and bend just below the flower head, making them unusable. In trials with the 'Benary's Giant' and 'Oklahoma' series, the attractive flowers in a wide range of colours and with long stems, were stronger, but VL was five to seven days (just acceptable to good). A number of post-harvest trials were carried out, and overall the results appeared to show that, under some circumstances at least, zinnias are

capable of an acceptable, borderline VL. Zinnia have a range of colours that should make their presence in a bouquet of interest to retailers. Apart from this, zinnia should have good prospects as a UK cut flower, and it is hoped further post-harvest work can be done.

Crops with trials concluded by 2017

- **Basil** can be used as a fragrant filler in mixed bunches and bouquets. Four cultivars were trialled in a tunnel, and, although making strong growth and having attractive foliage and flower spikes, their VL was unacceptable (less than five days). Further cultivars recommended from trials in the USA ('Aromato' and 'Cardinal') were subsequently grown but also produced an attractive product with a poor VL, the stems apparently failing to take up water. If the industry shows further interest in basil, post-harvest treatments could be researched, but this is a specialised crop and has poor prospects as a UK cut flower crop.
- September-flowering **aster** (*Aster ericoides*) is imported as a cheap filler. At the start of this project it was thought the introduction of new, double-flowered cultivars might open a new market. Trials elicited industry interest in these cultivars as a pinched crop flowering in tunnels in September/October. As a short-day (SD) plant, blacking-out for part of the day under long days (LD) would advance floral initiation. Eleven double cultivars were planted in 2012 in a tunnel and outside, overwintered, and the tunnel crop used in 2013 to investigate the use of blackout covers (the outside crops acting as a natural-season 'control'). Blackouts were placed over the plots overnight for 13 hour/day from week 22 (stems 60cm-tall) to week 31 (plants with large buds almost showing colour). The main flower picking period was weeks 32–33, somewhat later and with longer stems than required, indicating the blackout was probably started too late; otherwise quality was superb. A second flush in early-November was too short-stemmed to be marketable. In comparison the controls produced a single flush over weeks 37-43. In 2014 'Cairo', 'Cape Town', 'Cassy' and 'Chicago' were transplanted to a tunnel and the same

blackout treatment started in week 25 (stems 50cm-tall) and stopped in week 30; by this time the buds of 'Cairo' and 'Cassy' had started to develop and went on to produce high-quality stems with high yield and no premature budding. But 'Cape Town' and 'Chicago' showed premature bud development resulting in poorer quality and lower yield. Samples of the four cultivars gave a good VL of eight to nine days. The plants were cut back hard and a second flush grew well in all cultivars, and was approaching a marketable stage when the tunnel was de-skinned for winter (week 43); for comparison the controls' cropped around week 42. Attempting two flushes per year appears to be pushing the crop to its limit in the restricted growing period available in a tunnel, although it would be achievable under glass or perhaps in a fixed tunnel.

- Industry and consumer interest in **ornamental brassica** remains high, despite uncertainties about some aspects of husbandry and which cultivars to grow. Trials in 2015 and 2016 addressed the choice of cultivar for the higher quality tunnel crop, growing newer cultivars alongside the familiar 'Crane' series. In 2015, compared with trial averages, 'Bright Wine' and 'Olga' produced heavier stems, 'Bogdana', 'Crane Queen' and 'Katya' lighter stems, 'Anthonia' larger heads and 'Agathana', 'Crane White', 'Olga' and 'Varvara' smaller heads. With high-quality heads and a long VL of 10 to 17 days, some of the less familiar cultivars showed real promise, generating more interest than the 'Crane' series. One cultivar, 'Kysia', failed to colour-up. A further trial was carried out in 2016. 'Kysia' again failed to colour-up, while the others all produced heads of high quality, but those with dissected leaves (such as 'Crane King', 'Crane Queen' and 'First Lady) failed to equal the marketable yields of others. In contrast to the 2015 results they attained only the minimum guaranteed VL of five days. While there appears to be some resistance by the industry to take up newer cultivars in place of the established cultivars, a larger problem seems to be the inconsistency of the VL obtained. Some preliminary work was carried out with a local grower in 2016. Re-cutting or not re-cutting the stem

base when placing the stems in the vase did not appear to have a general effect on VL. Post-cropping conditioner treatment with 'Chrysal CVBN' at a high rate gave a better VL (seven days) than other treatments that gave only the minimum guaranteed VL of five days. There was less leaf yellowing when 'Chrysal Lily and Alstroemeria BVB' had been used as the post-harvest treatment. 'Chrysal CVBN' used at a high rate was beneficial as a bactericide. Further post-harvest studies are clearly needed.

- **Carthamus** has attracted attention in the industry as an unusual, thistle-like filler, and demonstration plots were planted in 2014 and 2015. Cultivars 'Kinko', 'Nemo' and 'Shiro' were direct-drilled outside and in a tunnel. The plants grew and budded-up quickly. In 2014 plants from week 25 and 27 sowings flowered over weeks 35–37, while those from the week 30 sowing failed to produce marketable stems before the tunnel was de-skinned (week 43). In 2015 sowings in the tunnel over weeks 17–28 reached picking in weeks 29–40, while the week 31 sowing again failed to produce marketable stems before winter. Samples taken for VL testing had a good VL of seven days, though quality was spoiled by bract-tipping. Carthamus produces a reliable, sturdy stem and is already being used successfully as a bouquet filler, and no further trials are planned. Bract quality does remain an issue, however.

- **China asters** (annual asters, *Callistephus chinensis*), especially the 'Matsumoto' spray type, have become an important outdoor summer cut flower in the UK. Earlier trials opened up a new market for an alternative, the large-headed, 'bloom'-type of the 'Krallen' series. It showed real potential for commercialisation here, until post-harvest quality became an issue with the development of petal-spotting and flower-tip browning, disorders that have not been remedied. Alternative cultivars are needed. Between 2010 and 2015 trials were conducted with the 'Beautiful Day', 'Benary Princess', 'Harlequin', 'Jewel', 'Lady Coral', 'Matador', 'Meteor' and 'Standby' series, and while many of the cultivars included stem and flower attributes with promise for growing in the UK, none was considered an alternative for 'Krallen'. In 2016 a new spray-type series, 'Julie' was trialled. 'Julie'

has a different colour range and a claim for earliness compared with 'Matsumoto'. Used as a source of material for showing to the industry, samples from the trial were well received and as a result it is being trialled on a larger scale by local growers.

- **Cleome** is a sturdy, attractive garden annual with unusual flowers, a possible candidate for wider growing. In 2016 four cultivars were sown into plugs and planted into beds in a tunnel, where establishment was satisfactory. There were no obvious differences in growth or development of the plants grown at two spacings (25 and 65 plants/m²). Transplanted in week 18 or 25 they started flowering in weeks 26 and 30 and continued flowering into October. Cleome was a very prolific crop producing constant flushes of large, showy and distinctive flowers over a long period. Samples had a good VL of at least seven days, but cleome's spines and aroma could prove difficult in handling and during retail.

- **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. Over the period 2013–2015 many cultivars were trialled in tunnels and outside, all sharing a number of characteristics. Cosmos were relatively easy to grow, with good germination rates, rapid establishment and vigorous growth – under tunnels sometimes so vigorous as to be unruly. Flower production tended to begin slowly and unevenly, but was soon prolific. Although appearing somewhat wispy and feathery, flowering stems were usually long and surprisingly robust and substantial, especially when grown outside. Drilling sequentially from weeks 17 to 28, picking covered the period 29–41, though the late picks tended to be rather short. Over several tests, VL was unacceptable or only just acceptable with a maximum of five days, and further development work is needed to address ways of improving VL.

- **Craspedia** is a novel cut flower in the UK, with slender, unbranched stems and ball-shaped clusters of yellow flowers. It is useful as a filler and also as a dried

flower. In 2016 three cultivars were trialled in a tunnel. Rooted cuttings of 'Paintball Globe' and 'Ellisse' were potted-on and transplanted, and 'Sun Ball' was obtained as seed, sown into plugs and transplanted. 'Paintball Globe' and 'Ellisse' gave large flushes of very strong, tall flowers that were very similar in form. Seed-raised 'Sun Ball' produced weaker plants with smaller flower heads with shorter, kinked stems and fewer stems per unit area. Samples of 'Paintball Globe' and 'Ellisse' were subjected to VL testing and all stems remained in acceptable condition on vase-day seven, a good VL. Craspedia is an unusual product with specific potential and appears relatively easy to grow.

- **Dahlia** are generally considered to have a poor VL, and the 'Karma' series, bred for a longer VL, were grown over the period 2009–2013, primarily for VL testing. Plots of 18 'Karma' cultivars were grown in a tunnel and outside and grew vigorously, especially under protection. The blooms were striking, but the results of VL tests using various conditioning treatments were disappointing, the flowers failing to reach the minimum guaranteed VL of five days.
- **Annual dianthus (spray carnations)** are a supermarket staple and new cultivars with unusual flower forms have been trialled as they could give UK growers the opportunity to produce a premium product not competing with imports. In 2013 potted cuttings of the 'Floristar' series, 'Solomio' series and 'Star Cherry Tessino' were transplanted under a tunnel and pinched two weeks later. Cropping started in mid-July and continued until the trial was ended in late-October when there were still immature stems present. Among the 'Solomio' cultivars the yield of stems/m² varied from 108 to 197. Overall they produced good quality, strong stems, but there was an issue with bud abortion in some cultivars, especially 'Edo'. 'Star Cherry Tessino' appeared attractive to rabbits. Plants of the 'Floristar' series produced few flowers. From another novel series, 'Tiara Coral Pink' and 'Tiara Lilac' were trialled in 2014. In these cultivars the central bud developed well before the others and needed to be pinched out to preserve the remaining spray, though this is difficult and labour

intensive. The overall picking period was weeks 35–37 and the flowers were attractive and appreciated by growers. Stems of ‘Tiara Coral Pink’ were sampled for testing and had a good VL of an average seven days.

- With their spiky flower-heads and attractive colouration, **eryngium** remain popular. Small plots of seven cultivars were planted in a tunnel and outside in 2011. Marketable flowers were produced from 2012 and stems shown to potential customers evoked keen interest. By 2013 the tunnel-grown plants had become over vigorous and were grubbed out. In the outside plots many plants did not survive the cold winters of 2011/2012 and 2012/2013. By this time the outstanding cultivars were ‘Blue Bell’ and ‘Deep Blue’ which appeared to be hardy and that year produced 56 and 113 stems/m², respectively; the other cultivars had plant survival rates between 43 and 69% and produced between 28 (‘Marbella’) and 88 (‘Magical Purple Falls’) stems/m². In 2013 necrotic, black spots appeared on the foliage of ‘Arabian Dawn’ and ‘Marbella’ and were identified as symptoms of *Alternaria*. VL testing confirmed earlier results, with stems of ‘Blue Bell’, ‘Magical Blue’, ‘Magical Cloud’ and ‘Marbella’ all having a good VL, eight to nine days. The stem yields recorded in 2015 showed that ‘Arabian Dawn’ had more than doubled its annual yield, to 93 stems/m² and that the yield of ‘Deep Blue’ had fallen slightly (to 94/m²); the yields of the other five cultivars had fallen to between 5 and 33/m². The trial has information on the performance and hardiness of a range of cultivars, and no further trials are planned.

- **Leucanthemum** was included in trials in 2014 to demonstrate a new range of cut flower cultivars, the ‘Real’ series. Pinched plants of three cultivars were transplanted under a tunnel. ‘Real Frilly’ budded prematurely and flowered on short stems, ‘Real Fancy’ and ‘Real Fizzy’ flowered normally. The plots were mulched and over-wintered but over half the plants died and any flowers produced had short stems. These cultivars appeared unsuitable for growing in a tunnel.

- **Lion's ear** (*Leonotis* species) is a South African plant being introduced to cultivation elsewhere in Europe. *Leonotis leonurus* 'Alba' and 'Staircase', *L. mollis* and 'Wild Dagga' were identified as possible subjects. In 2014 young plants were transplanted under a tunnel and established and grew away quickly. By week 43 'Staircase' was in bud, but gales in late-October flattened the plants before any flowers opened; none of the other *Leonotis* reached a visible bud stage. No further trials were undertaken.
- **Lupin** may be an unlikely choice as a commercial cut flower crop, but research in the USA showed the genus has distinct possibilities as a 'cut'. In 2013 young plants of several 'Gallery' and 'Russell' cultivars were transplanted under a tunnel and outside. Initially growth was weak, but the plants recovered and established well, and flowering started in week 32 and continued over a long period, producing reasonable numbers of stems. Plants of the 'Gallery' series were shorter than the 'Russell' cultivars, but the lengths of both were adequate, while outdoor plants produced much shorter stems than in the tunnel. Left *in situ* to overwinter, many plants failed to survive the winter, but nevertheless the high quality of the remaining stems and the wide range of colours of both series were striking. However, samples tested by a local packer were reported to have an unacceptable VL (less than five days) and no further trials were planned.
- **Ornamental peppers** proved to be successful novelties in the Association of Specialty Cut Flower Growers (ASCFG) trials, and two cultivars, 'Black Pearl' and 'Masquerade', were trialled in 2014. Plug plants were transplanted under a tunnel: both cultivars were slow-growing but eventually produced large, strong plants. Some fruits were visible on both cultivars by week 36, but they remained more or less static without growing or ripening until the tunnel was de-skinned at the end of the season. No further trials were planned.

- **Physostegia** is another crop seen as a potentially useful cut flower in trials in the USA, and 'Crystal' was trialled in 2014. Plug plants were transplanted to a tunnel. 'Crystal' was rather short-stemmed and late flowering, and in VL testing the stems failed on day two in the vase. *Physostegia* therefore seems unsuitable as cut flowers and no further trials were planned.
- **Rudbeckia** is another well-known garden plant with potential for development as a cut flower. Demonstrations with seed-raised annuals of *Rudbeckia hirta* 'Green Eye' and 'My Joy' had been carried out in a tunnel in 2011. Although the flowers were attractive in themselves, the stems were too vigorous and unruly to be practical for commercial growing. More robust perennial cultivars, *R. laciniata* 'Herbstsonne' and 'Goldquelle', were trialled in 2012–2013, with young plants planted in a tunnel. They showed some market potential, but many of the stems were weak and they were probably unsustainable as cut flowers because they were too vigorous and produced unmanageable stems. See also the section on the similar genus *Echinacea* (also called coneflower); the evidence we have suggests *echinacea* would be the better choice.
- **Sedum** cultivars, *Sedum spectabile* 'Brilliant', 'Herbstfreude' and 'Matrona', were planted as a perennial demonstration in outside beds in 2010. Growth was weak in the first year, but once established growth was vigorous, with impressive stem counts, length and weight, and tests showed their VL was good, at least seven days. In 2011 the trial was extended by adding four further cultivars. By 2012 the plots had probably generated more attention than any others. No further trials on *sedum* are planned
- **'Pumpkin-on-a-stick'** (a cultivar of *Solanum aethiopicum*) is an unusual novelty that caught the eye of trial participants in the USA. The plant, with its bright red 'pumpkins', is related to the winter cherry (*Solanum pseudocapsicum*). In 2016 plug plants were transplanted under a tunnel at two planting densities. 'Pumpkin-on-

a-stick' was incredibly vigorous and started flowering in July, with fruits seen developing soon after. The lower planting density produced the sturdier stems, but there would probably be a market for both larger and smaller products. The plants have spines on their stems and leaves and removing them would add costs. Further trials are unlikely.

- **Sunflower** became a fashionable cut flower in the early-2000s and its popularity has lasted. Two cultivar trials had an emphasis on new and dwarf cultivars. In 2013 seed of 13 cultivars and numbered lines were sown by hand outdoors and in a tunnel. Despite the dry weather some outside cultivars started to produce marketable stems from week 24 onwards, with the second planting coming into flower around week 32. The majority of the cultivars were 120 to 160cm-tall and large-headed. 'Galilee Miracle' and 'Tavor Lemon' were short (80 to 100cm-tall), though with normal-sized flower heads, while 'Tanya' was short and had smaller flower heads. Growing in the tunnel produced much taller plants than outside, while in most cases flower head diameters were smaller in the tunnel than outside. In 2014 further cultivars and lines were trialled in a tunnel. The main picking periods were weeks 35-37 for week 27 sowing and weeks 39-40 for week 30 sowing. Samples picked for VL testing and had a consistent VL averaging a good seven days.

Crop improvement

- **Alstroemeria: a seasonal tunnel crop?** Commercial cut flower production involves growing contemporary cultivars in a glasshouse. The availability of tunnels suggests the possibility of growing a cheap, seasonal crop of older cultivars (with no royalties attached). A feasibility trial was run over 2014–2017 with twelve older cultivars grown in a tunnel or outside. In the tunnel marketable flowers were produced from week 31 in 2014 and from about week 22 in later years, and each year picking continued until weeks 41–44 (when the tunnels were de-skinned for winter). The plants were vigorous and produced strong stems that some growers

considered better than a typical glasshouse crop. The outside crop produced marketable stems (starting week 33 in 2014 and week 26 subsequently) and was less vigorous. With 12 cultivars and tunnel and outside plots the supply of flowers was reasonably constant over a five month period. Yields in the tunnel were more than double those for outside plots, with annual production increasing over the four year period. 'Nina' was the highest yielder overall, and 'Dana', 'Flaming Star', 'Friendship' and 'Tanya' also yielded well. Samples had a long average VL, twelve days. Growing non-PVR/PBR cultivars in tunnels appeared to have strong potential. Despite lower quality and yields, growing in the open may have a place for smaller scale businesses.

- **Column stocks: improving control of fusarium wilt.** Column stocks are a mainstay of glasshouse cut flower production in the UK. But variety trials in tunnels in 2012 and 2013 stimulated the industry's interest in the 'Katz' series as a late-summer crop that could better the quality of comparable glasshouse-grown plants. Growing stocks in steamed and non-steamed soil demonstrated the benefits of steaming on stem weight and enabled resilient cultivars to be identified. Increasing concerns about poor establishment and uniformity was found not to be due to any one factor, but to a combination of the poor performance of some cultivars on non-steamed soil and the presence of *Pythium* or *Fusarium*. In 2016 a new demonstration of column stocks showed the cultivars currently available and investigated the effects of steam-sterilisation, and, although the expected results were confirmed, the difference was less marked than previously seen. In 2017, as part of a new project on *Fusarium oxysporum* in horticultural crops an experimental site sufficiently infested with *F. oxysporum* was needed as a site for trials and was set up in the tunnel previously used for stocks trials. The soil was infected with *F. oxysporum* f.sp. *matthioli* culture and one day later the tunnel was planted with plug plants of a range of stock cultivars, together with lisianthus and brassica plots included for checking the host-specificity of the fusarium culture. The first symptoms of *F. oxysporum* infection was

seen in three weeks, and the severity of symptoms and number of marketable stems were recorded when the plants were fully grown. There were large differences in susceptibility/tolerance to fusarium between colours within series, for example, there were high fusarium scores and few marketable stems in 'Anytime White' and the reverse in 'Anytime Rose'. The absence of infection in lisianthus and brassica plots confirmed the culture's host-specificity. The *Matthiola* race of fusarium was spread across the tunnel in concentrations high enough to be pathogenic. The site was rotavated and left in ready for a replicated trial in 2018.

- **Lily: alternatives to peat-based growing media.** The UK's production of lilies from imported bulbs has been very successful and they remain hugely popular with customers. To avoid soil-borne pathogens the bulbs are grown in crates of peat growing medium, and so there is interest in finding alternatives or diluents for peat. Over 2013–2017 alternative media including aerobic digestate (AD), coir, cocopeat, 'Forest Gold' (peat:wood based media), green compost, green waste (GW), wood fibre and mixes - were compared with a typical peat-based lily medium ('peat').

(2013) Bulbs were grown in peat, GW and peat + GW 50:50 mix. Compared with peat, stem length was slightly reduced in peat + GW and more so in GW, but the differences were small and product quality was superb in all three.

(2014) The range of materials was extended to include AD, coir and 'Forest Gold'. Bulbs were planted in peat, coir, 'Forest Gold' and mixes of peat + coir (50:50), peat + AD (80:20 and 60:40) and peat + GW (50:50 v/v). There were no significant differences in stem length or weight. Compared with peat, peat + AD gave better leaf colour; peat + GW delayed picking by a week, produced some stunted stems with chlorotic leaves and slightly reduced the yield of marketable stems. Hence 100% coir or 'Forest Gold' were suitable alternatives, and peat + AD mixes might confer nutritional benefits. But the addition of GW to peat in this trial had some adverse effects; note that, while proprietary materials such as peat, coir and 'Forest Gold' are

likely to be of consistent quality, the properties of 'experimental' materials like GW and AD could vary between sources and explain the detrimental effects of GW here.

(2015-1) The previous trial was modified by substituting 'green compost' for 'Forest Gold' and expanding the range of peat + AD mixes (80:20, 60:40 and 40:60). There were insignificant differences in stem length and weight between media, no differences in picking date and no visual differences. In this case the 'green compost' was suitable for growing lilies, as was adding a larger proportion of AD to peat.

(2015-2) Bulbs were grown in AD, coir, peat and the mixes peat + AD (60:40, 40:60 and 20:80) and coir + AD (33:67). Plants grown in 100% AD were stunted, chlorotic and distorted, and those from peat + AD (20:80 v/v) only marginally better; those in AD + coir were of good height but had chlorotic foliage. Plants grown in peat, coir or the weaker mixes of peat + AD (40:60 and 60:40) were normal and marketable. Stems were tallest and heaviest in peat and slightly shorter and lighter in AD mixes. Despite the optimistic results with AD in the previous trials, there are limits to how much AD can be added: using 100% AD (or 80% AD with peat, or 67% AD with coir) had seriously detrimental effects here.

(2016) The emphasis in this trial was assessing peat + wood fibre and peat + cocopeat mixes. The media used were peat, cocopeat and mixes of peat + with wood fibre or cocopeat (90:10, 80:20 and 70:30). Lilies grown in 100% cocopeat had shorter, lighter stems, but otherwise there were no visual differences between treatments and no effect on picking date. These mixes were worthy of further consideration.

(2017) The latest trial returned to AD-based media. Peat and five peat + AD mixes with increasing proportions of AD (details were confidential) were tested with two batches of bulbs. In the earlier batch growth and development were normal with all media and flower quality was superb. Stem lengths and weights were greatest using peat, but the range of averages values was small (142 to 158cm in length and 87 to

105g in weight). In the later batch - which were moved into a glasshouse in the last stages of growth - growth and development were again normal in all treatments though trimmed stem weights were lighter, probably because bulbs were 'forced' in the warmer environment.

The suitability of AD-based media improved over the course of the project, and there seem to be real prospects for further AD use in lily production, subject to its availability in uniform supplies and specified quality. There are prospects here for up to 60% reduction in peat usage. This does not rule out the use of other alternative materials such as coir- or wood-based materials, which are already being incorporated into growing mixes by some growers. GW materials require further trials as products will be prone to variation between sources. Presently there is industry reluctance to adopt AD into lily media, but this may change if other alternatives (e.g. coir) become less available or less acceptable to the end-customer.

- **Herbicide for outdoor cut flowers.** The loss of key active ingredients (such as oxadiazon, chlorthal-dimethyl and propachlor) continues to be a major concern for cut flower growers. (In the following account, '+' indicates a tank-mix). In 2015 parts of a project to seek alternative herbicide treatments was carried out at the CFC site on four drilled crops. 'Stomp Aqua' (pendimethalin) + 'Gamit 36 CS' (clomazone) (post-drilling, pre-emergence) was safe and effective for use on **drilled china aster**, and could be followed up with post-emergence 'Shark' (carfentrazone-ethyl) if required. In **drilled sweet william** tank-mix 'Stomp Aqua' + 'Goltix 70 CS' (metamitron) provided the best weed control and was the safest option. In **drilled wallflower** 'Butisan S' (metazachlor), 'Gamit 36 CS' and low rate 'Wing-P'(dimethenamid-p + pendimethalin) appeared safe, applied at drilling. Low rate 'Wing-P' + 'Gamit 36 CS' also appeared safe on wallflowers. The active ingredient benfluralin (was safe as a pre-drilling incorporated treatment and could be combined

with some of the post-drilling treatments). The **drilled larkspur** trial proved challenging because of phytotoxic effects from the herbicides used.

In 2016 this work was continued as part of the CFC project. For **transplanted china aster** the aim was to follow-up the current recommendation for 'Stomp Aqua' + 'Gamit 36 CS' pre-planting. 'Stomp Aqua' + 'Gamit 36 CS', 'Nirvana' (imazamox + pendimethalin) or 'Wing-P' were applied pre-planting and followed, three weeks post-planting, by 'Butisan S', 'Venzar Flo' (lenacil) + 'Flexidor 500' (isoxaben) or 'Successor' (pethoxamid). There were many weeds on the untreated plots; pre-planting treatments of 'Wing-P' or 'Nirvana' were better in reducing their numbers, 'Stomp Aqua' + 'Gamit 36 CS' were much less effective. Applied at this stage, however, 'Wing-P' and, especially, 'Nirvana' resulted in stunting of the crop, while 'Stomp Aqua' + 'Gamit 36 CS' resulted in only slight stunting. Of the post-planting treatments, 'Butisan S' was effective, and 'Venzar Flo' + 'Flexidor 500' and 'Successor' less so. Treatment with 'Butisan S' or 'Successor' resulted in slight marginal leaf scorch on young leaves, though this was rapidly outgrown, while there was no scorch with 'Venzar Flo' + 'Flexidor 500'. Overall, the combination of 'Stomp Aqua' + 'Gamit 36 CS' pre-planting, followed by 'Butisan S' three weeks post-planting, was probably the best compromise between weed control and crop safety. On some sites 'Wing-P', either alone or followed by 'Venzar Flo' + 'Flexidor 500', might be an option.

For drilled sweet william the current recommendation is 'Stomp Aqua' + 'Goltix 70 SC' at drilling, followed-up at the 4-true-leaf stage by 'Shark'. A tank-mix of 'Stomp Aqua' + 'Goltix 70 SC' at drilling was followed by either 'Butisan S', 'Butisan S' + 'Shark', 'Springbok' (dimethenamid-p + metazachlor), 'Springbok' + 'Shark', 'Successor', 'Successor' + 'Shark', 'Venzar Flo' + 'Flexidor 500' or 'Venzar Flo' + 'Flexidor 500' + 'Shark'. In addition there was a treatment of 'Goltix 70 SC' at drilling followed by 'Shark'. In the untreated controls weed cover was complete, with the

'Goltix 70 SC' and 'Shark' programme weed cover reached 47%, while for the other programmes (all based on an initial application of 'Stomp Aqua' + 'Goltix 70 SC') weed growth varied widely. The most effective follow-up programme for weed control was 'Venzar Flo' + 'Flexidor 500' + 'Shark' (5% weed cover), followed by 'Springbok', 'Springbok' + 'Shark', or 'Venzar Flo' + 'Flexidor 500' (18–22%) and the remaining programmes resulted in weed cover of 33% or more. In the early stages slight to mild stunting occurred in all treatments except the control, and the four treatments giving good (up to 22%) weed control gave relatively more stunting. The stunting effect, however, was transient, and as a result the recommended herbicide programme would be the one giving the best weed control: 'Stomp Aqua' + 'Goltix 70 SC' at drilling followed by 'Venzar Flo' + 'Flexidor 500' + 'Shark' post-emergence. In addition, the following herbicide applications were made to the dormant crop in mid-February, prior to spring growth; 'Shark', 'Devrinol' (napropamide) + 'Flexidor 500', 'Venzar Flo' + 'Flexidor 500', 'Butisan S' + 'Flexidor 500' and 'Venzar Flo' + 'Flexidor 500'. Assessed six weeks later, 'Devrinol' + 'Flexidor 500' and 'Butisan S' + 'Flexidor 500' were both crop safe and could be applied if required.

- **Spectral filters for tunnel-grown crops.** In an earlier project spray carnation, spray chrysanthemum, column stocks and godetia were grown in 'Spanish tunnels' under a range of polythene films (spectral filters). One conclusion was that specialist films should not be used unless an advantage could be demonstrated for a specific crop/film combination. In 2013 trials on column stocks and bloom chrysanthemum were conducted at commercial nurseries in conjunction with the present project. **Column stocks** cultivars were grown in tunnels covered with either a standard clear polythene film or 'SteriLite SuperThermic' film (with UV-blocking, light-diffusing and IR-reflecting properties). Random samples were taken from each tunnel at picking and assessed. Average stem lengths were consistently longer under

'SteriLite SuperThermic' film than under standard film, but only by between 1 and 9cm in the different cultivars.

Bloom chrysanthemum were grown in tunnels covered with either a standard film ('Aster TR' with light diffusing, UV-opaque and some thermal properties) or 'SunMaster Smart Blue' (a blue film reducing light intensity in the near- and far-red regions, transmitting UV and reducing light and heat levels). Plants under 'SunMaster Smart Blue' bloomed two weeks later than under 'Aster TR', perhaps because of the former's lower temperatures. Superficially the blooms looked similar, but under 'Aster TR' the stems were thicker and stronger and the petals and leaves slightly lighter in colour compared with those under 'SunMaster Smart Blue', under which the petals and leaves were slightly darker and the leaves thinner. Stem lengths and trimmed stem weights were slightly shorter and lighter under 'SunMaster Smart Blue' film than under 'Aster TR', but these differences amounted to only 2 to 5cm or 2 to 5g. The marketable yield was only 54% under 'SunMaster Smart Blue' film, with one to two usable stems per plant, but 84% under 'Aster TR' with two to three stems/plant. The VL of stems was unaffected by film type, a long 22 days in both cases. In this case 'SunMaster Smart Blue' film was not suitable for growing this product.

Financial benefits

As this is the final year of the current five-year programme it is useful to now try and assess the financial benefits to the industry over this period as a result of the activities of the CFC. From his other activities within the cut flower industry, the Project Manager is aware that a number of crops have been trialled and grown commercially as a direct result of the CFC trials programme. Examples known to have been grown on a small-scale include the annual dianthus from Hilverda, *Aster ericoides*, carnation 'Solomio', *Dahlia* 'Karma', phlox, seasonal alstroemeria, scented pinks, new cultivars of scabious and solidago, veronica, and zinnia. Others have been grown on a more commercial scale, the main ones being antirrhinum, spot-

crops of bupleurum, lisianthus, trachelium and various hardy perennials including hypericum, salix, sedum, symphoricarpos (snowberries) and viburnum. Some of the subjects of the 2017 trials are also likely to be grown on a commercial scale in 2018 including ornamental grasses and gomphrena. The following is an estimate of the area grown and farm-gate value of some of the trialled product already being grown, the hardy perennials being included as a single category.

- Antirrhinum: extra production over the five-year period - approximately 5.0ha with a farm-gate value of £575,000 over this period.
- Lisianthus: extra production over the five-year period - approximately 3.75ha with a farm-gate value over this period of about £427,500 on an 80% yield.
- Hardy perennials: extra production over the five-year period - approximately 15ha. However, because it can take three to five years for these crops to reach maximum yield, it is hard to calculate their exact value over the past five years. However, if a farm-gate value of £50,000 is used, which is based on hypericum with an average yield figure and assume that only half of the 15ha was mature enough to crop over the period, the farm-gate value can be estimated at £1,875,000 over the five year period.
- 'Others' are a category for which it is not easy to give an accurate estimate of area, but when taking into account outdoor bupleurum, trachelium and the various crops planted by the large number of small, artisan flower growers, this could represent between 2 and 5ha of additional plantings. It is impossible to estimate the value of these crops, but the fact that the specialist subjects grown by the artisan growers commands a premium price, means that the farm-gate value could be in excess of £100,000 per ha.

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 material costs (in sterling or euro depending upon the source).

- Alstroemeria: planting density of 5 plants/m² with an average yield (across all cultivars) over the four years of about 300 stems/m² of planted bed, the plant cost is approximately £3.50 for a 7cm pot and £4.50 for a 9cm pot, plus delivery.

- Antirrhinum: planting density around 64 plants/m² of bed, with 80 to 95% of stems being harvested (one stem produced per plant); the plant cost is approximately €46 per 1,000 plus delivery.
- Hardy perennials, using hypericum as an example: planting density around 2.4 plants/m² (excluding paths and headlands) and 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 €1.60 per plant and snowberries at about €2 per plant. The expected life of these crops would be around 10 years before the quality of the product starts to deteriorate.
- Lisianthus: planting density between 64 and 80 plants/m² of bed, with 80 to 95% of stems being harvested (one stem produced per plant); the plant cost is approximately €95 per 1,000 (dependent on variety) plus delivery.
- Scabious: planting density of 6 to 8 plants/m² with a yield of between 30 and 50 stems per plant; the plant cost is approximately 75 Eurocents each plus delivery. The economics of this crop will be entirely dependent on the stem price achieved (the Dutch auction price ranged from 12 to 30 Eurocents) because harvesting is very labour-intensive.
- Trachelium: planting density around 64 plants/m² of bed with at least one lead-stem harvested per plant and with some cultivars in 2016 also producing one or two additional side-shoots; the plant cost is approximately €75 per 1,000 plus delivery. The economics of a pinched crop should also be considered by growers to reduce the cost of plant material.

In addition to the new crops being grown by commercial cut flower growers a wide range of new products have also been grown on a small scale by a large number of artisan growers. A number of UK mail order companies have also taken on board products such as annual dianthus, dahlia and zinnia.

Action points

- Asclepias, craspedia, echinacea, gomphrena, scabious and a range of ornamental grasses are suitable potential novel ventures for UK cut flower growers.

- *Ammi majus*, *A. visnaga*, anethum, bupleurum and ornamental carrot are economic, direct-drilled 'alternative fillers' for tunnel or outside production; carthamus could be grown in a similar way.
- 'Breanthus' and 'Solomio' carnations are potential new crops for UK growers to investigate, subject to a realistic price per stem.
- Trachelium can be grown successfully under polythene as opposed to glass helping to reduce production costs.
- Older cultivars of alstroemeria can be grown as a natural-season tunnel crop with the advantage of lower plant costs.
- A wide range of hardy foliage including cotinus, hypericum, salix, sedum, symphoricarpos and viburnum perform well under UK conditions and should be considered for outdoor production.
- *Aster ericoides* 'Cairo' and 'Cassy' can be grown using a summer blackout treatment for earlier floral initiation and two flower flushes, improving the economics of production.
- The work on fusarium wilt susceptibility can be used by column stock growers to help plan their future production. The 'Anytime' series of column stocks for example is quicker to crop, has a lower susceptibility to fusarium wilt and seems less prone to heat-induced blindness, compared with other series.
- A range of other growing media mixes beyond straight peat can be used for box-grown lily production. Production in peat + aerobic digestate gives lilies of equal quality, while peat + wood fibre or peat + cocopeat mixtures are also suitable, but care should be exercised when using anaerobic digestate until a standard specification is available.
- Trial the residual herbicide products suggested for weed control on field-grown cut flowers on a small scale to ascertain efficacy and phytotoxicity risk before widespread use.

Science Section

Introduction

Government statistics show there has been a huge increase in cut flower imports to the UK since the 1990s, despite all the economic difficulties of the period. From 1988 to 2013 all cut flower imports (excluding from the Channel Islands) to the UK rose from £122million to £663million *p.a.*, and again to £750million *p.a.* by 2016 (Defra Basic Horticultural Statistics 2014; Defra Horticultural Statistics 2017). (Over the same years total UK cut flower exports and re-exports rose from £6million to £26million and then £29million.) Evidently the *per capita* spend of UK consumers on cut flowers has increased from its historically low levels.

Despite the opportunities for UK growers such statistics might suggest, cut flower production in the UK has declined for many years. The value of UK-grown cut flowers had remained static at around £50million *p.a.*, the bulk made up of glasshouse crops (including forced bulbs) and field-grown daffodil, but also including some £5million to £10million *p.a.* of outdoor crops. The area of 'other bulbs and flowers' (i.e. excluding daffodil and gladiolus) grown in the open in England (which includes those in Spanish tunnels), fell from 1,274ha in 1988 to 638ha in 2004 and 620ha in 2008, so it is possibly 'bottoming-out' (Defra 2008 Survey of Vegetables and Flowers – England). In 2008 (the last year for which these data are available) the 'other bulbs and flowers' comprised 'other bulbs, corms, rhizomes and tubers' (64ha), pinks and sweet williams (56ha), foliage (46ha), dried flowers (25ha), natural-season chrysanthemum (16ha) and 'all other flowers (inc. asters)' (413ha). By 2017 sunflowers and peony had become more widely grown.

There are other incentives for UK growers too, such as the freshness of produce and its proximity to markets (a useful environmental message), the availability of Spanish and similar tunnels (to protect delicate crops from weather, extend their season and augment growing outside or under cold glass) and the enduring popularity of

'cottage-garden' flowers (that grow well in the UK). Several possible explanations have been suggested as to why home production has not increased in line with imports:

- A lack of technical know-how (partly due to the loss of free agricultural and horticultural advisory services and the difficulties in attracting R&D funding to 'minor' crops).
- Dutch pre-eminence in horticultural growing and marketing, with the ability to provide supermarkets with cut flowers over a long season, in quantity and at competitive prices.
- Growers' difficulties in getting appropriate returns from supermarkets, despite providing a fresher product with UK-branding, and particularly when growing novel products or superior cultivars that are plainly more expensive to produce because of PVR/ PBR, the use of tissue culture or the risks attached to growing a new crop.

It was primarily because of lack of know-how that the HDC (now AHDB Horticulture) funded the National Cut Flower Trials Centre (CFC) project in 2007. The project's continuance for ten years bears some witness to its success. The work of the CFC covers the growing of cut flowers and cut foliage, primarily in tunnels or in the open. In this report the work is described under three themes:

- *Crop information* – reviewing information on cut flower crops, especially concerning novel products and cut flower trials that might benefit UK growers.
- *Crop introduction* – 'new product development', demonstrating and trialling cut flower crops novel to commercial growers in the UK (the word 'novel' is used in a very broad sense, from crops entirely new to commerce to those grown widely abroad but unfamiliar to UK growers, and it includes new series or cultivars of familiar crops when their novel properties might revitalise interest in those crops).

- *Crop improvement* – ‘new ways with old crops’, new techniques or husbandry that might improve the production or quality of familiar crops (such as growing alstroemeria as a summer crop in tunnels).

Keeping to the layout of previous project reports, this final report gives full details of work carried out in 2017 and summarises work done over 2013–2016. Full details of the earlier work can be found in the respective annual reports which are available through the CFC and AHDB Horticulture websites.

Crop information

Collating information on cut flower crops has made use of CABI's '*Horticultural Abstracts*' ('HA') database (a compilation of all significant research on horticultural crops worldwide since the 1970s), the annual review *International Statistics, Plants and Flowers* of the Association of International Horticultural Producers (AIPH) and Union Fleurs, and Internet sources. The information was summarised separately into the databases and reviews listed below, which are available through the CFC and AHDB Horticulture 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 and updated in 2015.

Review of new cut flower crops and cut flower trials programmes

R&D on new cut flower crops and reports on cut flower trials programmes were compiled and presented in a review in 2013 and updated at the end of the project.

Production levels and trends in the cut flower trade

International statistics on the global production and trade in cut flowers were reviewed in 2015 and updated at the end of the project.

Experimental programme: Materials and methods²

Protocols

By arrangement with David Robinson (managing director, R Robinson & Son Ltd), the trials programme was hosted at Rookery Farm, Holbeach St John, Spalding, Lincolnshire. The National Cut Flower Trials Centre (t/a Cut Flower Centre Ltd; CFC) is directed by project leader Lyndon Mason and overseen by a management group comprising representatives of growers, packers, retailers and AHDB Horticulture. Practical arrangements were agreed between David Robinson and the project leader, aiming to achieve a good standard of commercial husbandry adapted as necessary to suit small trial plots that might require individual pesticide, irrigation, fertiliser and other treatments to be made.

The experimental programme was developed annually by the CFC management group, taking into account views received from the industry and information from the review of new crops and cut flower trials. The programme included crop introduction (new product development) and several novel crops were trialled each year following discussion of their potential as commercial cut flower crops in the UK and, where appropriate, taking them forward for further trials or experiments. Depending on their stage of commercialisation, different crops might require simple demonstration plots, agronomic or cultivar trials, trouble-shooting experiments or larger-scale evaluation at a commercial nursery.

The general protocols are described here in 'Materials and methods' and the details of individual trials are given under 'Results'.

Facilities and site preparation

The CFC facility at Rookery Farm comprises a single-span 'Haygrove' tunnel (7.9m

² For the sake of accurate reporting, reference is made to product names and company names throughout this report; no recommendation is implied by such mention, nor any criticism implied of those not mentioned.

wide × 38.1m long; Haygrove Ltd, Redbank, Ledbury, Herefordshire), a triple-span 'Pro-Tech' tunnel (overall 22.7m wide × 38.0m long; Pro-Tech Marketing Ltd, Ironbridge, Telford, Shropshire) and a 600m² adjacent area of outdoor beds provided with anti-rabbit fencing. Since it is an exposed site, wind-breaks of 2.5m-high polypropylene netting were provided at each end of the 'Pro-Tech' tunnel. The tunnels were covered with a standard polythene film and, as is usual, in order to protect the structure of the tunnels the polythene covers were removed for the winter in late-October, which in some cases will have brought crops to a forced end. Typical of the area, the Soil Survey of England and Wales' *Soils of England and Wales* describes the soil as a deep alluvium drained by ditches and pumps.

As required by the trials programme, the growing areas were usually steam-sterilised for two years and then sterilised using dazomet (as 'Basamid') in the third year (any other arrangements are given under the individual trials, see 'Results'). For the 2017 season no sterilisation was undertaken because the 'Haygrove' tunnel was fully planted with ranunculus, some areas of the other tunnels would not be hosting a crop planted into the soil (e.g. the lily trials in crates), and there had been no soil-borne disease problems evident in 2016.

Each year in April samples were taken across the site for standard glasshouse soil analysis. As it's not possible to give a fertiliser recommendation for all cut flower crops, the aim was to bring base fertiliser levels up to those required for column stocks or chrysanthemum, indices of 2 for N, 5+ for P, 4 for K and 4 for Mg. Before planting in 2017 the 'Haygrove' tunnel received 30g/m² ammonium nitrate (as 'Nitram') and 50g/m² sulphate of potash, 'Pro-Tech' bay 1 30g/m² ammonium nitrate only, bay 2 50g/m² sulphate of potash only and bay 3 15g/m² ammonium nitrate, 50g/m² triple superphosphate and 50g/m² sulphate of potash, and the outside area 30g/m² ammonium nitrate, 110g/m² triple superphosphate and 50g/m² sulphate of potash.

Plant material and planting³

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

Most plants were transplanted into labelled plots along 1m-wide beds at the specified density. Individual plot lengths were dependent on the trial and plant availability, and wherever practical unplanted areas were left between plots and at the ends of the beds as 'guard plots' to limit any effects due to an adjacent crop or 'end effects'. Up to and including 2014, beds were generally covered with 1.2m-wide, 120-gauge, micro-perforated black polythene film, planting was through the film, otherwise planting was directly into the soil. In 2015 and later, planting was made directly into the soil, no clear advantage having been previously seen of using a film mulch at this location. Crops were watered with a hand-lance immediately after planting and then to ensure establishment.

Crop husbandry

Once plants were established most water was applied as needed through 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 N:P:K:MgO with trace elements; Everris, Geldermalsen, The Netherlands). Beds were provided with one or more layers of support netting as required by the crop, raising the netting with crop growth. Sometimes plants were stopped (pinched) or other treatments applied, in which case details are given under 'Results'.

³ Handling plant material and contact with plant sap may cause skin irritation, and ingestion may cause other inimical effects, so appropriate precautions should be taken.

Pesticide applications

The pesticides applied in 2017 are listed below, with '+' indicating a tank-mix. Products marked with † ('Pirimicarb 50' and 'Systhane 20 EW') were withdrawn after having been used in this year's spray programme and they are not currently approved for use.

- For aphids, flonicamid and pirimicarb (as 'Mainman' + 'Pirimicarb 50' †) to all crops, week 21
- For leaf miners, abamectin (as 'Dynamec') to ranunculus, week 21
- For powdery mildew, myclobutanil and bupirimate (as 'Systhane 20 EW' † + 'Nimrod') to all crops in tunnels, week 21
- For slugs, ferric phosphate (as 'Iroxx') to all crops except those in tunnel 1, week 24
- For caterpillars and capsids, deltamethrin (as 'Decis') to zinnia and gomphrena, week 24
- For thrips and two-spotted spider mite, abamectin (as 'Dynamec') to gypsophila, solidago, lobelia and scabious, week 24
- For powdery mildew, downy mildew and rust, boscalid + pyraclostrobin and potassium hydrogen carbonate (syn. potassium bicarbonate, a commodity substance) (as 'Signum' + potassium hydrogen bicarbonate) to all crops except those in tunnel 1, week 24
- For caterpillars and aphids, *Bacillus thuringiensis kurstaki* ABTS-351, pirimicarb and pymetrozine (as 'DiPel DF' + 'Pirimicarb 50' † + 'Chess WG') to all crops except those in tunnel 1, week 25
- For downy mildew, mancozeb + metalaxyl-M and 'HortiPhyte' (a phosphite-containing liquid fertiliser) (as 'Fubol Gold WG' + 'Hortiphyte') to scabious, week 25
- For thrips, spinosad (as 'Tracer') to gypsophila, solidago, lobelia and scabious, week 25

- For powdery mildew and downy mildew, myclobutanil and potassium hydrogen carbonate (as 'Systhane 20 EW' † + potassium hydrogen carbonate) to all crops except those in tunnel 1, week 25
- For powdery mildew and rust, azoxystrobin (as 'Amistar') to all crops except those in tunnel 1, week 26
- For caterpillars and aphids, *Bacillus thuringiensis kurstaki* ABTS-351 and deltamethrin (as 'DiPel DF' + 'Decis') to all crops except those in tunnel 1, week 26
- For weeds, flufenacet (as 'Sunfire') to fusarium trial plots in tunnel 1, week 30
- For powdery mildew and rust, boscalid + pyraclostrobin and flonicamid (as 'Signum' + 'Mainman') to all crops except those in tunnel 1, week 31
- For weeds, carfentrazone-ethyl and isoxaben (as 'Shark' + 'Flexidor') to all paths and non-crop areas, week 31
- For powdery mildew, cyflufenamid and deltamethrin (as 'Takumi SC' + 'Decis') to all crops except those in tunnel 1, week 32.

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/m²), along with (for an appropriate random sample of each plot) picking dates, lengths and weights of stems (either overall figures or after trimming to a specified length) and other measurements as appropriate (such as spike length or flower head diameter). Other than as required by trimming, the stem lengths and weights quoted always refer to the total weights and lengths of the whole stem (including buds, flowers or inflorescences).

As appropriate to the practical nature of the project, demonstration plots were not usually replicated, but, where replicated and randomised trials were appropriate, the data were subjected to analysis of variance. In the analysis of variance tables the

value of P (probability) indicates the statistical significance of the source of variation (say, growing medium, herbicide treatment or cultivar). In the 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; NS indicates not significant ($P>0.05$).

Less formally, but importantly, the plots were assessed at intervals by the CFC management group and others from the industry. In the case of preliminary demonstrations emphasis was placed on photographs and grower comments. Numerous samples of products were made available to the industry to gather feedback and for promotion.

Trials at commercial nurseries

Some evaluations were carried out at appropriate commercial nurseries, either because conditions at the CFC were unsuitable or in order to assess crops on a larger scale or more 'commercial' basis. No CFC trials were conducted at commercial nurseries in 2017.

Vase-life testing

Typically, flowers are picked at a specific stage of floral development and placed promptly in buckets of water in a cold store, from which they may be withdrawn for bunching, trimming, placing in sleeves, packing, etc., before being returned to the store until required. The water in which flowers are held at the various stages may be augmented with appropriate conditioning solutions. Storage is followed by transport (sometimes refrigerated) to a packer, intermediate warehouse or retail store. The product then reaches the sales floor, with its ambient temperature and lighting, and finally the consumer's vase. *Retailers will often demand a guaranteed vase-life (VL) of at least five days, but note that this period in the vase is in addition to all the time spent between picking and retail sale, which can typically last a further five days.*

Before carrying out a VL test the chain from grower to consumer is simulated using appropriate conditioning solution, a few days' cold storage and retail store conditions. Testing takes place in a VL test room, and as there is a shortage of such facilities it was impractical to use a single test room throughout this project. Nevertheless, VL test protocols have become standardised, with the basal part of the stem removed before placing the stems in a clean vase of about 1L capacity and containing water with a proprietary flower food, at 20°C and 60% RH with fluorescent lighting at 1,000lux for 12 hours/day. Testing typically involves daily checks of quality (such as petal desiccation, flower dropping, foliage yellowing and loss of water clarity) and determining the longevity of the product in an 'acceptable' state defined by agreed 'throw-out' criteria. Where varied, any specific details about VL testing are given under 'Results'. In this report an unacceptable VL is taken as less than five days, five days is regarded as just acceptable (just reaching the minimum guaranteed period), six days is acceptable and more than six days is good or (if greater than 10 days) long. VL tests in 2017 were carried out by Helen Markillie (Butters Group) and (for scabious only) Emma Bradford (Floralife and Oasis Grower Solutions). In 'Results' the VL quoted refer only to the number of days in the vase, not including the preparatory stages.

Results

The work involving *Crop Introduction* (new product development) is described first, under three sections: (1) the most recent introductions, those crops included for the first time in 2017; (2) crops included before 2017, seen as having potential, and with ongoing trials; and (3) crops included before 2017 with trials now concluded. Following these sections the *Crop Improvement* trials are described.

Crop introduction (1) Crops with first trials in 2017

Asclepias (milkweed, silkweed) (cultivars of *Asclepias curassavica* and others)

Asclepias was one of the many flowers that performed successfully in the ASCFG trials and elsewhere and was considered likely to grow well in the UK and to be appreciated as a novel cut flower. Examples were planted as demonstration plots as detailed in Table 1.

Table 1. Details of 2017 demonstration of asclepias cultivars

Location	Rookery Farm
Cultivars	<i>Asclepias curassavica</i> 'Apollo Orange' <i>A. incarnata</i> 'White'
Plant longevity and hardiness	Perennials; <i>A. curassavica</i> is frost-tender, others are fully hardy
Format(s) and supplier(s)	Seed from Chiltern Seeds
Propagation and pre-planting treatment(s)	Sown into module trays week 21
Planting or sowing date(s)	Transplanted week 25
Plots	2m long
Planting/housing site(s)	'Pro-Tech' tunnel bay 1
Layout	Demonstration plots
Plant spacing(s)	25/m ²
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	Prone to two-spotted spider mite
Picking stage(s) and market specification(s)	Not available
Picking and recording date(s)	<i>A. curassavica</i> 'Apollo Orange': weeks 35–39 <i>A. incarnata</i> 'White': flowers browned before reaching picking stage
Records taken	Observations
VL testing	<i>A. curassavica</i> 'Apollo Orange' tested week 43 by Butters Group



Figure 1. Asclepias in demonstration plots in 2017: top, *A. curassavica* 'Apollo Orange' (week 36) and, bottom-right, cut stems from side-shoots (week 37); bottom left, *A. incarnata* 'White' (week 33)

The two asclepias cultivars established and grew well with no obvious losses, flowering in their first year. 'Apollo Orange' produced prolific, attractive, orange-red inflorescences from week 35 to week 39. Its stem length averaged about 60cm and each plant produced one strong leading stem and a further five or six weaker, but still marketable, side-shoots (Figure 1). *A. incarnata* 'White', however, produced flowers that browned before they were ready to pick, so no further assessments were made

(Figure 1 shows these plants three weeks earlier). Both cultivars appeared prone to two-spotted spider mite, and a preventative spray programme was required. Standard VL testing was carried out on 'Apollo Orange' using 'Chrysal Professional 2 T-bag' in the flower bucket and a universal liquid flower food in the vase. In the limited tests undertaken in 2017, the samples failed on vase-day five, an only just acceptable VL, with some foliage having already become dehydrated by that stage and water uptake having been poor. Subject to confirmation of an acceptable VL, and based solely on this trial, 'Apollo Orange' appeared as visually excellent with prolific flowers. Further trialling of cultivars and VL is needed before drawing any conclusions about its potential as a UK commercial cut flower.

Echinacea (coneflower) (cultivars of *Echinacea purpurea* and others)

Echinacea was another of the many flowers that performed successfully in the ASCFG trials and elsewhere and was considered likely to grow well in the UK and to be appreciated as a novel cut flower. Examples were planted as demonstration plots as detailed in Table 2. Note that examples of *Rudbeckia*, a closely related genus also known as coneflower, have been grown previously at the CFC (see later section).

Table 2. Details of 2017 demonstration of echinacea cultivars

Location	Rookery Farm
Cultivars	<i>Echinacea purpurea</i> <i>E.</i> 'Yellow Cone'
Plant longevity and hardiness	Perennials, fully hardy
Format(s) and supplier(s)	Seed from Chiltern Seeds
Propagation and pre-planting treatment(s)	Sown into module trays week 21
Planting or sowing date(s)	Transplanted week 25
Plots	2m long
Planting/housing site(s)	'Pro-Tech' tunnel bay 1
Layout	Demonstration plots
Plant spacing(s)	25/m ²
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	None evident
Picking stage(s) and market specification(s)	Not available

Picking and recording date(s)	Weeks 35–42
Records taken	Observations
VL testing	<i>E. purpurea</i> tested week 43 by Butters Group

Both cultivars established and grew well, with no obvious losses or pest and disease (P&D) issues. They produced attractive flowers through September and into October but these were very sparse (Figure 2), perhaps due to relatively late planting and the crop's perennial habit. Standard VL testing was carried out with *E. purpurea* using 'Chrysal Professional 2 T-bag' in the flower bucket and a universal liquid flower food in the vase. The flowers failed on vase-day five, an only just acceptable VL and with some foliage having already become dehydrated by that time. Although visually the flowers appear to have potential as a cut flower, further trialling is needed before drawing any conclusions about its future as a commercial crop for the UK. Subject to confirmation of an acceptable VL, further trials should include cultivar testing and scheduling.



Figure 2. Echinacea in demonstration plots in 2017, *Echinacea purpurea* on right (week 37)

Helipterum (strawflower) (cultivars of *Rhodanthe chlorocephala* subsp. *rosea*)

Helipterum (*Rhodanthe*) was another of the many flowers that performed successfully in the ASCFG trials and elsewhere and was considered likely to grow well in the UK and to be appreciated as a novel cut flower. Two cultivars of *Rhodanthe chlorocephala* subsp. *rosea* (syn. *Acroclinium roseum*, *Helipterum roseum*) were grown in demonstration plots in 2017 (Table 3).

Table 3. Details of 2017 demonstration of helipterum cultivars

Location	Rookery Farm
Cultivars	<i>Rhodanthe chlorocephala</i> subsp. <i>rosea</i> 'Priest' <i>R. chlorocephala</i> subsp. <i>rosea</i> 'Sensation'
Plant longevity and hardiness	Annual, half-hardy (other species are perennials usually grown as annuals)
Format(s) and supplier(s)	Seed from Chiltern Seeds
Propagation and pre-planting treatment(s)	Sown into module trays week 21
Planting or sowing date(s)	Transplanted week 25
Plots	3m long
Planting/housing site(s)	'Pro-Tech' tunnel bay 3
Layout	Demonstration plots
Plant spacing(s)	64/m ²
Post-planting treatment(s)	One layer of support netting Plants cut back to about 15cm after first flush
Pests, diseases and disorders	None evident
Picking stage(s) and market specification(s)	Not available
Picking and recording date(s)	Weeks 28–32
Records taken	Observations
VL testing	No

Both cultivars appeared to establish well and in mid-July produced a large flush of flowers that were too weak, short and small-flowered for use as cut flowers (Figure 3). After the first flush and cutting-back, the crop went on to produce a prolific second flush in mid-August, but these stems were also thin, with little potential as a cut flowers because many would have been required to make a bunch and they would be insignificant as a filler. The trial was discontinued, and further trials with helipterum would only be justified if stronger cultivars were available.



Figure 3. Helipterum (*Rhodanthe*) in demonstration plots in 2017, top-row L-R: 'Priest', 'Sensation' (week 28) and after cutting-back (week 29); bottom-row: 'Priest' (with 'Sensation' in background of LH picture) (week 32)

Lobelia (species and cultivars of *Lobelia*)

Lobelia was one of the many flowers that performed successfully in trials elsewhere in Europe and was considered likely to grow well in the UK and to be appreciated as a novel cut flower. Two cultivars were planted in demonstration plots in 2016 for flowering in 2017 (Table 4).

Table 4. Details of 2016–2017 demonstration of lobelia cultivars

Location	Rookery Farm
Cultivars	<i>Lobelia</i> 'Queen Victoria' <i>L. siphilitica</i> (blue cardinal flower)
Plant longevity and hardiness	Perennials ('Queen Victoria' a short-lived perennial) and fully hardy (other lobelias are annuals or perennials, fully hardy to frost-tender)
Format(s) and supplier(s)	Seed from Econseeds
Propagation and pre-	Sown in module trays in week 15

planting treatment(s)	
Planting or sowing date(s)	Transplanted week 21
Plots	2m long
Planting/housing site(s)	'Pro-Tech' tunnel bay 1
Layout	Demonstration plots
Plant spacing(s)	24/m ²
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	Some aphids and two-spotted spider mite
Picking stage(s) and market specification(s)	Not available
Picking and recording date(s)	Around week 29
Records taken	Observations
VL testing	'Queen Victoria'

Both cultivars of lobelia established and grew well, with no obvious losses or P&D issues, and started flowering in the second year (Figure 4). 'Queen Victoria' produced prolific, pretty bright red inflorescences, with stem length averaging about 60cm and stem weight and strength appearing very good. 'Queen Victoria' was subjected to VL testing by a local grower and showed a good VL of 10 days. *L. siphilitica* had attractive, bright blue flowers, but was not particularly floriferous. Although the results with 'Queen Victoria' were very promising, further cultivar trialling and VL testing would be needed before drawing any firm conclusions about lobelia as a potential commercial cut flower for the UK. For 'short-term perennials' like 'Queen Victoria' their productive life-span would also be needed.



Figure 4. Lobelia (planted 2016) in demonstration plots in 2017: left and centre, lobelia 'Queen Victoria' in front with *L. siphilitica* behind (week 23 and 29, respectively); right, 'Queen Victoria' (week 29)

Ranunculus (cultivars of *Ranunculus asiaticus*)

Ranunculus was one of the many flowers that performed successfully in the ASCFG trials and elsewhere and was considered likely to grow well in the UK and to be appreciated as a novel cut flower. As there was an opportunity to evaluate ‘Rococo’, a new breeding line of ranunculus, this was used in demonstration plots. ‘Rococo’ has tall, strong stems, a distinct single flower and is frost-hardy. They were planted in autumn 2016 for flowering in 2017 (Table 5).

Table 5. Details of 2016–2017 demonstration of *Ranunculus* ‘Rococo’

Location	Rookery Farm
Cultivars	‘Rococo’ series (pink, orange and yellow lines)
Plant longevity and hardiness	<i>Ranunculus asiaticus</i> is a tuberous perennial and half-hardy: ‘Rococo’ is said to be frost-hardy (other species are annuals, biennials or perennials, mostly fully hardy)
Format(s) and supplier(s)	Young plants from Plants for Europe Ltd
Propagation and pre-planting treatment(s)	No
Planting or sowing date(s)	Transplanted week 42 of 2016, for flowering in 2017
Plots	Ca 20m long
Planting/housing site(s)	Haygrove tunnel
Layout	Demonstration plots
Plant spacing(s)	12/m ²
Post-planting treatment(s)	One layer of support netting Left <i>in situ</i> over winter (unmulched) Tunnel de-skinned week 45, re-covered week 14
Pests, diseases and disorders	Some leaf miner damage, controlled by spray programme Necessary to maintain a good spray programme against powdery mildew
Picking stage(s) and market specification(s)	When first bud is fully open
Picking and recording date(s)	Started week 16, main flowering period around week 18–20
Records taken	Observations
VL testing	No

The plugs established well and made some good roots before the tunnel was de-skinned for the winter. Once the cover was replaced in spring the plants put on rapid growth (Figure 5). The main flowering period was around week 18 and was reasonably prolific, but the colour range available was fairly limited. There was unresolved debate amongst growers as to whether ‘Rococo’ was entirely suitable for

cut flower use, or was purely suited as a garden plant. Unless the breeder brings forward any new cultivars there are unlikely to be any further trials at the CFC, but from the general appearance of the plots in 2017 there is no reason why other established cultivars of this very attractive flower might not be trialled in future.



Figure 5. *Ranunculus* 'Rococo' in demonstration plots in 2017 (week 18)

Crop introduction (2) Crops with trials on-going in 2017

Annual dianthus (pinks) (cultivars of *Dianthus barbatus*)

Although they were already well known as commercial crops in the UK, annual dianthus were trialled extensively in the early years of the CFC (2007–2012) to assess new cultivars as they became available. Around 2012 the main cultivars being grown were from the 'Amazon' and 'Sweet' series. In 2012 HilverdaKooij introduced 'Breanthus', one of their 'Sparkz' range of annual dianthus. With large, spherical flower heads, 'Breanthus' brought new genetics to the crop. Demonstration plots of four 'Breanthus' cultivars ('Duke', 'Earl', 'King' and 'Queen') were planted at the CFC to assess their market potential and collect basic data on performance. Wet weather following delivery delayed planting, but the tunnel-grown crop nevertheless produced stems of high quality. There were substantial differences in stem length and weight and flower yield and quality across the four cultivars. Despite the weather, the tight, spherical heads were considered especially appealing, and there was a positive response from retailers and growers and the work was continued.

In 2013 plugs of 'Breanthus Baron', 'Duke', 'Earl', 'Elmo', 'Findis' and 'Lord' were transplanted to plots in a tunnel in weeks 14 and 16. Half of each plot was pinched two weeks after planting, as this had previously been shown to reduce stem length and weight in very vigorous cultivars. They produced a steady supply of stems with large and consistent yield differences between cultivars, 'Baron' being high yielding and 'Elmo' low yielding. Both later planting and pinching reduced stem yield. Some premature budding was observed in 'Breanthus Findis', and leaf scorch in 'Breanthus Elmo'. The plants were left *in situ* for assessment the next year but did not overwinter well. The issues of premature budding and leaf scorch have not been investigated, and further work on 'Breanthus' is unlikely unless further cultivars become available.

New, green-flowered cultivars became available from HilverdaKooij in 2015. Rooted cuttings of 'Green Magma', 'Green Trick' and 'Green Wicky' were potted-on, pinched and transplanted into demonstration plots in a tunnel. The bright green flower heads were handsome and flowered prolifically around week 29. At the time of writing green dianthus are already being imported from the Netherlands; disappointingly, however, at the time of the trial there was little or no support for growing or sourcing the crop here.

Further new cultivars, again strikingly different to the familiar types, became available from Whetman Pinks in 2015. Rooted cuttings of 'Cherry Daiquiri', 'Cosmopolitan', 'Mojito', 'Shirley Temple' and 'Tequila Sunrise' and were planted-on from their plugs into demonstration plots in a tunnel. The picking period was weeks 29–31. As the stems were rather weak and short it was decided they should be grown-on to assess in 2016. However, in 2016 it became evident that they are good garden plants but were unsuitable as cut flowers.

In 2017 plants of a new breeding line, including both named and coded cultivars, became available from Dümme Orange and were planted in demonstration plots (Table 6).

Table 6. Details of 2017 demonstration of new annual dianthus ‘Barberatus’ and other lines

Location	Rookery Farm
Cultivars	‘Barberatus Burgundy’ ‘Barberatus Cerise’ ‘Barberatus Rose’ ‘Barberatus Snow’ ‘Barberatus Verde’ ‘Trigreen 323512’ 2013 MSFG 1 2014 MSB 2
Plant longevity and hardiness	Short-lived perennials often grown as biennials, fully hardy
Format(s) and supplier(s)	Rooted cuttings in plugs from Dümme Orange
Propagation and pre-planting treatment(s)	Those intended for outside planting were potted-on into 50’s trays in week 18 and pinched in week 19
Planting or sowing date(s)	Transplanted into tunnel week 18, and outside in week 21
Plots	3m long
Planting/housing site(s)	‘Pro-Tech’ tunnel bay 1 Outside beds
Layout	Demonstration plots
Plant spacing(s)	35/m ² (one per mesh square with two in the outside squares)
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	Rust Ring spot
Picking stage(s) and market specification(s)	When the first whorl of petals is open
Picking and recording date(s)	Weeks 28–32
Records taken	Observations
VL testing	No

The new lines (Figure 6) established well but grew away slowly, with much vegetative growth. The early flowers had short stems, though length increased later. There was a wide range of colours, though these would need to be compared with those available from other producers. A spray programme would be required to control rust and ring spot (Figure 7). As would be expected the protected crop performed better than the outdoor crop, especially as regards stem length.

As with previous trials of annual dianthus, these lines were generally appreciated by growers and packers alike, but at the current time the economics do not stack up as a supermarket product because the customer will not pay more than for a cheap, standard sweet william.



Figure 6. Annual dianthus (pinks), 'Barberatus' series in demonstration plots 2017: above, LH column, plots in weeks 28 (above) and 29 (bottom); middle column, numbered line 2013 MSFG 1 and RH column, 'Barberatus Verde' (all week 31); on left, mixed vase (week 32)

Figure 7. Annual dianthus 'Barberatus' series in demonstration plots 2017 showing leaf spot symptoms



Caryopteris (blue spirea) (cultivars of *Caryopteris x clandonensis*)

Caryopteris is a popular garden shrub up to 1.5m tall and bearing usually bright blue flowers in clusters near the branch ends. It was included in CFC trials in 2008, but at the time concerns were raised about an unacceptable smell sometimes associated with the crop. Although individual opinions varied, and there appeared to be differences in odour between cultivars, sufficient concerns was raised to discourage further trialling at that time. In 2016, however, Danziger introduced a new range – the ‘Pagoda’ series - bred specifically for cut flower production. Three cultivars were planted in demonstration plots in a tunnel in 2016 and again in 2017 (Table 7).

Table 7. Details of 2016–2017 demonstration of *Caryopteris* ‘Pagoda’ series

Location	Rookery Farm
Cultivars	‘Pagoda Blush’ ‘Pagoda Lagoon’ ‘Pagoda Ocean’
Plant longevity and hardiness	Perennial; fully hardy (some other caryopteris are frost-hardy)
Format(s) and supplier(s)	Plug plants from Danziger
Propagation and pre-planting treatment(s)	None
Planting or sowing date(s)	Transplanted week 21 2016 Transplanted week 18 2017
Plots	1m long
Planting or housing site(s)	‘Pro-Tech’ tunnel bay 1
Layout	Demonstration plots
Plant spacing(s)	24/m ²
Post-planting treatment(s)	One layer of support net 2016 planting left down but failed to overwinter
Pests, diseases and disorders	None evident either year
Picking stage(s) and market specification(s)	Stems with buds showing colour or with the lowermost whorl of flowers open
Picking and recording date(s)	Started cropping mid-September both years
Records taken	Observations
VL testing	‘Pagoda Blush’ week 43 (2017) by Butters Group

In 2016 the three cultivars grew and established well, with no obvious losses or P&D issues (Figure 8). ‘Pagoda Lagoon’ showed real promise because of its rich colour, a nice, bright blue; ‘Pagoda Blush’ was thought disappointing because of its rather insipid colour and short stems; and ‘Pagoda Ocean’ also had potential, though the flowers were not as bright as ‘Pagoda Lagoon’. Caryopteris is generally considered

fully hardy, and the crop was left down for a further year, but did not overwinter successfully. A second planting was made in 2017. By mid-September of both years flower spikes were prolific and the plants continued to crop well into October. The stems were robust and of marketable length (50cm+) and weight. In 2017 standard VL testing was carried out with 'Pagoda Blush' using 'Chrysal Professional 2 T-bag' in the flower bucket and a universal liquid flower food in the vase. The flowers failed on vase-day 10, a good VL, although some foliage had become dehydrated by that time. There was some interest in caryopteris from the trade, but it was considered unlikely to attract a large demand at present.



Figure 8. Caryopteris demonstration plots in 2016 (top-left then clockwise): 'Pagoda Blush', 'Pagoda Lagoon' and 'Pagoda Ocean' (all week 38), and general view (week 40)

Delphinium (cultivars of *Delphinium*, Belladonna Group)

In earlier CFC projects delphiniums were trialled extensively, and the industry continues to debate whether more of their potential might be realised in the UK, say by the introduction of new cultivars. Compared with the traditional delphiniums (the Elatum and Pacific Hybrid Groups), those of the Belladonna Group have wiry, branching stems bearing more delicate spikes of smaller florets. Some new cultivars from this group were trialled starting in 2014. At the suggestion of growers, new cultivars from Miyoshi - 'Sea Waltz' and 'Sky Waltz' (from the 'Waltz' series) and 'Tango Dark Blue' were grown in demonstration plots in 2014–2015. The 'Waltz' series was selected for high productivity and relatively large single florets, the shorter but faster growing 'Tango Dark Blue' for its double flowers. In trials they gave potentially three flushes a year when cut back after the first and second flushes, although in this instance the third flush was still developing when the plants were flattened by gales in late-October. Grown-on to 2015 they produced dense growth with productive flushes in mid- to late-June and mid- to late-August, and a weak flush on October.

Examples of another new Miyoshi series from the Belladonna Group, 'Trick', were grown in demonstration plots in 2016–2017 (Table 8). 'Trick' cultivars have delicate coloured florets in small spikes that are produced continuously from new shoots.

Table 8. Details of 2016–2017 demonstration of *Delphinium* 'Trick' series

Location	Rookery Farm
Cultivars	'Trick Lilac' 'Trick Pink' 'Trick Yellow'
Plant longevity and hardiness	Perennial (some may be grown as annuals or biennials) and fully hardy
Format(s) and supplier(s)	Plugs ex-tissue culture from Miyoshi
Propagation and pre-planting treatment(s)	None
Planting or sowing date(s)	Transplanted week 19
Plots	3.5m long plots
Planting or housing site(s)	'Pro-Tech' tunnel bay 2
Layout	Demonstration plots

Plant spacing(s)	25/m ²
Post-planting treatment(s)	One layer of support netting Cut back to ground after first and second flushes Left <i>in situ</i> to grow-on into 2017
Pests, diseases and disorders	In both years a low level of powdery mildew appeared and was controlled by the spray programme In both years the first flush showed virus-like symptoms, blotchy leaf colour and chlorosis, though but this was not evident in the second flush
Picking stage(s) and market specification(s)	Not available
Picking and recording date(s)	2016: First flush weeks 28-29, second flush weeks 35-36 2017: First flush weeks 19-26, second flush weeks 27-38 (the crop was removed before the third flush)
Records taken	Observations
VL testing	Samples taken week 38, 2016 and tested by Chrysal

In their first year the crop produced a good flush of flowers in mid- to late-July (Figure 9) and a second, heavy flush in early-September. The flowers were elegant, upright and well liked by growers. Left to grow-on, in 2017 the flower spikes were prolific, and ready for picking in week 20 (first flush) and week 27 (second flush). Stem length averaged about 80cm and stem weight was acceptable, albeit they were much lighter than the traditional outdoor crop of the Elatum Group. Chlorotic symptoms – potentially an issue and so far unresolved - were seen on the leaves in the first flushes in 2016 and 2017 (Figure 10), but not in the second flushes.

In 2016 samples of each cultivar were taken for VL testing. Two different post-harvest treatments were used - 'AVB' and 'RVB Clear' - and the end of VL was taken as when >50% of the flowers on a stem had wilted or dropped. By vase-day four, the stems treated with 'AVB' showed no flower abscission, while 'Trick Pink' stems treated with 'RVB Clear' were shedding flowers and 40% of the stems had been terminated. The first stem deaths occurred in 'Trick Lilac' and 'Trick Yellow' on vase-days seven and eight, respectively, with 'Trick Yellow' losing hardly any flowers in either treatment, suggesting there are varietal differences in sensitivity to ethylene. All stems treated with 'AVB' lasted at least eight days, a good VL, and flowers

opened better and were visibly larger when this product had been used.



Figure 9. *Delphinium* 'Trick' cultivars in demonstration plots in 2017, LH column: 'Trick Pink' (week 26), 'Trick Lilac' and 'Trick Yellow' (week 36), and (above, top) as picked week 27; above: re-growth in week 38

The 'Trick' series, as well as the 'Waltz' series and 'Tango Dark Blue', were considered to have good potential as straight bunches and for use in bouquets. Their uptake as commercial cut flowers in the UK would depend on economics (the planting material, derived from tissue culture, being relatively expensive),

confirmation of VL and, possibly, resolving the issue of leaf chlorosis (the cause of which has not yet been established).



Figure 10. Foliage of *Delphinium* 'Trick' showing chlorotic symptoms (week 19, 2017)

Eremurus (foxtail lily) (cultivars of *Eremurus stenophyllus*)

Eremurus stenophyllus is a fleshy-rooted or rhizomatous plant producing tufts of linear leaves at ground level and bearing leafless, upright stalks (to 1.5m-high) with dense racemes of yellow flowers. Interspecific hybridization has produced a wider range of colours including whites and pinks. Eremurus are fully hardy, needing a winter cold period to initiate flowers, but young growth can be damaged by frost. Three cultivars were planted in demonstration plots in 2016 and kept down into 2017 (Table 9).

Table 9. Details of 2016–2017 eremurus cultivar demonstration

Site	Rookery Farm
Cultivars	'Cleopatra' 'Moneymaker' 'Tap Dance'
Plant longevity and hardiness	Rhizomatous perennials; fully hardy, but early growth is frost-tender
Format(s) and supplier(s)	Rhizomes from Kolster
Propagation and pre-planting treatment(s)	None
Planting or sowing date(s)	Planted week 45, 2015
Plots	Duplicate 4m long plots
Planting/housing site(s)	'Pro-Tech' tunnel bay 1
Layout	Demonstration plots
Plant spacing(s)	12/m ² The rhizomes were planted with the tip about 5cm

	below soil level
Post-planting treatment(s)	Left down, grown-on into 2017
Pests, diseases and disorders	In 2016 the foliage appeared to die-down prematurely, while the plants were still flowering (this effect was not observed in 2017) No other issues were evident
Picking stage(s) and market specification(s)	Spikes with the top 50 to 75% of the florets still closed (and with no open florets having turned brown); buds must have formed up to the tip of the spike
Picking and recording date(s)	2016: May 2017: late-May to early-June
Records taken	Observations
VL testing	No

In 2016 leaf growth was adequate, but leaf senescence appeared to start early and the leaves were often dying-down by flowering time (May). Flower yield was low, but the flower spikes and stem were certainly long and impressive (Figure 11). Stem length varied between cultivars, although all cultivars were more than tall enough. The crop was left *in situ* and overwintered without loss. In 2017 all cultivars grew and flowered prolifically in May/June, with no sign of the early foliar senescence seen in the previous year (Figure 11). Flower stems were robust and about 1.2m long. The spectacular stems mark out eremurus as a potential crop for the luxury market, a suitable crop for the artisan or niche grower. For any wider use it would be necessary to consider the relatively high cost of rhizomes, the apparent sparseness of flowers, the possibility of early foliar senescence, and the longevity and rate of bulking-up of the rhizomes.

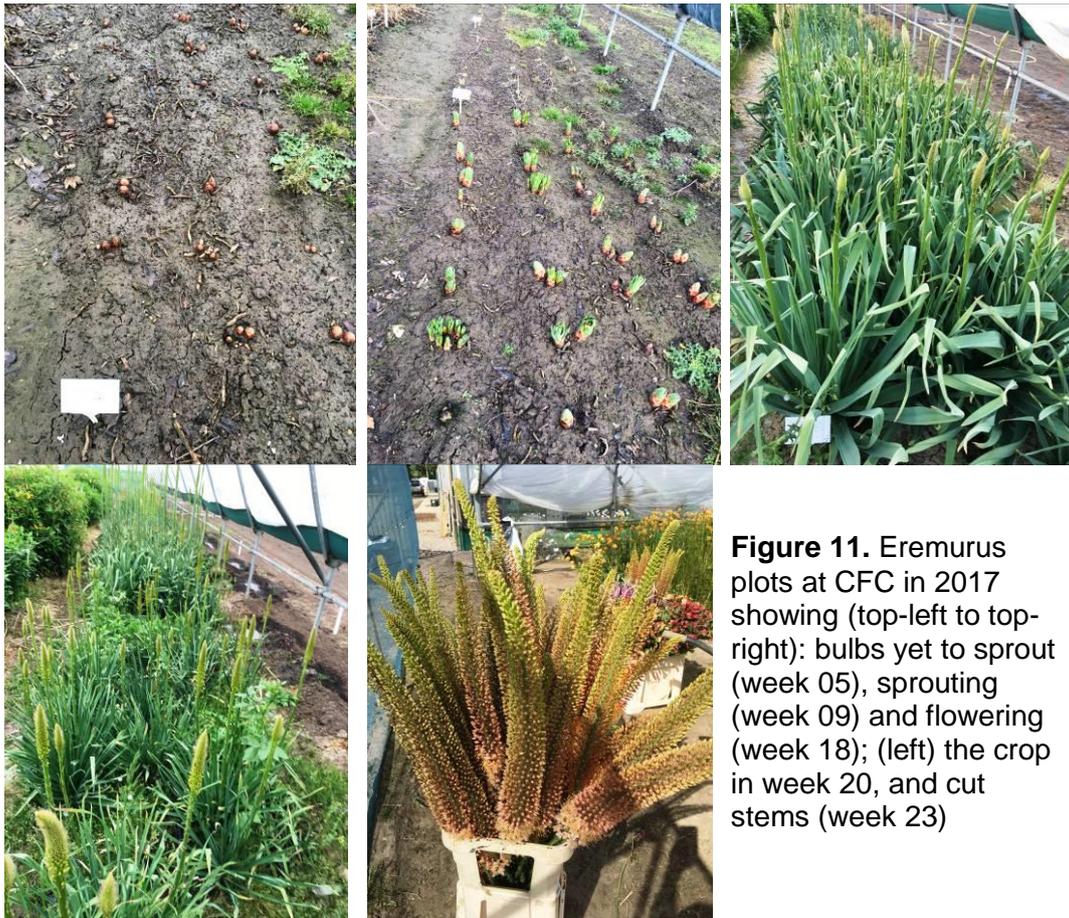


Figure 11. Eremurus plots at CFC in 2017 showing (top-left to top-right): bulbs yet to sprout (week 05), sprouting (week 09) and flowering (week 18); (left) the crop in week 20, and cut stems (week 23)

Fillers, seed-raised (species and cultivars of *Ammi*, *Anethum*, *Anthriscus*, *Bupleurum*, *Daucus*, *Euphorbia* and *Ridolfia*)

Although formerly sourced almost entirely from outside the UK, recent years have seen an increase in the interest of UK growers in producing cheap, seed-raised fillers either in tunnels or outside. Hence a range of fillers was demonstrated in 2014 and 2015 in both tunnel and outside beds and mainly based on direct-drilling. Initially success was limited, probably largely because of the current lack of familiarity and knowledge of these crops in the UK. There were follow-up trials with *Ammi majus* and *A. visnaga* cultivars in 2016–2017, and in the same years *Daucus carota* was added to the demonstration.

In the 2014 demonstration *A. visnaga* seed germinated poorly and the consequent wide plant spacings led to stems that were too large and branching for use as a filler. *A. visnaga* (Figure 12) was ready for picking starting weeks 33, 38 and 42 from week 21 (tunnel), 25 (tunnel) and 27 (outside) sowings, respectively, but plants from the

week 30 (outside) sowing were not ready by week 43 when trial recording was brought to a halt by de-skinning the tunnels. These poor results suggested that *A. visnaga* should either be drilled at a higher density to reduce plant size, or should be grown more reliably from plugs; alternatively the more robust *A. majus* might be grown instead.

In the trials in 2015 both species were sown in a tunnel in weeks 17, 20, 24 and 28 and outside in week 24 (Figure 13). *A. visnaga* was slower to mature than in the previous year, perhaps because of the very cold weather in spring and early summer that year. *A. majus* was also slow to mature, but produced marketable stems from the later sowings both in tunnels and outside. Although the two early tunnel sowings of both species failed to produce a crop, the *A. visnaga* sown in week 24 was cropped mainly in week 40 (tunnel) and week 41 (outside) and the corresponding picking dates for *A. majus* were weeks 37 and 41. The trial confirmed the potential of *A. visnaga* to produce large flower heads, however, suggesting this species may be useful for the larger, more expensive bouquets. The late, week 28 sowings in the tunnel failed to produce marketable heads by week 44 in either species. In post-harvest tests conducted in 2015, stems of both species achieved long VL, 17 days (*A. visnaga*) and 22 days (*A. majus*). Despite the somewhat disappointing results with ammi initially, the trials generated notable enthusiasm from customers and growers for the CFC to carry out further comparative trials of ammi cultivars.



Figure 12. Continued on next page

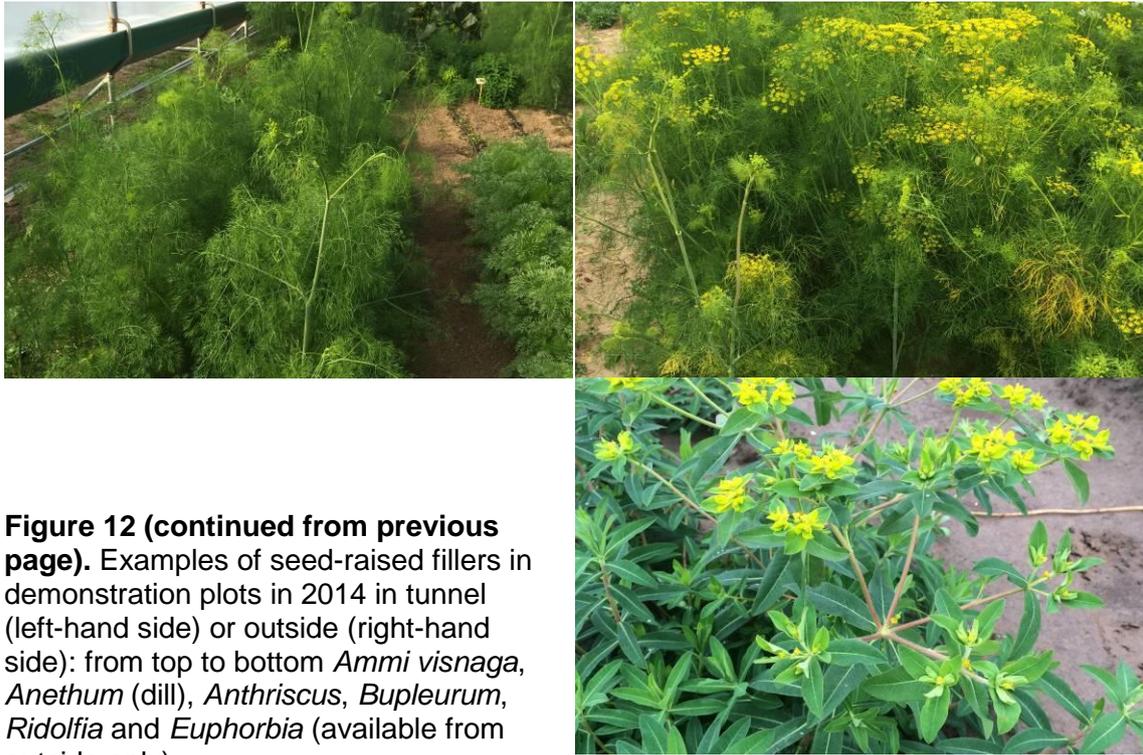


Figure 12 (continued from previous page). Examples of seed-raised fillers in demonstration plots in 2014 in tunnel (left-hand side) or outside (right-hand side): from top to bottom *Ammi visnaga*, *Anethum* (dill), *Anthriscus*, *Bupleurum*, *Ridolfia* and *Euphorbia* (available from outside only)



Figure 13. Typical plots of (left) *Ammi majus* and (right) *A. visnaga* growing in tunnels, 6 August 2015 (week 32)

In 2016 *Ammi majus* 'Bishop's Flower', 'Queen of Africa' and 'Snowflake' and *A. visnaga* 'Green Mist', 'Mystique', 'Queen Anne's Lace' and 'White Spray' were investigated. Seed was direct-drilled under a tunnel (week 18) and outside (week 20). At both sites the main picking period for *A. majus* cultivars was week 28 onwards and for *A. visnaga* cultivars from week 30 or 31 onwards. Growth in the tunnel was still rather too vigorous, but this has to be balanced against the crop protection afforded by tunnels. Differences between the ammi cultivars were relatively small, though *A. majus* 'Queen of Africa' and 'Snowflake' and *A. visnaga* 'Green Mist' and 'Queen Anne's Lace' were selected as probably the most useful for a further trial in a tunnel in 2017 (Table 10).

Table 10. Details of 2017 demonstration of *Ammi* cultivars

Location	Rookery Farm
Cultivars	<i>Ammi majus</i> 'Queen of Africa' <i>A. majus</i> 'Snowflake' <i>A. visnaga</i> 'Green Mist' <i>A. visnaga</i> 'Queen Anne's Lace'
Plant longevity and hardiness	Annual, fully hardy (some ammi are biennial)
Format(s) and supplier(s)	Seed from Chiltern Seeds, Sarah Raven and Genesis Seeds
Propagation and pre-planting treatment(s)	Seed sown into plugs in week 18
Planting or sowing date(s)	Plugs transplanted week 22
Plots	3m long plots
Planting/housing site(s)	'Pro-Tech' tunnel bay 3
Layout	Demonstration plots
Planting spacing(s)	64 plants/m ²
Post-planting treatment(s)	One layer of support
Pests, diseases and disorders	No problems evident
Picking stage(s) and market specification(s)	When the umbel is showing colour
Picking and recording date(s)	Week 30 onwards for <i>A. majus</i> cultivars Week 32 onwards for <i>A. visnaga</i> cultivars
Records taken	Observations
VL testing	No

The trial showed that ammi grows prolifically in the UK, but very little difference could be observed between the different cultivars. Ammi appears to be too vigorous when grown under protection and is therefore probably better suited to outdoor production.

Other seed-raised fillers were included in CFC trials in 2014 and 2015, prior to ammi being selected as probably the best candidate to take forward: The other fillers were *Anethum graveolens*, *Anthriscus sylvestris*, *Bupleurum rotundiflorum*, *Euphorbia oblongata* and *Ridolfia segetum* (Figure 12). Production methods followed those used for ammi, tunnel and outside plots being grown.

Anethum graveolens (dill) was quick to germinate and fast growing in both 2014 and 2015 trials, with several secondary stems being produced after the main stems had been picked. In 2014 picking started in weeks 29, 32, 34 and 39 from week 21 (tunnel), 25 (tunnel), 27 (outside) and 30 (outside) sowings, respectively, and in 2015 the picking dates were weeks 32, 34, 34 and 41 from week 24 (tunnel), 24 (outside), 28 (tunnel) and 31 (tunnel) sowings (earlier tunnel-sown crops, weeks 17 and 20, having failed). Post-harvest tests in 2014 and 2015 gave a long VL between 10 and 15 days, exceeding the usual number of 'guaranteed' days, though substantial stem elongation (up to 90%) was noted post-harvest, which may be disadvantageous. Although the stems initially became flaccid post-harvest they 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.

Anthriscus sylvestris 'Ravenswing' seed failed to germinate following direct-drilling in 2014, and replacement plugs were planted in a tunnel and outside in week 25. These established quickly but produced only a handful of flowers. In the outside plots anthriscus were seriously damaged by two-spotted spider mite. The plants were left *in situ* and produced a good crop in early-May 2015, especially in the tunnel. Anthriscus may be better grown as a perennial.

Bupleurum rotundiflorum 'Griffithii' was slow to germinate and grow in both years, appeared to bud-up early, but did eventually produce long, strong stems. In 2014 the picking dates were weeks 31, 36 and 39 from weeks 21 (outside), 25 (outside) and 27 (tunnel) sowings, respectively, and in 2015 weeks 29, 31, 35 and 37 from weeks

17 (tunnel), 20 (tunnel), 24 (tunnel) and 24 (outside) sowings; in both years later sowings (weeks 30 or 28) in a tunnel failed to produce a marketable crop by weeks 43 or 44 (tunnel de-skinning). In 2014 and 2015 the tunnel crops had some plants with leaf scorch, which, if taking trials further, would need to be investigated, but was thought due to growth being too soft following a period of high temperatures and light levels, with *Botrytis* subsequently colonising the damaged tissue. Stems were sampled for VL testing and gave a VL of five days, just reaching the usual number of 'guaranteed' days, but by day five the umbel had started to discolour and by day six the foliage was dehydrated and browning despite their having taken up a relatively large amount of water. Based on other experience such a short VL was unexpected, and it may have been due to picking at too mature a stage. Nevertheless, there was renewed grower interest in bupleurum as it is easy to grow and pick, but regular production would require weekly sowings, seasonal extension is also desirable, and post-harvest quality would need to be investigated. Nevertheless, as a result of these trials the crop is now grown commercially in the UK.

Euphorbia oblongata was slow to germinate and grow in 2014, producing stems that were too short for cutting - about 20cm. At the end of the growing season part of the tunnel crop was transplanted to another tunnel where it could be grown-on for a year. The transplanted euphorbia produced a good flush of long stems in late-May/early-June 2015, and then continued steadily producing shorter stems (40–50cm) through to autumn. While samples cropped from both tunnel and outside plots became limp soon after harvest, they recovered overnight in a cold store, thereafter giving a long VL of 14 days in tests. The overall look of euphorbia was well liked, with its bulk and zesty green colour, but it should be noted that euphorbia exudes milky sap freely when cut, making for messy handling, a risk of skin irritation for both workers and customers, and possibly inimical effects on other cut flowers if used in mixed vases; these factors would need to be investigated before taking it further.

Ridolfia segetum is similar to anethum, though slower germinating and growing. In 2014 it was ready for picking starting weeks 30, 35 and 36 from week 21 (outside), 25 (outside) and 27 (tunnel) sowings, respectively, while plants from the week 30 (tunnel) sowing were not ready for picking by week 43 when the tunnel was de-skinned. In 2015 the crops failed from the early sowings (weeks 17 and 20 in the tunnel), while stems from the week 24 sowings were ready to pick by week 35 (outside) and by week 36 (tunnel); a later sowing (week 28 in the tunnel) failed to crop before de-skinning (week 44). After cutting the main stem, secondary stems were produced. Overall it was considered that anethum would be a better option.

Daucus carota 'Dara', ornamental carrot, was the subject of a small demonstration plot in a tunnel in 2016. It generated much interest from growers for its distinctive flowers. Direct-seeded in a tunnel in week 18, it produced marketable stems from week 25 onwards. There was a further demonstration plot in 2017 (Table 11).

Table 11. Details of 2017 demonstration of ornamental carrot

Location	Rookery Farm
Cultivars	<i>Daucus carota</i> 'Dara'
Format(s) and supplier(s)	Seed from Chiltern Seeds
Plant longevity and hardiness	Annual or biennial, fully hardy
Propagation and pre-planting treatment(s)	Seed sown into plugs week 18
Planting or sowing date(s)	Plugs transplanted into beds week 22
Plots	2m long plots
Planting/housing site(s)	'Pro-Tech' tunnel bay 3
Layout	Demonstration plots
Plant spacing(s)	64 plants/m ²
Post-planting treatment(s)	One layer of support
Pests, diseases and disorders	Plants suffered from root rot and poor growth after planting; assumed to be due to pythium
Picking stage(s) and market specification(s)	When the umbel is showing colour
Picking and recording date(s)	Week 28
Records taken	Observations
VL testing	No

The 2017 trial with ornamental carrot again produced a product that was liked by the market but the yield was low and head size variable. For this crop to be commercially

viable a more reliable seed stock would be needed to be found, though this is not unlikely because of the ornamental carrot's current popularity.

The trials of seed-raised fillers provoked considerable interest within the industry. Bupleurum has now been produced commercially for a couple of years and a wide range of the other subjects are grown in small quantities by artisan growers. The industry remains keen to see further demonstrations of ammi and some other fillers - *Atriplex*, *Orlaya* and common cereals have been suggested.

Gomphrena (globe amaranth) (cultivars of *Gomphrena globosa* and *G. haageana*)

Gomphrena is another example of a cut flower produced abroad but unfamiliar to UK customers. An annual herbaceous plant bearing white, pink, purple or red solitary flower spikes at the stem tips, gomphrena can be used fresh-cut or dried. Nine cultivars were grown in demonstration plots at the CFC in 2016, four colours of each of the 'Globosa' and 'Haageana' series together with 'Fireworks'. Plug plants were transplanted (at 25 and 64/m²) into plots in a tunnel in weeks 19 and 25. The earlier planting started flowering around week 29. Initially the stems were very short and looked unlikely to be suitable as a cut flower. After three to four weeks, however, much longer stems were being produced, with real potential. There were no obvious differences between plants grown at either planting density. Samples of mixed cultivars were subjected to standard VL testing incorporating alternative post-harvest treatments – either 'RVB Clear' or 'CVBN'. Although the stems wilted rapidly after picking, they recovered once they were placed in the post-harvest treatment and cooled. The stems, flowers and foliage remained in acceptable condition on VL day seven, with no obvious differences between either post-harvest treatment or cultivars. The interest in gomphrena was sufficient to justify a second demonstration with selected cultivars in 2017 (Table 12).

Table 12. Details of 2017 gomphrena demonstration

Site	Rookery Farm
Cultivars	'Globosa Pink' 'Globosa White' 'Haageana Carmine' 'Haageana Red'
Plant longevity and hardiness	Annual, half-hardy to frost-tender
Format(s) and supplier(s)	Seeds from EconSeeds
Propagation and pre-planting treatment(s)	Sown into plugs week 15
Planting or sowing date(s)	Transplanted week 21
Plots	2m long
Planting/housing site(s)	'Pro-Tech' tunnel bay 3
Layout	Two replicated plots per cultivar
Plant spacing(s)	25/m ²
Post-planting treatment(s)	Support netting supplied
Pests, diseases and disorders	Insubstantial level of aphid
Picking stage(s) and market specification(s)	First buds fully open
Picking and recording date(s)	Weeks 30–37
Records taken	Observations, picking dates and number of marketable stems/plot/date
VL testing	No

All cultivars showed high rates of germination and established well once planted. However, once flowering started it was evident that the stems of the 'Globosa' cultivars (and particularly of 'Globosa White') were too short for marketing (Figure 14). and these were therefore removed from the tunnel just leaving the 'Haageana'. Records were therefore taken only of the 'Haageana' cultivars, the length of which increased through the season; they gave average yields of marketable stems of 347 stems/m²plot ('Haageana Pink') and 332 ('Haageana Red'). Flower cropping peaked in week 33 for both cultivars, though 'Haageana Pink' had a second peak in week 35.

Gomphrena were attractive (especially the brighter colours) and prolific, with an acceptable VL and (in 'Haageana' cultivars) long stems (Figure 14). Initially, gomphrena generated a lot of interest and it still has potential as a filler. However, its soft foliage and tendency to tangle could add difficulties to handling in a commercial situation - although this might be balanced by growing small plots and once-over cropping. Further trials along these lines should be carried out with a view to forming an economic assessment of the crop. Further cultivar selection would also be crucial

and should pay particular attention to stem length.



Figure 14. Gomprena in 2017 demonstration plots showing (top left, front then back) 'Globosa Pink' and 'Haageana Carmine', and (top right) 'Haageana Red' and 'Haageana Carmine' (week 29); (bottom left) 'Globosa Pink' and 'Haageana Carmine' and (bottom right) 'Globosa White' and 'Haageana Red' (week 32)

Grasses, ornamental (species and cultivars of *Bromus*, *Chasmanthium* (*Uniola*), *Eragrostis*, *Panicum*, *Setaria*, *Sorghum* and *Stipa*)

Recent years have seen strong interest in sourcing ornamental grasses as bouquet fillers, and several were grown in demonstration plots in 2016 and 2017 (Table 13).

Table 13. Details of 2016 and 2017 demonstrations of ornamental grasses

Location	Rookery Farm
Cultivars	<p><u>2016 planting only:</u> <i>Chasmanthium latifolium</i> (syn. <i>Uniola latifolia</i>) <i>Stipa capillata</i> 'Lace Veil'</p> <p><u>2016 and both plantings in 2017:</u> <i>Panicum elegans</i> 'Sprinkles' <i>Panicum miliaceum</i> 'Violaceum' <i>Setaria italica</i> 'Max' <i>Sorghum nigrum</i></p> <p><u>2016 and only week 25 planting in 2017:</u> <i>Bromus macrostachys</i> <i>B. secalinus</i> <i>Eragrostis elegans</i> <i>Setaria pumila glauca</i></p>
Plant longevity and hardiness	<p><i>Bromus macrostachys</i>: annual, hardy <i>B. secalinus</i>: annual, hardy <i>Chasmanthium latifolium</i>: perennial, hardy <i>Eragrostis elegans</i>: annual, hardy <i>Panicum elegans</i>: perennial grown as annual, half hardy <i>Panicum miliaceum</i> 'Violaceum': annual, hardy <i>Setaria italica</i> 'Max': annual, hardy <i>Setaria pumila glauca</i>: perennial grown as annual, hardy <i>Sorghum nigrum</i>: annual, hardy <i>Stipa capillata</i>: perennial, hardy</p>
Format(s) and supplier(s)	Seed from Chiltern Seeds, EconSeeds and Genesis Seeds
Propagation and pre-planting treatment(s)	<p>2016: Plugs seeded week 12 2017: Plugs seeded weeks 18, 21 and 26</p>
Planting or sowing date(s)	<p>2016: Plugs transplanted to tunnel week 16, outdoors week 17 Seeds direct-drilled to tunnels weeks 18 and 28, outdoors week 18 2017: Plugs seeded week 18 transplanted to tunnel and outside plots week 21; plugs seeded week 21 transplanted to tunnel and outside plots week 25; and plugs seeded week 26 transplanted to tunnel only week 30 Seeds direct-seeded to tunnel week 14 but germination erratic and plugs used for further plantings (see above)</p>
Plots	3m long
Planting/housing site(s)	<p>2016: Outdoors and 'Pro-Tech' tunnel bays 2 and 3 2017: Outdoors and 'Pro-Tech' tunnel bay 2</p>
Layout	Unreplicated demonstration plots
Plant spacing(s)	25/m ² (plugs) and 64/m ² (direct-drilled)
Post-planting treatment(s)	No support netting used in 2016 but it was provided in 2017
Pests, diseases and disorders	Powdery mildew was evident on <i>Bromus secalinus</i> in 2016 and 2017, otherwise free of P&D
Picking stage(s) and market specification(s)	Tentatively, as soon as the individual florets are becoming visible, but this varies with the species and

	would be guided by the market outlet
Picking and recording date(s)	2016: From week 27 onwards, but from week 36 for the week 28 planting 2017: Direct-seeded (week 14) and week 18 plugs in week 28; week 21 plugs in weeks 31-33; and week 26 plugs in weeks 37-38
Records taken	Observations
VL testing	Tested week 31, 2016 by Chrysal: <i>Bromus macrostachys</i> <i>Eragrostis elegans</i> <i>Panicum elegans</i> 'Sprinkles' <i>Panicum miliaceum</i> 'Violaceum' <i>Setaria italica</i> 'Max' <i>Sorghum nigrum</i> <i>Stipa capillata</i> 'Lace Veil'

In 2016 all species germinated well and grew vigorously in the tunnel. Most were very easy to grow and, with their varied and interesting flower forms, there was much interest from packers and supermarkets (Figure 15). Plugs took slightly longer to flower than direct-drilled plants. It may be possible to achieve continuous supply by sequential planting. The outdoor plots were unsuccessful in this year because of the weather, plants being frosted soon after planting with some species severely affected; although there was a partial recovery they were then held back by wet weather in June. Powdery mildew was severe on *Bromus secalinus* in tunnels and outdoors and on both planting dates (powdery mildew also affected this species in 2017). *Stipa capillata* had an interesting head form and was well liked, but the stems were weak and slow to harvest, so it may be more suitable for an artisan grower rather than as a supermarket product.

In 2016 samples of most species were taken for VL testing which included the use of alternate post-harvest treatments, 'Chrysal RVB Clear' or 'Chrysal CVBN'. All samples remained in an acceptable condition on vase-day seven, with no obvious differences between post-harvest treatments. On vase-day seven some leaves of *Bromus macrostachys*, *Panicum miliaceum* 'Violaceum' and *Setaria italica* 'Max' were showing some yellowing or dehydration (not to an extent that would have resulted in the failure of a mixed bouquet) and the leaves of the others were

unaffected. Little or no shedding of anthers or pollen was seen.

With the exception of *Stipa capillata* the ornamental grasses were trialled again in 2017, when they continued to attract interest, and especially the two *Panicum* cultivars. It should be noted, however, that all of the species trialled produced marketable stems, so the decision as to which to grow would need to be determined by the intended market outlet. The trials indicate that continuity might be achieved by fortnightly sowing (or transplanting), monthly sowings resulting in gaps in the picking season. Ornamental grasses can be produced both outdoors and under protection, the outdoor crop being shorter and less vigorous, but still producing stems of a marketable quality.



Bromus macrostachys



B. secalinus
(note powdery mildew)



Eragrostis elegans
(in centre of
photograph)



Panicum elegans
'Sprinkles'



P. miliaceum
'Violaceum'



Setaria italica
'Max'



Setaria pumila
glauca



Sorghum nigrum



Stipa capillata
'Lace Veil'



Chasmanthium latifolium
(sea oats)

Figure 15. Examples of the tunnel-grown ornamental grasses in demonstration plots at CFC in 2016 (taken on various dates)

Gypsophila (cultivars of *Gypsophila paniculata*)

Danziger has introduced many new cultivars of *Gypsophila paniculata* that would be suitable for upgrading bouquets. It has been stated that they have advantages such as whiter flowers (e.g. 'Cosmic' and 'Xlence'), larger flowers (e.g. 'Xlence'), higher productivity (e.g. 'Dynamic Love') and a new colour, 'My Pink'. Several of the new cultivars were grown in demonstration plots starting in 2016 (Table 14).

Table 14. Details of 2016–2017 gypsophila cultivar demonstration

Location	Rookery Farm
Cultivars	'Andromeda' 'Beauty Bride' 'Dynamic Love' 'Orstar' 'My Pink' 'White Victoria' 'Xlence'
Plant longevity and hardiness	<i>Gypsophila paniculata</i> : perennial, fully hardy Some other gypsophila are annuals and some are frost-hardy
Format(s) and supplier(s)	Plugs from Danziger
Propagation and pre-planting treatment(s)	None
Planting or sowing date(s)	Planted week 21
Plots	1m long
Planting or housing site(s)	'Pro-Tech' tunnel bay 1
Layout	Demonstration plots
Plant spacing(s)	6/m ²
Post-planting treatment(s)	One layer of support netting Left <i>in situ</i> to assess in 2017
Pests, diseases and disorders	Minor infestation with two-spotted spider mite in 2017
Picking stage(s) and market specification(s)	When 50% of flowers are open
Picking and recording date(s)	Flowering from week 30 onwards in 2016 and from week 27 onwards in 2017
Records taken	Observations
VL testing	No



Figure 16. Examples of the new cultivars of gypsophila trialled in 2016–2017: from front to back, 'Xlence', 'Orstar', 'My Pink' and 'White Victoria' (week 28)

In 2016 all cultivars produced some marketable stems from week 27 onwards (Figure 16). As expected, in 2017 flowering was much more prolific, with 'Xlence' and 'My Pink' looking most substantial. They grew well with no issues and have good prospects as commercial cut flowers in the UK.

Scabious (cultivars of *Scabiosa atropurpurea* and *S. caucasica*)

Scabious are well-known as vigorous garden plants with prolific, attractive flowers in a wide range of colours, and are often used for cutting. In 2016 a substantial demonstration was set up at the CFC, using cutting-raised plants of a new series from Danziger, 'Scoop'. Plugs of 'Scoop Blackberry', 'Cherry Vanilla', 'Cotton Candy', 'Lavender', 'Marshmallow', 'Raspberry' and 'Vanilla' were transplanted under a tunnel in week 17 and to outside plots in weeks 18 and 20, at a planting density of 8/m² in two rows along the bed. As recommended, they were pinched two to three weeks later and then grew vigorously. Some cultivars developed leaf chlorosis during August, growing-out of it as the weather improved; no specific symptoms of virus were seen. Flowering started in week 26, with cropping in quantity from week 29

onwards (attracting much attention), and continued into October when the tunnels were de-skinned for winter. There was a heavy yield of stems in July to September, but many were too short for marketing (<45cm). In July, for example, the percentage of longer stems varied between 15% for ‘Scoop Raspberry’ and 30% for ‘Scoop Marshmallow’. The outdoor plantings also cropped well, considering the poor weather (frost a week after planting, water-logging in June, drought and high temperatures in August). As it was not practical to obtain plugs of ‘Scoop Vanilla’ and ‘Scoop Cherry Vanilla’ in time for planting in the tunnel, they could only be planted outside in week 20, and then ‘Cherry Vanilla’ was found to be very prone to leaf chlorosis and ‘Vanilla’ performed poorly. The 2016 plantings were left *in situ* to test their hardiness: they did not survive the winter.

From the 2016 demonstration, scabious appeared to have great potential for cut flower production in the UK, both under plastic and outdoors. A further substantial demonstration was planted in 2017, including, as well as the ‘Scoop’ series, new cultivars from HilverdaKooij (Table 15).

Table 15. Details of 2017 demonstration of scabious

Location	Rookery Farm
Cultivars	‘Scoop’ series ‘Blackberry’, ‘Cherry Vanilla’, ‘Cotton Candy’, ‘Lavender’, ‘Marshmallow’, ‘Raspberry’ and ‘Vanilla’ ‘Corneille’, ‘Gauguin’, ‘Goya’, ‘Matisee’, ‘Munch’, ‘Murillo’, ‘Picasso’, ‘Ribera’, ‘Royo’ and ‘Saura’
Plant longevity and hardiness	<i>S. atropurpurea</i> : biennial or short-lived perennial, fully hardy <i>S. caucasica</i> : perennial, fully hardy Some other scabious are annuals or biennials and some are frost-hardy
Format(s) and supplier(s)	Plugs from Danziger (‘Scoop’ series) and HilverdaKooij (others)
Propagation and pre-planting treatment(s)	None
Planting or sowing date(s)	Transplanted to tunnel week 17 Transplanted outdoors week 21 (‘Scoop’ series only)
Plots	2m long (‘Scoop series’) 1m long (other cultivars)
Planting/housing site(s)	Outdoors and ‘Pro-Tech’ tunnel bay 2
Layout	Demonstration plots
Plant spacing(s)	8/m ² in two rows along bed

Post-planting treatment(s)	Pinched three weeks after transplanting and then again three weeks after the first pinch to remove premature buds One layer of support netting
Pests, diseases and disorders	Small amounts of aphid, easily controlled
Picking stage(s) and market specification(s)	When first whorl of petals opens
Picking and recording date(s)	First flowers from 'Scoop' in week 27 and from Hilverdakooij cultivars week 29, through to week 40
Records taken	Observations
VL testing	Samples taken week 30 from four 'Scoop' cultivars grown in the tunnel, tested by Floralife

As recommended, all plants were pinched three weeks after transplanting, but owing to the high temperatures in June causing premature budding, they had to be pinched again after three weeks. In 2017 the 'Scoop' cultivars (Figures 17 and 19) were less vigorous than in 2016, and as a result made less growth than expected and many of the stems were too short for marketing. The HilverdaKooij cultivars (Figures 18 and 19) also lacked stem length and strength, to the extent that they were relatively more difficult to harvest, as agreed by growers at the CFC open day. (Unfortunately, we did not have a previous year's results for the HilverdaKooij cultivars to use for comparison.) Although this lack of stem length would limit how the stems could be used, in this case the problem was largely overcome by harvesting to the required stem length (45cm) and accepting that a side-shoot had to be removed. After discussions with Dutch growers it would appear that the technique will be regularly required when producing this crop, in order to achieve a consistent adequate stem length.

'Scoop Blackberry'



'Scoop Cherry Vanilla'



'Scoop Cotton Candy'



'Scoop Lavender'



'Scoop Marshmallow'



'Scoop Raspberry'



'Scoop Vanilla'



Figure 17. Danziger 'Scoop' scabious cultivars in demonstration plots 2017 (week 32)

'Cornielle'



'Gauguin'



'Goya'



'Matisse'



'Munch'



'Murillo'



'Picasso'



'Ribera'



'Royo'



'Saura'



Figure 18.
HilverdaKooij
scabious
cultivars in
demonstration
plots 2017
(week 32)



Figure 19.
Mixed stems of
scabious (left-
hand vase)
'Scoop' series
and (right-hand
vase)
HilverdaKooij
cultivars (week
32, 2017)

Plots of 'Scoop' cultivars planted in outside beds grew and flowered satisfactorily and seem to be perfectly suited to growing outdoors in UK conditions.(Figure 20). In both 2016 and 2017 the outdoor crop had to contend with a wide variety of extreme weather conditions, including late frosts, gales, torrential rain and a heat-wave and they appeared to be adequately weather proof to cope with these extremes.



Figure 20. 'Scoop' scabious cultivars in outside plots in 2017 (week 29)

Samples were taken of tunnel-grown 'Scoop' stems for standard VL testing in 2016 and 2017. In 2016 the test incorporated alternative post-harvest treatments, 'Chrysal RVB Clear' or 'Chrysal CVBN'. All stems (mixed cultivars) remained in acceptable condition on vase-day seven, with no obvious differences between treatments or cultivars, and it was reported that the stems were robust and easy to handle. In 2017 four cultivars ('Blackberry Scoop', 'Cotton Candy Scoop', 'Cherry Vanilla Scoop' and 'Raspberry Scoop') were sampled; after initially placing in plain water they were moved the same day to water containing 'Floralife Express 300', and when placed in vases the stem bases were re-cut and 'Floralife Express 300 Universal' flower food added. All remained in good condition on vase-day seven, and at the end of the test, on vase-day nine, condition was still reasonable except for some stem bending giving a less acceptable appearance.

Despite the observation on stem length and strength, the high productivity of both sets of cultivars, their colour range and vibrancy, and the enthusiasm of growers for them, indicate the potential of scabious as a commercial cut flower crop for the UK. But some further development seems necessary: selected cultivars from both series should be trialled to examine how they respond to temperature; and although promising VL results have been obtained by the CFC for 'Scoop', and reported elsewhere for Hilverdakooij cultivars, further VL tests should be carried out. Scabious could become a useful cut flower for artisan or specialist growers.

Solidago (golden rod) (cultivars of *Solidago*)

Solidago is often used as a filler with flowers such as freesia, requiring small stems (weighing about 15g) which can be supplied cheaply from imports. Solidago had previously been included in CFC demonstrations in 2008, when stems from tunnel plantings averaged 124cm in length and 274g in weight and those from outside plots 106cm and 222g. But solidago stems of this size would be suitable only for bunch sales, for which there is unlikely to be a demand. To examine the crop further, new cultivars of the 'Glory' series were grown in demonstration plots in 2016 and 2017 (Table 16). Three of the new cultivars – 'Angels Glory', 'Moonlight Glory' and 'Romantic Glory' – are unusual in having cream flowers.

Table 16. Details of 2016–2017 solidago demonstration

Site	Rookery Farm
Cultivars	2016-2017: 'Golden Glory' 'Moonlight Glory' 'Solar Glory' 2017: 'Angels Glory' 'Romantic Glory'
Plant longevity and hardiness	Perennial, fully hardy
Format(s) and supplier(s)	Rooted cuttings in plugs from Danziger
Propagation and pre-planting treatment(s)	None
Planting or sowing date(s)	2016: planted week 21 (and overwintered to 2017) 2017: planted week 18
Plots	1m long (2016) 2m long (2017)
Planting or housing site(s)	2016: 'Pro-Tech' tunnel bay 1 2017: 'Pro-Tech' tunnel bay 1 and outside
Layout	Demonstration plots
Plant spacing(s)	25/m ²
Post-planting treatment(s)	One layer of support net 2016 crop overwintered (without mulch) to 2017 Plants pinched only if they did not break naturally
Pests, diseases and disorders	Powdery mildew and two-spotted spider mite evident, controlled by spray programme
Picking stage(s) and market specification(s)	2016: About 50% of flowers open 2017: When first whorl of petals open
Picking and recording date(s)	2016: from week 24 onwards Overwintered to 2017: weeks 25-26 2017: weeks 32-33
Records taken	Observations
VL testing	No

In 2016 tunnel-grown 'Golden Glory', 'Moonlight Glory' and 'Solar Glory' all produced a heavy crop of high-quality stems in mid- to late-August (Figure 21), but gave no second flush. The plants were left *in situ* to assess their production next year.



Figure 21. Examples of solidago cultivars trialled in 2016: left, 'Golden Glory'; right, 'Moonlight Glory'

In 2017 both the overwintered tunnel-grown crop ('Golden Glory', 'Moonlight Glory' and 'Solar Glory') and the new tunnel and outside plantings (all five cultivars) produced good quality stems, the overwintered plants, as expected, being earlier and more productive (Figure 22). The outdoor-raised plants produced much lighter stems, suitable for a supermarket specification, while the stems of indoor plants were too heavy. All stems were of good quality but needed an effective powdery mildew programme.

The new cultivars generated interest amongst existing solidago growers, and some have already been planted in autumn 2017.



Figure 22. Solidago cultivars demonstration, 2017: top-left, top-right and bottom-left, general views in weeks 29, 30 and 32, respectively, and ‘Solar Glory’ and ‘Moonlight Glory’ in the vase, week 32

Trachelium (cultivars of *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-known seed houses and several series are available, including the ‘Lake Collection’ which is marketed as a cut flower trachelium. *Trachelium caeruleum* seemed well worth testing as a tunnel crop. In 2013 seeds of a selection of cultivars were sown into plugs - but all failed to germinate. Some reports state that germination is sometimes poor, though no unusual germination requirements were

indicated in the seed catalogues consulted. However, discussions at the time with other growers and propagators in the UK and the Netherlands revealed that germination seemed to have been an industry-wide issue in 2013 (though it does not seem to have caused any issues since). Subsequently, plug plants of cultivar 'Corine Purple' were obtained as replacements. They were transplanted in week 23 at 64/m² to a plot in a tunnel. The plants grew well and produced an attractive display that started in late-August. It was clear that trachelium may have potential for UK production, so the trial was repeated in 2014 using plug plants of 'Corine Purple' and examples from the 'Lake Michigan' series, mostly transplanted in week 22. Although the initial growth appeared weak and budding-up occurred early, the stems lengthened and strengthened as the plants matured and each plant produced at least one heavy lead stem and a number of marketable side-shoots. The colours were impressive. The total yield of marketable stems ranged from 86/m² for 'Corine Purple' to 158/m² for 'Lake Michigan Blue'. For the lead stems, average lengths varied between 57 and 66cm and average weights (trimmed to 55cm) from 23g ('Lake Michigan White') to 32g ('Corinne Purple'). A later (week 27) planting of 'Lake Michigan Purple' proved too late to achieve natural season flowering and the stems obtained were short.

A further trial was set up in 2015 to investigate transplanting dates (weeks 18, 22 and 25) and compare pinched and non-pinched (single-stemmed) crops; the planting density was kept at 64/m² for the non-pinched plants but reduced to 25/m² in the plots destined for pinching. Pinching was to four to five leaves two weeks after transplanting. As in 2014, initially growth was weak and budding-up premature, the plants strengthening later to produce large numbers of marketable stems. Stem length was satisfactory, though with large varietal differences, 'Lake Forrest White' and 'Lake Michigan Red' producing the tallest stems (70cm) and 'Lake Forrest Blue' and 'Lake Forrest Purple' the shortest (64cm); for three cultivars ('Lake Forrest

Purple', 'Lake Michigan Purple' and 'Lake Michigan White') the stems from non-pinched plants were significantly taller than their pinched equivalents. Trimmed stem weight, however, varied little between the treatments. Again, the non-pinched plants grew vigorously, producing at least one or two side-shoots. Overall, stem yields were quite variable, with mean numbers of marketable stems/m² of between 133, equivalent to 5.3 stems/plant (for pinched 'Lake Forrest Blue') and 273, equivalent to 4.3 stems/plant (for non-pinched 'Lake Michigan White'). Non-pinched plants cropped around 10 days earlier than pinched plants. VL testing showed a range of cultivar averages from 14 to 17 days.

The effects of pinching were further investigated with 'Lake Michigan White' and 'Lake Forrest Blue' in 2016. In week 21 plugs were transplanted into beds in a tunnel at the same planting rates as in the previous experiment. Pinching appropriate plots of plants took place two weeks after transplanting. The crop established and grew away well and ultimately produced a superb crop with long, strong healthy stems. Pinched plants, planted at 26/m², produced an average of just over 5 stems per plant, while single-stemmed plants, planted at a rate of 64/m², gave about 3.5 stems per plant. This means that the pinched crop produced more stems per plant, but less per m². 'Lake Michigan White' gave taller stems than 'Lake Forrest Blue' and non-pinched plants taller stems than pinched ones, meaning that many of the stems of 'Lake Forrest Blue' did not reach the 55cm specification. There were no statistically significant effects on trimmed stem weight.

There appears to be good potential for growing tunnel-raised tracheliums in the UK. Tracheliums had a poor reputation because of browning and the low weight of imported stems: the UK product seems greener, taller and heavier. Samples had a long VL of 14–17 days. At present the high cost of plants is deterring growers from trying trachelium, but the additional stems thrown by pinched plants should reduce costs. A new, green-flowered trachelium, 'Briba Green', became available in 2017

and was examined in a demonstration plot (Table 17).

Table 17. Details of 2017 *Trachelium* 'Briba Green' demonstration

Site	Rookery Farm
Cultivars	'Briba Green'
Plant longevity and hardiness	Perennial; <i>T. caeruleum</i> is half-hardy
Format(s) and supplier(s)	Plugs from DecoNova
Propagation and pre-planting treatment(s)	None
Planting or sowing date(s)	Transplanted week 28
Plots	20m long
Planting/housing site(s)	'Pro-Tech' tunnel bay 2
Layout	Demonstration plots
Plant spacing(s)	64/m ²
Post-planting treatment(s)	One layer of support netting Not pinched
Pests, diseases and disorders	None evident
Picking stage(s) and market specification(s)	With about 50% of florets open
Picking and recording date(s)	Started picking in week 41
Records taken	Observations
VL testing	Sampled week 42 and tested by Butters Group

After transplanting 'Briba Green' established well, starting to flower in week 41 (Figure 23). Standard VL testing was carried out, using 'Chrysal Professional 2 T-bag' in the flower bucket and a universal liquid flower food in the vase. The stems were still in acceptable condition, and the flowers still bright green, by vase-day 10, a good VL, although the lower foliage had begun to fade (but not sufficiently to adversely affect VL) on vase-day four. The full, bright green flower heads, with a good VL, should find a place in bouquet work (Figure 24).



Figure 23. Demonstration plots of *Trachelium* 'Briba Green' in 2017: top row, week 37; bottom row, week 40



Figure 24. *Trachelium* 'Briba Green' in VL test 2017: left, vase-day five; right, vase-day 10

Veronica (speedwell) (cultivars of *Veronica longifolia*)

Cultivars of *Veronica longifolia* are the most suitable veronicas for cut flower production, having sufficient height (up to 1.2m) and a good range of colours, including the commercially desirable blue. *V. longifolia* (and other well-known species) is a fully hardy perennial. Veronicas had previously been demonstrated at the CFC in 2008, when four colours from the 'Spark' series had been grown in tunnels and outside. Across the cultivars, stems from tunnel plantings averaged 63cm in length and 29g in weight, and those from outside plots 44cm and 18g. At the time it was concluded that, for a number of reasons, including their small production window, veronica cut flowers were unlikely to be economic in the UK. However, following a revival of interest, a further demonstration in tunnels was suggested in 2016, and plots of three cultivars of the newly available 'Skyler' series were trialled in 2016 and 2017 (Table 18).

Table 18. Details of 2016 and 2017 veronica cultivar demonstrations

Site	Rookery Farm
Cultivars	'Skyler Blue' 'Skyler Pink' 'Skyler White'
Plant longevity and hardiness	Like many other veronicas, <i>V. longifolia</i> is perennial and fully hardy
Format(s) and supplier(s)	Rooted cuttings in plugs (Danziger)
Propagation and pre-planting treatment(s)	None
Planting or sowing date(s)	2016: Transplanted week 19 (tunnel) 2017: Transplanted week 18 (tunnel) and 21 (outside)
Plots	1m long plots (2016) 2m long plots (2017)
Planting site(s)	'Pro-Tech' tunnel bay 1 (2016) 'Pro-Tech' tunnel bay 1 and outside (2017)
Layout	Demonstration plots
Plant spacing(s)	20/m ² (2016 planting) 25/m ² (2017 planting)
Post-planting treatment(s)	One level of support netting 2016 planting cut back to ground after first flush and overwintered (unmulched) to 2017 2017 planting in tunnel: plants broke naturally but some had a dominant lead shoot and these were pinched out in week 23
Pests, diseases and disorders	Powdery mildew evident in both years and was

	kept under control by the spray programme
Picking stage(s) and market specification(s)	With a maximum of 30 to 50% of florets open
Picking and recording date(s)	2016 crop: weeks 33-35 2016 crop overwintered to 2017: first flush weeks 22-24 and second flush weeks 37-38 2017 planting: first flush weeks 28-30 and second flush weeks 39-42 (tunnel crop; outside crop was poor quality)
Records taken	Observations and samples
VL testing	No

The three 'Skyler' cultivars produced a good crop of flowers in tunnels during August 2016: they were prolific, with straight stems and well coloured spikes. A spray programme against powdery mildew was necessary. Judging by these plots there was a consensus that veronicas showed real potential as a commercial cut flower for the UK. The 2016 plantings were left *in situ* and new plantings (in tunnels and outside) were also made in 2017.

In 2017 both the overwintered crop and the new plantings in tunnels grew well, the overwintered plots flowering earlier (Figure 25). The outdoor plots were damaged by the weather. 'Skyler Blue' was consistently the earliest of the three. Compared with flowers of the first flushes, those from the second had thinner stems and smaller heads – they were (just) marketable. Tests by a grower in 2016 indicated a good VL.

In these trials veronicas produced a large number of good, strong stems with long flower spikes. With these limited plantings the window of production was rather short, so the cropping period would need to be extended to gain the interest of growers. In 2018 it is hoped to investigate season extension by using different planting dates and pinching.



Figure 25. *Veronica* 'Skyler White', 'Skyler Blue' and 'Skyler Pink' in 2017 demonstration: top-left and top-right, overwintered plots from 2016 (weeks 23 and 32, respectively); bottom-left, 2017 planting (week 28); bottom-right, mixed cultivars in the vase (week 33)

Woody foliage (various genera)

There are many opportunities for producing woody foliage from hardy shrubs. As a demonstration rather than with any idea of collecting quantitative data, a selection of popular types was planted in outside beds in spring 2010 and 2011, usually at spacings of 100 x 100cm, and maintained as a long-term crop. The plantings were *Callicarpa bodiniera* 'Profusion', *Cornus alba* 'Flaviramea', 'Kesselringil' and 'Sibirica', *Corylus avellana contorta*, *Cotinus* 'Magical Green Fountain' and 'Royal Purple',

Hedera helix arborescens, *Hypericum inodorum* 'Magical Green Fall', 'Magical Tropical Fall' and 'Magical White Fall', *Philadelphus* 'Snowbelle', *Photinia* 'Purple Peter' and 'Red Robin', *Quercus palustris*, *Q. rubra*, *Salix alba* 'Darts Snake', *S. 'Caradoc'* and *S. udensis* 'Sekka', *Symphoricarpos* 'Bright Fantasy', 'Charm Fantasy', 'Magical Avalanche' and 'Magical Pride', *Viburnum opulus* 'Compactum' and 'Roseum', *V. tinus* and *V. tinus* 'Red Spirit'. All plantings established well and marketable stems were cropped from 2012 onwards (Figure 26). Maintenance was minimal, except for pruning back hard for rejuvenation in January each year.



Figure 26. Examples of hardy foliage plants at CFC photographed in 2011, one year after planting, L to R symphoricarpos, photinia and hedera



Figure 27. *Hypericum* cultivars (left to right) 'Magical Green Fall', 'Magical Tropical Fall' and 'Magical White Fall' at the Centre in 2014 (week 32)

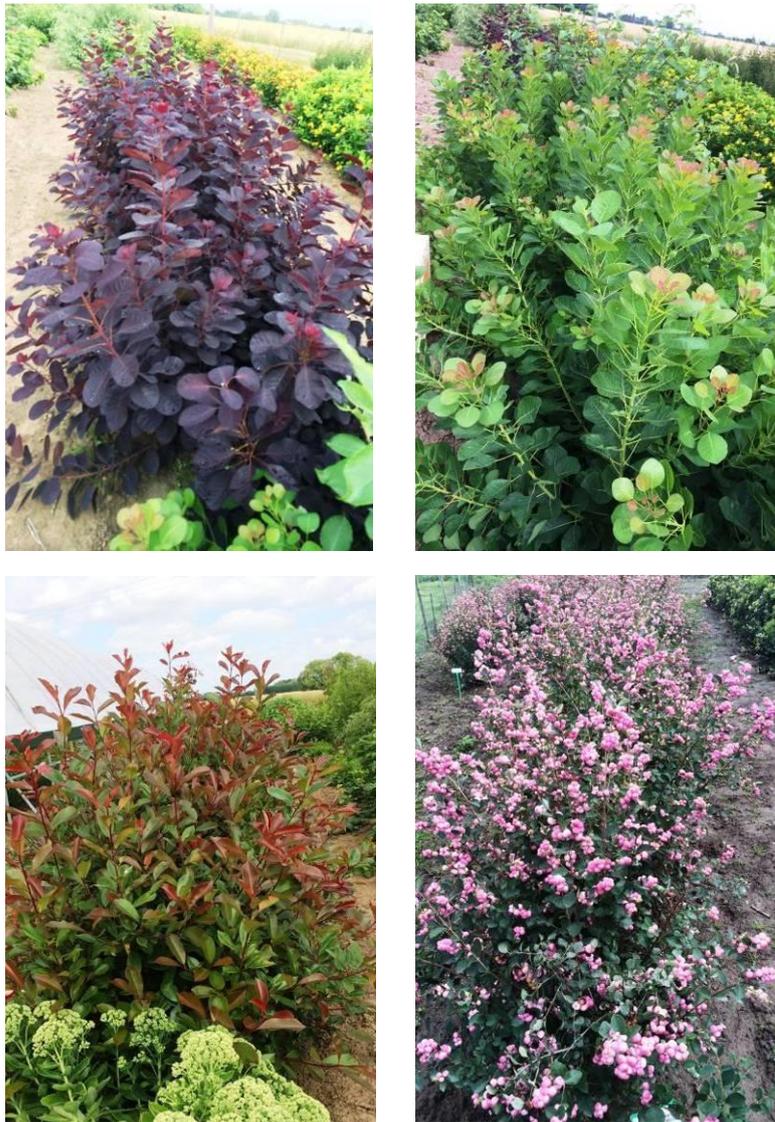


Figure 28. Some highly rated performers from the woody foliage plots in 2014, from top-left clockwise: *Cotinus* 'Royal Purple', *Cotinus* 'Magical Green Fountain', *Symphoricarpos* 'Magical Pride' and *Photinia* 'Red Robin' (*Symphoricarpos* week 41, others week 29)

The growth and quality of most of the subjects has been superb, and *cotinus*, *hypericum*, *photinia* and *symphoricarpos* were considered particularly impressive (Figure 28). As an indication of the possible marketable stems, in 2014 the plants of *Hypericum* 'Magical Green Fall', 'Magical Tropical Fall' and 'Magical White Fall' (Figure 27) yielded between 20 and 25 marketable stems each. In 2012 marketable stems of *cotinus*, *hypericum* and *symphoricarpos* were sampled for standard VL testing. The VL of *Cotinus* and *Hypericum* cultivars varied from one to a good seven days, depending on the hydrating solution used, while *Symphoricarpos* cultivars

achieved an acceptable six days. Considerable foliar wilting was seen during testing, so there appears to be a problem with water uptake, despite flower conditioners being used. As these results were so variable, they need to be repeated, the more so as they conflict with comments from local growers who considered hypericum (but not cotinus) to have a very good VL.

There has been distinct interest from the industry in the woody foliage demonstration, and it is known, for example, that substantial commercial plantings of hypericum, symphoricarpos and other hardy foliage have subsequently been made on UK nurseries. The CFC plantings have all now been grubbed out, and no new plantings are planned for any further project.

Zinnia (cultivars of *Zinnia elegans*)

Zinnias were trialled in previous CFC projects in 2007 and 2008, when the industry was enthusiastic about their wide range of cheerful, vibrant colours. After picking, however, the hollow stems can collapse and bend just below the flower head, making them unusable. Trials with zinnia were put on hold until cultivars with improved stem strength became available. Meanwhile, a different conclusion had been reached in trials in the USA: thus 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 CFG trials, *Zinnia* 'Benary's Giant Lime' and Z. 'Queen Red Lime' 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 CFC's zinnia trials.



Figure 29. ‘Benary Giant’ and ‘Oklahoma’ zinnia cultivars in 2014 demonstration plots (week 32)

In 2013, seed of seven cultivars of the ‘Oklahoma’ series and thirteen of the ‘Benary’s Giant’ series were transplanted in weeks 22 and 23 to plots outside and in a tunnel. When the plants were only a few inches high, premature buds became visible, apparently a common occurrence (John Dole, personal communication, 2013), and when pinched they grew away vigorously. Some stems were ready for picking by mid-July, and some interesting flower colours and forms were evident (Figures 29 and 30). ‘Benary’s Giant’ cultivars were stronger and attracted more interest than ‘Oklahoma’, but the latter were still considered superior to the cultivars previously grown at the Centre. The tunnel crop was more vigorous than those grown outside, with more and longer stems.

Samples were taken for VL testing throughout summer, and flower quality was marginally acceptable with a maximum vase-life of seven days, despite testing various flower conditioners and foods (using a hydrating solution was ineffective in retaining quality). 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.



Figure 30. Zinnia demonstration plots at the end of the season in 2014 (week 42)

In 2014, a selection of cultivars was tunnel-grown specifically to provide material for VL testing. 'Benary's Giant' cultivars 'Bright Pink', 'Coral', 'Deep Red', 'Golden Yellow', 'Lilac', 'Lime', 'Orange', 'Purple', 'Salmon Rose', 'Scarlet', 'White', 'Orange', and 'Wine' and 'Oklahoma' cultivars 'Carmine', 'Ivory', 'Pink', 'Salmon', 'Scarlet' and 'White' were 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 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 into October. 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 four day retail store phase. It was suggested that this may have been due to adverse effects of the cool-chain, resulting in early dehydration. Further VL studies were desirable, and consultants from Chrystal UK suggested there may be treatments available that could avoid such damage and

further work was planned for 2015 with a view to mitigating the effects of the cool-chain and investigating the use of growth regulators to strengthen the neck. Despite these shortfalls, zinnia appeared to be a good candidate for ambient direct sales such as mail-order.

In 2015 further 'Benary's Giant' cultivars were grown to provide 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. 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 could not be sampled until 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, using a mixture of cultivars. They were cold-stored overnight in clean 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 then 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 containing six stems each and using standard VL conditions. The stems were fully assessed daily for 10 days (any stems not written-off by vase-day 10 were assigned a nominal VL of up to 12 days). The write-off criteria were $>90^\circ$ bending of the stem or $>75\%$ of the petals wilted or showing signs of discolouration. Overall they performed reasonably well, most stems lasting beyond the guarantee day, day five. But between vase-days five 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. 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. But VL was not obviously shorter for the most advanced stems compared with those cropped at an earlier stage. It was suggested that neck bending may occur only 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 Streit, 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 (10 days) and most stems remaining at vase-day 10 (94%), whereas 'white' had the poorest responses (six 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 five throughout. Water quality was good across the trial, with very little clouding seen until after vase-day five.

In 2016, further supplies of tunnel-raised zinnia from the 'Benary's Giant' series ('Lime', 'Purple', 'White' and 'Wine') were grown for VL testing. Seed were sown into module trays in week 14 and transplanted in week 19 into beds in a tunnel with a planting density of 25/m². Occasionally aphids and caterpillars were seen on the crop, but there was no problem with bacterial blight this year. Flower picking started in week 28, continuing until the cover was removed. A mixed sample of half- and fully open flowers from all four cultivars was taken in week 36 for standard VL testing at Holbeach Campus, University of Lincoln. Alternative post-harvest treatments were applied, either 'CVBN' or 'Professional 2 T-bag'. In previous tests petal browning had been noted in zinnia during the cold cabinet (2°C) treatment, and had been attributed

to cold damage, but this was not observed here, although petal browning was noted towards the end of VL testing, and it was now concluded that this was a natural part of the aging process. The relatively weak stems typical of zinnia were noted to have strengthened after harvest, resulting in very few flowers with neck damage. The first stem deaths occurred on VL day six and the last on vase-day 10, with an average VL of a good 8.5 days over both post-harvest treatments. In most cases the leaves remained green until the termination of VL (Figure 31).



Figure 31. Zinnia stems from 2016 VL testing on vase-day 10, following post-harvest treatment with (left) 'CVBN' or (right) 'Professional 2 T-bag'

These results appear to show that, under some circumstances at least, zinnias are capable of a (just) acceptable and unpredictable VL. Further post-harvest work should be carried out to see if their VL could be extended, unaccompanied by bending of the stem. If successful, the range of colours available should ensure that their presence in a bouquet would be of interest to retailers.

In 2017 preliminary tests of a calcium spray were carried out as a possible means of increasing stem strength. The sprays used in 2017 resulted in scorching and the method will be investigated further in 2018.

Crop introduction (3) Crops with trials concluded by 2017

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

When this project started, *Aster ericoides* (syn. *Symphyotrichum pilosum* var. *pringlei*, *Aster pilosus* var. *pringlei*) was imported as a cheap filler (mainly the single 'Monte Cassino' types) and it was suggested that introducing new, double-flowered lines might open up a new market, maybe even for straight bunches. But, as with many new cultivars, the high cost of planting material meant production costs needed to be kept low.

CFC trials in 2010–2012 had generated market interest in new cultivars of *A. ericoides* as a pinched crop flowering in tunnels in September/October, and growers had wondered about season extension. As a short-day (SD) plant, floral initiation in *A. ericoides* could be advanced under long days (LD) by using black-out covers for part of the day. Plots of 'Blue Tail', 'Cape Town', 'Cassandra', 'Cassy', 'Chicago', 'Cirina Dark', 'Double Fun Blue', 'Double Fun Pink Dark', 'Double Fun White', 'Linda' and 'Pretty Wendy', planted in a tunnel and outside in 2012, were left to over-winter *in situ* and used to try out blackouts in 2013. The covers were placed over the tunnel plots from week 22 (stems 60cm tall) at night for 13 hours/day. By week 31 this SD regime had produced plants with large buds almost starting to show colour, and blacking-out was stopped, flowering following in weeks 32–33, later than expected and on stems taller than required, but nevertheless of superb quality. A second flush in early-November produced stems too short to be marketable. The untreated outdoor plots produced a single flush in September/October and the plants were less vigorous (and more manageable) than those in the tunnel. If the blackout treatment had been started before the stems were 60cm-tall, perhaps more timely flowers would have been obtained.

A further blackout experiment was carried out in 2014. Un-rooted cuttings of 'Cairo', 'Cape Town', 'Cassy' and 'Chicago' were rooted into plugs (week 11), potted-on

(week 14), pinched (week 16) and transplanted under a tunnel (week 18) at 15 plants/m². The blackout was started when stems were 50cm tall (week 25) and the plants already breaking. For 'Cairo' and 'Cassy' plant establishment was good and buds started to develop in week 30 when the blackout was removed, giving good yields of high-quality stems with no premature budding. But in 'Cape Town' and 'Chicago' (which had been included successfully in the 2013 trial) bud development had occurred a month earlier, leading to premature budding, poor quality and low yield. In the first flush 'Cassy' produced 88 marketable stems/m², with progressively fewer 'Cairo' (53), 'Chicago' (41) and 'Cape Town' (38). The main picking period was around week 32, a week later in 'Cassy'. After picking the plants were cut back 2cm above ground and a second flush grew-away well in all cultivars: it would have made a marketable crop had it been in a glasshouse instead of a tunnel - which had to be de-skinned because of an impending storm. The outdoor plots from 2012, still retained as a natural-season comparison, flowered 10 weeks later. Stems of the four cultivars from the blackout treatment were sampled in week 32 (buds starting to show colour) for VL testing, and gave an average (and good) VL of eight to nine days. By vase-day eight or nine the undersides of the flower-heads were slightly dehydrated, while the condition of the foliage remained good. Other samples, shown to potential customers, were well received.

The trials showed that blackout covers could be used to advance floral initiation in some cultivars of September-flowering aster, thereby giving two flushes a year. To harvest the second flush – in October – the crop would need to be grown in a permanent tunnel or in cold glass, rather than a 'Spanish tunnel'. Had there been continued market interest, in order to reduce growing time it may be worth looking at starting the plants in pots and planting pinched plants with side-shoots already present.

Basil (cultivars of *Ocimum basilicum*)

Basils can be a fragrant filler added to mixed bunches and bouquets. Several cultivars are suitable for ornamental as well as culinary use and are 30 to 60cm tall with attractive flower spikes and (in some) attractive red foliage. In 2013, seed of cultivars 'Dark Red Opal', 'Floral Spires Lavender', 'Floral Spires White' and 'Sweet Dani Lemon' were sown in plugs and transplanted to plots in a tunnel at 64 plants/m². They grew well, flowering from week 32, with attractive flowering stems and red foliage. But samples tested by a local packer were reported to have an unacceptable (less than five days) VL.

Trials in the USA suggested some better cultivars for cut flower use, and in 2016 two, 'Aromato' and 'Cardinal', were grown in demonstration plots in a tunnel. Seed were sown into plugs in week 17 and transplanted (at 64 plants/m²) under a tunnel in week 21. They grew well, producing attractive flowering stems in August, but once again samples tested by a local grower had an unacceptable (less than five days) VL: the stems failed to take up water.

Despite these results, as of 2017 renewed interest in 'scented' fillers has been reported. There may be a case for further trials, investigating conditioner treatments to increase water uptake, and growing outside to produce harder plants.

Brassica, ornamental (cultivars of *Brassica oleracea*)

A substantial demand has developed for using the heads of ornamental brassicas in vases and bouquets, and has remained strong despite growers' uncertainties about some aspects of husbandry and the best cultivars to grow. At the CFC several trials were carried out over the 2008–2012 period and further trials took place under the present project.

In 2015 and 2016 a range of cultivars was grown in a tunnel (at 64 plants/m²) to compare performance. In 2015 some cultivars produced notably 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; the other cultivars grown were 'Condor Early White', 'Condor Pure White', 'Crane Bicolour', 'Crane Pink', 'Crane Red', 'Crane Rose', 'First Lady', 'Galina', 'Ksenia', 'Kysia', 'Svetlana', 'Varvara' and 'Vera'. Only the heads of 'Kysia' failed to colour, all others colouring-up normally. 'Katya' and 'Condor Early White' were sampled for VL testing and lasted for 10 and 17 days, respectively. Numerous samples from the trial were sent to potential customers and growers, some of the less familiar cultivars clearly impressed them. 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 familiar 'Crane' series. However, an impression was also received from growers that many would prefer to stick with the well-tried 'Crane' series until more experience had been gained with the alternatives. Alternative cultivars will need considerable exposure and economic advantage before gaining acceptance.

In 2016 the cultivars trialled were 'Agathana', 'Anthonia', 'Bogdana', 'Condor Pure White', 'Crane King', 'Crane Pink', 'Crane Queen', 'Crane White', 'First Lady', 'Ksenia', 'Kysia', 'Olga' and 'Vera'. Apart from the failure, again, of 'Kysia' to colour, all cultivars grew well and produced heads of high quality, with good hearts and leaf colour and lengths of 60cm+. With the high planting density used the yield of marketable heads was reduced in some cultivars, particularly those with dissected leaves (such as 'Crane King', 'Crane Queen' and 'First Lady'). Following the long VL found in the 2015 trial, all cultivars were sampled for VL testing. However, all lasted for only five days (acceptable) or six days (good) in the vase before dehydration and (or) yellowing started, thereby just reaching or exceeding the guaranteed five days.

To investigate the discrepancy in VL between the two years' results, stems of three 'Crane' cultivars were sampled from a commercial nursery's glasshouse crop in week

49 (2016). Four post-harvest treatments were applied: 'Chrysal CVBN' (standard and high rate), 'Chrysal RVB Clear Intensive' and 'Chrysal Lily and Alstroemeria BVB', followed by further storage in water with 'Chrysal Professional 2 T-bag' (one bag/2L water) and the VL test itself in water with 'Chrysal Universal Liquid Food' (one stick/L water). As some bouquet makers are reportedly not re-cutting the stems of ornamental brassicas before use, this factor was also tested: for each post-harvest treatment one sub-treatment had the basal 2cm of stem removed as usual when placed into the vases, and the other was left intact. There were two vases of three stems for each of the eight treatment combinations. Stems were examined up to vase-day 10 and stems written-off when >50% of the leaves had wilted, drooped or were showing browning. With no consistent effects of re-cutting or not re-cutting the stem base on VL, the post-harvest treatment means ranged from five days (for 'Chrysal RVB Clear Intensive') to seven days (for 'Chrysal CVBN' high rate), only just acceptable and with little difference between the four post-harvest treatments. Bacterial contamination in the treatment water was assessed at the end of the post-harvest phase using a 'Petrifilm' technique, the results suggesting that 'Chrysal CVBN' (particularly used at the higher rate) had been beneficial as a bactericide. There was less leaf yellowing when 'Lily and alstroemeria BVB' had been used as the post-harvest treatment. While stem quality began to deteriorate from about vase-day four, this was insufficient to result in an unpleasant smell at the end of VL.

Carthamus (cultivars of *Carthamus tinctorius*)

Carthamus has attracted much attention as an unusual, thistle-like filler, and demonstration plots were planted in 2014. Cultivars 'Kinko', 'Nemo' and 'Shiro' were direct-drilled in week 25 outside and weeks 27 and 30 in tunnels. Germination was satisfactory and the plants budded-up quickly (starting in week 30 outside). Subsequent development was slow, plants from the week 25 and 27 sowings flowered over weeks 35–37, while those from the week 30 sowing failed to produce

marketable stems before the tunnel was de-skinned (week 43). Samples taken for VL testing had a good VL of seven days, though quality was spoiled by bract-tipping. *Carthamus* showed both potential and problems for further commercialisation.

In 2015 the same cultivars were direct-drilled outside (week 24) and in a tunnel (weeks 17, 20, 24, 28 and 31) and later thinned to 5–6cm apart. Germination was good and plant growth vigorous. From sowings in the tunnel over weeks 17 to 28, the picking period covered weeks 29–40, while the week 31 sowing failed to produce marketable stems before the tunnel was de-skinned (week 44). The outdoor sowing (week 24) cropped in week 38. Hence the earlier sowing this year successfully gave earlier picking. As before, stem quality was marred by the brown-tipping of bracts (and also by leaf mottling).

Carthamus produces a reliable, sturdy stem and is already being used successfully as a bouquet filler, and no further trials are planned. Bract quality does remain an issue, however.

China aster (cultivars of *Callistephus chinensis*)

In the last decade china asters (annual asters) have become an important outdoor cut flower crop in the UK: by 2016 about 9 million stems were produced annually. They are dominated by the 'Matsumoto' spray type. Prior to 2013, work at the CFC had opened up a market for an alternative to 'Matsumoto', the large-headed 'bloom'-type china aster for summer production. 'Krallen' and 'Gala', both new series with vibrantly coloured blooms, were trialled at the CFC in 2007. They generated strong interest from growers and there appeared to be potential to commercialise them in the UK.

In 2010 a multifactorial trial, investigating the effects of plug- versus block-raised plants, planting date and growth retardant treatments, was carried out with cultivars of 'Krallen' and 'Gala'. Five of the six 'Krallen' cultivars produced stems that were

long and particularly heavy, in the cases of 'Kameo' and 'Kartthausen' reaching nearly 80g each, while stems of the 'Gala' series were longer but lighter. Largely as a result of these trials, 'Krallen' cultivars were taken up by local producers in quantity, with 'Karthausen' and 'Perser' in demand by supermarkets. VL tests by a packer on batches being sold through supermarkets showed their VL consistently met or exceeded the guaranteed five days. But post-harvest quality became an issue when petal-spotting and petal-tip necrosis became apparent, and the cause of these disorders remains unknown, despite diagnostic testing in the Netherlands and UK and detailed discussions with the breeder and propagator. 'Krallen' asters might have become a key cut flower in the UK, but instead, losses became severe and 'Krallen' is unlikely to be grown again unless petal spotting and tip-necrosis can be rectified. Growers now needed an alternative to the alternative. In 2010–2012 cultivars from the 'Benary Princess', 'Bonita', 'Matador', 'Meteor', 'Ribbon' and 'Standby' series were trialled, but it was evident that none was a prospective alternative for 'Krallen'.

In 2013, cultivars from the 'Beautiful Day', 'Harlequin', 'Jewel', 'Lady Coral' and 'Meteor' series were trialled. ('Bonita' was not included as 'Matsumoto' growers were planning their own trials.) Trial plots were planted in weeks 19 and 26. The main cropping period for the earlier planting was weeks 32–34, cultivars of the 'Meteor' and 'Harlequin' series producing longer stems and the remaining cultivars being shorter. For the later planting the cropping period was weeks 39–41 and the stems of all cultivars were relatively short (the tallest were those of the 'Harlequin' and 'Jewel' series). Many of these cultivars had stem and flower attributes with promise as a UK crop, with long, heavy stems and flowers that were vibrant, uniform, positioned at the top of the plant and free of petal disorders. None was considered outstanding like 'Krallen'.

In 2016 'Julie', a series of spray-asters and two coded bloom-type lines became available from Miyoshi: they had a different colour range and (it was claimed) were

two weeks earlier than 'Matsumoto'. Seed was sown in plugs in weeks 18 and 20 and transplanted in weeks 22 and 25 under a tunnel and outside (at 64 plants/m²). Like 'Matsumoto' they suffered from aphid damage, though they were controlled by insecticides. No formal assessments were made but the plots were used as a source of samples for packers and supermarkets. It was reported that samples were well received by one supermarket but were similar in timing and quality to some other cultivars being grown in the industry (though the colour assortment was a change). Grown in tunnels the plants were larger and paler than outside-grown plants. No adverse petal or leaf-tip damage was noted. As a result of the trials two local growers trialled commercial plantings of 'Julie' in 2017. The crop flowered earlier than 'Matsumoto' but some of the colour variants were too short, and they will not continue with them in 2018. It is likely that further trials will be required as new cultivars reach the market.

Cleome (cultivars of *Cleome hassleriana*)

Cleome hassleriana is a sturdy, attractive garden annual with unusual flowers - a possible candidate as 'something different' for the UK. Demonstration plots of four cultivars ('Cherry Queen', 'Colour Fountain Mix', 'Rose Queen' and 'Violet Queen') were planted in 2016, sown into plugs in weeks 13 and 20 and transplanted under a tunnel in weeks 18 and 25 (at 25 and 65 plants/m²). The plugs established well. There were no obvious differences in growth or development of the plants grown at the two spacings, and, apart from flower colour there were no obvious differences between the cultivars. Flowering started in week 26 and 30 for the two planting dates and (for both plantings) continued into October, so there may be no need for two plantings to extend the season. Flowers being picked when the first buds were fully open. Leaf miner and powdery mildew were evident and were adequately controlled. In week 31 samples were taken for VL testing, which included alternative

conditioning treatments, 'RVB Clear' or 'CVBN'. Cleome wilted very quickly after harvesting but recovered when re-hydrated in a chilled cabinet. The flowers, leaves and stems remained in acceptable condition with no desiccation on vase-day seven, although there was some abscission of flowers and shedding of the fine, black pollen, which appeared worse when 'CVBN' had been used.

Cleome proved a very prolific crop that kept producing constant flushes of flowers over a long period, the flowers being large, showy, distinctive with a VL of at least a good seven days. Despite that, further trials are probably not appropriate because some consider that the cleome's spines and aroma render them unsuitable for supermarket sales. They could be considered unsuitable to handle on a processing line too. They may be suitable for supplying to florists for use in specialised situations where the flowers will not be handled by customers. It is known that small quantities of cleome are being grown by artisan growers.

Cosmos (cultivars of *Cosmos bipinnatus*)

Cosmos are well known garden plants producing masses of bright flowers and feathery foliage. They appear rather feathery to be used as a cut flower, but some cultivars have given good results in trials in the USA. Cosmos has potential as a 'short-season filler', used to introduce variety to bouquets through the year. In 2013, 15 cultivars from the 'Razzmatazz', 'Sensation' and 'Sonata' series were germinated in plugs and transplanted in week 22 to a tunnel and outside at 64plants/m². They were vigorous in growth – too vigorous and unmanageable grown in a tunnel – and flowered slowly and unevenly but, eventually, prolifically, from week 30 onwards.

'Double Click Cranberries', 'Fizzy Rose Picotee', 'Psyche White', 'Rubenza', 'Sensation Antiquity', 'Sensation Dazzler', 'Sensation Purity', 'Sonata Pink', 'Sonata Premium Mix' and 'Sonata White' were tested in 2014. Direct-drilled in weeks 21 and 25 outside and in weeks 27 and 30 in a tunnel, germination was good, the plants

thinned to 60/m². Growth was vigorous, though the flowers were slow to develop and flowering was uneven. The best performer was 'Double Click' which produced stems of substantial length and weight even when grown outside, and more so in the tunnel. The picking period covered weeks 30–41, though stems from the last sowing were only about 40cm-long, too short to be marketable. The bunched stems were substantial, despite the initial impression of the plant's wispieness.

In 2015 cosmos 'Antiquity', 'Candy Stripe', 'Double Click Cranberries', 'Fizzy Rose Picotee', 'Psyche White', 'Purity', 'Rubenza', 'Sensation Dazzler', 'Sonata White' and 'Sonata Pink' were again direct-drilled outside (week 24) and a tunnel (weeks 17–28). Although the flowers were slow and uneven in development, some growth was so vigorous as to result in lodging, while stems from the last sowing were again too short to be marketable. Picking covered the period weeks 29–41.

In 2014 stems of four cultivars were sampled for VL testing, but had a very short VL (one to three days) with stems visibly breaking-down during this time. Further post-harvest work was needed, and in 2015 stems of three cultivars were harvested and cold-stored overnight in water with added 'Chrysal RVB Clear Intensive' (1ml/L), 'Chrysal CVBN' (1 tablet/2L) or 'Chrysal CVBN' (1 tablet/L). The stems were transferred to buckets of water with 'Chrysal Clear Professional 2 T-Bag' and kept in a VL room for three days, when the VL test was set-up. The flowers started wilting and showing petal discolouration even during the store phase, and symptoms were worse in the second 'CVBN' conditioning treatment than in the other treatments. Only the 'RVB Clear Intensive' treatment achieved the minimum required VL of five days.

Craspedia (cultivars of *Craspedia globosa*)

With its slender unbranched stems and ball-shaped clusters of yellow flowers, craspedia is another cut flower produced abroad but unfamiliar as a UK crop. It is useful as a filler and also as a dried flower. In 2016 three cultivars - 'Paintball Globe'

and 'Ellisse' (from rooted cuttings) and 'Sun Ball' (from seed) were grown in a tunnel. The cuttings were potted-on in week 16 and transplanted in week 21, while seed were sown to plugs week 13 and transplanted week 16, all planting being at 10 plants/m². 'Paintball Globe' and 'Ellisse' produced large numbers of very strong, tall flowers, starting week 28 and continuing into October; their flowers were very similar, and consultation with the propagator indicated that the two cultivars may not differentiate head shapes when grown in temperate climates. The seed-raised 'Sun Ball' made weaker plants, with smaller flower heads, shorter, kinked stems and fewer stems per unit area. Samples of 'Paintball Globe' and 'Ellisse' were subjected to VL testing incorporating alternative conditioner treatments ('RVB Clear' or 'CVBN'). All stems remained in acceptable condition on VL day seven, with no obvious differences between either the post-harvest treatments or the cultivars. Further samples showed that craspedia also dried well, with the flowers retaining their colour. Craspedia samples were well received by the industry. Craspedia is an unusual product considered to have high potential for sales as fresh or dried flowers and as a filler in bouquets. Two disadvantages are the high labour inputs needed to pick the crop, i.e. disentangling stems without causing damage (although this is less of an issue with the more uniform cutting-raised crop) and the limited colour range (yellow). Craspedia appears to be relatively easy to grow and deserves further evaluation.

Dahlia (cultivars of *Dahlia hybrida*)

Dahlias were once considered to have a poor vase-life. The 'Karma' series, bred for a longer VL, were grown over the period 2009–2013, primarily for VL testing. Demonstration plots of 18 'Karma' cultivars were grown in a tunnel and outside and grew vigorously, especially under protection. The blooms were striking, but the results of VL tests in 2009 and 2013, in which various conditioning treatments were used, were disappointing. The flowers failed to reach the minimum guaranteed five

days VL necessary for a commercial product and the vase-water became very cloudy. While the management group was able to confirm supermarket interest in sourcing dahlias as a cut flower, this was considered inadvisable until the VL issue had been resolved. New options for improving VL will be looked for.

Dianthus (spray carnations), annual (cultivars of *Dianthus caryophyllus*)

Spray carnations are a supermarket 'staple', mostly cheap imports from Africa and South America. Could novel types of spray carnations provide UK growers with an opportunity for a premium product that would not compete head-on with imports? 'Star' and 'Solomio' are new series of annual carnations with an unusual flower form, introduced by HilverdaKooij and trialled in 2012. While the trial was compromised by unusually wet weather at delivery time, leading to delays and the curtailment of growth and flowering with the onset of winter and the need to de-skin the tunnel, the demonstration received positive feedback from the industry for the novel flower form of this new range. Enough stems were available for VL testing, all cultivars achieving at least an adequate six days. The work was continued in 2013. Plugs of the 'Solomio' series ('Edo', 'Fen', 'Gill', 'Ken', 'Sem' and 'Vin'), 'Star Cherry Tessino' and the 'Floristar' series ('Mix', 'Salmon Pink', 'Scarlet' and 'White') were transplanted under a tunnel in weeks 14 and 16 (at 32 plants/m²) and pinched two weeks later. Picking the 'Solomio' cultivars started in week 29 and continued until the trial was curtailed in week 44 (by de-skinning the tunnel for winter) when there were still immature stems left from the first flush. Overall these cultivars produced good quality, strong stems that received favourable comments from the industry. Marketable stems (60cm+) were harvested, with the average yield among the 'Solomio' cultivars varying between 141 to 197 stems/m² for the earlier planting, but only 108–144 for the later planting. 'Star Cherry Tessino' (which was heavily predated by rabbits) produced 126 and 83 stems/m², respectively. The only problem with these cultivars was occasional bud abortion, especially in 'Solomio Edo', where the central bud

became desiccated before reaching maturity, although stems were still marketable if the aborted bud was first removed manually. In contrast, the 'Floristar' cultivars produced few stems, no more than ten per plot.

Further new cultivars, also strikingly different to the familiar types, became available in 2014, also from HilverdaKooij: the 'Tiara' series. Rooted cuttings of 'Tiara Coral Pink' and 'Tiara Lilac' were potted-on (week 14), pinched (week 17) and transplanted into a tunnel (week 22). They were slow growing but produced some strong stems: the central bud developed before the others and needed to be pinched out to preserve the remaining spray, though this was a labour-intensive task. 'Tiara' were clearly susceptible to thrips damage, with white flecking on the flowers, and once damage was seen the interval between insecticide sprays was reduced, which was effective. They were picked once two or more buds were showing good colour, in week 35–37. Stems of cultivar 'Coral Pink' sampled for VL testing gave an average seven days, adequate to achieve the usual number of guaranteed days. The flowers were attractive and appreciated by growers, and were left *in situ* for a further year's growth. In 2015 both cultivars produced a good second-year flush in weeks 30–31.

Eryngium (sea holly) (cultivars of *Eryngium*)

Responding to grower requests, small demonstration plots of a selection of eryngium cultivars were planted in 2011. The cultivars were 'Arabian Dawn', 'Blue Bell', 'Deep Blue', 'Magical Blue Falls', 'Magical Cloud', 'Magical Purple Falls' and 'Marbella'. Few flowers were produced in the first year, the production of marketable stems starting in 2012, and samples shown to potential buyers evoked keen interest. By 2013 the plants in the tunnel had become over-vigorous and were grubbed out. Many of the outside plantings had not survived the severe winter of 2012–2013; the outstanding cultivars were 'Blue Bell' and 'Deep Blue', which appeared to have been almost fully hardy, while for the remaining cultivars survival varied between 43 and 69%. Scaling-

up these yields to the equivalent of 100% plant survival, 'Deep Blue' would have produced 113 stems per m² and 'Blue Bell' 56, while the other cultivars produced between 28 ('Marbella') and 88 ('Magical Purple Falls') stems per m². By 2015, two years later, 'Deep Blue' had maintained its performance and 'Arabian Dawn' had doubled its yield, but the yields of the other cultivars fell, often sharply. In 2015 all cultivars flowered between weeks 25 and 31.

In 2013 stems of cultivars 'Blue Bell', 'Magical Blue', 'Magical Cloud' and 'Marbella' were sampled for VL testing in week 27, giving a good VL of eight to nine days, confirming earlier results. During testing stems of 'Blue Bell' showed signs of foliar dehydration by vase-day eight, and stems of the other cultivars had dehydrated flower heads and yellowing or browning foliage by vase-day 10. Also in 2013 necrotic, black spotting appeared on the foliage of 'Arabian Dawn' and 'Marbella' and was identified as *Alternaria*, subsequently confirmed by the Stockbridge Technology Centre Plant Clinic. *Alternaria* had been reported on eryngium previously.

Leucanthemum (cultivars of *Leucanthemum* × *superbum*)

Leucanthemum (Shasta daisy; syn. *Chrysanthemum* × *superbum*) was included in trials in 2014 to demonstrate a new range of cut flower cultivars, the 'Real' series. 'Real Fancy', 'Real Fizzy' and 'Real Frilly' were obtained as pinched 9cm liners and transplanted in week 17 to plots in a tunnel (at 16 plants/m²). The pinched plants supplied had many breaks and grew away well. 'Real Frilly' started to bud prematurely (week 22) and started to flower on short stems in week 25. 'Real Fancy' and 'Real Fizzy' started to flower normally in week 28. The plots were mulched with peat and over-wintered to allow assessment in the second year; despite being described as a fully hardy perennial there were >50% plant losses and the resultant flower stems were short, hence no further assessments were made. These cultivars appeared unsuitable for production in tunnels. If other potential cut flower

leucanthemum cultivars become available they could be trialled.

Lion's ear (species and cultivars of *Leonotis*)

Leonotis is a South African plant being introduced to cultivation. It has attractive orange flowers, is aromatic, and is reputedly easy to grow in various regions. For example, in Poland it flowered from July to late-autumn with dense inflorescences on long, upright stems. Four likely cultivars were identified from the literature and catalogues: *Leonotis leonurus* 'Alba' and 'Staircase', *L. mollis* and 'Wild Dagga'. In 2014 seed were sown in module trays (week 20) and transplanted (week 27) to beds in a tunnel (24 plants/m²), where they established and grew away quickly. 'Staircase' was very vigorous, while *L. mollis* was relatively compact. By week 43 'Staircase' was in bud, but gales in late-October flattened the plants before any flowers opened; none of the other *Leonotis* reached a visible bud stage. No further trials were undertaken.

Lupin (species and cultivars of *Lupinus*)

For a UK consumer, the familiarity of lupins as garden plants may make them an unlikely choice as a commercial cut flower crop. However, researchers at Texas A&M and New Mexico State Universities noted that *Lupinus harvardii* (the big bend bluebonnet), a Texas native, produces attractive, tall blue flowers with potential as a specialty cut flower, and this led to some commercial production with the release of 'Texas Sapphire' and 'Texas Sapphire'. As well, lupin 'Morello' was among the plants included in the ASCFG trials. On this basis lupins seemed worthy of trialling in the UK, where many cultivars are widely available, mainly from the 'Gallery' and 'Russell' series derived from *L. polyphyllus* (the big leaf lupin).

In 2013 seed of 'Gallery' and 'Russell' cultivars were sown into module trays (week 20) and transplanted to a tunnel and outside (week 26 at a density of 10 plants/m²). The 'Gallery' cultivars were 'Blue', 'Pink', 'Red' and 'White' and the 'Russell' cultivars

'Band of Nobles', 'Chandelier', 'Noble Maiden', 'My Castle', 'The Chantelaine', 'The Governor' and 'The Pages'. Initial growth was weak overall, but the plants recovered and established well, although slow to begin flowering. Flowering started on a few stems in week 32, and they continued to produce reasonable numbers of stems over a long period. Plants of the 'Gallery' series were shorter than the 'Russell' cultivars, but still long enough. The outdoor plants produced much shorter stems than those grown under protection. Infestations of lupin aphid, *Macrosiphum albifrons*, occurred rapidly and was controlled with the routine spray programme; careful monitoring for pests would be needed.

The plants were left *in situ* to overwinter in the unprotected tunnels and their potential as cut flowers was further assessed in 2014. Many plants failed to survive the winter, resulting in uneven plots. Nevertheless, the high quality and wide range of colours of both series was striking. The stems of 'Russell' lupins were consistently the taller, though the stem lengths of both series were satisfactory, and the stems of the outdoor plants were again shorter than those under protection. Samples tested by a local packer were reported to have an unacceptable (less than five days) VL. Because of this, and the untidy appearance the plots, the lupin plots were grubbed out after flowering and no further trials were planned.

Pepper, ornamental (cultivars of *Capsicum annuum*)

Ornamental peppers proved to be successful novelties in the ASCFG trials, and two cultivars were included in trial in 2014. Seed of 'Black Pearl' and 'Masquerade' were sown into module trays (week 20) and transplanted to a tunnel (weeks 25 and 27, at 25 plants/m²). Both were slow-growing but eventually produced large, strong plants. Although some fruits were visible on both cultivars by week 36, they remained more or less static without growing or ripening until the tunnel was de-skinned in week 43, and no further trials were planned.

Physostegia (cultivars of *Physostegia virginianum*)

Physostegia is another crop seen as a potentially useful cut flower in trials in the USA. Only a small number of cultivars is available, and one, 'Crystal', was trialled in 2014. Seed were sown into module and young plants transplanted to beds in a tunnel. 'Crystal' was rather short stemmed and late flowering, and it was planned to grow it on to a second year to assess again. However, in VL testing the stems failed on day two in the vase, suggesting they may be unsuitable as cut flowers, and no further trials were planned.

Rudbeckia (coneflower) (cultivars of *Rudbeckia hirta* and *R. laciniata*)

Rudbeckia is another well-known garden plant with potential for development as a cut flower, its inclusion in trials was suggested by a supermarket representative. Initial demonstrations with seed-raised annuals of *Rudbeckia hirta* 'Green Eye' and 'My Joy' were carried out in 2011 and, although the flowers were attractive in themselves, the stems were too vigorous and unruly to be considered practical for commercial cut flower use.

More robust perennial cultivars, *R. laciniata* 'Goldquelle' and 'Herbstsonne', were included in demonstration plots in 2012. Plants were obtained in 7cm pots and transplanted under a tunnel (week 25) at 6 plants/m². They showed some market potential, but many of the stems were weak and, as is the case with many perennial crops, their true potential was likely to be shown in established plantings, so the plots were left *in situ* for assessment in 2013. However, it was subsequently agreed that they were probably unsustainable as cut flowers because they were far too vigorous and produced unmanageable stems.

See also the section on the similar genus *Echinacea* (also called coneflower). The evidence we have suggests echinacea would be the better choice.

Sedum (cultivars of *Sedum*)

In an earlier project three sedum cultivars, *Sedum spectabile* 'Brilliant', 'Herbstfreude' and 'Matrona' were planted as a perennial demonstration in outside beds in 2010. Growth was weak in the first year, but once established subsequent growth was vigorous, with impressive stem counts, length and weight and tests showed their VL was at least a good seven days, and the trial was extended into 2011 by adding cultivars 'Mr Goodbud', 'Magical Bon Bon', 'Magical Lizzy' and 'Magical Twist'. In 2012, the sedum plots probably generated more attention than others at CFC. The numerous, substantial stems could be cropped at a range of stages, from relatively tight to well developed, and they have potential uses in a range of bouquets as well as straight lines. Numerous samples were made available to the industry for information and promotion, and it is known that, as a result, significant commercial plantings have been made in recent years. No further trials on sedum are planned, though the plots have been retained for demonstration purposes.

Solanum, ornamental (cultivars of *Solanum aethiopicum*)

'Pumpkin-on-a-stick' is an unusual novelty that caught the eye of ASCFG trial participants. The bright red 'pumpkins', actually resembling small tomatoes, are related to the winter cherry (*Solanum pseudocapsicum*) sold as a brightly coloured fruiting house-plant. Many *Solanum* fruits are toxic.

In 2016 'Pumpkin-on-a-stick' was grown to assess the UK industry's response. Seed was sown into module trays (week 13) and transplanted under a tunnel (week 18) at 25 and 64 plants/m². It was an incredibly vigorous plant that started flowering in July, with fruits seen developing soon after. These plants suffered much damage from rodents which destroyed a lot of the fruit. As would be expected the lower planting density produced sturdier stems than the higher density, although there would

probably be a market for both. A disadvantage is that the plants have vicious spines on stems and leaves; in the USA it is usual to remove the spines at harvest, which adds costs and makes it a specialty crop rather than a mainstream one. The labour involved in harvesting the crop and removing the leaves and thorns means that the product would only be considered by specialist, perhaps artisan growers would could sell them at a premium price. The industry was not enthusiastic about them.

Sunflower (cultivars of *Helianthus annuus*)

The sunflower became a fashionable cut flower in the early-2000s, and its popularity has been maintained despite the higher handling and storage costs associated with flowers of this size. About 100ha of sunflowers are now field-grown in the UK, in addition to the glasshouse crop. Sunflowers have been included in the trials since 2010, and trials have highlighted the difficulties of achieving a uniform plant stand from direct-drilling and of achieving satisfactory restriction of stem growth, especially under the conditions of outdoor production. One approach has been to investigate the use of new, dwarf cultivars.

In 2013, a range of cultivars and numbered lines were demonstrated ('Galilee Adami', 'Galilee Miracle', 'Galilee Orange', 'Helios Flame', 'Tanya', 'Tavor Flash Bicolour', 'Tavor Joy', 'Tavor Lemon' and five numbered lines, CF 100, 639, 652 and 654 and KB 198). Seed was sown by hand outdoors (weeks 15 and 23) and in a tunnel (week 30) in four rows 30cm-apart across the bed and 10cm-apart within the rows. Despite the dry weather that year, in the outside beds some cultivars started to produce marketable stems from week 24 onwards, with the second planting coming into flower around week 32. The majority of the cultivars were 120 to 160cm-tall and large-headed. 'Galilee Miracle' and 'Tavor Lemon' were shorter (80 to 100cm-tall), though with normal-sized flower heads, while 'Tanya' was short (about 100cm) and had smaller (3.5cm-diameter) flower heads. Overall, growing in the tunnel produced

much taller plants than growing outside, while in most cases flower head diameters were smaller in the tunnel than outside.

In 2014 the cultivars grown were 'Galilee Orange', 'Happy Face', 'Helios Flame', 'Lemon Party', 'Rio Carnival', 'Solar Flash', 'Stellar Sun', 'Superted', 'Tanya', 'Tall Timber' and 'Tavor Flash', in addition to new numbered lines PV174, PV197 and PV199. Seed was direct-drilled as before (weeks 27 and 30). 'Solar Flash' and 'Rio Carnival' are bedding cultivars, and it was confirmed they were too short for cut flowers (requiring a trimmed length of 65cm, the overall stem would need to be reliably longer than this to meet the appropriate specification in all weather). The main picking periods were weeks 35-37 from the week 27 sowing and weeks 39-40 from the week 30 sowing. Picking when the ray petals had just started to expand, 'Helios Flame', 'Tavor Flash' and the three numbered lines were picked for VL testing from week 32 onwards. They had a consistent average VL of seven days, thereby exceeding the usual number of 'guaranteed' days. Some stems started to bend on vase-day three ('Helios Flame') or by days five and seven (numbered lines). Petal tipping was slight from vase-day four with 'Helios Flame' and PV197 and more progressive from vase-day three with 'Tavor Flash'. Some flower heads of PV197 and PV199 were breaking down by vase-day seven.

Crop improvement

This section covers commercial cut flowers that are already established in the UK, but which could provide further opportunities for growers by using new or different growing systems. Thus growing older cultivars of alstroemeria in tunnels has been shown to provide an alternative, cheaper seasonal crop than growing modern cultivars all-year-round under glass, while lily production would benefit by the development and testing of reduced-peat or peat-free growing media. With column stocks, new work is looking at the understanding and control of *Fusarium oxysporum*. Many cut flower crops would benefit from the development of more effective

herbicide programmes or the testing of alternative herbicides to replace withdrawn products. Two trials of spectral filters, on column stocks and bloom chrysanthemum, are also reported.

Alstroemeria: A seasonal tunnel crop?

Alstroemeria, more familiar as a glasshouse crop of modern, high quality, protected cultivars, had not been included in earlier CFC projects, but by 2014 the ready availability of tunnels suggested the possibility of growing a seasonal crop of the older cultivars, free of PVR/PBR and therefore cheaper to source. A feasibility trial using twelve such cultivars was planted in 2014 in a tunnel and outside, and grown-on for four years (Table 19).

Table 19. Details of 2014–2017 alstroemeria cultivars feasibility study

Site	Rookery Farm
Cultivars	'Apollo' 'Avanti' 'Bonanza' 'Candy' 'Dana' 'Flaming Star' 'Friendship' 'Golden Delight' 'Nina' 'Orange Supreme' 'Pink Sensation' 'Tanya'
Plant longevity and hardiness	Perennial with fleshy tubers, generally hardy to -10°C (a few lower)
Format(s) and supplier(s)	7 and 9cm plug plants from Parigo
Propagation and pre-planting treatment(s)	None
Planting or sowing date(s)	Transplanted week 22, 2014 (tunnel) Transplanted week 23, 2014 (outside)
Plots	2m long plots (tunnel) 1m long plots (outside)
Planting/housing site(s)	'Pro-Tech' tunnel bay 1 and outside
Layout	Demonstration plots
Plant spacing(s)	5/m ²
Post-planting treatment(s)	One layer of support netting in 2014, subsequently increased to three layers Weak and short stems removed at the start of each season to encourage stronger growth Flower heads removed in the early stages until

	stems started to reach specification Mulch applied to outside plots over first winter
Pests, diseases and disorders	Minor caterpillar and aphid damage noted in 2016 No other pests, diseases or disorders noted
Picking stage(s) and market specification(s)	Buds just starting to show colour Stem length 60cm
Picking and recording date(s)	2014: from week 30 to week 44 (tunnel) or week 45 (outside) 2015: tunnel from week 23 to week 44 when they were still cropping but the tunnel was de-skinned; outside, from week 26 to week 41 2016: in tunnel from week 22 to week 41 when they were still cropping but the tunnel was de-skinned; outside, week 26 to week 41 2017: in tunnel main flush weeks 20-24, second flush starting in week 28 and still on-going when the tunnel was de-skinned in week 42; data not collected from outside plots due to poorer quality when compared with the protected crop Picked 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, 2014 (tested by Butters Group)

Plant establishment in 2014 was considered very good, and, as expected for new alstroemeria plantings, the earlier stems were short and weak and were cut out and discarded. Marketable flowers (with 60cm minimum stem length) were produced from week 31 in the tunnel, while outside stems were slower growing and the first stems were not picked until week 33. Plants were very vigorous under protection, producing good, strong stems that some visiting growers commented were better than some glasshouse crops; in the outside beds stems were much less numerous. Picking continued to weeks 44–45, when it was terminated to allow the tunnel to be de-skinned.

The tunnel crop overwintered to 2015 with no losses evident, and started to produce shoots for thinning as soon as the tunnel was covered in week 17. Marketable stems of high quality were picked starting in weeks 23 to 26 for the different cultivars, one to two months earlier than in the first year. In the outside plots (which had been covered with a layer of mulch over winter) marketable stems were cropped starting between

week 26 and 28; overall growth was less vigorous than under protection. Marketable flowers were still being produced in the tunnel when cropping was stopped for de-skinning (week 44), while the last pick outside was in week 41.

This generally strong performance continued into 2016. For the different cultivars marketable stems were picked starting from week 22 or 23 in the tunnel and from week 26 to 29 outside. Marketable flowers were still being produced in the tunnel and outside when cropping was stopped for de-skinning (week 41).

In 2017, the final year of the trial, the tunnel crop again produced many long stems, though perhaps slightly weaker compared with the earlier years. The main flush started in week 20 but was virtually terminated by unusually high temperatures in week 24, resuming from week 28 and lasting until week 42 when cropping was stopped for de-skinning. The loss of quality in the outside plots was more pronounced, and in general it can be stated that the outside crop performed like the garden cultivars they are, i.e. there were many weaker, shorter stems, but growing them under protection totally transformed the performance of these cultivars into a superior high-quality product. For this reason there seemed very little point continuing to record the outdoor crop and so no further records were taken from them.

Marketable yields and picking periods are summarised across the four years of the trial in Table 20. In round figures yields from the tunnel plots were double those for outside plots, while annual production increased substantially over the four years in the tunnel-grown plants, with a smaller increase over time in the outside plots. In the year of planting there was a slow build-up of picking, with most picked in the second half of the season, while in subsequent years there was a shift to earlier picking with a rapid build-up to the main picking period - especially notable in year four of the tunnel crop.

It was considered that the crop could have continued to a fifth year in the tunnel, although more thinning than usual would have been required. At that point the

outside crop was probably not commercially viable.

Table 20. Summary of marketable stem yields and (below) picking periods for twelve alstroemeria cultivars grown 2014–2017 in tunnel and 2014–2016 outside

Measurement and cultivar	Tunnel				Outside			Three year totals (2014-2016)		
	2014	2015	2016	2017	2014	2015	2016	Tunnel	Outside	Total
Total marketable stems/m ²										
'Apollo'	113	327	249	284	42	65	217	689	324	1013
'Avanti'	204	296	326	356	73	81	139	826	293	1119
'Bonanza'	224	162	252	309	154	47	76	637	277	914
'Candy'	201	276	367	324	162	108	115	843	385	1228
'Dana'	218	315	383	453	188	105	100	915	393	1308
'Flaming Star'	151	400	337	443	57	58	291	888	406	1294
'Friendship'	215	400	330	350	82	52	296	944	430	1374
'Golden Delight'	117	351	280	397	29	95	202	748	326	1074
'Nina'	259	331	355	469	131	191	254	944	576	1520
'Orange Supreme'	130	203	179	269	49	53	162	512	264	776
'Pink Sensation'	187	278	347	391	120	35	122	811	277	1088
'Tanya'	210	343	457	407	103	149	200	1009	452	1461
Average of above	185	307	322	371	99	87	181	814	367	1180
Overall picking periods										
from week no.	31	23	22	20	33	26	26			
to week no.	44	44	41	44	45	41	41			

Flower production in alstroemeria tends to run in cycles rather than continuously, so continuity of production can be a problem. Figure 32 shows the profile of annual flower picking as totals across all cultivars. With this combination of twelve cultivars and tunnel and outside plots the supply of flowers was reasonably consistent and occurred over a long, five-month period - which would have been longer had it been possible to leave the cover in place. Nevertheless the flower supply was still somewhat patchy, with few or no flowers available in some weeks each year (exacerbated in 2017 by the high temperatures around week 24). This might be improved by starting new plantings annually or every two years, or by making a small number of sequential plantings.

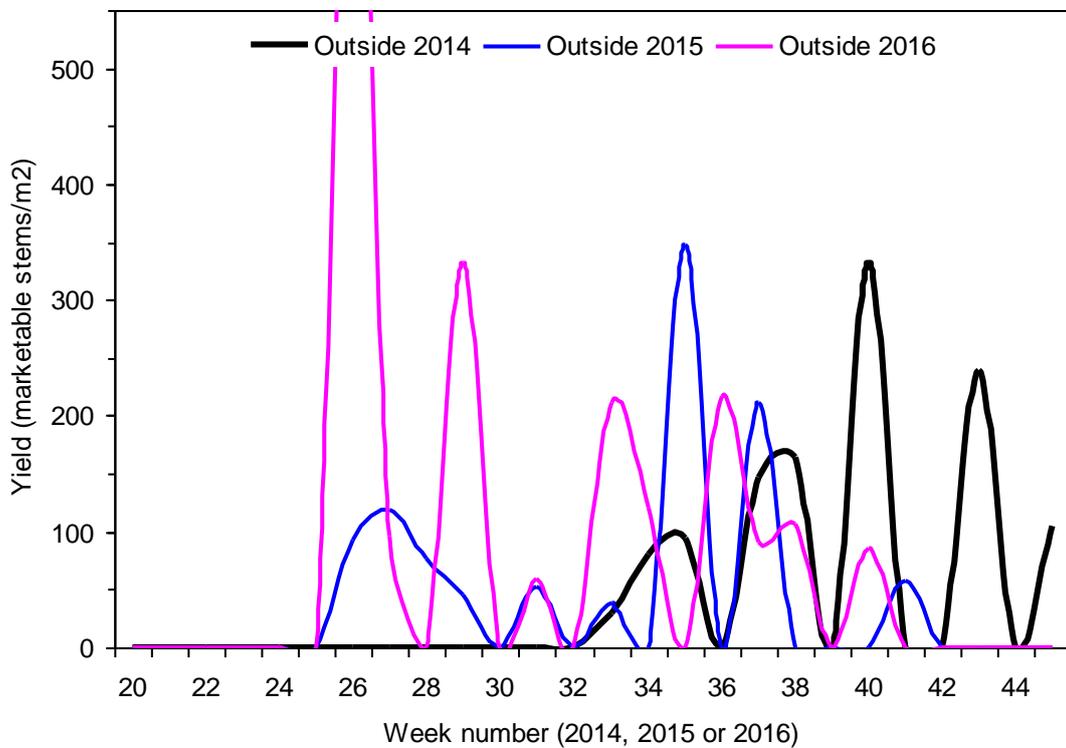
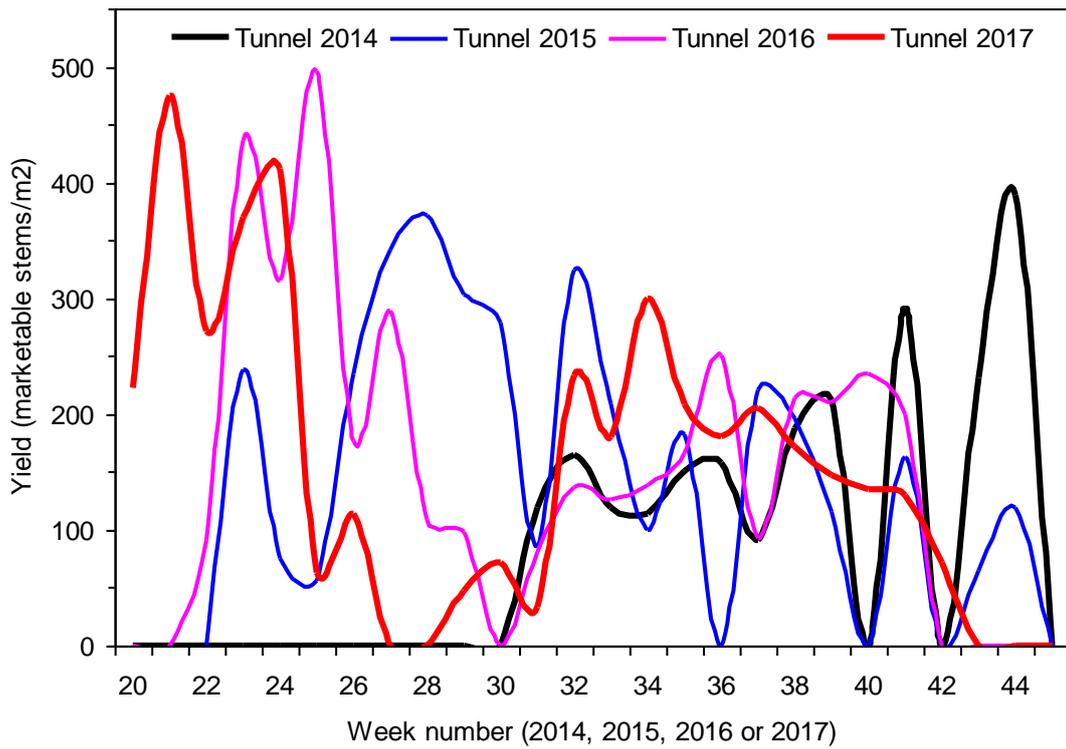


Figure 32. Total weekly stem yield across twelve cultivars of alstroemeria (1m² of each) growing in a tunnel for four years (top) and in outdoor plots for three years (bottom) (yields were not recorded in the fourth year of outside plots because of falling stem quality). Data plotted as 'smoothed' lines to show 'cycling'.

Figure 33 shows the yields of marketable stems for each cultivar. The yields of individual cultivars varied markedly. In the tunnel or outside, the productivity of half of the cultivars increased annually, while most of the rest peaked in the second year. Overall, 'Nina' was the highest yielder, being consistently so in the tunnel, outside and across the three years. 'Dana', 'Flaming Star', 'Friendship' and 'Tanya' were also consistently among the higher producers, with 'Dana' doing particularly well as a first-year crop and in outside beds and 'Friendship' doing particularly well in the tunnel. Overall poorer performers were 'Apollo', 'Bonanza', 'Golden Delight' and 'Orange Supreme'. Most cultivars appeared to crop over the whole picking period to some extent.

In 2014, stems were taken for standard VL testing. With alstroemerias it appears to be important to allow the flowers to show good colour before picking, which makes them much more attractive without appearing to shorten their VL. Stems of eight cultivars, all at a similar stage of development, were sampled. The samples had a consistent average (and long) VL of 12 days. By vase-day 13 the petals were dropping and the foliage was senescing.

Growing non-PVR/PBR cultivars in tunnels appeared to have strong potential, with the ability to achieve reasonable continuity of supply using some combination of cultivars, tunnel and outside growing, and sequential planting. As a direct result of this trial a number of small commercial plantings of these types of alstroemeria have been made. Despite the poorer yields obtained outside, growing alstroemeria in the open may still have a place for small growers.

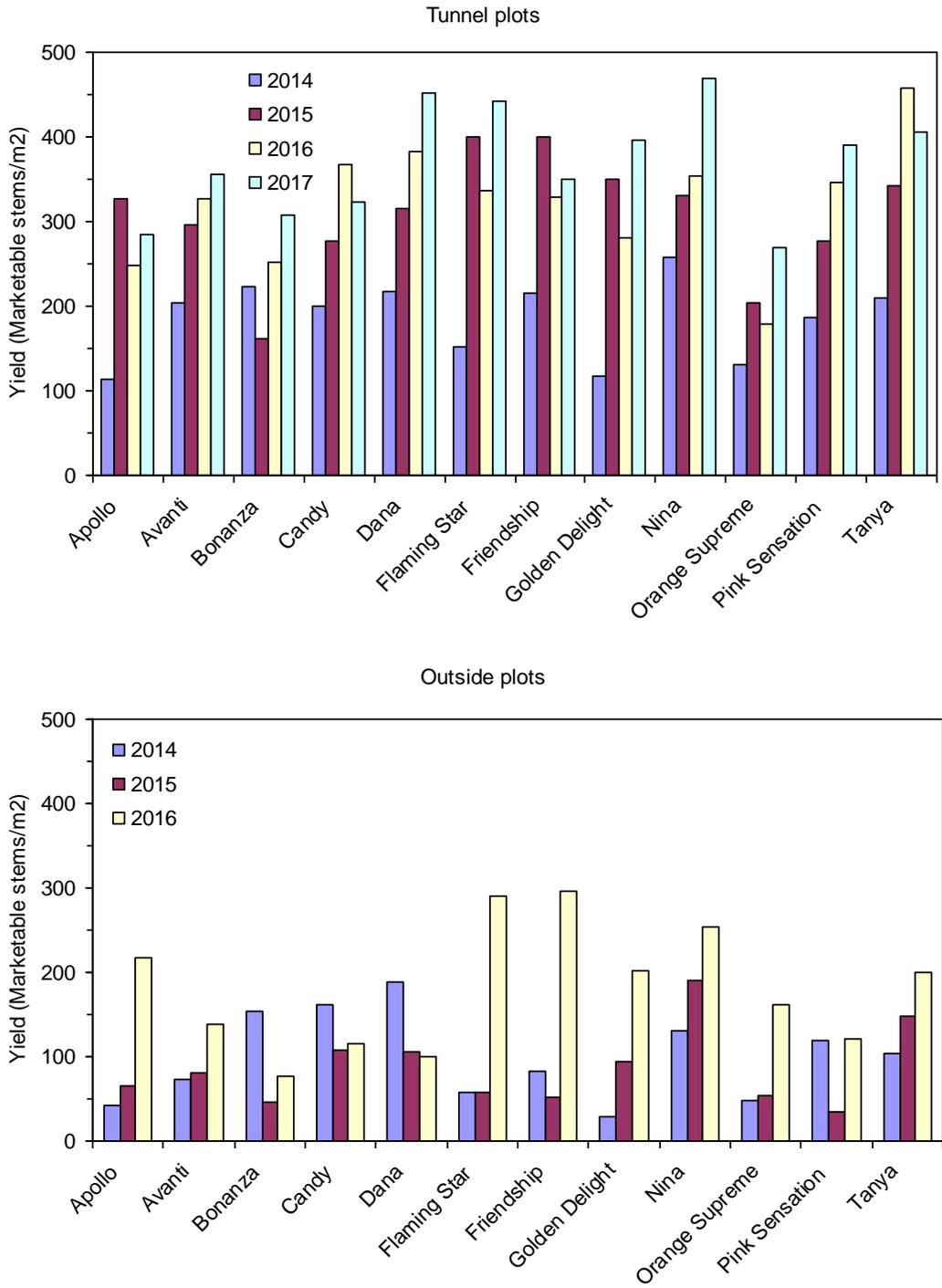


Figure 33. The number of marketable stems/m²/y produced by plots of 12 alstroemeria cultivars (1m² of each) over four years growing in a tunnel (above) and after three years growing outside (below) (yields were not recorded in the fourth year of outside plots because of poorer stem quality). To aid comparisons, the histograms are drawn to the same vertical scale

Column stocks: Improving control of fusarium wilt

Column stocks are a mainstay of UK protected cut flower production, so it is appropriate they have been the subject of several CFC trials concerned with crop

improvement, particularly the major problem of the control of *Fusarium oxysporum*. In 2012, prior to the current project, a large cultivar trial in steamed and non-steamed soil had shown a strongly beneficial effect of steaming on stem weight (although the effects on stem and spike length were insignificant). Due to interest in one of the new series, 'Katz', as a summer or late crop, several cultivars were compared in 2013, grown either in a tunnel at CFC or in a commercial glasshouse in the locality. For the 'Katz' lines grown in the tunnel, though stem strength was poorer than expected (possibly due to hot weather through much of the crop's life), their quality was nevertheless far superior to that of a commercial glasshouse trial which was mostly unmarketable due to weak stems. On a commercial nursery the full range of column stocks cultivars from Combinations Young Plants and Florensis Cut Flowers were (1) grown as a further cultivar trial and (2) planted under glass at a commercial nursery for testing for susceptibility to fusarium wilt (of which the glasshouse had a history). The hot weather brought plants on much quicker than anticipated and some of the 'Anytime' cultivars and coded lines were ready for cropping in week 30. Despite the hot weather during this period, nearly all the cultivars produced marketable stems. In the susceptibility trial the resilient, productive cultivars were 'Avalanche White', 'Fantasy Red', 'Fantasy Red Imp', 'Phantom Cream Imp' and 'Phantom Red' (in Combinations cultivars) and 'Anytime' cultivars 'Apple Blossom', 'Pink', 'Red', 'Sea Blue', 'White' and 'Yellow', 'Katz' cultivars 'Bright Rose', 'Cherry Blossom', 'Light Lavender', 'Pink' and 'Yellow', 'Figaro Lavender' (in Florensis cultivars) and some of the coded lines. These properties were not shared by the 'Opera' series. Since undertaking this trial there have been significant changes to the range of commercial cultivars available, some having been discontinued, with some new families introduced, and it is therefore proposed to repeat this trial in 2018.

There was also increasing concern among growers about poor establishment and growth and lack of flower uniformity in column stocks. No single factor was identified

as responsible but a combination of issues, such as the poor performance of some cultivars on unsteamed soil and the presence of *Pythium* or *Fusarium*, were shown to have a role. As a result, separate AHDB Horticulture-funded projects were carried out in 2013 to survey cultural practices and investigate the role of *Pythium* and *Fusarium* in the findings (project PO 005) and to consider the possibly of remedial effects of soil amendments (PO 005a). Reports for those projects are available from the CFC and AHDB Horticulture websites. In 2014 the control of fusarium wilt was investigated at the CFC using a range of fungicides. Cercobin, Octave and Signum appeared to give options for control, while Plover and Switch appeared successful initially but most plants subsequently died. It had been hoped that, with further investigations, it may have been possible to optimise *Fusarium* treatment and include the new succinate dehydrogenase-inhibiting (SDHI) fungicides such as boscalid, but this was prevented by registration issues.

In 2016 a new demonstration of column stocks was set up to show the effects of steam-sterilisation on the commercial cultivars currently available from the only two suppliers to the UK at the time (Florensis and Noordam; subsequently Noordam decided to withdraw from this market after 2016). In all there were 24 cultivars from Florensis, covering the 'Aida', 'Anytime', 'Centum', 'Figaro', 'Mathilda', 'Milla' and 'Opera' series, and 14 cultivars from Noordam covering the 'Centum', 'Jordyn' and 'Milla' series. In week 25 plug plants were transplanted at 64 plants/m² to beds in a tunnel, with one bed of each cultivar in the south half of the tunnel which had been steam-sterilised in week 16 and a second in the north half that had been left untreated. The plugs established well, despite initial grazing from rabbits, but were stressed by hot weather in mid-July. As was the case with late-planted commercial crops this year, the trial suffered from uneven flowering, the 'Mila' cultivars being worst and only 'Mila Apricot' producing a reasonable number of marketable stems (although 'Mila White' did produce a late flush of flowers towards the end of August).

Downy mildew, diamond-backed moth and sclerotinia were further problems, necessitating rouging of the crop and an intensive spray programme. As expected, performance in the non-steamed soil was poorer than in the steamed area, but the difference was less marked than that seen in previous trials.

As part of a new AHDB Horticulture-funded project on *Fusarium oxysporum* in horticultural crops, primarily onions and column stocks (FV/PO/BOF 452), an experimental site sufficiently infested with *F. oxysporum* was needed as a permanent site for trials investigating fusarium control in stocks. This was set up at the CFC in 2017. In late-June to early-July the soil in the 'Haygrove' tunnel was rotavated and ammonium nitrate (as 'Nitram') added at 30g/m². On 6 July (week 27) the soil was infected with *F. oxysporum* f.sp. *matthioli* culture (produced at Warwick Crop Centre, Wellesbourne) by evenly spreading the inoculum over the surface and then raking in by hand. One day later the tunnel was planted in plots with plug plants of a range of stock cultivars (from Florensis and Stars Plants) at a density of 64 plants/m², together with plots of lisianthus and brassica (Florensis) included for checking the host-specificity of the fusarium culture. In all there were 40 plots, 3.5m long, comprising randomised, replicate plots of 'Anytime Rose', 'Anytime White', 'Centum Blue', 'Centum Lavender', 'Centum Pink', 'Centum Red', 'Centum White', 'Mathilda Blue', 'Mathilda Yellow' and 'Mathilda White' as well as the plots of brassica and lisianthus. The plots were inspected regularly and the first symptoms of *F. oxysporum* infection on the stocks were seen three weeks later (29 July). After growing-on the plants for as long as practicable in order to ensure maximal infection, an assessment of the severity of fusarium symptoms and number of 'marketable' stems (those likely to have been marketable had they been picked at the optimal stage) in each plot was made on 12 October. The crops were rotavated on 13 October and the site left over the winter in readiness for fully a replicated trial in 2018.

As observed on commercial nurseries and in earlier trials at the CFC, there were

large differences in susceptibility/tolerance to fusarium between the colours within series. Thus, there were high fusarium scores and low numbers of marketable stems in 'Anytime White', but low fusarium scores and high stem numbers in 'Anytime Rose'. Among the 'Centum' series there were generally low stem yields and high fusarium scores, though 'Centum Pink' and 'Centum Red' had relatively low fusarium scores and 'Centum White' produced high stem yields despite a high fusarium score. The three 'Matilda' cultivars had low stem yields and low fusarium scores. There were no indications of fusarium infection in either the lisianthus or the brassica plots, confirming the host-specificity of the fusarium culture used. The results suggested that the *Matthiola* race of fusarium was both widespread across the tunnel and sufficiently high enough to be pathogenic, as required for further work to proceed on the site in 2018, which was the main aim of the work in 2017.

Lily: Alternatives to peat-based growing media

Bulbous ornamentals were included in CFC trials for the first time with the start of the current project in 2013. Lilies remain hugely popular with UK customers: generally the bulbs are grown in crates of growing media in order to avoid the soil-borne pathogens common in glasshouse soil. For many years peat was used as the growing medium, either alone or mixed with other materials; more recently most serious growers have developed their own bespoke peat-based media for lilies (referred to below as 'grower's peat-based medium'). As a result of environmental concerns over possible habitat loss, there has been a long search – going back at least to the 1980s - for alternative materials to use as growing media, or at least to use as diluents for peat media. In recent years there has been renewed interest from growers and customers to discover more acceptable peat-alternatives in the production of lily cut flowers, and this has been a target of CFC trials over the course of the current project (PO/BOF 002a). With the increasing availability and acceptability of green waste (GW) and anaerobic digestate (AD) over this time, these materials have been of particular interest; other more familiar alternative materials

included were wood-derived media and coir.

In 2013 a selection of modern cultivars was evaluated, namely 'Burlesca', 'Carolyn', 'Crystal Bianca', 'Fiction', 'Mnadaro', 'Oberto', 'Pintado', and 'Sambuca' (Oriental Hybrid group), 'Adelante', 'Hacienda', 'Hypnose', 'Ovatie', 'Profundo' and 'Tupelo' (OT Hybrid group), and 'Beau Soleil' and 'Castille' (LA Hybrid group). They were grown in grower's peat-based medium (representing a typical medium currently used by UK lily growers), 100% GW or a 50:50 v/v mixture of the two. With minor exceptions stems were longest when grown in grower's peat-based medium, shorter in the 50:50 mixture, and shortest in 100% GW. Bud count and other aspects of plant quality did not vary between lilies grown in the three media. All the cultivars tested responded in a similar fashion.

For the 2014 lily trial 'Dynamite' (Oriental group) was grown in a grower's peat-based medium, 100% coir, 100% 'Forest Gold' (a wood-derived growing medium), or mixtures of grower's peat-based medium with coir (50:50 v/v), AD (80:20 and 60:40 v/v) and GW (50:50 v/v). Compared with grower's peat-based medium, stem length varied little in the alternative media. Growing in grower's peat-based medium + AD and in 'Forest Gold' gave heavier stems than growing in grower's peat-based medium alone, though the differences were slight. However, using grower's peat-based medium + AD mixtures produced plants with better leaf colour than grower's peat-based medium alone (possibly due to the base dressing added at blending). Growing in grower's peat-based medium + GW resulted in some stunted stems, chlorotic leaves, slightly reduced yield and a week's delay in picking. In a second run of this trial later in the season the visual differences between treatments were less pronounced.

Two trials were carried out in 2015, concentrating on adding AD to peat or coir growing media. Cultivar 'Capistrano' was used in trial 1 and 'Alma Ata' in trial 2 (both Oriental group). The bulbs were grown in 100% grower's peat-based medium, coir or

AD, grower's peat-based medium + AD mixtures (60:40, 40:60 or 20:80 v/v) and a coir + AD mixture (33:67 v/v). In both trials the lilies grown in 100% AD were stunted, chlorotic and distorted, while stems from grower's peat-based medium + AD 20:80 mix were only marginally better. Lilies grown in AD + coir, despite making good height, had chlorotic, mottled foliage. On the other hand, plants grown in 100% grower's peat-based medium, 100% coir or the 'weaker' mixes of grower's peat-based medium + AD (40:60 and 60:40 v/v) were entirely normal and marketable. In trial 1 ('Capistrano'), production in the grower's peat-based medium gave the longest stems, but generally stem weight was greater where higher rates of AD were added. In trial 2 ('Alma Ata'), the differences between growing media were less pronounced. On the basis of these results 40 to 60% AD could be mixed with grower's peat-based medium to reduce peat use without having any detrimental effects. Analysis of nutrients in the different growing media suggested that some effects of AD were due to differences in N, P, K and Mg concentrations between supplies.

In 2016 the oriental cultivar 'Dynamite' (Oriental group) was assessed grown in 100% grower's peat-based medium, 100% coir, 100% of a peat-based medium (with added nutrients, lime and 'Dolodust', supplied by Bulrush Horticulture) and the same 'Bulrush medium' mixed with 10, 20 or 30% of either wood fibre ('Chip-N') or 'Cocopeat' washed coir. Sprouting and early growth of the crop were normal but, perhaps because of the relatively late planting this year (week 28) subsequent development was slow (growth was expedited by transferring the trial to a heated glasshouse in week 45, shortly prior to picking). The lilies grown in 100% coir were short, but otherwise there were no indications of visual differences between plants in any treatment and all were picked within a few days. Total stem length averaged 70cm when grown in 100% coir, but hardly varied in the other media, with averages between 77 and 80cm. Stem weight (trimmed to 70cm) was similarly affected, averaging only 99g grown in 100% coir, but 126g in grower's peat-based medium,

136–141g in the peat + wood fibre mixes and 147–151g in the peat + ‘Cocopeat’ mixes. The results suggested that these trial mixes were all worthy of further investigation, but particularly the peat + ‘Cocopeat’ mixes with its potential to reduce peat usage by 30% or more.

The use of AD was further investigated in 2017, growing two batches of lily ‘Santander’ (Oriental group) in five mixtures, along with a grower’s peat-based medium for comparison (Table 21).

Table 21. Details of 2017 alternative growing media trial for lily production in crates

Location	Rookery Farm
Cultivars	‘Santander’ (Oriental group)
Plant longevity and hardiness	Bulbous perennial, frost-hardy to fully hardy (young growth can be damaged by frost)
Format(s) and supplier(s)	16-18cm grade bulbs (GAV Lilies)
Propagation and pre-planting treatment(s)	None
Planting or sowing	Planted in standard lily crates using the following media: 1. ‘Mix 1’ (Peat + 100L AD/m ³) ^a 2. ‘Mix 2’ (Peat + 200L AD/m ³) 3. ‘Mix 3’ (Peat + 300L AD/m ³) 4. ‘Mix A’ (AD + peat 50:50) ^b 5. ‘Mix B’ (AD + peat 75:25) 6. Grower’s peat-based medium ^c ^a Mixes 1-3, supplied by Bulrush Horticulture, were trial media based on peat with added base fertiliser (NPK + trace elements), additional N, lime, wetting agent, ‘Forest Gold’ and increasing amounts of AD ^b Media coded A and B, supplied by Lincoln University, were trial media based on peat with increasing amounts of AD (from energy crops and farm waste), with no added fertiliser or lime ^c Grower’s medium was peat with added base fertiliser, lime and wetting agent
Planting or sowing date(s)	Bulbs planted week 21 (first planting) and week 26 (second planting)
Plant spacing(s)	15 bulbs/crate
Layout	Three replicate crates per growing medium, arranged in three blocks
Post-planting treatment(s)	Crates placed in cold-store (9°C) for 4 weeks after first planting, for 3 weeks after second planting The liquid feed regime was the same as for the remainder of the tunnels and was applied at each watering (see ‘Materials and Methods’)
Planting/housing site(s)	Crates moved to ‘Pro-Tech’ tunnel bay 3 week 25 (first planting) and week 29 (second planting) The second planting was then moved to a heated

	glasshouse in week 37 to ensure that the crop was harvested before being damaged by early frosts
Pests, diseases and disorders	Some virus symptoms evident
Picking stage(s) and market specification(s)	Buds starting to show colour
Picking and recording date(s)	Week 37 for the week 21 planting Week 42 for the week 26 planting
Records taken	Total stem length before trimming and stem weight after trimming to 70cm (on a random sample of 12 stems per crate), flower and foliage quality
VL testing	No

In the earlier batch (planted week 21) growth and development were normal in all growing media, with the crop ready to pick in week 37. Stem lengths and trimmed weights were greatest where the grower's peat-based medium had been used, though the overall range of average values was small, between 142 and 158cm in length and 87 and 105g in weight (Figure 34). All AD mixtures produced stems lighter in weight than the grower's peat-based medium. Analysis of variance showed that the effect of growing media failed to reach significance at the 5% level of probability for stem length, while being statistically (though probably not for practical purposes) significant at the 1% level of probability for weight (Table 22). In the earlier stages of growth there was some evidence that plants in the AD mixes were shorter than in the grower's peat-based medium, but by the time of flowering these differences had all but disappeared (this initial difference in length was not evident in the second planting, perhaps due to the AD mixes having 'matured' and perhaps dissipated excess ammonia, etc.). Final flower quality was superb for all the mixes.

In the later batch (planted week 26) growth and development were again normal in all treatments, and the picking date was week 42 (Figure 35). However, while stem lengths were similar to those of the earlier batch, trimmed stem weights were conspicuously lighter, presumably due to their being 'forced' in the glasshouse. In line with the earlier trial, analysis of variance showed no significant effect of growing medium on stem length but a statistically (though probably not for practical purposes) significant effect on stem weight (at the 0.1% level of probability; Table 22).

The experiment clearly demonstrated that all the trial AD-containing growing media produced stems of a quality close to that of the typical grower’s peat-based medium. The suitability of AD-based media has improved over the course of the project, and there seem to be real prospects for further utilisation of AD in lily flower production, subject to the availability of uniform supplies of AD of specified quality. This does not rule out the adoption of other alternative materials such as coir or wood-based materials, which have also showed promise over the course of the trials and are already incorporated into growing mixes by some growers. At the current time there is industry reluctance to adopt AD into lily media, but this may change if other alternatives (e.g. coir) become less available, or less acceptable, to the end-customer.

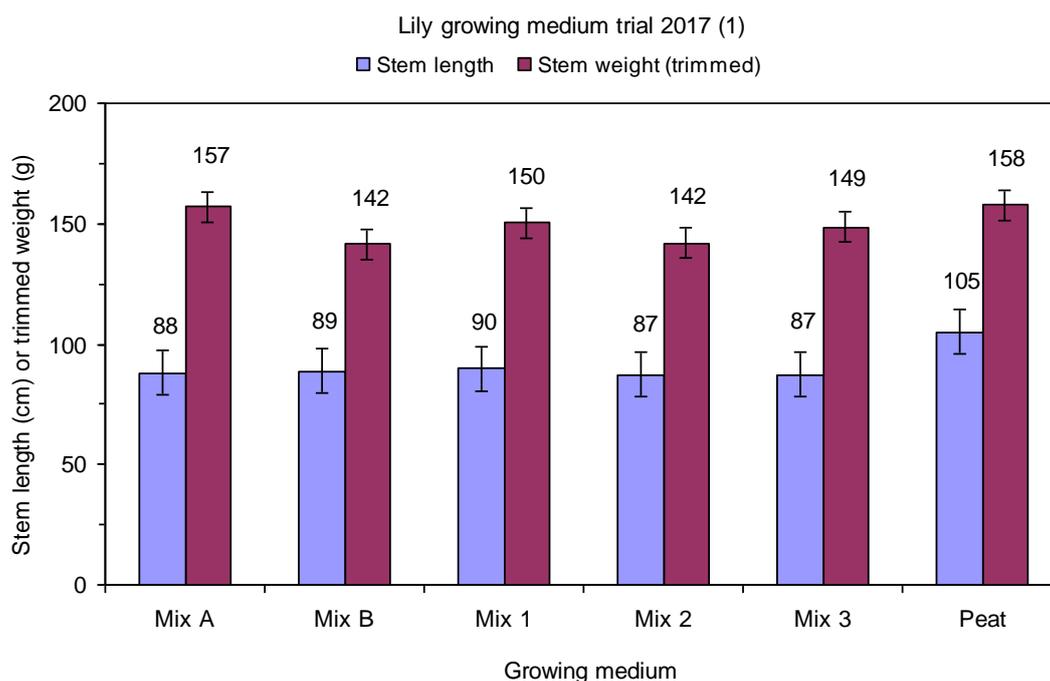


Figure 34. Stem lengths and trimmed weights of lily ‘Santander’ produced in five growing media containing AD and in typical grower’s peat-based medium (‘peat’; for details, see text), 2017 trial 1 (the error bars represent the LSD (5%) values either side of the means, ± 9.2 for length and ± 6.2 for weight)

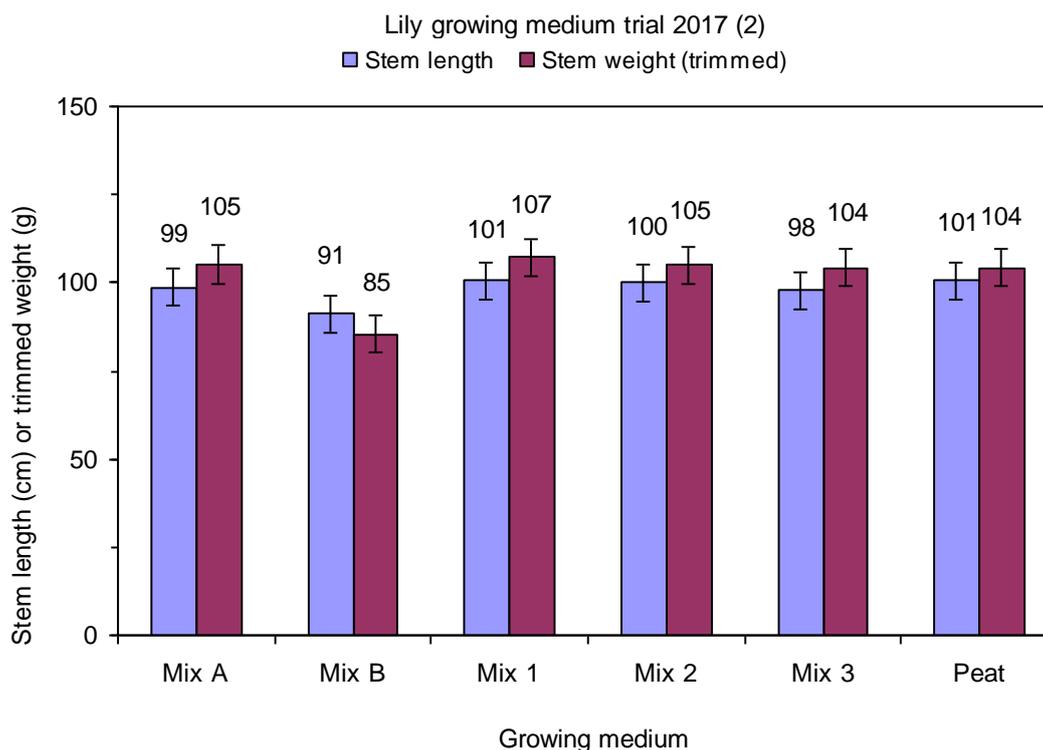


Figure 35. Stem lengths and trimmed weights of lily 'Santander' produced in five growing media containing AD and in typical grower's peat-based medium ('peat'; for details, see text), 2017 trial 2 (the error bars represent the LSD (5%) values either side of the means, ± 5.3 for length and ± 5.3 for weight); note the vertical scale is expanded compared with that of Figure 34

Table 22. Analysis of variance for stem length and weight in the 2017 lily trials

Source of variation	SS	DF	MS	F	P
Trial 1, stem length					
Growing medium	707.053	5	141.411	2.647	0.078 NS
Residual	641.000	12	53.417		
Total	1348.053	17			
Trial 1, stem weight					
Growing medium	741.410	5	148.282	6.204	<0.005 **
Residual	286.806	12	23.900		
Total	1028.216	17			
Trial 2, stem length					
Growing medium	193.960	5	38.792	2.145	0.127 NS
Residual	216.982	12	18.082		
Total	410.942	17			
Trial 2, stem weight					
Growing medium	1007.202	5	201.440	11.336	<0.001 ***
Residual	213.245	12	17.770		
Total	1220.448	17			

Herbicides for outdoor cut flowers

The loss of key active ingredients, such as oxadiazon, chlorthal-dimethyl and propachlor, continues to be a major concern for growers of outdoor cut flowers. Trials of alternative active ingredients were carried out over the period 2014–2016.

In 2014 and 2015, trials were carried out mainly at the Rookery Farm site, where the main problem weeds were chickweed, groundsel, redshank and shepherd's purse. Sited adjacent to the regular CFC trials, and under the project leadership of John Atwood, ADAS (AHDB Horticulture projects HNS/PO 192 and 192a), the following crops were drilled – china aster, larkspur, sweet william and wallflower or transplanted - china aster. The main findings are summarised below (full details can be obtained from the project reports, available from AHDB Horticulture).

- A tank-mix of 'Stomp Aqua' (pendimethalin) + 'Gamit 36 CS' (clomazone), applied post-drilling, pre-emergence, was safe and effective used on **drilled china aster**; it could then be followed by a post-emergence application of 'Shark' (carfentrazone-ethyl) if required.
- 'Stomp Aqua' + 'Gamit 36 CS' was also found to be the best on **transplanted china aster**, applied pre-planting.
- The tank-mix 'Stomp Aqua' + 'Goltix 70 SC' (metamitron) provided the best weed control and was the safest option in **drilled sweet william** trials.
- In the **drilled wallflower** trial 'Butisan S (metazachlor)', 'Gamit 36 CS' and (at the lower rate) 'Wing-P' (dimethenamid-p + pendimethalin) appeared safe when applied at drilling, and 'Wing-P' at the lower rate + 'Gamit 36 CS' also appeared to be safe as a tank-mix. The active ingredient benfluralin was safe as a pre-drilling incorporated treatment on wallflower, and could be combined with other post-drilling treatments, but it is not yet available in the UK.

- **Drilled larkspur** proved to be a challenging subject because of its slow emergence and growth, combined with phytotoxic effects from the herbicides used; nevertheless the trial gave some pointers for future trials.

In 2016, herbicide treatments were further evaluated on transplanted china aster and drilled sweet william, in collaboration with John Atwood but as part of the core CFC project.

- For **transplanted china aster** 'Matsumoto Blue Tipped' the aim was to follow-up the above recommendation for pre-planting 'Stomp Aqua' + 'Gamit 36 CS'. Overall, the combination of pre-planting 'Stomp Aqua' + 'Gamit 36 CS' followed by 'Butisan S' three weeks post-planting was probably the best compromise between weed control and crop safety. Pre-planting, 'Wing-P' would probably be an alternative, either alone or followed by 'Venzar Flo' (lenacil) + 'Flexidor 500' (isoxaben). (The other herbicides tested were pre-planting 'Nirvana' (imazamox + pendimethalin) and post-planting 'Successor' (pethoxamid).)

For **drilled sweet william** 'Floriade Mix' the aims were to see if the above recommendation (to apply 'Stomp Aqua' + 'Goltix 70 SC' at drilling, followed at the four-true-leaf stage by 'Shark') could be bettered by using other herbicides post-emergence, and to determine the effect of an additional, winter herbicide. Following the application of post-emergence treatments stunting was evident in all treatments except the control, with the treatments giving good weed control also resulting in more stunting. Despite this phytotoxicity the plants subsequently recovered completely or very nearly so, and for all practical purposes the transient stunting could be discounted. As a result the recommended herbicide programme would be the one giving the best weed control: 'Stomp Aqua' + 'Goltix 70 SC' at drilling followed by 'Venzar Flo' + 'Flexidor 500' + 'Shark' post-emergence. (The other treatments tested were 'Goltix 70 SC' at drilling and 'Butisan S', 'Butisan S' + 'Shark', 'Springbok' (dimethenamid-p + metazachlor), 'Springbok' + 'Shark', 'Successor' and

Venzar Flo' + 'Flexidor 500' post-emergence.) Subsequently, additional winter herbicide treatments were applied in mid-February prior to spring growth: 'Shark', 'Devrinol' (napropamide) + 'Flexidor 500', 'Venzar Flo' + 'Flexidor 500', 'Butisan S' + 'Flexidor 500' and 'Venzar Flo' + 'Flexidor 500'. Assessed six weeks later, 'Devrinol' + 'Flexidor 500' and 'Butisan S' + 'Flexidor 500' were both crop safe and could be applied if required.

A summary of herbicide trials on outdoor flower crops can be found in AHDB Horticulture Factsheet 02/17 'Chemical weed control in outdoor cut flower crops' by John Atwood.

Spectral filters for tunnel-grown cut flowers

The increasing popularity of Spanish tunnels provided opportunities to incorporate spectral filters into cut flower production. In previous AHDB Horticulture-funded work (project PC 168) over 1999–2000, spray carnations, spray chrysanthemum, column stocks and godetia were grown for two years under a range of the films then available. In all four crops there were large year-to-year differences in growth and productivity, over-shadowing any effects of the spectral filters. There were few consistent benefits of any of the specialist films on the four crops, meaning that in many cases a standard, clear (and relatively inexpensive) film would be the covering material of choice (though it does have the disadvantage of high heat gain, demanding adequate ventilation). Therefore, only in cases where a specific advantage could be demonstrated, for example to manipulate the red to far red ratio, reduce soil temperature or alter the UV input, should the use of a more expensive specialist film be considered. Since the work described was done several years ago, there was scope for the CFC to re-visit the issue while applying the experience gained in the interim period, and in 2013 trials were carried out on bloom chrysanthemum and column stocks.

At a commercial nursery in Terrington St Clement, Norfolk, areas of **column stocks** 'Deborah', 'Figaro Light Rose', 'Figaro Lavender' and 'Fedora' were grown in two 'Spanish tunnels' covered with either a standard clear polythene film or 'SteriLite SuperThermic' film which has UV-blocking, light-diffusing and IR-reflecting properties. The crop was planted in week 20 and stems cropped in week 28 (in the main picking period) were sampled, recording the overall stem and flower spike length for a sample of 35 stems taken randomly from across the whole crop as harvested by nursery staff. Average stem lengths were consistently longer under the 'SteriLite SuperThermic' film than under the standard film, but only by between 1 and 9cm in the different cultivars, a statistically significant effect, though only at $P=0.04$. Between cultivar differences were not significant. Spike lengths were similar under both films, except in the case of 'Fedora' where spikes were about 3cm longer under the specialist film, analysis of variance showing that the effects of film and cultivar were not significant. Although the differences in stem length under the two films were small, in a poor growing year this could have made the difference between meeting the required specification or not.

Bloom chrysanthemum were the subject of a second trial of spectral filters carried out at a commercial nursery in Pinchbeck, Lincolnshire. Cultivar 'Hananburg Red' were grown in 'Spanish tunnels', one covered with 'Aster TR', a film with light diffusing, UV-opaque and some thermal properties, the other with 'SunMaster Smart Blue', a blue polythene film that reduces light intensity in the near- and far-red regions, transmits UV and reduces light and heat levels. Blocks were planted in week 19 and pinched to three leaves after 21 days. 'B-Nine SG' (daminozide) was applied to half of each tunnel, the other halves being untreated. The temperature in the 'SunMaster Smart Blue' tunnel was, on average, 3.9°C lower than in the 'Aster TR' tunnel on a hot day, while in cool, dull conditions no temperature differences were noted. The plants under 'SunMaster Smart Blue' bloomed two weeks later than under

'Aster TR', perhaps because of its substantially lower temperatures. Superficially the blooms appeared similar under both films, although under 'Aster TR' the stems were in fact thicker and stronger than under 'SunMaster Smart Blue' film. Under 'Aster TR' the petals and leaves were slightly lighter in colour (probably not to the extent that the average consumer would notice). While under 'SunMaster Smart Blue' the petals and leaves were slightly darker and the leaves appeared thinner. Stem lengths were slightly shorter under 'SunMaster Smart Blue' film than under 'Aster TR', and when daminozide was used, but mostly these differences amounted to only 2 to 5cm. Average stem weights (after trimming to 60cm-length) were slightly greater under 'Aster TR' and when retardant was used, but again these differences amounted to only 2 to 5g. There was no interaction between film type and retardant treatment. The average width of the lead bud, both at picking (8cm) and at the end of VL (14cm), was the same in all four treatment combinations. More importantly, the crop-out was only 54% under the 'SunMaster Smart Blue' film but 84% under 'Aster TR', the former effect due to there being more thin, light-weight and therefore unmarketable stems that failed to reach the required specification, and because a higher proportion of the crop produced only one to two usable stems, compared with two to three in the 'Aster TR' crop. The post-harvest life of the stems was unaffected by the film type, 22 days in all cases. Overall, the results indicated that the 'SunMaster Smart Blue' film was not suitable for growing this product. It caused the crop to grow more slowly, with a smaller percentage of the crop suitable for market, compared to the standard 'Aster TR' film.

Discussion

Context of the project

It was recently estimated that there are approaching 400,000 species of known flowering plant species.⁴ Making the bold assumption that 1% of these might be thought of as attractive or interesting enough to be considered as cut flowers, we would be limited to 4,000 or so species. Of these, only a handful of species has risen to global pre-eminence as cut flower crops - rose, carnation, chrysanthemum, gladiolus and lily. A few dozen others make smaller but substantial contributions to the cut flower trade worldwide or regionally, and probably a few hundred more are traded as cut flowers in smaller quantities, often locally or by small growers catering for the more discerning customer.

Today, these figures are important to production horticulturists, because of the major shifts taking place in the pattern of cut flower production globally. In the West, after more than a century's development of the cut flower industry to a high level of competence, the production of the top-ranking species (rose, carnation, chrysanthemum, gladiolus and lily) has been taken up by producers in Africa and Central and South America, capitalising on their lower labour costs, climatic advantages and improvements in transporting fresh produce in bulk. Some producers in the West will probably still be able to compete, perhaps through automation, mechanisation, better cultivars and business acumen. Many other flower growers across Europe and North America are cutting-back on the mainstream crops that have been their preserve for many decades, with forward-looking growers seeking alternative, 'novel' or unusual cut flowers to fill the void - which is where the CFC project comes in. The essence of the project is to gather *information* on novel crops, *introduce* and trial species deemed suitable for the UK, and seek *improvement* in the husbandry of cut flowers generally.

⁴ Lucas N, Joppa DL, Roberts S & Pimm L (2010) How many species of flowering plants are there? <https://doi.org/10.1098/rspb.2010.1004>

Globally, it is difficult to imagine changing fortunes amongst the five top-ranking cut flower species, but, amongst the secondary group, it is known that markets can sometimes be re-shaped relatively easily, and sometimes relatively quickly: for example, consider the rise to popularity of sunflowers and ornamental brassicas. This flexibility could afford opportunities for innovative businesses to consider growing cut flowers that are alternative, 'novel', unusual or unfamiliar, perhaps just in their particular country or region, whilst continuing production of their established crops such as (in the UK) column stocks, tulips, lilies, sunflowers, sweet william, peony, gladioli and daffodils.

Prospects for crop introductions

In assessing the potential of a novel cut flower crop, the key factors that should be taken into account are listed below.

- The cost of planting material (especially of tissue-cultured and PVR/PBR plants), any specific husbandry or handling costs, the yield of marketable stems and the percentage of plants producing marketable stems. *The return from the buyer must be high enough to generate a margin commensurate with the grower's costs and reasonable margins.*
- The stems should have sufficient length (generally 40–65cm, depending on straight-line or bouquet use) and weight, and should be strong and robust enough to support the inflorescence and withstand the stresses of picking, handling and transport.
- At least 85% of the plants should produce a marketable stem or stems, depending on the sales price per stem.
- The product should be free of any properties that make picking and handling, or handling by the end-user, difficult or unpleasant (spines or superfluous foliage that need to be removed, bleeding sap, excessive pollen, unpleasant aroma (or excessive scent) and risk of allergy or other harm to humans and creatures.

- Ideally, the crop should be free of the need for any specific, additional husbandry, such as pinching, training or applying growth retardants, but such attributes would not rule out the crop being commercialised.
- Once in the end-user's vase and properly supplied with water and flower-food, the flowers, stems and (if present) foliage should remain in an acceptable condition for a minimum of five to seven days, ideally the vase-water remaining clear over this period.
- Whether the crop is an annual or a perennial and is sufficiently hardy for the locality and the situation where it is to be grown, such as outside in beds or straight in the field, in a polythene tunnel (noting that plastic film is usually removed from Spanish tunnels over winter) or cold glass or similar options.

How do the 39 species (or groups of species) tested in this project meet the above requirements? Based on our findings, they have been grouped in Table 23 by their prospects as novel commercial crops (or new cultivars to reinvigorate existing crops) for UK cut flower growers. Six 'prospect groups' were defined:

- *High prospects (and already being grown commercially)
- High prospects (and could be grown now)
- Good prospects (but there are some specific issues)
- Encouraging prospects (but more data needed)
- Low prospects (despite having no specific failings)
- Poor prospects (because of specific failings)

Only ten subjects, 26% of the 39 species/groups included, were classed as having high prospects, but it should be noted that three of these were large groups comprising several or many individual species – ornamental grasses, seed-raised fillers and woody foliage. A further ten species/groups were classified as having good or encouraging prospects, indicating the need for further trials. A surprisingly high number of the species/groups, 19 in all (49% of the total) were classed as having low or poor prospects. After Table 23 each species/group is briefly considered in their

prospect group.

Table 23. Prospects of novel crops for commercial cut flower production in the UK

Prospects	Crops	Issues
☺☺☺☺☺ *High... and already being grown commercially	Ornamental grasses (bromus, chasmanthium, eragrostis, panicum, setaria, sorghum and stipa)	Some commercial plantings to be made in 2018; more species could be assessed
	Sedum	Significant commercial plantings have been made in recent years; grown in perennial beds outside there are no obvious problems
	Seed-raised fillers (ammi, anethum, anthriscus, bupleurum, daucus, euphorbia and ridolfia)	Bupleurum being grown and interest in growing others; trial other species; need better seed quality; clarify effect of euphorbia sap
	Solidago (new cultivars) 'Glory' series	Some known to have been planted; no specific issues
	Sunflower (new cultivars) including dwarf types	Already an established crop, with requirements for dwarf and improved types; cultivar trials likely to be an on-going need
☺☺☺☺ High... and could be grown now	Woody hardy foliage (e.g. hypericum, cotinus, photinia and symphoricarpos)	Substantial commercial plantings of hypericum, symphoricarpos and others made; huge range of alternative species
	Brassica (ornamental) (new cultivars)	Already an established crop with some alternative new cultivars now being grown; uncertainties over economics and VL need to be addressed
	Gypsophila (new cultivars) 'Xlence', 'My Pink' and others	Improved cultivars grow well in tunnels with no apparent issues
	Scabious	Productive with good colour range and VL; need to study effects of high temperature on premature budding, high proportions of short stems and hardiness across range of cultivars

Prospects	Crops	Issues
	Trachelium regular types (e.g. 'Lake Forrest' and 'Lake Michigan' series) and novel cultivars ('Briba Green')	Vigorous, well liked, better quality than imported product but more expensive planting material, so needs to get reasonable returns from supermarkets; investigate yield manipulation, e.g. by pinching
☺☺☺ Good... but there are some specific issues	Craspedia	Good, straight-stemmed cultivars available; other cultivars may be weak-stemmed and suitable for once-over cropping; limited colour range
	Delphinium, Belladonna Group (new cultivars) 'Trick' and 'Waltz' series, 'Tango Dark Blue'	Trials helped growers with other new cultivars, interest from markets but problem of getting reasonable returns from supermarkets; virus-like symptoms in 'Trick' series unresolved; varietal differences in response to ethylene
	Eremurus	Investigate growing-on rhizomes to recoup high costs; need data on cultivars, VL, longevity
	Gomphrena	Investigate once-over cropping to reduce costs; study cause and remedy of inconsistent stem length; trial further cultivars for consistent stem length and bright colours
	Ranunculus (new cultivars) 'Rococo' series	Impressive crop but doubts over adequacy of stem length and colour range; other cultivars could be trialled
	Veronica (new cultivars) 'Skyler' series	Superior quality hindered by short production, investigate season extension; need VL data
☺☺ Encouraging... but more data needed	Asclepias	More data on cultivars, VL, hardiness, effects of sap
	<i>Aster ericoides</i> (September-flowering, double lines)	Need further work on seasonal extension (SD treatments, alternative growing systems, cultivar responses)

Prospects	Crops	Issues
	Lobelia	More data on cultivars, VL, hardiness, longevity, effects of sap
	Echinacea	More data on cultivars, VL, scheduling, tunnel/outside growing
☺ Low... despite having no specific failings	Caryopteris	Likely to be insufficient demand (else need VL, cultivar, hardiness data)
	Eryngium	No specific grower interest; if required beds could be planted to assess current cultivars
☹ Poor... because of specific failings	Annual carnations (new cultivars) 'Floristar', 'Solomio', 'Star' and 'Tiara' series	Expensive planting material, unlikely to get reasonable returns from supermarkets; trial other new series as available; check for possible flower abortion problems
	Annual pinks (new cultivars) 'Barberatus'	Expensive planting material, unlikely to get reasonable returns from supermarkets; trial other new series as available
	'Breanthus'	Premature budding and leaf scorch issues unresolved
	'Cocktail Pinks'	Stems too short for cut flowers
	'Green Trick'-type	Not taken up by industry, now supplied by imports
	Basil	Short less than five day VL; renewed interest in fragrant fillers makes trials of other cultivars and post-harvest treatments desirable
	Carthamus	Limited interest from industry; bract-tipping a problem
	China aster (cultivars to replace 'Krallen' and 'Gala')	No replacement cultivars identified; monitor cultivars now grown and any emergent series
	Cleome	Spines and aroma make handling difficult and might deter customers
	Cosmos	Short VL, vigorous growth adds to picking costs; watch for more suitable new cultivars
	Dahlia 'Karma' series	Poor VL, post-harvest treatments ineffective

Prospects	Crops	Issues
	Helipterum	Thin, weak, short stems, need improved cut flower cultivars
	Leucanthemum (new cultivars) 'Real' series	Poor performance in tunnel; could be further investigated with other cultivars, but no specific grower interest
	Lion's ear (<i>Leonotis</i>)	No flowers produced within the year; no specific grower interest
	Lupin	Striking flower spikes but less than five day VL; no specific grower interest
	Peppers, ornamental	Fruit did not ripen in tunnel; no specific grower interest
	Physostegia	Short-stemmed, less than five day VL; no specific grower interest
	Rudbeckia	Growth too unruly for commercial production; no specific grower interest
	Solanum 'Pumpkin-on-a-stick'	Eye-catching novelty with spines on stems and leaves that would have to be removed before sale; growers disinterested
	Zinnia 'Benary's Giant' and 'Oklahoma' series	Short five day VL hinders uptake, need work on post-harvest treatments

*High prospects (and already being grown commercially)

Ornamental grasses In recent years there has been more interest in using ornamental grasses as fillers for bouquets, and in growing them in the UK as tunnel or outside crops, either direct-drilled or from plug plants. The species and cultivars trialled were from the following genera: *Bromus*, *Chasmanthium*, *Eragrostis*, *Panicum*, *Setaria*, *Sorghum* and *Stipa*. All appeared relatively easy to grow, producing attractive heads in a great variety of forms. Tunnel-grown grasses benefitted from protection from the weather, but tended to grow very vigorously, while those grown outside also yielded marketable product. All cultivars tested remained in acceptable condition by vase-day seven. Of all of the recent CFC trials, the ornamental grasses generated most interest amongst growers, packers and

supermarkets. There would be several aspects to carry forward to further trials, such as screening further genera (including common cereals, as observed during the study tour to Israel in 2016), scheduling to ensure continuity and post-harvest work to guarantee a good VL. The management group feels the CFC has gone as far as it needs for the industry to develop the crop on a commercial scale, and indeed discussions with some growers and packers indicate that commercial quantities will be planted in 2018.

Sedum Several cultivars of sedum were grown as a perennial demonstration in outside beds. After weak growth in the planting year they were vigorous, with impressive stem counts, length and weight, and tests showed their VL was an acceptable seven days or more. Stems could be cropped at a range of stages, and have potential in bouquets and as straight lines. Numerous samples were made available to the industry, and significant commercial plantings have been made in recent years. No further trials are planned, but could be re-established if there is interest from the industry in further cultivars.

Seed-raised fillers Recent years have seen great interest in producing cheap seed-raised fillers in tunnels or outside. Trials with *Ammi majus*, *Ammi visnaga* (both species are available in a number of cultivars), *Anethum graveolens*, *Anthriscus sylvestris*, *Bupleurum rotundiflorum*, *Daucus carota*, *Euphorbia oblongata* and *Ridolfia segetum* showed that a range of attractive flower heads could be produced, with positive comments from growers. It is known that bupleurum is now being grown commercially, while others are grown by specialist producers. The most favoured were *Ammi* species and *Daucus carota* (ornamental carrot). Whether there are any specific risks associated with the milky sap of euphorbia species needs to be determined. It seems likely that most of these species could be grown successfully. A general problem in direct-drilling was poor or slow germination, leading to difficulties in establishing the desired plant spacings (and hence height and strength), so ideally

better quality seed is needed. Growth in tunnels could be over-vigorous and would need to be managed, while outside crops were subject to the effects of inclement weather. VL tests, mainly on *Ammi* species, found a long (more than 10 days) VL. The industry was keen to see further trials of fillers, and other species could be evaluated in further trials.

Solidago – new cultivars Solidago is a well known filler and only small stems are required, supplied cheaply from imports. Earlier trials produced long, heavy stems suitable only for bunch sales for which there is limited demand. Cultivars of the more recent 'Glory' series were trialled, and all produced high-quality stems, though tunnel-grown stems were too heavy for current requirements; outdoor-grown stems were suitable for current supermarket requirements. Interest amongst existing solidago growers was high and some new cultivars were planted in autumn 2017.

Sunflower – new cultivars It can be difficult to achieve a uniform plant stand and satisfactory restriction of stem growth from direct-drilling the still-fashionable sunflower. Many new cultivars have appeared in recent years, including naturally shorter cultivars which could reduce handling costs without the use of a growth retardant. In cultivar trials several shorter and/or more attractive cultivars were identified under tunnel conditions, where sunflowers generally grow taller. The sunflower is now an established crop and there will probably continue to be scope for testing new cultivars.

Woody foliage Cut foliage used to be imported, but the demand for a wide selection of woody foliage and flowering branches has now increased. Technologically, this crop is in its infancy, so a demonstration area for some popular types was set up, rather than attempting any trialling as such. After planting in 2010, marketable stems were cropped from 2012. Cotinus, hypericum, photinia and symphoricarpos were considered particularly effective. Marketable stems of cotinus, hypericum and symphoricarpos were sampled for VL testing, giving VL for *Cotinus* and *Hypericum*

cultivars varying from one to seven days depending on the hydrating solution used, and *Symphoricarpos* cultivars achieved an acceptable six days, but with considerable foliar wilting, and local growers have reported a longer VL. There has been distinct interest from the industry in this subject and it is known that substantial commercial plantings of hypericum, symphoricarpos and other hardy foliage have subsequently been made on UK nurseries. The scope for alternative species is huge, and some have been listed in AHDB Horticulture/CFC Information Sheet 8.

High prospects (and could be grown now)

Brassica (ornamental) – new cultivars Ornamental brassicas are an established crop in the UK, being grown in the field (for cheap but uncontrolled production), in tunnels (offering protection from weather and some season extension) and under glass (for a better product and a longer season). Recent trials have concentrated on the middle path of growing in tunnels, and several good, newer cultivars can be listed as alternatives to standard cultivars such as the ‘Crane’ series. New cultivars offer some alternative colouring and a range of head sizes, and may have different colouring-up responses and VL. ‘Crane’ cultivars do not always colour-up in mild weather, a problem noted in some commercial crops in 2015 and also observed with one of the newer cultivars in trials, and different cultivars may have different temperature requirements for this response. Post-harvest studies have given rather variable results, with VL between five and 17 days, with no obvious benefits of using various post-harvest treatments, or of re-cutting or not re-cutting stems when placing into vases, but VL may be adversely affected by longer holding periods before picking and sale. Clearly the issues of achieving a satisfactory VL and maintaining the vase-water in good condition are paramount for brassica. Understandably, growers can be unwilling to take on alternative cultivars at this time: they need to see a clear economic advantage to move away from growing the established cultivars.

Gypsophila – new cultivars Gypsophila is another well-known cut flower where the

availability of new cultivars could stimulate the market. Danziger has introduced many new cultivars that would be suitable for upgrading bouquets. They have advantages such as whiter flowers (e.g. 'Cosmic' and 'Xlence'), larger flowers (e.g. 'Xlence') or higher productivity (e.g. 'Dynamic Love'), and a new colour, 'My Pink'. They performed well with no evident issues, and could be taken up for cut flower production in the UK.

Scabious A well-known garden plant in the UK, scabious are not familiar here as cut flowers although they are grown successfully elsewhere, such as in the USA. CFC trials corresponded with the availability of new cultivars from Danziger (the 'Scoop' series) and HilverdaKooij. In 2016 'Scoop' cultivars were transplanted under a tunnel and into outside plots, quickly producing premature buds which were pinched-out, followed by vigorous growth. In the tunnel and outside, flowers were prolific and could be picked over a long period, but a high percentage of the stems were too short for marketing. In 2017 both series were trialled, the high temperatures in June leading to premature budding and necessitating pinching the plants twice. Growth was relatively poor and the prolific flower stems were generally short. Both series had an attractive range of colours, high yields and good VL, and were well received by the industry, having good potential for use by retailers in mixed bouquets. There were two significant issues to be followed up: the excess of short stems and the effect of adverse weather (especially high temperatures). The plant's response to temperature and pinching need to be evaluated, preferably in a range of cultivars as there is evidence for varietal effects on stem length. It was noted that, for the 'Scoop' series in 2017, growth was much better in trial at Greenmount (Northern Ireland), where the weather was cooler than in eastern England. Discussions with Danziger and other growers suggested that the crop needs to be planted in March or April to enable the plant to have produced an adequate framework leading to a good stem and root structure, before the potentially hot summer weather takes effect. They

appear more suited to growing in the protection of tunnels than outside, but the hardiness of the choice cultivars, presumably dependent on its ancestry, also needs to be understood.

Trachelium This is a crop currently grown by one or two growers in the UK. Regular trachelium cultivars were trialled and demonstrated this vigorous and attractive flower can be grown in tunnels to a standard excelling that of the imported product, some having given the crop a poor reputation because of petal browning and low weight. The UK product seems greener, taller and heavier. VL was long, 14–17 days. Interesting new cultivars are becoming available, for example the green-flowered 'Briba Green' which has also been successfully trialled. The higher cost of plants is deterring growers from trying trachelium, but it may be possible to reduce costs because the number of marketable stems can be manipulated by pinching, varying planting density and using different cultivars.

Good prospects (but there are some specific issues)

Craspedia Not well known in the UK, craspedia, with its slender, unbranched stems and ball-shaped clusters of yellow flowers, could make a novel cut flower for sales as fresh or dried flowers and as a filler in bouquets. Varietal choice is important, and in trials 'Paintball Globe' and 'Ellisse' were successful in a tunnel, giving large flushes of strong, tall flowers with straight stems and an acceptable VL. Disadvantages are the high labour inputs needed for picking (i.e. disentangling stems in weaker cultivars without causing damage) and its limited colour range. Ways of growing a more uniform crop should be investigated, so that labour-saving once-over cropping could be practiced.

Delphinium (Belladonna Group, new cultivars) Debate about whether there is potential for increasing delphinium cut flower production in the UK has continued from the early years of the CFC, when they were trialled extensively. More recently trials have been restricted to distinctive looking new series in the Belladonna Group,

grown as a tunnel crop. 'Sea Waltz', 'Sky Waltz' and 'Tango Dark Blue', with delicate flowers and elegant flower spikes and (in the series as a whole) a wide colour range. They were very productive, potentially giving three flushes a year. 'Trick Lilac', 'Trick Pink' and 'Trick Yellow', from another new series, were similarly trialled and also gave two or three flushes each year. Although more than adequate, plants of the Belladonna Group produce stems somewhat lighter than the traditional outdoor delphinium. Samples of the 'Trick' series had a good (over eight days) VL testing when 'Chrysal AVB' had been used, and, since the cultivars differed in response, there was evidence of varietal differences in sensitivity to ethylene. In 'Trick' delphiniums, virus-like symptoms were seen on leaves of the first flush each year, and this is still unresolved at present, possibly requiring investigation. The 'Trick' and 'Waltz' series and 'Tango Dark Blue' were considered to have good potential as straight bunches and for use in bouquets. However, the main issue, as with many other recent introductions, is the price of the plant material, which would necessitate a premium price for the stems, at present seeming most unlikely; they may be more suited to the florist market and as a niche crop for the artisan grower.

Eremurus Eremurus is known as a structural garden plant but is not well known as a cut flower – despite its stunning appearance which should raise its perception to that of a luxury flower. Three cultivars were grown in a tunnel over a two-year period, stems being sparse in the first year and increasing in numbers in the second. The tall (1.2m+) flower spikes made good use of the weather protection afforded by tunnels. The cost of planting material (rhizomes) is high and would need to be recouped via an appropriate return, perhaps by bulking-up the rhizomes *in situ* in semi-permanent beds. If taken up, further data would be needed on cultivar differences, the longevity of the crop and VL. They might also be a suitable crop for the artisan or niche grower.

Gomphrena Gomphrena is not known to be grown commercially in the UK, but its

brightly coloured flowers can be a valuable filler. Several cultivars of the 'Globosa' and 'Haageana' series were trialled as possible tunnel crops. Some crops appeared prone to producing stems too short to be marketable as a cut flower: in trials in 2016 all cultivars initially produced short stems, but after a few weeks they produced stems of marketable length. In 2017 only four selected cultivars were grown, and once again the early flowers were short-stemmed, but while the stem length of the two 'Haageana' cultivars increased through the growing season, stems of two 'Globosa' cultivars remained short throughout. 'Haageana' cultivars produced a large number of stems across an eight week period, and these had a good VL of seven days. This suggests that gomphrena 'Haageana', especially those with brighter colours, may have potential as a commercial cut flower or filler for the UK. Gomphrena generated a lot of interest in the industry for its potential as a filler. Experience may help to explain the lack of stem length, but trialling more cultivars could identify those with reliable stem length and the brightest colours.

Ranunculus – new cultivars Little grown in the UK, the 'Rococo' series appeared suitable for trialling in tunnels. They were productive, but the colour range available was limited. There was unresolved debate amongst growers as to whether the stems of 'Rococo' were long enough or otherwise suitable as a commercial cut flower, or was it purely suited as a garden plant. Further trials of 'Rococo' will depend on the agent. However, from the general appearance of the plots there is no reason why other established cultivars of this very attractive flower might not be trialled in future.

Veronica – new cultivars One series, 'Spark', was featured in earlier trials, but its lightweight stems and small production window made it unlikely to be economic to grow here. Following renewed interest, plots of the new 'Skyler' series were trialled. In a tunnel flowering was prolific, with straight stems and well coloured spikes, and overwintered they produced two flushes the next year. But the window of production was relatively short - seasonal extension would need to be investigated (by

scheduling and pinching) to gain the interest of growers. VL data is also needed.

Encouraging prospects (but more data needed)

Asclepias Asclepias is not known to be grown commercially in the UK but it is an attractive flower grown as a cut flower elsewhere. Grown in a tunnel *Asclepias curassavica* 'Apollo Orange' produced prolific and attractive, orange-red inflorescences on long stems, each plant producing one strong leader and five or more marketable side-shoots. Visually, it had obvious potential. In limited testing its VL was not acceptable owing to issues with water uptake, and this requires further investigation. The only other asclepias tested, *A. incarnata* 'White' initially grew well but the flower buds turned brown during development. Further information is needed on cultivars, VL and post-harvest treatments, hardiness (some are frost-tender, others fully hardy), and on any implications of its milky sap.

Aster ericoides (September-flowering) A familiar, cheap filler, the advent of new double-flowered lines raised the possibility of a better quality product - perhaps even as a straight line. Growers expressed interest in seasonal extension of the new cultivars, which should be achieved in this SD plant by using blackouts during summer. SD treatment was successful in advancing flowers of high quality, if used at the right stage of growth and possibly only with some cultivars. Second flushes were also produced, though these were short-stemmed and the growing period in a Spanish tunnel was restricted (because of the need for de-skinning tunnels before winter), but should be achievable under cold glass or perhaps in a fixed tunnel. But, given market interest, it may be worth considering starting the plants in pots and planting pinched plants with side-shoots already present in order to reduce growing time. So far the product has not yet been taken up by commercial growers, but is grown in small quantities by artisan growers.

Lobelia Lobelia is not known to be grown commercially in the UK, but is popular in some other countries. 'Queen Victoria' and *L. siphilitica* grew well in a tunnel, having

few flowers in their first year but flowering well in the second. 'Queen Victoria' produced attractive, bright red inflorescences on substantial, long, strong stems having a good VL of 10 days. *L. siphilitica* was also attractive, with bright blue flowers (no VL test available). Both cultivars had potential, but further trialling is needed, covering a range of the taller species and cultivars and avoiding the few that are not fully hardy. Whether there are any practical implications arising from its milky sap would also have to be determined.

Echinacea Echinacea is not known to be grown commercially in the UK but it makes a colourful cut flower better known elsewhere. The two cultivars tested grew well in a tunnel, were easy to grow, and had bold flowers (available in a range of colours) that visually indicated obvious potential as a cut flower. Flowering in the trial was sparse and late, but the perennial was planted late and was in its first year. Further information is needed on scheduling, growing outside, cultivars and VL. Perhaps echinacea should be tested in association to rudbeckia, which is similar.

Low prospects (despite having no specific failings)

Caryopteris Caryopteris is not known to be grown commercially as a cut flower in the UK. Three 'Pagoda' cultivars were trialled in a tunnel where they grew well and flowered prolifically and into October, with resultant interest from growers, particularly for 'Pagoda Lagoon' with its rich blue flowers. Although caryopteris is generally considered fully hardy, some types evidently need winter protection, the trial plants not surviving winter 2016/2017. Accounts describe caryopteris as having aromatic foliage and flowers, though our evidence from earlier trials was that some people found its aroma unpleasant, but this issue was not raised during the recent trials: there may be variations between cultivars or in human perception. Despite the interest of the industry, it was considered unlikely to attract a large demand at present. There may be a case for further cultivar trials, including tests for winter hardiness and aroma), but basic VL tests would also be needed before any

conclusions can be drawn about its potential.

Eryngium Popular thistle-like flowers used in mixed bouquets and arrangements, eryngium is not usually grown commercially in the UK. Several cultivars were planted in a tunnel and outside to assess their hardiness and potential flower yield when left down as a perennial crop. This indicated that growing outside with a protective mulch was the better option: growing in a tunnel the plants became unmanageable after two years. There was no specific grower interest, but, should more interest be shown in the future the currently available cultivars could be planted in a perennial bed to assess performance.

Poor prospects (because of specific failings)

Annual dianthus (spray carnations) – novel cultivars Although spray carnations are a supermarket staple, novel cultivars could give UK growers the opportunity to produce a premium product while not competing with imports. Cultivars of the ‘Floristar’, ‘Solomio’, ‘Star’ and ‘Tiara’ series, all with distinctive flower forms compared with the standard product, were trialled and received positive feedback from the industry. However, they would need to be branded accordingly and receive a premium covering the higher cost of the planting material and operations such as pinching, and unfortunately getting reasonable returns from supermarkets is unlikely. If that were successful there would be scope for further cultivar screening, including for flower bud abortion which occurred in some cultivars.

Annual dianthus (pinks) - novel cultivars Annual pinks used to be an important part of UK commercial cut flower production, but have now become much reduced in area. When new cultivars that are substantially better than, or different to, the older ones, become available, this can revive interest in a crop. Four new series of annual pinks were trialled during this project. The ‘Breanthus’ series, with large, spherical flower heads, received a positive response from growers. However, premature budding and leaf scorch became problematic in some ‘Breanthus’ cultivars, and, as

the disorders have not been resolved, they are now only grown on a limited scale; further work is unlikely unless resistant cultivars become available. Several green-flowered cultivars - 'Green Trick' and others – also became available. With striking bright green flower-heads, they were well liked by growers, but there was little enthusiasm to grow them; soon, similar dianthus were being imported from the Netherlands and there was no incentive to grow them here. Whetman's 'Cocktail Pinks' - 'Cherry Daiquiri' and others – with delicately coloured flowers, were also trialled, but, while suited as garden pinks, their short stems (25–35cm long) made them unsuitable as cut flowers. Finally, in 2017, plants of a new line, 'Barberatus', came onto the market and were trialled. These were appreciated by growers and packers alike, but at present the economics do not stack up for a supermarket product: the planting material is expensive and supermarkets will not pay any more than for an ordinary sweet william.

Basil There was interest from the industry in growing basil as a fragrant filler for mixed bunches and bouquets. In trials several cultivars produced attractive foliage and flowering stems, but all had an unacceptable VL (less than five days). No further trials were contemplated, but in 2017 there was renewed interest in 'scented' fillers so there may be a case for further trials of selected cultivars, investigating conditioner treatments to enhance water uptake, and growing outside to produce harder plants.

Carthamus The thistle-like flower heads of carthamus are appreciated as an unusual and sturdy filler, and it is grown commercially on a small scale in the UK. Direct-drilling representative cultivars over a wide range of dates in a tunnel and outdoors produced good, marketable stems. Samples gave a good VL of seven days. Quality can be spoiled by bract-tipping and, if grown more widely, would need to be resolved. There appears to be limited industry interest in carthamus, so further work at present is not justified.

China aster – new cultivars Callistephus or China aster is an important outdoor

summer cut flower in the UK, continuing to be dominated by the 'Matsumoto' spray type. The advent of 'Krallen' and 'Gala', a new series of large-headed china asters with vibrant blooms and their trialling at the CFC resulted in large-scale take-up by the industry. Later, petal spotting and browning of the flower tip appeared, and the cultivars quickly lost favour. To identify possible replacements many other series of china aster were trialled, but despite some excellent features none equalled the quality of 'Krallen' or was able to displace 'Matsumoto'. There do not appear to have been any developments towards understanding or remedying the flower disorders of 'Krallen'. There may be opportunities to assess new cultivars as they come along.

Cleome Trials demonstrated that cleome is very attractive, prolific with an unusual flower, but has the disincentives of spines and an aroma that make them difficult or unpleasant to handle and unsuitable for supermarket sales. They may be suitable for niche markets such as to florists for use in specialised situations where the flowers will not be handled by customers.

Cosmos Well known in gardens, there is a huge range of cosmos cultivars from which to choose. Making a surprisingly robust bunch despite the plant's feathery appearance, it is disappointing that it is ruled out as a supermarket cut flower by an only just acceptable (five day) VL. Cosmos would, however, have a place in direct sales, where a shorter VL can be tolerated. Its vigour, especially when grown in a tunnel, is another disadvantage when maintaining or picking the crop. Further, the lead bud develops and opens some time before the subordinate buds, so picking with the first bud open gives disappointing results; removing the lead bud would be effective, but this is a time-consuming job for a low-value crop. If more suitable new cultivars appear, it would be worth trialling them.

Dahlia As a commercial flower crop, dahlias are usually considered to have a poor VL, but the 'Karma' series was bred for a longer VL. Tunnel and outside plots demonstrated the range of brilliant colours and flower forms available in the series,

and trials were directed towards VL testing. Tests of conditioning treatments were disappointing, the flowers failing to reach the minimum guaranteed VL of five days.

Helipterum Helipterum is not known to be grown commercially as a cut flower in the UK. Two cultivars grown in a tunnel produced large flushes of flowers, but their stems were thin, weak and short and the flowers small, discounting them as a cut flower. Further trials would only be carried out if stronger cultivars became available. Helipterum may have a place for specialist growers as a dried flower.

Leucanthemum – new cultivars Trials were set up to demonstrate a new range of cut flower leucanthemum, the 'Real' series. Although perennial and fully hardy, these cultivars did not thrive when planted in a tunnel, with premature budding, short stems and some 50% plant losses overwinter. There was no specific grower interest, but if other cut flower cultivars become available they could be trialled.

Lion's ear *Leonotis* is a South African plant being introduced to cultivation, and four likely cultivars were identified for trialling. Although vigorous, only *L. leonurus* 'Staircase' had produced buds by the end of the season, too late to develop further in a tunnel. Since it has been grown successfully in trials in other European countries, it is likely that it could be commercialised in the UK, but this may be a large effort for unknown returns. There was no specific grower interest, but it may be suitable for a specialist nursery.

Lupin In the UK the lupin is a familiar garden plant and may seem an unlikely choice as a commercial cut flower, though research in the USA showed that some species and cultivars can be successful. 'Gallery' and 'Russell' cultivars planted in a tunnel and outside slowly produced stems over a long period. Left to overwinter many plants failed to survive (although classified as fully hardy perennials), but their flower spikes were striking in quality and wide range of colours. For marketability, the tunnel-grown stems were longer. An unacceptable (less than five days) VL was reported, and primarily because of this no further trials were planned. This conclusion

might be challenged if there were industry interest in testing post-harvest conditioners and trialling a wider range of plant material, but no specific grower interest was evident.

Ornamental peppers Ornamental peppers proved to be successful novelties in the USA, and two cultivars were trialled here. Both were slow-growing, but eventually produced large, strong plants on which some fruits developed - but did not ripen by the time the tunnel was de-skinned. This slow development under UK conditions suggests that ornamental peppers, like their edible equivalents, may be a crop for heated glass, or, alternatively, might simply be a case for earlier planting. Given there was no specific grower interest, no further trials were planned.

Physostegia Another crop seen as a potentially useful cut flower in trials in the USA was physostegia. Only a few cultivars are available, and one ('Crystal') was trialled. It proved short-stemmed and late flowering, and in VL testing the stems failed on day two. In this case it appeared unsuitable as a cut flower, and, as no specific grower interest was evident, no further trials were planned. This could change if more suitable cultivars were to become available.

Rudbeckia Rudbeckia is another well-known garden plant with potential as a cut flower. Despite the attractiveness of the flowers, earlier trials of annual *Rudbeckia hirta* 'My Joy' and 'Green Eye' showed that growth was too vigorous and unruly to be practical for commercial cut flower use. More robust perennials, *R. laciniata* 'Goldquelle' and 'Herbstsonne', were later trialled, and showed some market potential, but they too were considered probably unsustainable as commercial cut flowers because they were too vigorous and unmanageable. See also the section on the similar genus *Echinacea*.

Solanum 'Pumpkin-on-a-stick' An unusual novelty that can be eye-catching, with its bright red 'pumpkins', this ornamental solanum produced very sturdy stems and fruits. But they have vicious spines on stems and leaves that would probably have to

be removed before marketing, so the product could only be considered by a specialist grower who could sell them at a premium price. The mainstream industry was unimpressed.

Zinnia Several years of zinnia trials showed that the 'Benary's Giant' and 'Oklahoma' series were superior to other cultivars trialled because of their overall vigour, attractive flowers, wide range of colours and long stems, but zinnia's VL is problematic as the hollow stem often bends just below the flower. In post-harvest tests the VL was only a just acceptable five days. Picking stage and post-harvest experiments have failed to find a reliable means of increasing VL. The results appear to show that, under some circumstances at least, zinnias are capable of a just acceptable, borderline and unpredictable, VL. Further experimental treatments are planned.

Improvements through how crops are grown

As well as introducing new or unfamiliar crops to the cut flower industry and their customers, novel products can be introduced by adapting how we grow and present an established crop. Thus the concept of growing a relatively low-cost, seasonal alstroemeria crop of older (non-PVR/PBR) cultivars in Spanish tunnels, was tested on the trials site, and in fact achieved a surprisingly high level of quality compared with the typical alstroemerias produced under glass. It is understood that a couple of growers are trying this system on a small scale. Some resources were allocated to lever additional return from projects on herbicides that could be used on cut flower crops as replacements for withdrawn products, a topic of high concern to growers. Similarly, some work from AHDB Horticulture's cross-sector fusarium project, focussed primarily on onions, can now be carried out on column stocks at the CFC site. The CFC was able to take advantage of materials provided by commercial sources to build on the project for growing lilies in peat-free or reduced-peat media. Trials have shown that, for example, that lilies of at least the quality of those grown in

plain peat media, can be produced by growing in a peat and aerobic digestate (AD) growing medium containing as much as 60% of AD. The CFC was also able to facilitate a review of the factors responsible for unreliability in the current production of column stocks (AHDB Horticulture PO 005) and trials on the production of column stocks in hydroponic systems (AHDB Horticulture PO 005). These efforts were in direct response to the needs of growers.

Further developments in applied cut flower research

In considering the future direction of levy-funded cut flower R&D, it is clear that new cut flower and foliage crops have plenty to offer markets. Even with the established crops there are general issues that need to be investigated. A new programme of work has been agreed by the AHDB and the CFC Management Group is currently developing both new product development as well as trials to address specific crop issue such as herbicides and the control of fusarium.

Knowledge and technology transfer

Assisted by holding topical events and preparing technical articles and handouts, the easy style of the CFC's annual open days appears to have succeeded as a popular venue encouraging good rapport between growers and the project team. This has allowed rapid communication of the results of trials and feedback about the needs of the industry. As an example, in summer 2013 the Project Leader visited some 100 cut flower growers across the British Isles, and at over half of these businesses the growers initiated discussions on the work of the CFC, seeking further information about the results obtained and the future trials programme. Another factor has been the availability of samples of novel products from trials for growers and packers to discuss with their customers, drawing their attention to the quality and variety of cut flowers that can be grown successfully in the UK either in 'Spanish' or similar polythene tunnels or outdoors. The major example of knowledge transfer from the project, however, is the take-up on a commercial scale of several novel crops following their trialling by the CFC, such as antirrhinum, bupleurum, hypericum, lisianthus, salix, sedum, symphoricarpos and trachelium. Of course, commercial confidentiality will routinely prevent the full disclosure of such financial benefits arising from the project.

Website

The Centre's website includes a weekly blog which keeps growers up to date about what's happening at its trials site at Rookery Farm. The site carries news of events, notifications of handouts, reports and leaflets, and the latest Extensions of Authorisation for Minor Use (EAMUs). Copies of reports, handouts and leaflets, and further details of events, listed below, are available on the CFC⁵ and AHDB-Horticulture⁶ websites.

⁵ <http://www.thecutflowercentre.co.uk/>

⁶ <https://horticulture.ahdb.org.uk>

Events

The CFC Open Days have consistently attracted 80–100 attendees, and in some cases a very high percentage of the growers of particular crops (e.g. it is estimated that some 95% of the UK's column stocks growers attended an event where column stocks were highlighted).

- *AHDB/CFC Forced Tulip Event*, Winchester Growers, Nocton, Lincolnshire, 10 April 2013
- *CFC Open Day*, JA Collison & Sons, Terrington St Clement, Norfolk and Rookery Farm, Holbeach St John, Lincolnshire, 1 August 2013
- *AHDB/CFC Lily Technical Event*, Winchester Growers, Pinchbeck, Lincolnshire, 11 September 2013
- *AHDB/CFC Tulip Mechanisation Study Tour*, the Netherlands, 25-26 February 2014
- *AHDB/CFC Dutch Lily and Column Stock Study Tour*, the Netherlands, 20-21 May 2014
- *CFC Open Day*, EM Cole (Farms), West Pinchbeck, Spalding, Lincolnshire and Rookery Farm, Holbeach St John, Lincolnshire, 6 August 2014
- *AHDB/CFC Field-grown Sweet William Herbicide Event*, Belmont Nurseries, Terrington St Clement, Norfolk, 24 September 2014
- *AHDB/CFC Ornamental Cut Brassica Production Study Tour*, Multi Color Flowers, Takii Europe and grower visits, the Netherlands, 8-9 October 2014
- *CFC 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

- *CFC Open Day*, JA Collison & Sons, Terrington St Clement, Norfolk; National Centre for Food Manufacturing, University of Lincoln, Holbeach, Lincolnshire (vase-life test facility) and Rookery Farm, Holbeach St John, Lincolnshire, 10 August 2016
- *AHDB/CFC Optimising Crop Nutrition and Understanding Soil Steaming Techniques Workshop*, Whaplode Manor, Saracens Head, Spalding, Lincolnshire, 30 November 2016
- *AHDB/CFC Cut Flower Study Tour*, Israel, 9-13 January 2017
- *CFC 'Rococo' Ranunculus Open Day*, Rookery Farm, Holbeach St John, Lincolnshire, 2 May 2017
- *CFC Open Day*, Rookery Farm, Holbeach St John, Lincolnshire, 9 August 2017
- *AHDB/CFC Soil Health for Protected Cut Flowers (a GREATsoils Event)*, Rookery Farm, Holbeach St John, Lincolnshire, 28 September 2017

Articles

- *Firm future for cut flower R&D*, L Mason, HDC News 194, pp16-18, 2013
- *Cut Flower Centre [Open Day report]*, HDC News 196, pp10-11, 2013
- *Crops and techniques for UK flowers*, HDC News Supplement, Ornamentals Review 2013, p25, 2013
- *New breeding in trials at Cut Flower Centre*, L Mason, Commercial Greenhouse Grower, September, 2013
- *World of flowers on trial*. HDC News 199, p22, 2014
- *Forced through technology [Study Tour report, Dutch automated forced tulip production]*, W Brough, HDC News 202, pp19-21, 2014
- *Performance tested through to the vase*, L Mason, HDC News 202, pp22-23, 2014
- *Opening doors in the Netherlands [Study Tour report, Dutch growing and breeding of lilies and column stocks]*, W Brough, HDC News 205, pp16-17, 2014

- *A-Z at the CFC*, C Shaddick, HDC News 206, pp28-30, 2014
- *A bouquet of brassicas [Study Tour report, Dutch ornamental brassica production]*, W Brough, HDC News 208, p15, 2014
- *New crops, new techniques*, L Mason, HDC News 212, pp15-17, 2015
- *Flowers find their herbicide partners*, J Atwood and C Whiteside, HDC News 213, pp22-23, 2015
- *Investigating the shifts in flower production*, AHDB Horticulture Grower 215, pp 8-19, 2015
- *New technique floated at Cut Flower Centre*, C Shaddick, AHDB Horticulture Grower 216, pp28-30, 2015
- *Working it out with water*, L Mason, AHDB Horticulture Grower 219, pp19-21, 2015
- *Herbicides: the search continues*, AHDB Horticulture Grower Supplement, Ornamentals Review 2015-2016, p10, 2016
- *Cut flowers trialled on water*, AHDB Grower Supplement, Ornamentals Review 2015-16, p22, 2016
- *Interest sparked in new flower lines*, AHDB Grower Supplement, Ornamentals Review 2015-16, p23, 2016
- *Cut flower trials highlight potential new lines*, AHDB Horticulture Grower 220, p11, 2016
- *A head start for flowers*, J Atwood, C Whiteside and E Worrall, AHDB Horticulture Grower 221, p20-22, 2016
- *A testing summer*, L Mason, AHDB Horticulture Grower 224, pp16-18, 2016
- *All the way from nursery to vase*, C Shaddick, AHDB Horticulture Grower 226, pp19-21, 2016
- *Growers successfully challenge Dutch cut flower growers*, B Sherer, Commercial Greenhouse Grower, December 2016, pp13-15, 2016

- *Novel crops, new techniques*, L Mason, AHDB Horticulture Grower 233, pp19-21, 2017
- *A cut above*, S Gunn, The Grower (AHDB), 236, pp26-27, 2017

Leaflets and other publications

- *Summary of the Cut Flower Centre (CFC) trial examining the susceptibility of different varieties of column stocks (Matthiola incana) to fusarium wilt*, L Mason, AHDB/CFC Information Sheet 4, 2013
- *Field- and tunnel-grown cut flowers with potential for UK exploitation: a review of trials programmes and research in 'novel' subjects*, G Hanks, AHDB/CFC Report, 2013
- *The National Cut Flower Trials Centre & UK Cut Flower Growers' Association*, L Mason and G Hanks, AHDB/CFC Flier, 2014
- *Snapdragons (Antirrhinum majus) as a cut flower crop grown in polythene tunnels*, G Hanks & CFC management group, AHDB/CFC Information Sheet 5, 2014
- *Lisianthus (Eustoma grandiflorum) as a cut flower crop grown in polythene tunnels*, G Hanks & CFC management group, AHDB/CFC Information Sheet 6, 2014
- *Cut flower seed and young plant suppliers directory*, G Hanks, AHDB/CFC Report, 2014
- *Cut flower seed and young plant suppliers' directory (revised)*, G Hanks, AHDB/CFC Report, 2015
- *Field- and tunnel-grown cut flowers with potential for UK exploitation: a review of trials programmes and research on 'novel' subjects (revised)*, G Hanks, AHDB/CFC Report, 2015
- *A review of production statistics for the cut flower and foliage sector 2015*, G Hanks, AHDB/CFC Report, 2015
- *Delphinium as a cut flower crop grown in Spanish tunnels*, G Hanks, L Mason & CFC management group, AHDB/CFC Information Sheet 7, 2016

- *Field-grown woody cut foliage crops*, G Hanks, L Mason & CFC management group, AHDB/CFC Information Sheet 8, 2016
- *Sunflowers (Helianthus annuus cultivars) as a cut flower crop grown in tunnels and outside*, G Hanks, L Mason & CFC management group, AHDB/CFC Information Sheet 9
- *Alstroemeria (Alstroemeria hybrids) as a cut flower crop grown in tunnels*, G Hanks, L Mason & CFC management group, AHDB/CFC Information Sheet 10

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