Project title:	**The National Cut-flower Trials Centre Programme for 2013 - 2017**
Project number:	**PO/BOF 002a**
Project leader:	Lyndon Mason (Director, The Cut Flower Centre Ltd)
Report:	Annual Report (2013)
Previous report:	None
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Location of project:	R Robinson & Son Rookery Farm Joys Bank Holbeach St John Spalding Lincolnshire PE12 8SG Other commercial nurseries by arrangement
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Date project commenced:	01 January 2013
Date project completed (or expected completion date):	31 December 2017

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

AUTHENTICATION

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

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Grower Summary

Headline

- Reduce column stock losses from Fusarium wilt by eliminating susceptible varieties.
- Consider using the 'Anytime' series of column stocks for late production.
- For a novel outdoor cut-flower species with high-quality stems, the various *Sedum* varieties examined have proven successful.
- For hardy foliage production the *Hypericum* and *Symphoricarpos* varieties evaluated at CFC have generated interest.
- In lily growing, reduce costs by using a 1:1 mix of peat and quality checked 'green-compost'.
- For specialist projects, consider 'Breanthus' and 'Solomio' carnations, *Eryngium* cultivars and the 'Benary's Giant' series of *Zinnia*.

Background

The UK traditionally had a relatively low *per capita* consumption of cut-flowers compared with other western European countries, but between the late-1980s and early-2000s its imports of cut-flowers rose from some £125 m to around £550 m. Over the same period the value of UK-grown cut-flowers remained static at around £50 m, the bulk made up of glasshouse crops (including forced bulbs) and field-grown daffodil, but including some £5 m to £10 m annually of outdoor crops such as natural-season chrysanthemum, sunflower and peony.

In the 1990s the advent of relatively cheap Spanish tunnels, the increasing UK market for cut-flowers and environmental demands to cut 'air-miles', should have provided UK cut-flower growers with an opportunity to expand production. That this did not happen is anecdotally ascribed to (a) a lack of 'know-how' and (b) a culture of buying-in from 'across the water'.

To provide information on alternative or 'new' cut-flowers for production outdoors or under Spanish tunnels in the UK, a cut-flower trials project was proposed by industry representatives and funded by the HDC, starting in 2007. The longer-term aim was to stimulate UK cut-flower growers to develop and commercialise new products and new markets.

The current funding package provided by the HDC has enabled the Centre to enhance its role by taking on a 'crop association' role and developing a cohesive voice for the R&D

needs of the UK cut-flower industry. It has also extended its role beyond new product development to develop and facilitate trials on mainstream and bulb crops.

Summary

Information gathering

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

Novel crops

Six new cut-flower crops were selected for testing in 2013: basil, cosmos, *Leonotis*, lupin, *Trachelium caeruleum* and *Zinnia*. Work on three further crops was prioritised for 2014: cut-flower gentians (*Gentiana asclepiadeum* and others), *Dicentra spectabilis* (bleeding hearts) and *Helleborus* species (hellebores).

Basil (*Ocimum basilicum*) can contribute a fragrant filler to mixed bunches and bouquets, and four cultivars, 'Dark Red Opal', 'Floral Spires Lavender', 'Floral Spires White' and 'Sweet Dani Lemon', were grown in a Spanish tunnel and an outside bed. The plants produced dense foliage, perhaps too soft, but flowering stems taken for vase-life testing had an unacceptably short vase-life.

Cosmos (*Cosmos bipinnatus*) are well known garden plants that may appear too wispy to be adapted as a cut-flower, but have been widely trialled in the USA. Cultivars from the 'Piped Piper', 'Razzmatazz', 'Sensation' and 'Sonata', series, and the cultivar 'Antiquity' were grown in a Spanish tunnel and in outside beds. Growth was vigorous and unruly and might require controlling through cultural or chemical means, but flowering was prolific with a good range of colours and forms. Cut-flower cosmos could be seen in the context of 'monthly bouquets' (bouquets in which variety is introduced regularly by changing the fillers), if grown cheaply as an outside, drilled crop picked over a short season.

Leonotis leonurus is a South African plant being introduced to cultivation, having attractive orange flowers, an aromatic scent and apparently easy to grow in various regions. *Leonotis* 'Staircase' was grown in a Spanish tunnel, growing vigorously and flowering late in summer. In this form *Leonotis* would be difficult to handle, but the plants have been cut-back to grow-on next year, which research suggests may lead to more manageable growth. Shorter

species, such as *L. mollis*, will be evaluated in 2014.*Lupinus harvardii* and *L. densifolius* are natives of Texas producing attractive, tall blue flowers with potential as a new specialty cut-flower, and some improved selections have been made. However, it was not practical to obtain material of these new introductions, perhaps because of commercial sensitivity. As an interim measure, cultivars of the 'Gallery' and 'Russell' series of *Lupinus polyphyllus* were grown in a Spanish tunnel and in outside beds. The plants established well and produced good numbers of stems over a long period. Their full potential as cut-flowers will be assessed in 2014.

Trachelium caeruleum is not well known in the UK though widely grown in the Netherlands. Seed of several cultivars was sown but failed to germinate, despite no special requirements being apparent. Therefore plug-plants of cultivar 'Corine Purple', were grown in a Spanish tunnel; these grew well and producing an attractive display. With its colour and form, *Trachelium* may have potential for UK production, and the trial will be repeated in 2014 using plug-plants.

Unlike the other species in this 'new crops' section, *Zinnia* (*Zinnia elegans*) has been grown previously at the Centre, when the industry was enthusiastic about the flowers with their wide range of cheerful colours, though vase-life was poor due to the hollow stems which collapse and bend in the neck. However, in some trials in the USA *Zinnia* such as 'Benary's Giant Lime' were rated as most dependable. Several cultivars of the 'Oklahoma' and 'Benary's Giant' series were grown in a Spanish tunnel and in outside beds. When the plants were only a few inches high premature buds became visible on all plants; after pinching-out the buds the plants grew away vigorously. The 'Benary's Giant' varieties were stronger and attracted more interest than 'Oklahoma', but even the latter were considered far superior to the *Zinnia* cultivars previously grown at the Centre. Samples of 'Benary's Giant' varieties were used for vase-life testing and showed markedly less stem bending than the earlier cultivars, and vase-life appeared amenable to improvement by using other conditioning solutions immediately after picking.

Crop improvement: 1. Aster, September-flowering (*Aster ericoides*)

Aster ericoides are currently imported as a relatively cheap filler using the single-flowered 'Monte Casino' types. But the introduction of new double-flowering breeding lines has the potential to open up a new market. Previous trials had generated market interest in *A. ericoides* grown as a pinched, tunnel grown crop for September/October flowering, possibly augmented by seasonal extension. Floral initiation can be delayed by blacking-out the crop for part of the day, and plots planted in 2012 and left *in situ* in a Spanish tunnel and outside

beds were used in 2013 to investigate the use of blackout covers. The cultivars were 'Blue Tail', 'Capetown', 'Cassandra', 'Cassy', 'Chicago', 'Cirina Dark', 'Double Fun Blue', 'Double Fun Pink Dark', 'Double Fun White', 'Linda' and 'Pretty Wendy'. Blackout covers were placed over the plots for 13 hours a day from week 22 to week 31. By this time good-sized buds were present and about to show colour. Overall flowering was later than expected (mainly weeks 32 and 33), but the quality was superb. The second flush (early-November) was too short to be marketable. This experiment will be continued in 2014, with the blackout treatment beginning when the shoots are shorter (40 to 50cm-long).

2. Annual (or China) aster (*Callistephus chinensis*) ('bloom asters')

Annual asters are a mainstay of the UK outdoor summer cut-flower market, dominated by the 'Matsumoto' spray type. However, new series of large-headed China asters with vibrantly coloured blooms, the 'Krallen' and 'Gala' series, were introduced in Germany and became available in 2007, when demonstrations were planted at the Centre. They generated strong interest from growers and there appeared to be potential for commercialising them in the UK. This work opened up a new market for this alternative, large–headed, 'bloom' type of aster for summer production. As a result 'Krallen' cultivars were grown by local producers in quantity in 2009 and 2010, with 'Karthauser' and 'Perser' in great demand by supermarkets. Their vase-life consistently met or exceeded the guarantee of five days, but a severe petal-spotting problem occurred on the commercial plantings resulting in severe losses. Despite samples being submitted to numerous laboratories, the cause could not be determined and as a result 'Krallen' is unlikely to be grown again on any scale until this issue is remedied. Since then, trials have been carried out to find an alternative to 'Krallen'. Cultivars from the 'Beautiful Day', 'Harlequin', 'Jewel', 'Lady Coral' and 'Meteor' series were grown in Spanish tunnels, with two planting dates. The main cropping period for the early planting was week 32 to 34. Cultivars of the 'Meteor' and 'Harlequin' series gave taller plants, the remaining cultivars were shorter. For the later planting the main cropping period was week 39 to 41. All the cultivars had shorter stems than the earlier planting. Cultivars of the 'Harlequin' and 'Jewel' series gave taller plants, while the 'Beautiful Day' and 'Lady Coral' cultivars were shorter. Many of the cultivars tested had stem and flower attributes showing promise for greater use in the UK, and they were free of petal disorders. However, none was considered as outstanding or likely to provide an alternative for the favoured 'Krallen' varieties. The vigour of some types suggested that chemical growth regulator treatments might be beneficial, and they will be tested. No progress has been reported on the prevention of petal disorders in 'Krallen'.

3. Dianthus, annual (*Dianthus barbatus*), 'Breanthus' range

Annual dianthus are already available to the UK market, the main varieties being 'Amazon' and 'Sweet'. 'Breanthus' was introduced in 2012, with robust, voluminous flowers that stand out through their uniformity and spherical flower heads. In 2013 plants of 'Baron', 'Duke', 'Earl', 'Elmo', 'Findus' and 'Lord' 'Breanthus' were grown in a Spanish tunnel with two planting dates. One half of each plot was pinched two weeks after planting. A few premature buds occurred in mid-May. The first flowers were harvested mid-June and flowering started in earnest in week 26. The crop did not flush in the true sense, but provided a steady supply of stems over the whole period. There were significant effects of cultivar, with 'Baron' consistently high-yielding and 'Elmo' low-yielding. Both later planting and pinching considerably reducing yield, but this was exacerbated as a result of having to remove the tunnel covers at the onset of bad weather, which meant that not all of the later stems could be harvested. This may not be an issue under cold glass. Stem weight was very variable. These improved cultivars generated keen interest from packers and supermarkets, but it is thought a grower might struggle to make adequate returns, and consequently there has been little or no commercial uptake. For 'Breanthus' to achieve commercial viability, it needs to be perceived as a high-quality product, quite distinct from seed raised sweet william.

4. Dianthus, spray (*Dianthus caryophyllus*), 'Solomio' and 'Star'

Spray carnations are a supermarket staple, most being cheap imports from Africa and South America. 'Solomio' and 'Star' are new ranges of carnations, and with their unusual flower form could give UK growers the opportunity to produce a premium product not competing with imports. Earlier demonstrations received positive market feedback from the industry. Branded accordingly, these novel cultivars might be marketed at a more developed stage than the traditional spray carnation. In 2013 cuttings of several of the 'Solomio' series, and of 'Star Cherry Tessino', were grown in a Spanish tunnel with two planting dates. All plants were pinched two weeks after transplanting. Cropping started in mid-July and continued until the plants were cut down in late-October, when there were still immature stems from the first flush. Overall they produced good quality, strong stems, but there was an issue with bud abortion in some varieties, especially 'Edo' (the central bud dried-up, but the stem was still marketable if the aborted bud was removed manually). Among the 'Solomio' cultivars the yield of stems per m^2 varied from 141 to 197 for the earlier planting, and from 108 to 144 for the later planting. As in the case of 'Breanthus', 'Solomio' and 'Star' generated definite interest from packers and supermarkets. However, once again, a grower might struggle to make adequate returns, so they need to be sold as a

premium product that is distinct from the standard imported stem. ‘Breanthus’ yields would need to be boosted by a productive second flush of flowers, which their breeder’s state should be obtained through scheduled plantings. The productivity of the tunnel plants will be assessed in 2014.

5. *Eryngium* (Sea Holly) (*Eryngium* cultivars)

Eryngium are an expensive cut-flower, and responding to grower requests small demonstration plots have been grown at the Centre previously. In 2011 a small selection of new cultivars (‘Arabian Dawn’, ‘Blue Bell’, ‘Deep Blue’, ‘Magical Blue Falls’, ‘Magical Cloud’, ‘Magical Purple Falls’ and ‘Marbella’) were grown in plots in a Spanish tunnel and outside to assess their potential in the UK. Few flowers were produced in 2011 and the plants were grown-on for assessment in 2012, when some marketable stems were produced, but owing to plant losses in the cold winter of 2011/2012 and the wet summer and autumn of 2012, these yields were not considered meaningful. By 2013, the *Eryngium* in the tunnel had become over-vigorous and were grubbed-up, while the outside planting produced variable numbers of stems in 2013, again many of these did not survive the severe winter of 2012/2013. The outstanding cultivars were ‘Blue Bell’ and ‘Deep Blue’, which appeared nearly fully hardy and produced 56 and 113 stems per m^2, respectively. In the remaining five cultivars the percentage of plant survival (to 2013) was between 43 and 71% . In 2013 necrotic, black lesions appeared on the foliage, devastating ‘Arabian Dawn’ and ‘Marbella’, and was identified as being due to *Alternaria*. Despite the disappointing results so far, samples sent to packers and supermarkets generated considerable interest - the form of the flower-head is consistently regarded as appealing. There is considerable variability in winter hardiness of the crop, but they may be too vigorous in tunnels. It is planned to continue the trial of *Eryngium* to 2014, with the aims of identifying the best hardy cultivars and finding out how they can be grown to produce reliable, consistent stems.

6. Lily (*Lilium* cultivars)

In the last 20 years lilies have become a major phenomenon of the UK cut-flower trade, with large quantities grown in the UK from imported bulbs, in addition to the stems imported. Factors involved in this success include dynamic hybridisation programmes in the Netherlands, the relative rapidity of bulking-up new cultivars, and the avoidance of soil-borne diseases through the successful development of growing lilies in crates of soil-less media. Bulbs of newer cultivars were evaluated in 2013: ‘Adelante’, ‘Beau Soleil’, ‘Burlesca’, ‘Carolyn’, ‘Castelle’, ‘Crystal Bianca’, ‘Fiction’, ‘Hacienda’, ‘Hypnose’, ‘Mandaro’, ‘Oberto’, ‘Ovatie, , , ‘Pintado’, ‘Profundo’ ‘Sambuca and ‘Tupelo’. ’. The variety trial was combined with growing in a standard peat mix, green-compost, or a 50:50 mixture of the two. In week

17 the bulbs were planted in crates and either moved to a Spanish tunnel, or cold-stored at 9°C and moved to the tunnel four weeks later. With minor exceptions, stem length was longest in plants grown in peat and shortest grown in green-compost. However, it must be pointed out that there could have been a slight edge effect to these results but experienced lily growers who viewed the trial were of the opinion that the effect was too large to be just down to an edge effect and must therefore have been a result of the treatment.. Housing date did not have a significant effect on stem length. The quality of the stems was superb. The trial was successful in stimulating debate amongst the industry as to the need for alternative growing media, and showed that it was possible to produce good quality stems whether grown in peat, green-compost or a mix of the two, although growing in peat did produce the longest stems. Further alternative growing media trials will be undertaken in 2014 on a commercial nursery with established varieties.

7. Stocks, column (*Matthiola incana*)

Column stocks are one of the mainstays of UK protected cut-flower production, and there has been a series of trials at the Centre, either in response to specific industry problems, or as investigations of new varieties. Column stocks are prone to failing or abnormal flower initiation when grown at summer temperatures, but the 'Katz' series was bred for resilience to high temperatures. In the latest variety trial, in 2013, several 'Katz' varieties, 'Apricot', 'Bright Rose', 'Cherry Blossom', 'Lavender Blue', 'Light Lavender', 'Pink', 'White' and 'Yellow', were planted in a Spanish tunnel in week 24. The plants grew well, though their stem strength was not as good as in previous years, possibly due to hot weather throughout most of the life of the crop. However, their quality was far superior to some commercial crops, which were sometimes unmarketable because of weak stems. Cropping was from week 30 to week 32. Another trial showed that 'Katz' might be suitable as a late tunnel crop.

There has been increasing concern among growers about the poor establishment and growth, and lack of flower uniformity, in column stocks. No single factor had been identified as responsible for these unsatisfactory results, but Fusarium wilt has been implicated. A full range of cultivars was planted in a commercial glasshouse that had a history of Fusarium wilt, for testing for susceptibility. The trial followed a commercial crop of column stocks and the soil was not sterilised before the trial was planted. Of the Combinations varieties the resilient and productive ones were Avalanche White' 'Fantasy Red ', 'Fantasy Red Imp', ', 'Phantom Cream Imp' and 'Phantom Red'; amongst the Florensis varieties, many more fell into this category: 'Anytime' varieties 'Apple Blossom', 'Pink', 'Red', 'Sea Blue', 'White' and 'Yellow', Figaro Lavender', 'Katz' varieties 'Bright Rose', 'Cherry Blossom', 'Light Lavender', 'Pink' and 'Yellow', 'along with some of the coded lines, 'T0681P', 'T0311P' and 'T6340P'.

The resilience and productivity of the ‘Katz’ and ‘Anytime’ series were confirmed, while ‘Opera’ varieties did not perform well under summer stress conditions..

8. Sunflower (*Helianthus annuus*)

Sunflowers became a fashionable cut-flower in the early-2000s, and significant quantities are now field-grown in the UK. Sunflowers have been included in several of the Centre’s trials since 2010, the main needs being to reduce the resources needed in their harvest and handling, and this includes evaluating new dwarf cultivars and using plant growth regulators on standard cultivars. In 2013 seeds of cultivars ‘Galilee Adami’, ‘Galilee Miracle’, ‘Galilee Orange’, ‘Helios Flame’, ‘Tanya’, ‘Tavor Flash Bicolour’, ‘Tavor Joy’ and ‘Tavor Lemon’, and of five numbered lines (CF 100, 639, 652 and 654, and KB 198) were sown by hand into outdoor beds (weeks 15 and 23) and into beds in a Spanish tunnel (week 30). Despite the dry weather of 2013, some cultivars started to produce marketable stems from mid-June onwards, with the second planting coming into flowering in early August. Outdoors, the majority of the cultivars were 120 to 160 cm-tall and large-headed. ‘Galilee Miracle’ and ‘Tavor Lemon’ were shorter (80 to 100 cm), though with normal-sized flower-heads, while ‘Tanya’ was short (about 100 cm) and had smaller (3.5 cm-diameter) flower-heads. Overall, growing in the tunnel produced much taller plants. Almost without exception, flower-head diameters were smaller in the tunnel than outside.

9. Herbaceous perennial cut-flowers

Dahlia (*Dahlia hybrida*) has a poor vase-life, and the ‘Karma’ series was developed as a *Dahlia* with a longer vase-life. Crops of 18 ‘Karma’ cultivars had previously been trialled at the Centre, but, although growing vigorously and attracting much admiration for their striking blooms, the results of vase-life tests were disappointing. Although supermarket interest in sourcing *Dahlias* as a cut-flower has been confirmed, this is being resisted until the vase-life issues are resolved. Further vase-life tests on ‘Karma’ varieties grown at the Centre were carried out in 2013, but did not identify any better conditioning or vase treatments than those already tried.

The inclusion of *Rudbeckia* (*Rudbeckia hirta*) in trials was suggested by a supermarket representative. Initial demonstrations with seed-raised annuals showed that the stems were too vigorous and unruly to be suitable for commercial growing. Trials in 2012–2013 with more robust perennial varieties of *R. laciniata* also showed they were far too vigorous, producing stems that were unmanageable.

Sedum cultivars were initially planted as a demonstration in outside beds. Growth, once established, was very vigorous, with high stem counts, good stem length and weight, and adequate vase-life almost irrespective of picking stage. Numerous samples have been made available to the industry and it is known that, as a result, significant commercial plantings have been made, and consequently no further trials are planned.

10. Hardy foliage

A wide range of hardy foliage was planted outside in 2010 and 2011 and has now become established. There was distinct interest from the industry in 2013. It is know that substantial commercial plantings of *Hypericum*, *Symphoricarpos* and other hardy foliage have been made on local nurseries.

Non-crop-specific trials: 1. Green-compost container growing medium

With the increasing availability and interest in green-compost as a growing medium, concerns have been raised, including the potential for herbicide contamination. This was tested using a range of cut-flowers and two 'indicator' species (tomato and field beans, which are sensitive to herbicide residues) grown in peat or green-compost or a 50:50 mixture of each. The test failed to show any sign of herbicide contamination in green-compost. Growers should still exercise caution using green-compost: if in doubt, it may be possible to check batches using a simple biological pot test.

2. Spectral filters

Trials were undertaken with column stocks and bloom chrysanthemums. In the column stocks trial four cultivars were grown under clear polythene film or 'SteriLite SuperThermic', a film that diffuses light, blocks UV and reflects IR. It is claimed that this would produce more growth and that the tunnel would be 10% cooler in summer. Stem lengths were consistently greater under the specialist film than under clear film, but only by a few centimetres.

For one cultivar of bloom chrysanthemum grown under a standard film or a 'Smart Blue' film, the blue film was unsuitable because the stems produced under it were significantly later, shorter and lighter in weight and had a much reduced percentage crop-out (54% compared with 84% under standard film); vase-life was the same with either film. The blue film was chosen because it was claimed that it should reduce stem length, enhance the colour of the blooms and be about 10% cooler in summer.

Summary of the Centre's work

The Centre has now successfully developed its role as an information hub and cohesive voice for the UK cut-flower industry. This has been achieved by holding a number of grower events throughout the year, including a tulip study day, lily and spectral filter study day and an Open Day to look at the CFC trials on both a grower's holding and the main site at Rookery Farm. The project continues to produce appropriate technical literature, including a review of cut-flower trials worldwide and a summary of the Centre's column stock Fusarium wilt susceptibly trial. A number of crops that had been trialled at the Centre have now been planted commercially, including *Antirrhinum*, *Sedum*, hardy foliage and a summer spot-crop of lisianthus. In addition to the main trials, the Centre, in its role as a crop association, has facilitated additional studies, including trials on herbicides for column stocks and sweet williams, and a review of hydroponic growing for cut-flowers.

Financial Benefits

Since the inception of the CFC, members of the Management Group and the Project Manager have been aware of a number of crops that have been both trialled and grown commercially as a direct result of the programme of trials at the CFC. Examples of some of the crops trialled at the CFC that are known to be have been grown on a small scale include the Hilverda annual dianthus, *Aster ericoides,* 'Karma' *Dahlia*, *Phlox*, scented pinks, 'Solomio' carnations and *Zinnia*.

Other crops have been grown on a more commercial scale of which the main ones in 2013 include *Antirrhinum*, a spot crop of lisianthus, and various hardy perennials including *Hypericum*, *Sedum* and *Symphoricarpos* (snowberries). The following is an estimate of the area grown and the farm gate value for these products, with the hardy perennials being included under a single category:

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

Lisianthus: amount extra grown in 2013 - approximately 0.5 ha with a farm gate value of £70,000.

Hardy perennials: amount extra grown in 2013 approximately 2.5 ha with a farm gate value of £78,000 (this value is based on a middle figure for yield which takes into account the fact that these are relatively new plantings and have not yet reached maximum yield).

The production area of both lisianthus and hardy perennials is likely to increase in 2014.

In an attempt to enable growers to undertake a basic assessment of the commercial

potential of some of the plant material that has potential, this section will in future include some basic yield and planting density data starting with the three subjects listed above.

Antirrhinum: planting density around 64 plants/m^2 of bed with 80 to 95% of stems being harvested (one stem produced per plant). **The plant cost is approx €40 per 1000 plus delivery.**

Lisianthus: planting density between 64 to 80 plants/m^2 of bed with 80 to 95% of stems being harvested (one stem produced per plant) **); the plant cost is approximately €53 to €78 per 1000 (dependent on variety) plus delivery**.

Hardy perennials: using *Symphoricarpos* (snowberries) as an example, the planting density is around 1.3/m^2, with a yield of around 20 stems per plant from year 3 onwards. **The plant cost of hardy perennials varies with the subject, the cheapest being sedum at less than €1 per plant, then hypericum at about €1.5 per plant, and snowberries at about €1.75 per plant. The expected life of these crops would be between 10 and 20 years**

Action Points

- Column stock growers should use the results of the Fusarium wilt susceptibility trial to help plan their future production.
- The 'Anytime' series of column stocks should be considered for late production, especially for the second round, because it is quick to crop, has a lower susceptibly to Fusarium wilt (except 'Anytime Lavender') and, from commercial observation during the hot July and August of 2013, seems less prone to heat-induced blindness.
- 'Breanthus' and 'Solomio' carnations are potential new crops for UK growers to investigate, but the economics of production will depend on agreeing a realistic stem price.
- The 'Benary's Giant' range of *Zinnia* is also worthy of consideration, with stronger stems than the *Zinnia* varieties previously tested, but additional vase-life work is required before it can be regarded as a firm candidate for supply to supermarkets.
- The Centre's trials have generated an interest in *Eryngium*, but to date no commercial plantings are known. After consultation with their customers about the form of flower required, which varies considerably from the large-headed, spiky 'Arabian Dawn' to the more delicate 'Cloud' series, growers could consider small-scale commercial plantings of this crop. If planting in areas with potentially severe frosts, the hardiness of varieties in their first year will need to be taken into account.
- *Sedums* produce high yields of stems with good length and weight and a long vase-life irrespective of picking over a range of growth stages, and could be considered as a new crop.

- Amongst a range of hardy foliage tested, *Hypericum* and *Symphoricarpos* were effective and popular and could be considered as new crops.
- In lily growing there is potential to substitute some or all of the peat used in crates with a cheaper substrate such as ‘green-compost’, and this will be the subject of additional work by the Centre. Growers may also want to consider undertaking their own small-scale trials, but should be aware of the possibility of contamination by herbicides.
- Growers should continue to use the Cut-flower Centre, in its ‘crop association’ role, as a conduit for feeding in ideas that they believe would benefit their businesses or the wider industry, whether in the form of R&D requirements, study tours, technical workshops, additional publications, etc.

Science Section

Introduction

Traditionally, the UK has had a relatively low per capita consumption of cut-flowers compared with other western European countries, but between the late-1980s and early-2000s, its imports of cut-flowers rose from some £125m to around £550m. Over the same period the value of UK-grown cut-flowers has remained static at around £50m (farm-gate values for England & Wales). Over this period the bulk of UK production has been made up of glasshouse crops (alstromeria, chrysanthemum, dianthus, forced daffodil, lily and tulip bulbs, and, recently, column stocks), field-grown daffodil, and a small sector (worth some £5m to £10m annually) of outdoor, non-bulbous crops such as natural-season chrysanthemum, sunflowers and peony.[1]

In the 1990s the advent of relatively cheap Spanish tunnels (adopted from strawberry production), the increasing UK market for cut-flowers (including mixed bunches), the enduring appeal of 'cottage garden-style' species, and environmental demands to cut 'air-miles' and deliver a fresher product, should have provided cut-flower growers with an opportunity to expand their production in quantity, quality and variety. That this did not happen is anecdotally ascribed to two facts: a lack of 'know-how' (exacerbated by the huge number of species and varieties available) and a culture of buying-in from 'across the water'.

With the immediate aim of providing information on alternative ('new') cut-flowers for production outdoors or under Spanish tunnels under UK conditions, and the longer-term aim of stimulating UK cut-flower growers to develop and commercialise new products, a cut-flower trials project was proposed by industry representatives and funded by the HDC, starting in 2007.[2] The initial project (PC/BOF 268, 2007 – 2008) has been continued as projects PC/BOF 268a (2009), PC BOF 002 (2010 – 2012) and PC BOF 002a (2013 onwards), and project reports for each year are available from the HDC or the National Cut-Flower Trials Centre web-sites.[3]

By arrangement with David Robinson (Managing Director, R Robinson & Son Ltd), the trials programme is hosted at Rookery Farm, Holbeach St John, Spalding, Lincolnshire. The

[1] For further details, see (for example) the Annual Report for 2010 on HDC project PC BOF 002 (The National Cut-Flowers Trials Centre Programme for 2010-2012)
[2] In 2007 and 2008 the project was jointly funded by the HDC and the Lincolnshire Fenlands LEADER+ programme
[3] http://www.hdc.org.uk/ and http://www.thecutflowercentre.co.uk/

National Cut-Flower Trials Centre ('the Centre') is formally constituted as The Cut Flower Centre Ltd, with project leader Lyndon Mason as a Director, and is managed by a Management Group (MG) comprising representatives of growers, packers, retailers and the HDC. The trials programme is developed each year by the MG, taking into account comments received from growers and others through the year. The type of trials carried out is varied: depending on the present state of understanding of a crop, different species might require:

- A simple demonstration plot
- A comprehensive cultivar trial
- Trials necessary to develop a production protocol (e.g. investigating the effects of planting dates and plant density)
- A trouble-shooting experiment (e.g. to extend the growing season or control over-vigorous growth)
- A larger-scale evaluation at a commercial nursery.

Over time, a 'new' crop might go through all these five stages, and included in the Centre's programme is the testing of about some 'new' crops each year. 'New' crops will be assessed initially for their likely potential in UK production, deciding whether or not to take them forward for further testing. The term 'new' is interpreted very widely, and could include a species completely new to production horticulture, or might simply mean a crop with which UK growers are currently unfamiliar.

Starting in 2013, the scope of the project has been extended in ways that will make its role more comprehensive:

- An increased information gathering role, including reviewing other cut-flower trials programmes, new crop development, and trends in cut-flower production
- An enhanced technology transfer role including holding key technical meetings as well as the traditional Open Day, and with the Centre's web-site acting as a source of reports and reviews
- A remit extended to include 'bulbous' ornamentals and (where appropriate) production under glass as well as outdoors and in Spanish tunnels
- An extension in the types of trials and experiments carried out, including research relating to major themes identified by the HDC, such as herbicide replacement, spectral filters and sustainable pest and disease control (where appropriate working collaboratively)

- New roles in identifying knowledge gaps and encouraging the submission of concept notes for new R&D projects, developing contacts with education and training at all levels, and in moving forward to a ‘Crop Association’ role.

This report describes the work carried out in 2013, the first year of the enhanced project. It gives a brief review of the information gathering aspects, a detailed report of the trials programme, and an inventory of technology transfer activities (the latter, following the usual HDC report format, at the end of the report). The project leader would welcome comments and suggestions for future projects from the wider cut-flower industry.

Information gathering

Information gathering used both Internet sources and CABI's 'Horticultural Abstracts' ('HA') database. 'HA' is a compilation of all significant research on horticultural crops worldwide, and at the time of this report a period from about 2000 to July 2013 had been covered. The information was summarised into databases or reviews under a number of headings. It should be noted the databases and reviews produced so far should be considered works in progress, as they will be extended and updated over the lifetime of the project.

Database of seed and planting material suppliers

A database of companies supplying seeds and planting material for cut-flower production was compiled using Internet and other resources. As well as being a resource for the cut-flower industry, the database will facilitate contacts by researchers with the seed/plant industry and help in the identification and sourcing of new cut-flower species and hybrids for the trials programme. This exercise has already helped to identify new sources of subjects for trialling. The database is ready for adding to the Centre web-site.

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

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

Such 'new crop' projects often impinge on the cut-flower trials programmes that are carried on in horticulturally developed or developing countries; in the former, trials are likely to be funded partly through grower organisations and carried out by educational institutions, while in the latter they are often funded by government at government-funded institutes. In the more developed countries trials may concentrate on the finer points of between-cultivar differences, while in the less so there may be a wide range of species being assessed much more speculatively. Cut-flower trials programmes may be reported in the scientific press but are more likely to appear in the trade press or on web sites, and there is generally no way of questioning their objectivity in the way that growers can interact with the CFC trial. In general the in-house trials and demonstrations carried out by seed houses, etc., are not covered.

The initial review of new crops and cut-flower trials programmes was made available on the Centre's web-site in 2013.[4]

Sources of information on cut-flower production

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

Production levels and trends in the cut-flower trade

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

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

Experimental programme: Materials and Methods

Demonstrations, trials and experiments

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

The 2013 experimental programme consisted of many individual demonstrations, trials and experiments on numerous species and cultivars, and it seems less confusing to describe each of them (along with their specific materials and methods) alongside the results themselves. Descriptions of the individual demonstrations, trials and experiments are therefore given in the 'Results' section, along with details such as the source of plant material, where planted (in the 'Haygrove' or 'Pro-Tech' tunnels or outdoor beds at the Centre, or on a commercial nursery), date of planting, transplanting or sowing, plot size, planting density and any special treatments applied. As appropriate to the more practical nature of the project, many plots were not replicated, but, where practicable, appropriate replication and randomisation were used and are also described under 'Results'.

The remainder of this section describes the more general 'Materials and Methods'.

Facilities and protocols at the Centre

The facility at Rookery Farm, Holbeach St John, Spalding, Lincolnshire comprises a single-span 'Haygrove' tunnel[5] (7.9m wide × 38.1m long), a triple-span 'Pro-Tech' tunnel[6] (overall 22.7m wide × 38.0m long) (Figure 1) and an adjacent area of outdoor beds of about 600m^2. Since it is on an exposed site, wind-breaks of 2.5m-high polypropylene netting are provided at each end of the 'Pro-Tech' tunnel. Typical of the area, the soil is heavy silt.

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

[5] http://www.Haygrove.co.uk/
[6] http://www.Pro-Tech-marketing.co.uk/

Figure 1. Bay 1 of the Centre's 'ProTech' tunnel.

Crop husbandry – pre-planting

The growing areas were sterilised as required by the year's trials programme. For the 2013 season the 'Haygrove' tunnel and 'Pro-Tech' bay 1 were steam-sterilised in late-October 2012 and the sheets left down over winter. 'Pro-Tech' bay 2 was not sterilised as it held the ADAS column stock herbicide trial, while 'Pro-Tech' bay 3 remained planted with perennials and so could not be sterilised.

Prior to the start of planting each year, soil samples were taken across the trials site for standard glasshouse soil analysis, with the results shown in Table 1. The site was cultivated and 1m-wide beds marked out, with three (sometimes four) beds along each tunnel bay and further beds outdoors as required. The area was irrigated using zoned, computer-controlled lay-flat tubes, with three tubes for each bed, divided half-way along the tunnels to provide two separate zones. Unless otherwise stated, the beds were covered with 1.2m-wide, 120-gauge, micro-perforated black polythene film.

As it is not possible to give a base fertiliser recommendation for all minor cut-flower crops, the aim was to bring base fertiliser levels up to those required for column stocks, namely indices of 2 for N, 5+ for P, and 4 each for K and Mg. The analyses showed that all areas tested required P and K to be topped-up, along with N in 'Pro-Tech' bay 2. The whole 'Haygrove' tunnel and 'Pro-Tech' bay 1 (north) received 100g/m^2 each of sulphate of potash (SOP) and triple superphosphate (TSP). 'Pro-Tech' bay 1 (south) had 100g/m^2 of SOP and 130g/m^2 of TSP. 'Pro-Tech' bay 2 (north) had 100g/m^2 SOP, 100g/m^2 TSP and 30g/m^2 of ammonium nitrate (AN). 'Pro-Tech' bay 2 (south) received 50g/m^2 SOP, 80g/m^2 TSP and 30g/m^2 AN.

Table 1. Results of standard glasshouse soil analysis for the tunnels (March 2013).

Tunnel and end (N, north; S, south)	pH	P		K		Mg		NO3		Conductivity	
		mg/L	Index	mg/L	Index	mg/L	Index	mg/L	Index	µS	Index
'Haygrove' N	7.6	35	3	333	3	292	5	86	2	2671	3
'Haygrove' S	7.5	30	3	264	3	333	5	132	3	2700	3
'Pro-Tech' bay 1 N	7.2	37	3	247	3	454	6	204	4	2599	2
'Pro-Tech' bay 1 S	6.8	35	3	167	2	381	6	168	4	2466	2
'Pro-Tech' bay 2 N	7.4	33	3	270	3	508	6	19	0	2263	1
'Pro-Tech' bay 2 S	7.5	49	4	361	3	483	6	21	0	2288	1

Seed germination

Seed of the novel crops (basil, cosmos, *Leonotis leonurus*, lupin, *Trachelium caeruleum* and zinnia) were sown into individual cells of 'Jiffy 104' preforma plugs and germinated on a heated floor. Although not a commercial method, it was used for ease of management.

Crop husbandry – planting

Many of crops were obtained as plug-plants and transplanted into labelled plots along the 1m-wide beds at a specified density (Figure 2). Individual plot lengths were dependent on the trial, and 0.5m-long unplanted 'guard areas' were left between plots and longer areas at the ends of the beds to guard against shading effects and 'end' effects. These details are specified under 'Results'. Planting (or transplanting) was generally through the polythene film, or, in a few cases (column stocks, sunflowers and the perennials in 'Pro-Tech' bay 3), directly into the border soil. Crops were watered with a hand-lance immediately after planting.

Crop husbandry – post-planting

Once plants were established most water was applied as needed through the lay-flat irrigation lines. Once in growth, plants received a weekly liquid feed, with applications increased (if required) to twice per week on vigorous crops during the main growing season i.e. June onwards.. The liquid fertiliser used was 'Universol [*sic*] Green' (26-6-10 N:P:K + 2MgO + trace elements; Everris/The Scotts Company).

Beds were provided with support netting if required by the crop, the netting being raised with the growth of the crop, but in some cases, such as *A. ericoides*, side-support wires were provided as well owing to the crop's vigour. In some cases plants were stopped (pinched) or other treatments were applied, in which case the details are given under 'Results'.

Figure 2. Typical arrangements of beds at the Centre.

Pesticide applications

Pesticide advice was given by a BASIS-qualified agronomist and pesticides were applied as needed and according to recommendations. The pesticides applied in 2013 were:

- For thrips, spinosad (as 'Conserve') to all plants in all tunnels, weeks 22, 27 and 34
- For powdery mildew, sulphur (as 'Thiovit Jet') on all *Aster ericoides*, weeks 22, 26, 28, 35 and 38
- For aphid, spirotetramat (as 'Movento') to all plants (tunnels and outside), week 24, and to annual asters, week 29
- For downy mildew, mancozeb + metalaxyl-M (as 'Fubol Gold WG') to column stocks, weeks 24 and 26
- For powdery mildew, kresoxim-methyl (as 'Stroby WG') to all plants (tunnels and outside), weeks 27 and 40
- For powdery mildew, myclobutanil (as 'Systhane 20EW') to *A. ericoides*, weeks 24, 27 and 31, and to *A. ericoides*, delphinium, lupin and dahlia, weeks 34 and 36
- For botrytis, boscalid + pyraclostrobin (as 'Signum') to lilies, week 24, and to all plants in all tunnels except *A. ericoides*, weeks 28 and 32
- For aphid, pymetrozine (as 'Chess WG') to all plants (tunnels and outside), week 26, and to all plants in all tunnels, week 37
- For aphid, cypermethrin (as 'Toppel 100EC') to *A. ericoides*, week 26, and to all plants in all tunnels except *A. ericoides*, week 32
- For aphid, thiacloprid (as 'Calypso') to all plants (tunnels and outside), week 28
- For two-spotted spider mite, abamectin (as 'Dynamec') to dahlia and *A. ericoides*, weeks 30 and 36
- For thrips and aphid, spinosad and cypermethrin (as 'Conserve' and 'Toppel 100EC') to all plants in all tunnels, week 31

- For foliar diseases generally, including powdery mildew on *A. ericoides*, azoxystrobin (as 'Amistar') to all plants (tunnels and outside), week 31

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 (calculating the numbers of stems/m^2 from the plot lengths), 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 (such as spike length or flower-head diameter) as appropriate. Other than allowing for trimming, stem lengths and weights quoted always refer to the total weights and lengths of the whole stem, including buds, flowers or inflorescences. Less formally, the plots were also assessed at intervals by the MG and others as appropriate, and in the case of preliminary demonstrations emphasis was placed on photographs and grower comments.

Trials at commercial nurseries

Some evaluations were carried out at appropriate commercial nurseries, either because conditions at the Centre were unsuitable (e.g. the soil at Rookery Farm is considered too heavy for growing ornamental brassicas), or in order to assess crops on a larger scale or on a more 'commercial' basis than would be practical at the Centre, or if glasshouse facilities where required. Under these circumstances the grower would be expected to apply their normal high standards of cultural practices, but project staff would have less control than over trials at Rookery Farm.

Data analysis

Following preliminary data analysis, where appropriate data were subjected to the analysis of variance (AOV or anova), using either the data analysis tool within 'Microsoft Excel' or (where requiring a three-factor analysis) 'OpenStat'.[7] In some cases it was necessary to carry out factorial AOV without replication, in which case the significance of the 'main effects' (such as cultivar or planting date) can be analysed, but not the interactions between them. In graphs the Least Significant Difference at the 5% level of probability (LSD(5%)) is usually quoted as an indication of the variability of the data. Where AOV is used the value of probability (P) is given to indicate the statistical significance of the different sources of variation (such as cultivar or planting date). Following convention, the symbols *, ** and *** were used to indicate significance at the 0.05 ('significant'), 0.01 ('highly significant') and

[7] http://www.statprograms4u.com/OpenStatMain.htm

0.001 (‘very highly significant’) levels of probability, meaning that the result obtained could have be expected to have occurred by chance in one in 20, one in 100 or 1 in 1000 instances, respectively. ‘NS’ indicates not significant (i.e. P>0.05).

Vase-life testing

Stems of zinnia ‘Benary’s Giant’ and of dahlia ‘Karma’ varieties were assessed under standard vase-life test conditions in a range of conditioning solutions and flower foods by Emma Bradford (Floralife). Tests with zinnia are fully reported in this report, while the work with dahlia was of a preliminary nature and will therefore be included in the 2014 report. Freshly picked zinnia stems, as available and aiming for the 75% open stage, were placed in buckets with plain water or hydrating solution in a cold-store (5°C) to represent the storage and transport phases. Following this they were moved to a vase-life test room (20°C) on vases containing either plain water or a flower food. After 7 and 10 days they were assessed and photographed. There were five separate tests and details of the treatments are given under ‘Results’. The photographs were examined and overall quality (flower quality, foliage quality and condition of the vase-water) was assessed on a scale of 0 (worst) to 5 (best) as shown in Table 2.

Table 2. Overall quality scores used for vase-life assessments.

Score	Description
0	Dead
1	Quality is very poor, nearly all customers would throw out all the flowers in the vase
2	Quality is poor (has fallen significantly), most discerning customers would throw out all the flowers in the vase
3	Quality is reasonable/moderate (has started to fall), only the most fussy customer would throw out all the 4flowers in the vase
4	Quality is good (just showing the start of problems), no customer would throw out all the flowers in the vase yet
5	Quality is very good (no problems evident)

Experimental programme: Results

Novel crops

On the basis of the review of new cut-flower crops and cut-flower trials programmes, a number of crops were selected for testing in 2013. The results for six of these, basil, cosmos, *Leonotis*, lupin, *Trachelium caeruleum* and zinnia, are described below. There were three other selections where further work needed to be deferred until 2014. In the case of cut-flower gentians (*Gentiana asclepiadeum* and others), difficulties were encountered in sourcing suitable plant material, while in the case of perennials *Dicentra spectabilis* (bleeding hearts) and *Helleborus* species (hellebores) it was too late to source plant material in time for the 2013 season.

1. Basil (*Ocimum basilicum*)

Basils can contribute a fragrant filler to mixed bunches and bouquets, and were included in both the Association of Specialty Cut Flower Growers' (ASCFG) National Cut Flower Trials programme run by Dr John Dole at North Carolina State University, and the cut-flower trials programme of Professor HC (Chris) Wien at Cornell University.[8] Of a small selections of cultivars tested in both programmes, 'Aramato' (from Genesis Seeds) stood out, with good stem length, productivity and attractive foliage. Wien reported that hydration of the cut-stems was a problem with all varieties tested, which would probably have been improved by using a hydration solution. Dole made the point that whether basil was considered too fragrant, or not fragrant enough, was a highly personal judgement. Several cultivars are suitable for ornamental as well as culinary use, having heights from 30 to 60cm, attractive flower spikes, and, in some, attractive red foliage.

In 2013, seed of basil cultivars 'Dark Red Opal', 'Floral Spires Lavender', 'Floral Spires White' and 'Sweet Dani Lemon' (from Ball Colgrave) were germinated in plugs (see 'Materials and Methods') and transplanted to *ca* 2m-long plots in 'Pro-Tech' tunnel bay 1 at a planting density of 64/m^2.

The plants grew satisfactorily, produced dense foliage and started to flower in week 32 (Figure 3). Samples were taken for vase-life testing but they had an unacceptably short life, suggesting basil should be dropped from the programme. However, this observation may simply confirm the observation at Cornell University that an appropriate hydration solution should be used.

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

Sourcing ‘Aramoto’ might be investigated, and possibly the better cultivars should be grown outside under harder conditions with due attention to picking stage and post-harvest treatment.

Figure 3. Basil growing at the Centre in 2013. Top-left, ‘Floral Spires Lavender’ (22 July); top-right, ‘Dani Lemon’ with ‘Dark Red Opal’ in foreground (6 August); bottom, ‘Floral Spires White’ (20 September).

2. Cosmos (*Cosmos bipinnatus*)

Cosmos are well known garden plants, producing masses of bright flowers and feathery foliage. Although they may appear too wispy to be adapted as a cut-flower, they were included in the Santa Rosa Specialty Cut Flower Trials (NW Florida), the ASCFG cut-flower programme and the Cornell University trials.[9] They were deemed unsuitable for further uptake in the Santa Rosa trials, while at Cornell, where 'Double Click' and 'Sensation Mix' cultivars were compared, the former were productive but there were problems keeping them hydrated after harvest. 'Sensation Mix' is a short-day plant beginning to flower in late-summer on large plants.

A range of series and cultivars was tested at the Centre in 2013: The seed were germinated in plugs (see 'Materials and Methods') and transplanted to *ca* 1m-long plots in 'Pro-Tech' tunnel bay 1 in week 22 at a planting density of 64/m^2. Plugs of the 'Sensation' series were also transplanted to outside beds.

The plants grew vigorously and produced very bushy plants with profuse flowers which started to open in week 30 (Figure 4). The general impression was of over-vigorous, unruly growth that would require controlling through cultural or chemical means Comparing growth in the tunnel and outside, the outdoor crop was much less vigorous and consequently more manageable, indicating that this crop is probably not suitable for protected production.

Supermarkets have a requirement for a variety of novel flowers to use in 'monthly bouquets', i.e. bouquets in which variety is introduced regularly by changing the fillers. Cosmos might fit this role if grown cheaply as an outside, drilled crop, picked over a short season and bearing in mind their need for day-lengths of at least 11h to prevent premature budding. Testing for vase-life is also needed.

The different series should be compared as a drilled, outside crop in 2014, to see which cultivars would be best for this format. The 'QIS' series (available from EconSeeds) is marketed as a cut-flower, has larger than usual flowers on strong stems up to 120cm tall, and should also be considered.

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

Figure 4. Cosmos growing at the Centre in 2013: top, tunnel crop starting to flower on 22 July; bottom, (beyond the zinnia) outdoor crop ‘Sensation White’ (this end), ‘Pink’ and ‘Red’ (far end) (20 September).

3. Lion’s ear (*Leonotis leonurus*)

Leonotis is a South African plant being introduced to cultivation, having attractive orange flowers (Figure 5) and being aromatic and easy to grown in various regions. Field studies have been conducted in, for example, Poland, where it flowered from July to late-autumn; it was tall (120 to 300cm) and produced dense inflorescences on long, upright stems. *Leonotis* was successfully introduced to Israel, where research into improving its vase-life resulted in an extended longevity of 12 days with fully open flowers, following 48h of simulated transport. Other studies took place in Italy, where rooted cuttings were pruned back at the end of December and moved to an unheated plastic glasshouse where flowering started in April and continued throughout summer; plants kept outside flowered

from June/July to late-October. References and more details can be found in the 'new crops review'.[10]

Figure 5. *Leonotis leonurus* (photograph by R A Howard, courtesy of Smithsonian Institution).

Several specialist seed suppliers list *Leonotis* 'Staircase', one giving a height of 180cm and apparently suitable for growing in 'deep' patio pots and in the border. Some suppliers list other cultivars and species, some more dwarf than *L. leonurus*. *Leonotis* plants were spotted on one nursery in early October where it was being using it for florist bouquets; the plants were as triffid-like as those at the Centre.

Seed of *Leonotis* 'Staircase' (from EconSeeds) were germinated in plugs (see 'Materials and Methods') and transplanted to *ca* 1m-long plots in 'Pro-Tech' tunnel bay 1 in week 27 at a planting density of 15 plants/m^2. *Leonotis* grew vigorously and almost reached the top of the tunnel by week 40/41 when the buds began to open (Figure 6). This was rather too late for many growers to see. In this form *Leonotis* would be difficult to handle, but the plants have been cut-back and kept *in situ* in the tunnel. From Italian research, this may lead to more manageable growth and a useful crop of flowers. Other cultivars of *L. leonurus* (e.g. 'Alba') and shorter species (such as *L. mollis*) should be evaluated on a small scale in 2014.

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

Figure 6. *Leonotis leonurus* 'Staircase' just before flowering at the Centre (20 September 2013).

4. Lupin (*Lupinus* species)

Lupinus harvardii (big bend bluebonnet) is a native of Texas and produces attractive, tall blue flowers with potential as a new specialty cut-flower. It has been researched at Texas A&M and New Mexico State Universities, along with *L. densifolius* which is less sensitive to ethylene. Several blue, white and pink selections have been produced with reduced ethylene sensitivity and extended vase-life, and, following limited commercial production, 'Texas Sapphire' and 'Texas Ice' have been released. In addition, lupin 'Morello' was listed among the plants tested in the ASCFG trials, though no further details were given. References and more details can be found in the 'new crops review'.[11]

Contact with researchers at Texas A&M University early in 2013 failed to produce access to these new introductions, perhaps because of commercial sensitivity. However, the popularity of lupins as garden plants means that many cultivars are widely available, mainly from the 'Gallery' and 'Russell' series (*Lupinus polyphyllus*, 'big leaf lupin') which are about 50 and 130cm tall, respectively.

Seed of the 'Gallery' cultivars 'Blue', 'Pink', 'Red' and 'White' and 'Russell' cultivars 'Band of Nobles', 'Chandelier', 'Noble Maiden', 'My Castle', 'The Chantelaine', 'The Governor' and 'The Pages' were obtained from EconSeeds and Ball Colegrave. They were germinated in plugs (see 'Materials and Methods') and transplanted in week 26 to *ca* 2m-long plots in 'Pro-Tech' tunnel bay 1 at a planting density of 10/m^2.

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

Initially, growth was judged to be weak, but the plants recovered and established well, starting to flower, albeit only a handful of stems, in week 32 and continuing to produce reasonable numbers of stems over a long period. Although plants of the 'Gallery' series are shorter than the 'Russell' series, they still had adequate length. Comparing protected and outdoor cultivation in year 1, the outdoor flowers produced much shorter stems than those grown under protection. Their potential as cut-flowers will be assessed in 2014.

A source of *L. densiflorus* 'Aureus' (golden lupin) has now been located. Further attempts to obtain material of the recently introduced 'Texan' species and cultivars will be made in 2014. *Lupinus* × *regalis* 'Morello Cherry', probably the cultivar 'Morello' mentioned in the ASCFG trials, might also be tested as it is tall (90 to 110cm), well coloured, fast-flowering in its first year, and appears to be available from specialist seed merchants.[12]

[12] E.g. http://www.thompson-morgan.com/flowers/flower-seeds/perennial-and-biennial-seeds/lupin-regalis-morello-cherry/6929TM

Figure 7. Tunnel-grown lupins at the Centre in 2013: growth was initially weak (top, 22 July), but soon improved (bottom, 'Russell' varieties at the front and 'Gallery' at the back, 20 September).

5. *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. References and more details can be found in the 'new crops review'.[13] Seed is supplied by several of the well-know seed houses, with several series available, including the 'Lake Collection' (from Kieft Seeds) which is marketed as a cut-flower *Trachelium*.

Seeds of a selection of cultivars were sown into plugs (see 'Materials and Methods'), but all failed to germinate. Some writers have noted that germination is sometimes poor, though no unusual germination requirements were indicated in seed catalogues; discussions with other growers and propagators in the UK and Holland revealed that this seems to have been an industry-wide issue in 2013.

Subsequently, plug-plants of cultivar 'Corine Purple' were obtained from Combinations Young Plants. In week 23 they were transplanted to a *ca* 2m-long plot in 'Pro-Tech' tunnel bay 1 at a density of 64 plants/m^2. The plants grew well and produced an attractive display starting in late August (Figure 8). With its colour and form *Trachelium* may have potential for UK production, and the trial will be repeated in 2014 using plug-plants.

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

Figure 8. *Trachelium* 'Corine Purple' at the Centre (20 September 2013).

6. Zinnia (*Zinnia elegans*)

Unlike the other species in this 'new crops' section, zinnias have been grown previously at the Centre, in 2007 and 2008, when the industry was enthusiastic about the flowers with their wide range of cheerful colours. However, after picking, the stems, which are hollow, collapse and bend just below the flower-head, making them unsuitable as cut-flowers. Trials with zinnia were put on hold until varieties with improved stem strength became available.

In reviewing other cut-flower trials, a somewhat different conclusion was apparent from trials in the USA. For example, in the Santa Rosa Specialty Cut Flower Trials zinnia were rated "the most dependable flower in the trial [with] continuous flowering on 18" [45cm] stems", though "cultivar selection [was] critical." In the 2010 ASCFG trials zinnias 'Queen Red Lime' and 'Benary's Giant Lime' (from Benary) created most discussion with their colours and doubleness (though the flowers were smaller than some others tested). 'Benary's Giant Lime' made the 'top-five' in that year's trials. References and more details can be found in the 'new crops review'.[14]

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

In 2013, seed of ‘Oklahoma’ series ‘Carmine’, ‘Golden Yellow’, ‘Ivory’, ‘Pink’, ‘Salmon’, ‘Scarlet’ and ‘White’ and of the ‘Benary’s Giant’ series ‘Bright Pink’, ‘Carmine’, ‘Coral’, ‘Deep Red’, ‘Golden Yellow’, ‘Lilac’, ‘Lime’, ‘Orange’, ‘Purple’, ‘Salmon Rose’, ‘Scarlet’, ‘White’ and ‘Wine’ (from Benary) were germinated in plugs (see ‘Materials and Methods’). In weeks 22 and 23 they were transplanted at a density of 64/m^2 to ca 1m-long plots in ‘Pro-Tech’ tunnel bay 1 and in outside beds. Shortly after planting, when the plants were only a few inches high, premature buds became visible on all plants (Figure 9). Following correspondence with John Dole, these were pinched out, following which the plants grew away vigorously.

Figure 9. Recently transplanted zinnia in the Centre’s trials with premature budding (28 June 2013).

Some stems were ready for picking by mid-July, and some interesting flower forms were evident (Figure 10 and Figure 11). The ‘Benary’s Giant’ varieties were stronger and attracted more interest than the ‘Oklahoma’ series, but even the latter were considered far superior to the zinnia cultivars previously grown at the Centre. Comparing plants grown in the tunnel and outside, the protected crop produced a much more vigorous plant with more and longer stems.

Figure 10. Tunnel-grown zinnia at the Centre in 2013: top left, ‘Benary’s Giant’ cultivars; top right, ‘Oklahoma’ cultivars (both on 22 July), and, bottom, the same on 20 September.

Figure 11. Some of the variety of zinnia in the Centre's 2013 trials (20 September).

During July and August 2013 five lots of samples were taken for standard vase-life testing which was carried out by Emma Bradford of Floralife (see 'Materials and Methods'). Across the five tests the time at 5°C in the cold store (prior to transfer to vase-life conditions) was varied (between 2 and 7 days), while after picking the stems were stood in either plain water or a hydrating solution ('Floralife Hydraflor') and in the vase either plain water or one of several flower foods was used. Assessments were made between vase-days 6 and 14 (i.e. the number of days since being moved to vases).

Details of the treatments and a summary of results are given in Table 3, and Figure 12 shows the appearance of mixed varieties of 'Benary's Giant' series on vase-day 7 following 3 days of cold-storage and treatment with different flower foods in the vase. The main findings were:

- Vase-life was extended by using any flower food, from a quality score of 1 in water to 3 by vase-day 7 (but a score of 3 is unacceptable) (test 1), or from 0 in water to 2 or 3 by vase-day 6 (unacceptable) (test 3)
- Using a hydrating solution had no effect on the quality score after 7 days, but the score was increased from 1 to 4 (acceptable) by vase-day 7 by using a flower food, irrespective of whether the stems were picked into water or hydrating solution (test 2)
- Testing individual cultivars (held initially in water and with Universal Flower Food in the vase) gave scores from 0 to 2 or, rarely, 3, after 7 or 10 vase-days, all unacceptable
- Deterioration of the flowers consisted of the rays fading, wilting or dying, sometimes being affected by mould, and, relatively unusually, bending of the neck of the stem; however the latter symptom seemed to occur only on flowers that were more or less dead, not on flowers that were still retaining colour.

Plain water

Universal Flower Food

Chrysanthemum Flower Food

Rose Flower Food

Bulb Flower Food

Figure 12. Zinnia vase-test 1, with different flower foods in the vases, photographed on vase-day 7 (photograph: Emma Bradford and Floralife)

The results were generally unacceptable and rarely retained an acceptable quality score (4) by vase-day 6 or 7. However, the incidence of stem bending in the neck, the main problem seen with other zinnia cultivars tested previously, did not occur soon after transfer to the vase but was only apparent in flowers that were almost dead, a promising indication that these cultivars may have the potential for commercial use. Emma Bradford (Floralife) proposed that zinnias would benefit from treatment in a flower food immediately after picking, since using a hydrating solution was ineffective in retaining quality.

As these zinnia seem worthy of developing further, an approach in 2014 would be to grow a small selection of cultivars and evaluate a wider range of conditioning solutions.

Table 3. Vase-life test results for zinnia cultivars

Picking date	Time in 5°C	Hydrating solution[1]	Vase-life flower food[2]	'Benary's Giant' cultivar	First assessment			Second assessment[3]		
					Vase-day	Score	Description[4]	Vase-day	Score	Description[4]
26 July	3 days	Water	Water	Mixed	7	1	Almost dead	11	0	Dead, C
		Water	Chrysanth.	Mixed		3	Wilting, fading		2	Some dead
		Water	Universal	Mixed		3	Wilting, fading		2	Some dead
		Water	Rose	Mixed		3	Wilting, fading		2	Some dead, C
		Water	Bulb	Mixed		3	Wilting, fading		2	Some dead
3 August	3 – 4 days	Hydraflor	Water	Mixed	7	1	Almost dead	14	0	Dead, C
		Hydraflor	Universal	Mixed		4	Few florets wilting, fading, C		2	Half fading, dying, bending
		Water	Water	Mixed		1	Almost dead		0	Dead, C
		Water	Universal	Mixed		4	Few florets wilting, fading, C		2	Half fading, dying, bending
10 August	4 - 5 days	Water	Water	Mixed	6	0	Dead, C			
		Water	Universal	Mixed		3	Dying, wilting, fading			
		Water	Lily & alstroemeria	Mixed		2	Dead, wilting, faded			

16 August	7 days	Water	Universal	Lime	7	0	Dead C	
		Water	Universal	Bright Pink		2	Fading, dying, bending, C	
		Water	Universal	Golden Yellow		1	Fading, dead, bending, C	
		Water	Universal	White		0	Dead C	
		Water	Universal	Purple		0	Dead C	
		Water	Universal	Salmon Rose		0	Dead C	
		Water	Universal	Carmine		2	Fading, dying, bending	
		Water	Universal	Scarlet		1	Fading, dead, bending, C	
		Water	Universal	Wine		0	Dead C	
		Water	Universal	Lilac		1	Fading, dead, bending, C	
		Water	Universal	Deep Red		1	Fading, dead, bending, C	
		Water	Universal	Orange		0	Dead, C	
28 August	2 days	Water	Universal	Lime	10	1	Patches of rays dying	
		Water	Universal	Bright Pink		1	Wilting, fading, dying	
		Water	Universal	Golden Yellow		1	Wilting, fading, bending	
		Water	Universal	White		1	Patches of rays dying	
		Water	Universal	Purple		1	Wilting, fading, bending	
		Water	Universal	Salmon Rose		3	Some wilting, fading	
		Water	Universal	Carmine		3	Some fading	
		Water	Universal	Scarlet		2	Wilting, fading, mouldy	
		Water	Universal	Wine		2	Wilting, fading	
		Water	Universal	Lilac		2	Wilting, fading	
		Water	Universal	Deep Red		2	Wilting, fading	
		Water	Universal	Orange		3	Some fading	
		Water	Universal	Coral		2	Wilting, fading	

[1] 'Hydraflor' = 'Floralife Hydraflor Clear 100'
[2] 'Floralife Liquid Flower Foods' (either Universal, Chrysanthemum, Rose, Bulb or Lily & Alstroemeria
[3] Only for first two tests
[4] 'C' = cloudy vase-water (not assessable in last test)

Crop improvement

1. Aster, September-flowering (*Aster ericoides*)

Background

Aster ericoides are currently imported as a relatively cheap filler, mainly using the single-flowered 'Monte Casino' types. However, the introduction of new double-flowering breeding lines has the potential to open up a new market, possibly including straight lines. The high cost of planting material means that production costs must be kept to a minimum.

Previous trials at the Centre in 2010, 2011 and 2012 succeeded in generating market interest in these double-flowered cultivars grown as a pinched crop for September/October flowering in tunnels. Growers also expressed an interest in season extension.

Season extension

A. ericoides is a long-day plant and floral initiation can be delayed by blacking-out the crop for part of the day. A trial that had been set up in 2012 was left *in situ* in *ca* 3m-long plots in 'Pro-Tech' tunnel bay 3 and outside, and was used in 2013 to investigate the use of blackout covers for manipulating the flowering period. The cultivars included were 'Blue Tail', 'Capetown', 'Cassandra', 'Cassy', 'Chicago', 'Cirina Dark', 'Double Fun Blue', 'Double Fun Pink Dark', 'Double Fun White', 'Linda' and 'Pretty Wendy'.

Figure 13. Black-out covers used with tunnel-grown *Aster ericoides* in 2013.

Blackout covers made of 'Mypex' were placed over a frame covering the growing bed from 30 May 2013 (week 22) when stems were about 60cm tall (Figure 13). The cover was left in

place for14 hours per day, from 6 in the evening until 08:00h the next day. When using blackout there is always a risk of temperature build up under the covers but this has been mitigated by using Mypex rather than black poly and by covering in the early evening when the power of the sun has started to diminish. By week 31 this blackout procedure had yielded good-sized buds about to show colour, and blacking-out was discontinued at this stage. Overall flowering was later than expected, mainly in weeks 32 and 33, probably owing to a slow start into growth following a late spring (Figure 14). However, quality was superb, although stems were taller than required, indicating that the blackout should be started before the stems reach 60cms. As a consequence of this late flowering, the second flush in early-November was too short to be marketable.

Figure 14. *Aster ericoides* cultivars from black-out experiment at the Centre in 2013. Top-left, buds after black-out treatment; and, clockwise, cultivars in flower (6 August): 'Capetown', 'Cassandra', 'Chicago', 'Cirina Dark' and 'Double Fun White'.

2. Annual (or China) aster (*Callistephus chinensis*) ('bloom asters')

Background

Annual asters are now a mainstay of the UK outdoor summer cut-flower market, dominated by the 'Matsumoto' spray type which is grown in quantities of a few million stems annually. Work at the Centre has opened up a new market for the alternative large–headed, 'bloom'

type of aster, especially for summer production. However, the search for a trouble-free variety of the very popular blue-flowering form has proved very difficult.

Two new series of large-headed China asters with vibrantly coloured blooms – the ‘Krallen’ and ‘Gala’ series – were introduced in Germany and started to become available in 2007, when demonstrations were planted at the Centre. Generating a marked interest from growers, there appeared to be potential for commercialising these cultivars in the UK. In 2010 a large multifactorial trial was carried at the Centre, with ‘Krallen’ types ‘Chinchilla’, ‘Golden’, ‘Kameo’, ‘Karthauser’, ‘Lux’ and ‘Perser’ and ‘Gala’ types ‘Lavender’ and ‘Purple’. Stems of ‘Krallen’ cultivars (except ‘Golden’) were sufficiently long and particularly heavy, with stems of ‘Kameo’ and ‘Kartthausen’ reaching nearly 80g each, while those of ‘Gala’ cultivars were taller but lighter. ‘Krallen’ cultivars also had larger, more impressive flowers that were largely responsible for their high stem weight. The effects of using plug- and block-raised plants, of planting date, and of growth retardant treatments were also investigated at that time.

As a result of these trials ‘Krallen’ cultivars were grown by local producers in quantity in 2009 and 2010, with ‘Karthauser’ and ‘Perser’ being in great demand by the supermarkets. Vase-life tests were undertaken by a packer on batches being sold through supermarkets, and showed that their vase-life consistently met or exceeded the guarantee of 5 days. However, post-harvest quality became an issue when petal-spotting and browning of the flower-tip became apparent, and the cause of these disorders have not yet been identified despite sending numerous samples to laboratories in the Netherlands and the UK and holding detailed discussions with the breeder and propagator. Losses became severe, and as a result ‘Krallen’ is unlikely to be grown again on any scale until petal-spotting and petal-tip necrosis can be rectified, and this situation remains the case today. As a consequence growers were interesting in developing alternative cultivars. In 2010, 25 cultivars from the ‘Standby’, ‘Benary Princess’ and ‘Matador’ series were trialled at the Centre. Although they supplied an additional range of colours, growers and buyers thought none matched the quality of ‘Krallen’ blooms. In 2012 further alternatives were investigated from the ‘Meteor’, ‘Ribbon’ and ‘Bonita’ series (the ‘Bonita’ series is marketed as being complementary to the popular ‘Matsumoto’ series). Unfortunately the planned trial did not go well because of problems in seed supply and consequent late planting, the subsequent poor weather, and a severe attack of Tomato Spotted Wilt Virus (particularly on the ‘Meteor’ series), resulting in stems of poor quality. None of these cultivars appeared to have prospects as an alternative to ‘Krallen’. Because of these disappointing findings a trial of further varieties, incorporating earlier planting, was planned for the Centre in 2013.

At the time the ‘Bonita’ series generated interest from growers of ‘Matsumoto’ asters, and it seemed likely that growers would undertake their own trials of these cultivars. However, it appears that these varieties have not been taken up by the industry.

2013 trial of alternative cultivars

Plug-plants were transplanted (at 64 plants/m^2) to duplicate plots in two batches, week 19 in the ‘Haygrove’ tunnel and week 26 in the ‘Pro-Tech’ tunnel Bay 1. The cultivars were from the ‘Beautiful Day’ series (‘Dark Blue’, ‘Lavender’, ‘Light Blue’ and ‘Mix’), the ‘Harlequin’ series (‘Dark Blue’, ‘Formula Mix’, ‘Light Blue’ and ‘Violet’), the ‘Jewel’ series (‘Purpurit’ (lilac rose)), the ‘Lady Coral’ series (‘Dark Blue’, ‘Formula Mix’, ‘Lavender’ and ‘Light Blue’) (all from Seeds of Success International), and the ‘Meteor’ series (‘Carmine Red’, ‘Rose Pink’, ‘Violet Blue’ and ‘Yellow’) (from Kieft Seeds) (see Figure 16).

Figure 15. Part of the 2013 trial of bloom asters at the Centre (21 August).

Supply issues meant that not all cultivars could be included in each planting, but all 17 were included in the earlier planting. The main cropping period was from week 32 to week 34 (Figure 15). Their mean stem lengths are shown in Figure 17, with analysis of variance in Table 4. Cultivars of the ‘Meteor’ and ‘Harlequin’ series gave taller plants, with mean stem lengths of 119 to 126cm, and 110 to 117cm, respectively. The remaining cultivars were shorter, with mean lengths between 93 and 103cm (except for ‘Lady Coral Light Blue’ which was much shorter at 61cm). Analysis of variance showed that the between-cultivar differences were very highly significant ($P<0.001$).

Thirteen cultivars were included in the later planting. The main cropping period was from week 39 to week 41. Mean stem lengths are shown in Figure 18, with analysis of variance

in Table 5. All cultivars had shorter stems than for the earlier planting. Cultivars of the 'Harlequin' and 'Jewel' series gave taller plants with mean stem lengths of 81 to 94cm, while the 'Beautiful Day' and 'Lady Coral' cultivars were shorter with stems between 70 and 76cm (except for 'Lady Coral Light Blue' which was again shorter at 61cm). Analysis of variance showed that the between-cultivar differences were very highly significant ($P<0.001$).

Table 6 is a two-factor analysis of variance for the ten cultivars included at both planting dates. It showed that both cultivar and planting date exerted very highly significant effects on stem length ($P<0.001$). The earlier planting had an overall mean stem length of 100cm, while the length of the later planting averaged 78cm. The interaction between cultivar and planting date was not significant.

Many of the cultivars tested in 2013 had stem and flower attributes showing promise for greater use in the UK, i.e. tall, heavy stems with flowers that are vibrant, uniform, and positioned at the top of the plant, and free of petal disorders. None, however, was considered as outstanding or likely to provide an alternative for the favoured 'Krallen' varieties.

Figure 16. The China aster cultivars in trial at the Centre in 2013, all from week 19 planting (no picture available of 'Lady Coral Light Blue') (3 June).

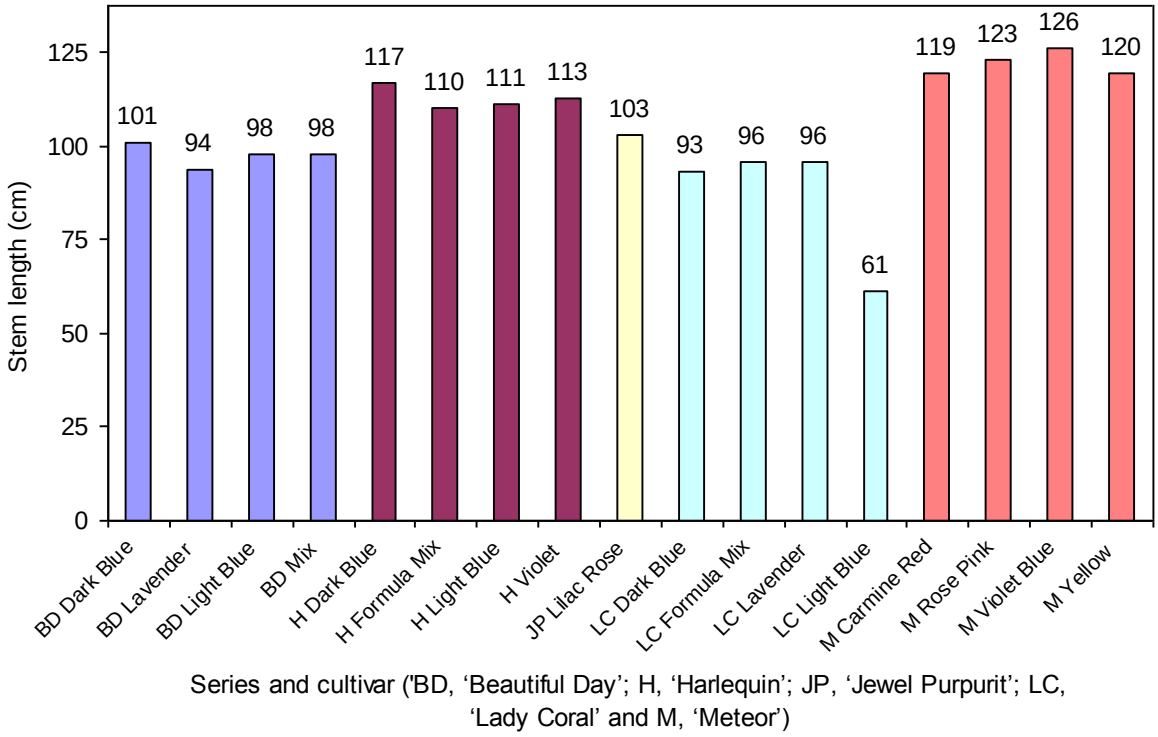

Figure 17. Overall stem length of 17 China aster cultivars from five series following transplanting to the 'Haygrove' tunnel in week 19. The figures are means of two replicate plots. LSD (5%) = 3.91.

Table 4. Analysis of variance for the stem length data of Figure 17.

Source of variation	DF	SS	MS	F	P	
Cultivar	16	7824.6	489.0	16.721	<0.001	***
Residual	17	497.2	29.2			
Total	33	8321.8				

The values of P (probability) indicate the statistical significance of the sources of variation (in this case cultivar). *, ** 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 (i.e. P>0.05).

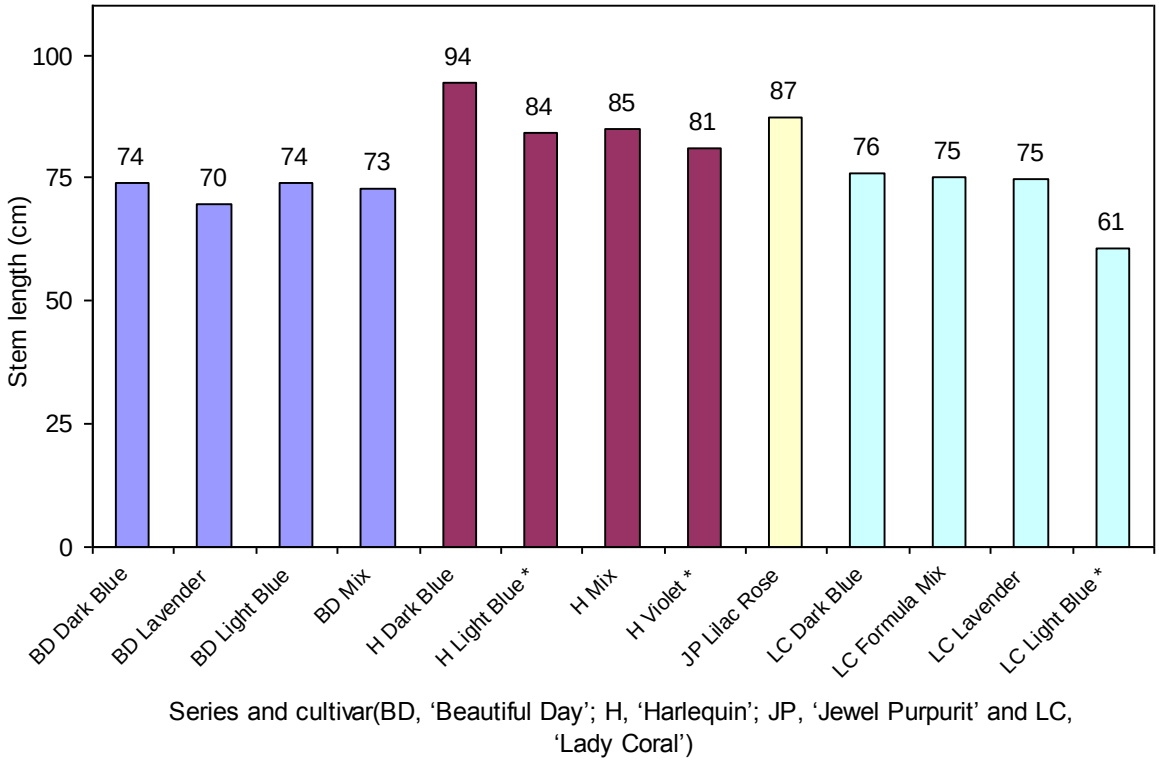

Figure 18. Overall stem length of 13 China aster cultivars from four series following transplanting to the 'Pro-Tech' tunnel in week 26. The figures are means of two replicate plots (except for the cultivars marked *). LSD (5%) = 3.48.

Table 5. Analysis of variance for the stem length data of Figure 18 (three non-replicated cultivars excluded).

Source of variation	DF	SS	MS	F	P	
Cultivar	9	1100.5	122.3	10.047	<0.001	***
Residual	10	121.7	12.2			
Total	19	1222.2				

See footnote to previous table

Table 6. Analysis of variance for the effect of cultivar and planting date on stem length in the ten cultivars common to Figure 17 and Figure 18.

Source of variation	DF	SS	MS	F	P	
Cultivar	9	2025.6	225.1	12.535	<0.001	***
Planting date	1	4936.2	4936.2	274.914	<0.001	***
Interaction	9	115.1	12.8	0.712	0.692	NS
Residual	20	359.1	18.0			
Total	39	7435.9	225.1			

The values of P (probability) indicate the statistical significance of the sources of variation (in this case cultivar, planting date or interaction between them). *, ** 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 (i.e. P>0.05).

3. Dianthus, annual (*Dianthus barbatus*), 'Breanthus' range

Background

Annual dianthus are already available to the UK market, the main varieties being 'Sweet' and 'Amazon'. 'Breanthus' is one of the 'Sparkz' range of annual dianthus introduced by HilverdaKooij in 2012 (Figure 19). It has introduced new genetics into the market, the flower being more akin to 'Sweet' in its form, i.e. a spherical flower-head. To quote HilverdaKooij's web-site, "Breanthus has robust, more lavish voluminous flowers that stand out through their uniformity and spherical flower heads. Breanthus is propagated from cutting and tissue culture, can be grown year-round and is therefore always available".[15]

In 2012 demonstration plots of four cultivars ('Duke', 'Earl', 'King' and 'Queen' 'Breanthus') were set up at the Centre to assess their market potential and collect some basic data. Because of wet weather at the time of delivery (week 14), it was necessary to pot-on the plugs and hold them until transplanting was practical, which was not until week 18 (tunnel) and week 21 (outside). The wet weather resulted in an outside crop too poor for worthwhile assessments to be made, but the tunnel-grown crop produced some good quality stems. The four cultivars were very different in length and weight of stems and the quality and number of flowers in the two flushes, and some stems failed to mature in the poor weather and late season. Pinching was found to reduce stem length (except in the least vigorous cultivar) and produce lighter stems in otherwise vigorous cultivars. But, despite the weather, the tight, spherical heads were considered especially appealing. A positive market response was received from retailers and growers. In standard vase-life testing, all cultivars achieved a 7-day vase-life. 'Breanthus' therefore showed promise, though, with the year's atypical weather, these results too may have been atypical, and a further trial would be needed before any recommendations could be made.

[15] http://www.hilverdakooij.nl/cutflowers/dianthus/breanthus/

Figure 19. The ‘Breanthus’ range of dianthus.[16]

[16] http://www.hilverdakooij.nl/cutflowers/dianthus/breanthus/

2013 trial of 'Breanthus'

Plug-plants of 'Baron', 'Duke', 'Earl', 'Elmo', 'Findis' and 'Lord' 'Breanthus' (HilverdaKooij) were transplanted to *ca* 1m-long plots in the Haygrove tunnel in two batches, weeks 14 and 16, at a density of 25 plants/m^2. One half of each plot was pinched 2 weeks after planting. There were three replicate plots for each treatment combination. A few weak stems with premature buds occurred in mid-May, and were common in 'Findis' (Figure 20). 'Elmo' commonly showed leaf scorch (Figure 20).

Figure 20. 'Breanthus' disorders seen in the 2013 trials at the Centre: left, 'Findis' with premature buds (14 May); right, 'Elmo' with leaf scorch (28 June).

The first flowers were harvested mid-June and flowering started in earnest in week 26. The crop did not seem to flush in the true sense of the word, but provided a steady supply of stems over the whole period (Figure 21). Marketable (>60cm long) stems were cropped twice-weekly. The total number of marketable stems per m^2 is shown in Figure 22, with analysis of variance in Table 7. Total number of stems/m^2 for six 'Breanthus' cultivars following planting in a tunnel in week 14 or 16 and either pinched or not. The figures are means of three replicate plots, with yields/plot adjusted to yield/m^2. LSD (5%) = 51.3.

There were highly significant effects ($P<0.01$) of cultivar, with 'Elmo consistently high low yielding; There were also significant effects ($P<0.05$) of planting date and pinching treatment, with both later planting and pinching considerably reducing the yield of stems. There was a significant interaction ($P<0.05$) between the effects of planting date and pinching treatment, the effect of pinching being more severe in the earlier planting than in the later. The trend for less stems from the later planting and less from pinching may simply

be a case of their having less time to produce marketable stems before the advent of low autumn light levels. Stem weight appeared to be very variable, both between and within varieties. The tunnel crop planted in 2013 will be left *in situ* in a covered tunnel, and its productivity recorded in its second year.

Figure 21. 'Breanthus Findis' flowering in the Centre's trials in 2013 (28 June)

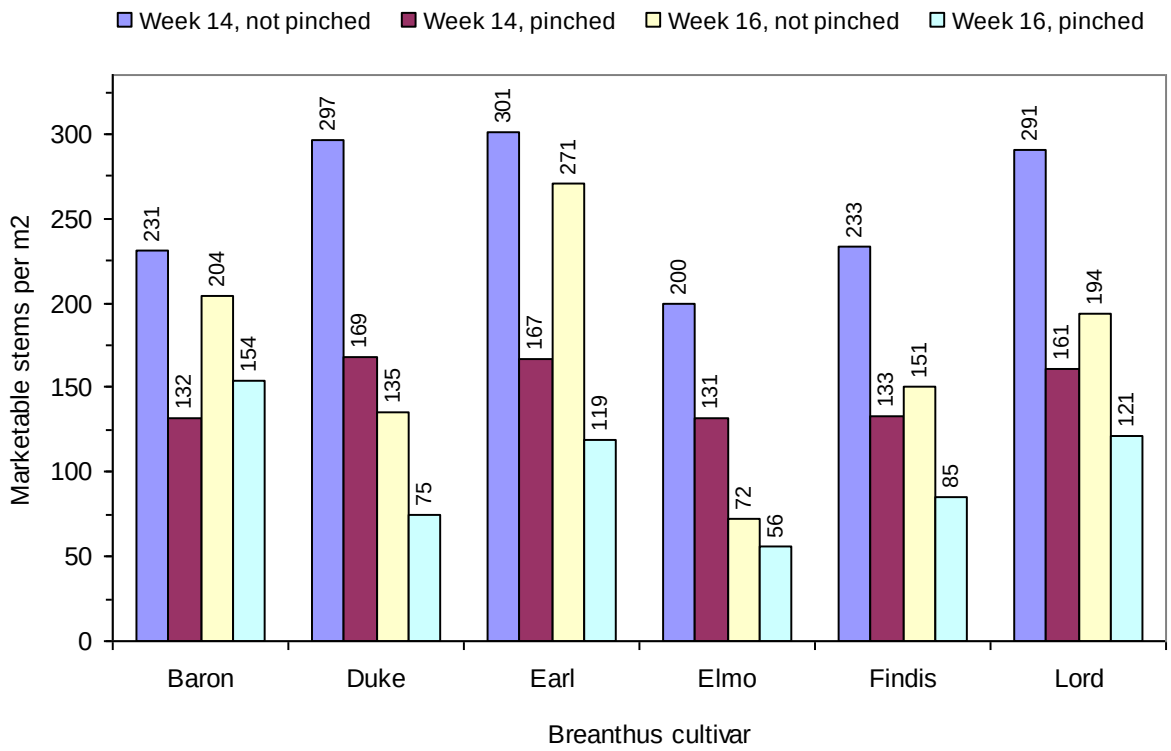

Figure 22. Total number of stems/m^2 for six 'Breanthus' cultivars following planting in a tunnel in week 14 or 16 and either pinched or not. The figures are means of three replicate plots, with yields/plot adjusted to yield/m^2. LSD (5%) = 51.3.

Table 7. Analysis of variance for the stem length data of Figure 22 (three non-replicated cultivars excluded).

Source of variation	DF	SS	MS	F	P	
Cultivar (C)	5	72040.7	14408.1	7.464	<0.001	***
Planting date (PD)	1	81877.6	81877.6	42.414	<0.001	***
Pinching treatment (PT)	1	145080.9	145080.9	75.154	<0.001	***
C × PD	5	29373.1	5874.6	3.043	0.018	*
C × PT	5	16620.4	3324.1	1.722	0.148	NS
PD × PT	1	7360.9	7360.9	3.813	0.057	NS
C × PD × PT	5	3551.1	710.2	0.368	0.868	NS
Residual	48	92661.3	1930.4			
Total	71	448566.0	6317.8			

The values of P (probability) indicate the statistical significance of the sources of variation (in this case cultivar, planting date, pinching treatment and the interactions between them). *, ** 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 (i.e. P>0.05).

4. Dianthus, spray (*Dianthus caryophyllus*), 'Star' and 'Solomio'

Background

These days spray carnations are a supermarket 'staple', but most are cheap imports from Africa and South America. 'Star' and 'Solomio' are new ranges of carnations introduced by HilverdaKooij: with an unusual flower form they would give UK growers the opportunity to produce a premium product that will not compete head-on with imports.

In 2012 demonstration plots of four cultivars ('Solomio Sem', 'Solomio Vin', 'Solomio Fen' and 'Star Cherry Tessino') were grown to assess their market potential and collect some basic data. As reported above for 'Breanthus' dianthus, these too were affected by the unusually wet weather around delivery time (week 14), so were potted-on and held for transplanting under better conditions. They were transplanted into plots in a Spanish tunnel in week 18 and outside in week 21, and were all pinched three weeks after planting. One cultivar, 'Star Cherry Tessino', was heavily predated by rabbits, despite rabbit netting being in place, and so yielded no data. In the outside beds crop growth and development was poor and no formal assessments were made.

In the tunnel 'Solomio Sem' was the first to flower, starting week 37, and two weeks later 'Solomio Vin' and 'Solomio Fen' were coming into bloom, though very slowly. By week 45 it was necessary to de-skin the tunnel for winter, and the plants were cut to the ground, though many of the stems were not yet ready for picking. 'Sem' produced stronger stems than 'Vin' and 'Fen'. Stem lengths and yields were adequate. In vase-life testing all samples achieved at least 6 days. The demonstration received positive market feedback from the

industry, noting the unusual flower form of this new range. It had been suggested that, branded accordingly, these novel cultivars might be marketed at a more developed stage than traditional spray carnations. As only 'Solomio Sem' completed flowering in a reasonable time-scale, further trials were needed.

2013 trial of 'Solomio' and 'Star' dianthus

In 2013 cuttings of the 'Solomio' series ('Edo', 'Fen', 'Gill', 'Ken', 'Sem' and 'Vin') and 'Star Cherry Tessino' (HilverdaKooij) were obtained and transplanted at 32 plants/m^2 into duplicate *ca* 1m-long plots in the 'Haygrove' tunnel in weeks 14 and 16. As available, one or two plots each of plugs of the 'Floristar' series ('Mix', 'Salmon Pink', 'Scarlet' and 'White') (sourced by Simon Crawford) were planted for additional observations. All plants were pinched 2 weeks after transplanting. 'Star Cherry Tessino' again proved attractive to rabbits, though this time efforts to protect them were more successful.

Cropping started in mid-July and continued until the plants were cut down in late-October, when there were still immature stems from the first flush. Overall they produced good quality, strong stems, and this was commented on at the Open Day (Figure 23). However, there was an issue with bud abortion in some varieties, especially 'Edo', where the central bud dried-up before it was fully mature, but the stem was still marketable if the aborted bud was removed manually.

Marketable stems – those 60cm or more in length – were harvested, and among the 'Solomio' cultivars the average yield of stems varied from 142 to 198 stems/m^2 for the earlier planting, and less, from 108 to 144, for the later planting. The one 'Star' cultivar trialled produced, after the effects of predation, 126 and 83 stems/m^2, respectively. These data are shown in Figure 24, with analysis of variance in Table 8. Analysis of variance showed that both the effects of cultivar and of planting date on stem yield were very highly significant ($P<0.001$). The interaction (cultivar × planting date) was not significant.

The additional plots of the four 'Floristar' cultivars produced few stems, a maximum of 10 per plot (Figure 25).

Figure 23. Some of the spray dianthus ‘Solomio’ and ‘Star’ cultivars planted at the Centre in 2012 and over-wintered (and suffering some losses) to 2013. From top-left and clockwise, ‘Solomio Sem’, ‘Star Cherry Tessino’ and (in bud) ‘Solomio Fen’ (6 August).

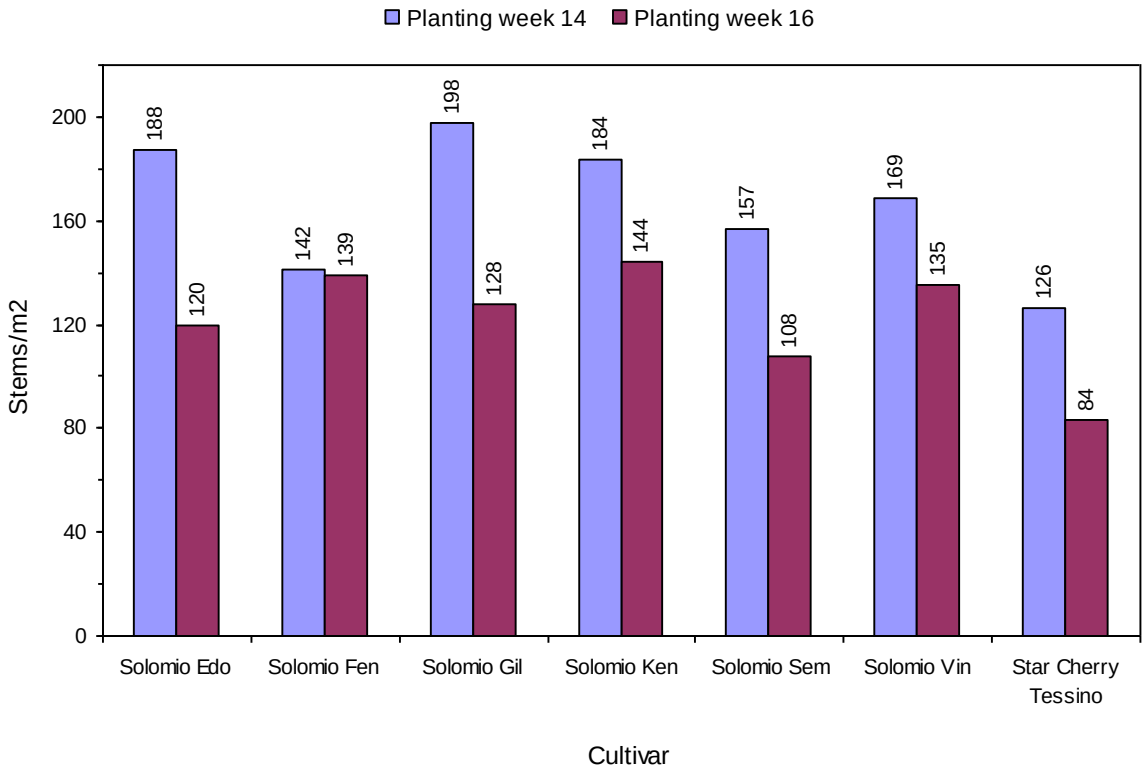

Figure 24. The yield of marketable stems per m^2 in seven 'Solomio' and 'Star' annual dianthus cultivars transplanted at week 14 or 16. The figures are means of two replicate plots. LSD (5%) = 18.1.

Table 8. Analysis of variance for the stem yield data of Figure 24.

Source of variation	DF	SS	MS	F	P	
Cultivar (C)	6	10314.4	1719.1	6.933	0.001	***
Planting date (PD)	1	13245.8	13245.8	53.418	<0.001	***
C × PD	6	3104.5	517.4	2.087	0.120	NS
Residual	14	3471.5	248.0			
Total	27	30136.1	1116.1			

The values of P (probability) indicate the statistical significance of the sources of variation (in this case cultivar, planting date and their interaction). *, ** 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 (i.e. P>0.05).

Figure 25. Spray dianthus 'Floristar' cultivars at the Centre in 2013 (6 August).

5. Eryngium (Sea Holly) (*Eryngium* cultivars)

Background

Eryngium are an expensive cut-flower, popular at Christmas. Responding to grower requests, small demonstration plots of eryngium cultivars were grown at the Centre in 2007, 2008 and 2011. In 2011 a small selection of new cultivars - 'Arabian Dawn', 'Blue Bell', 'Deep Blue', 'Magical Blue Falls', 'Magical Cloud', 'Magical Purple Falls' and 'Marbella' - were planted at 12 plants/m^2 in *ca* 3m-long plots in a Spanish tunnel and outside to assess their potential as a crop in the UK. Few flowers were produced in 2011 and the plants were grown-on for assessment in 2012. Some marketable stems were produced in this second year, having a 7-day vase-life in standard testing. Owing to plant losses as result of the cold weather in winter 2011/2012, and the wet summer and autumn in 2012, these yields were not considered meaningful, and the plants were grown-on to 2013.

Performance in 2013

Grown-on to 2013 the eryngium in the tunnel became over-vigorous and so were grubbed-up. Of the outside planting, many did not survive the severe winter of 2012/2013, and the survivors produced variable numbers of stems. The data are shown in Figure 26. The

outstanding cultivars were ‘Blue Bell’ and ‘Deep Blue’, which appeared to be almost fully hardy, while for the remaining five cultivars the percentage of plant survival was between 43 and 69. Scaling-up the yields of stems to equate to 100% plant survival, ‘Deep Blue’ would produce 113 stems/m^2 and ‘Blue Bell’ 56, while the other cultivars would produce between 28 (‘Marbella’) and 88 (‘Magical Purple Fall’) stems/m^2.

In 2013 necrotic, black lesions appeared on the foliage, which devastated ‘Arabian Dawn’ and ‘Marbella’. The spots were identified as due to *Alternaria* (Figure 27) and this was confirmed by the Stockbridge Technology Centre (STC) Plant Clinic, who stated that this pathogen has been reported previously on eryngium.

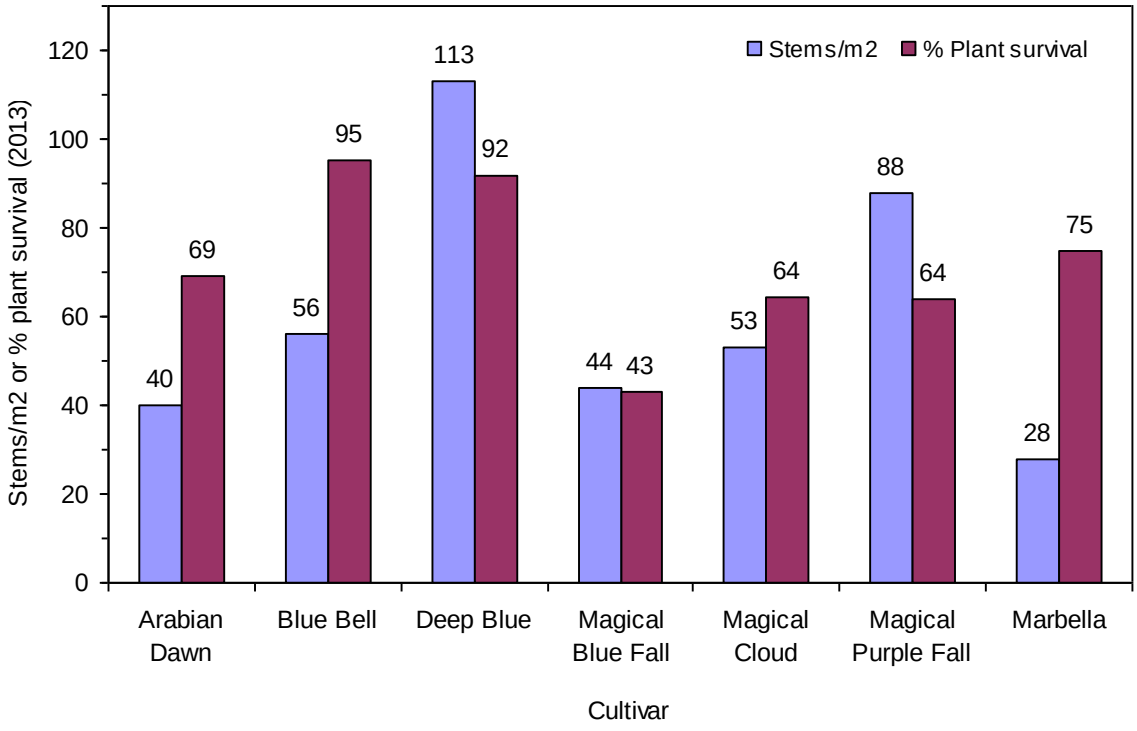

Figure 26. The yield of stems/m^2 and percentage plant survival in 2013 for seven eryngium cultivars planted in outside beds in 2011. Stem yield has been scaled-up to equate to yields for 100% plant survival.

Figure 27. Symptoms of *Alternaria* infection on eryngium ‘Arabian Dawn’ at the Centre in 2013.

6. Lily (*Lilium* cultivars)

Background

The remit of previous Cut-Flower Centre projects (e.g. PO/BOF 002) did not include bulbous plants, but this has now changed and they have been included in the current project. (The term ‘bulbous’ is used in its loose, horticultural sense to include bulbs, corms, tubers, etc.). In the last 20 years lilies have become a major phenomenon of the UK cut-flower trade, with large quantities grown in the UK (from imported bulbs) in addition to the stems imported. Factors involved in this success include dynamic hybridisation programmes in the Netherlands, the relative rapidity of bulking-up new cultivars, AYR supplies, the avoidance of soil-borne diseases through the successful development of growing lilies in crates of soil-less media, and their good post-harvest qualities – multiplied by the ‘wow factor’ that the cut-flowers often evoke. The initial lily trial at the Centre focussed on

demonstrating new cultivars and investigating the use of green-waste as an alternative growing medium.

2013 New lily cultivars and green-waste trial

Bulbs of the following cultivars were obtained in mid-April 2013: ‘Adelante’, ‘Burlesca’, ‘Carolyn’, ‘Crystal Bianca’, ‘Hacienda’, ‘Hypnose’, ‘Oberto’ and ‘Ovatie’ (from Nord Lommerse Flower Bulbs Group), ‘Castille’, ‘Fiction’, ‘Pintado’, ‘Profundo’ and ‘Tupelo’ (from Onings) and ’Beau Soleil’, ‘Mandaro’ and ‘Sambuca’ (from VWS Flowerbulbs). In week 17 the bulbs were planted in standard lily crates (58 × 29 × 20cm) of either 100% standard commercial lily peat, a mixture of 50% peat and 50% green-waste, or 100% green-waste (Donarbon Ltd, Waterbeach, Cambridgeshire). Each crate was planted with 15 to 18 bulbs per crate, depending on bulb grade (which varied from 14-16 to 18-20cm for the different supplies). Two crates were planted for each cultivar × growing medium combination, except that insufficient bulbs of ‘Beau Soleil’, ‘Mandaro’ and ‘Sambuca’ were available to plant the second crate. One crate of each combination was moved to the ‘Haygrove’ tunnel on the same day, while the second was cold-stored at 9°C and moved to the ‘Haygrove’ tunnel in week 21. At the picking stage the overall length and bud count were recorded for six stems per crate.

Stem lengths and bud numbers for the earlier planting are shown in Figure 28, with analysis of variance in Table 9 and Table 10. With minor exceptions, stem length was longest in plants grown in peat and shortest grown in green-waste. There was no obvious relationship between the number of buds per stem and growing medium. Analysis of variance showed that there was a very highly significant ($P<0.001$) effect of cultivar on both stem length and bud numbers, while the effect of growing medium was significant at the same level ($P<0.001$) on stem length but was not significant for the number of buds per stem. The quality of the stems was superb and in fact some growers commented that they were actually too good for a supermarket grade!

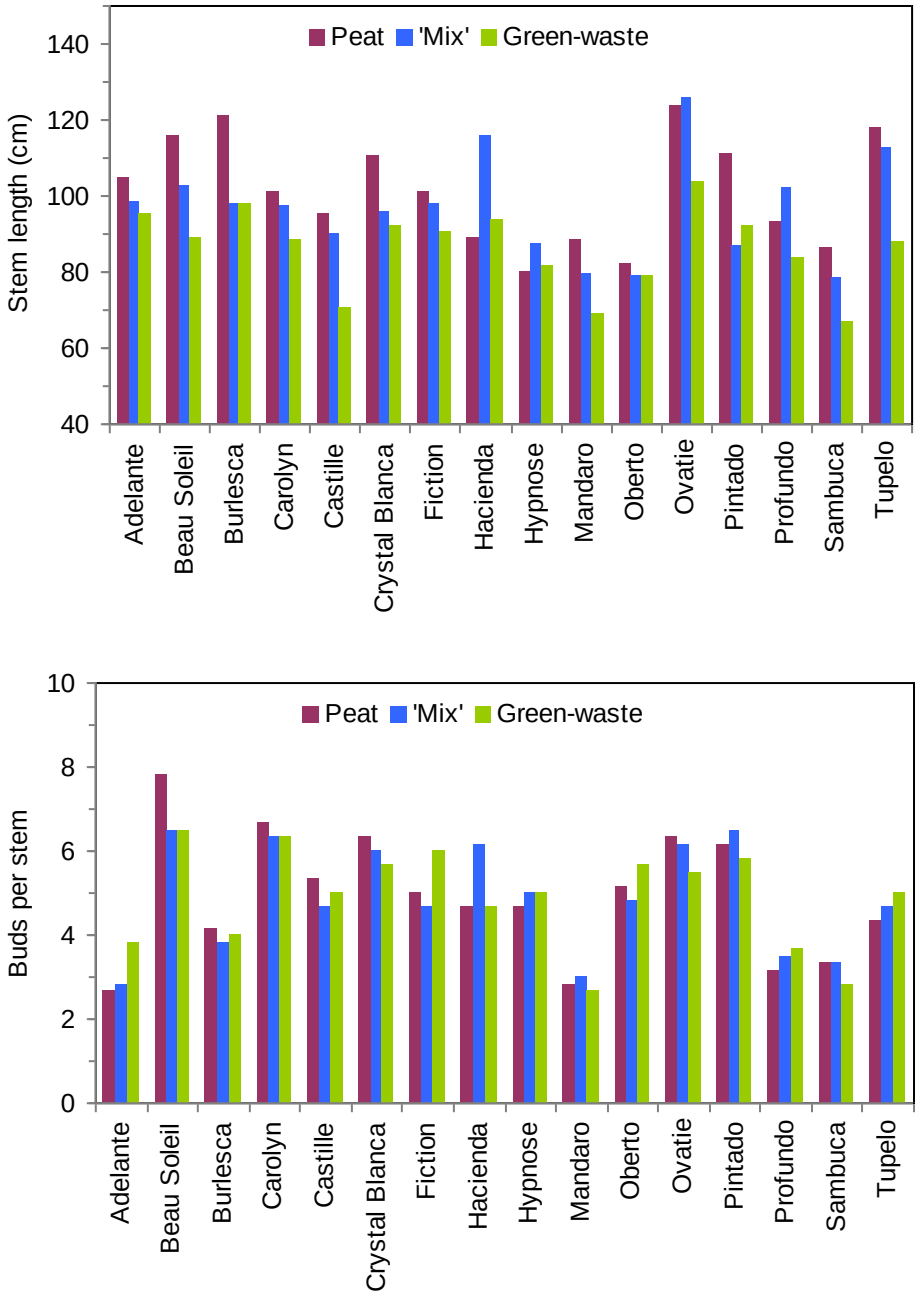

Figure 28. Stem length (above) and number of buds per stem (below) of 16 lily cultivars planted in three growing media and housed in week 17. LSD (5%) for stem lengths = 5.4 (between cultivars) and 12.5 (between growing media) and for bud numbers = 0.34 (between cultivars) and 0.78 (between growing media).

Table 9. Analysis of variance for the stem length data of Figure 28 (16 lily cultivars planted in three growing media and housed in week 17).

Source of variation	DF	SS	MS	F	P	
Cultivar	15	5761.44	384.096	6.833	<0.001	***
Growing medium	2	1875.13	937.562	16.679	<0.001	***
Residual	30	1686.32	56.211			
Total	47	9322.88				

The values of P (probability) indicate the statistical significance of the sources of variation (in this case cultivar and growing medium). *, ** 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 (i.e. P>0.05).

Table 10. Analysis of variance for numbers of buds per stem from Figure 28 (16 lily cultivars planted in three growing media and housed in week 17).

Source of variation	DF	SS	MS	F	P	
Cultivar	15	73.009	4.867	22.075	0.000	***
Growing medium	2	0.015	0.008	0.034	0.966	NS
Residual	30	6.615	0.220			
Total	47	79.638				

See footnote of previous table.

Results for the later planting (after cold storage) are shown in Figure 29, with analysis of variance in Table 11 and Table 12. The results were similar to those of the first planting. With only slight exceptions, stem length was longest in plants grown in peat and shortest grown in green-waste. There was no obvious relationship between the number of buds per stem and growing medium. Analysis of variance showed that there was a very highly significant (P<0.001) effect of cultivar on both stem length and bud numbers, while the effect of growing medium was significant at the same level (P<0.001) on stem length but was not significant regarding the number of buds per stem. The quality of the stems was very good in all treatments, even though the stems were shorter in the peat/green-waste mix.

A further analysis of variance was carried out for the 13 cultivars that occurred in both housing dates (Table 13 and Table 14). This confirmed the very highly significant (P<0.001) effects of cultivar and growing medium on stem length and showed that the effect of housing date was not significant. The marginal means for stem length in peat, ‘mix’ and green-waste were 106.5, 100.1 and 88.8cm, respectively. For number of buds per stem, the effect of cultivar was again very highly significant (P<0.001) but the effects of both growing medium and housing date were not significant.

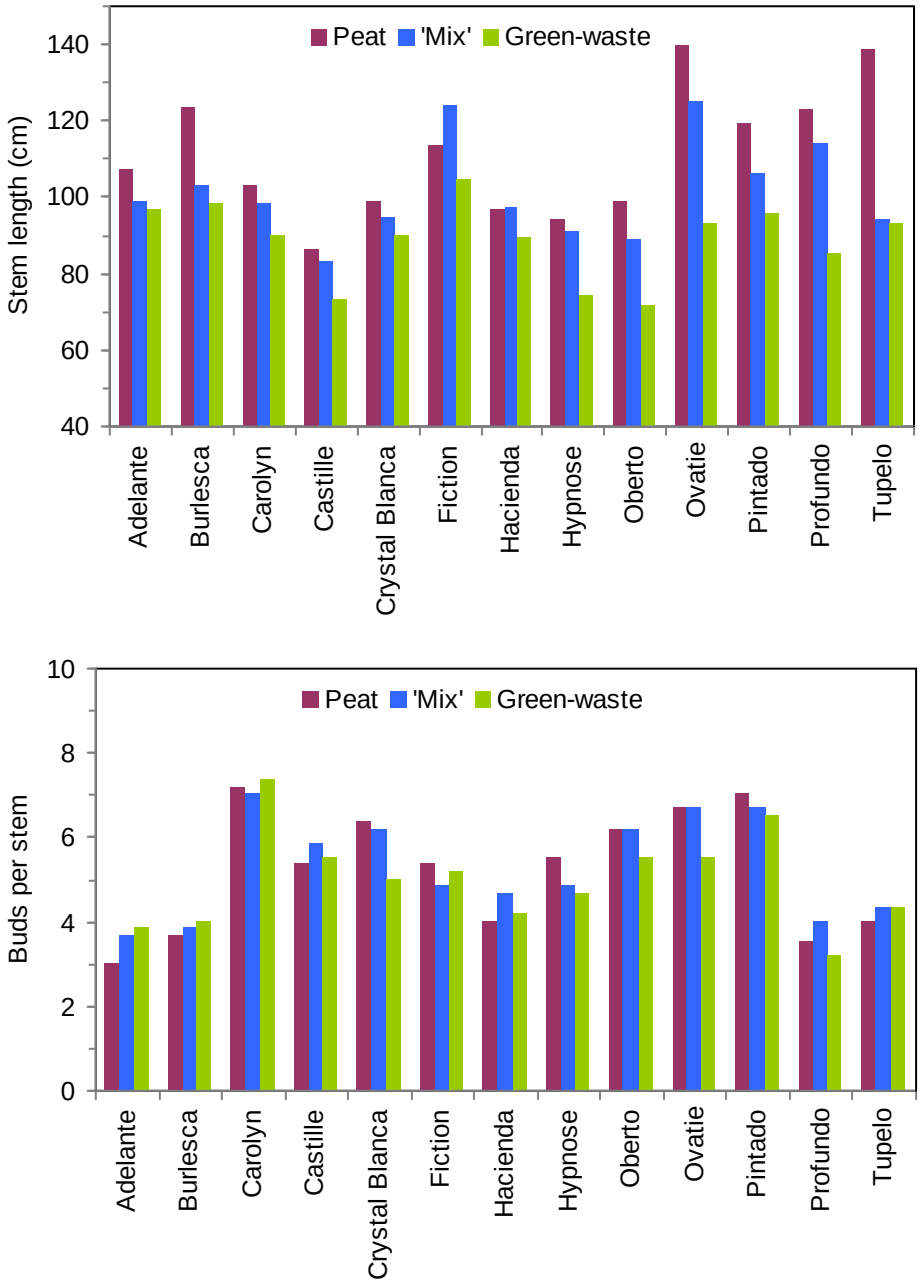

Figure 29. Stem length (above) and number of buds per stem (below) of 13 lily cultivars planted in three growing media, cold-stored and housed in week 21. LSD (5%) for stem lengths = 7.1 (between cultivars) and 14.7 (between growing media) and for bud numbers = 0.31 (between cultivars) and 0.65 (between growing media).

Table 11 Analysis of variance for the stem length data of Figure 29 (13 lily cultivars planted in three growing media, cold-stored and housed in week 21).

Source of variation	DF	SS	MS	F	P	
Cultivar	12	4831.19	402.599	5.309	0.000	***
Growing medium	2	3187.21	1593.603	21.016	0.000	***
Residual	24	1819.90	75.829			
Total	38	9838.30				

The values of P (probability) indicate the statistical significance of the sources of variation (in this case cultivar and growing medium). *, ** 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 (i.e. P>0.05).

Table 12. Analysis of variance for numbers of buds per stem from Figure 29 (13 lily cultivars planted in three growing media, cold-stored and housed in week 21).

Source of variation	DF	SS	MS	F	P	
Cultivar	12	53.151	4.429	30.054	0.000	***
Growing medium	2	0.667	0.333	2.262	0.126	NS
Residual	24	3.537	0.147			
Total	38	57.355				

See footnote of previous table.

Table 13. Analysis of variance for the stem length data for 13 lily cultivars planted in three growing media and either planted and housed in week 17, or planted and cold-stored and housed in week 21.

Source of variation	DF	SS	MS	F	P	
Cultivar	12	7707.50	642.29	8.770	<0.001	***
Housing date	1	239.93	239.93	3.276	0.075	NS
Growing medium	2	4177.76	2088.88	28.521	<0.001	***
Residual	62	4540.86	73.24			
Total	77	16666.04				

The values of P (probability) indicate the statistical significance of the sources of variation (in this case cultivar, growing medium and housing date). *, ** 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 (i.e. P>0.05).

Table 14. Analysis of variance for the bud number data for 13 lily cultivars planted in three growing media and either planted and housed in week 17, or planted and cold-stored and housed in week 21.

Source of variation	DF	SS	MS	F	P	
Cultivar	12	87.042	7.253	33.580	<0.001	***
Housing date	1	0.319	0.319	1.478	0.229	NS
Growing medium	2	0.173	0.086	0.401	0.672	NS
Residual	62	13.393	0.216			
Total	77	100.93				

See footnote of previous table.

7. Stocks, column (*Matthiola incana*)

Background

Column stocks are one of the mainstays of UK protected cut-flower production, with over fourteen million stems being produced in 2013. The series of column stocks trials at the Centre have either been in response to specific industry problems (including fusarium wilt, type of module, automated gapping-up, flower initiation in summer temperatures and steaming) or investigations of new varieties (including 'Anytime' and 'Katz').

In 2009 the suggested advantage of using block-raised plants (rather than plugs) was tested. No advantage due to using blocks could be demonstrated, and the technique has subsequently been discounted by the industry. In 2011 the purported damage to plants as a result of automated gapping-up was investigated. There was found to be only minimal differences in stem length and weight and spike length between non-gapped-up (undamaged) trays and gapped-up (damaged) trays. There was no substantial disadvantage of using automated gapping-up, a finding confirmed in trials at Greenmount College, Co. Antrim.

In 2011 samples of a new line, 'Anytime Yellow', were compared with established cultivars ('Centum Pink' and 'Figaro Lavender'). 'Anytime Yellow' was of average stem length but with a long spike, and was relatively light in weight, but still had potential to supplement the current range of varieties. The 'Anytime' series is now well accepted within the industry; during the 2013 season it was shown to perform well during very hot July weather.

Column stocks are prone to failing or abnormal flower initiation when grown in summer temperatures. The 'Katz' series was bred for resilience to high temperatures, and a summer crop of 'Katz' varieties was planned in 2011. The plugs did not arrive until late-August, and were planted in a tunnel that had already had its cover removed for winter. They were in full flower in early-December, and, although battered by the weather, were of basically good quality and appeared to last well in the vase. This suggested that, irrespective of its advantages as a warm summer crop, 'Katz' cultivars might be suitable as a late-flowering tunnel crop. Since the 'Katz' series is selectable for double flowers "only with difficulty", selection is uneconomic, but a profitable crop might still be possible if a reasonably high percentage of double flowers can be obtained in a Spanish tunnel or under minimally heated or unheated glass. The overall percentage of plants producing double flowers varied from 40 to 62% in the different lines (excluding non-opening flowers). In further tests in 2012, with four 'Katz' cultivars, the percentage of double plants varied less, between 46 and 57%.

In 2012, at the request of growers, the Centre undertook a variety trial using 48 lines comprising standard cultivars from the 'Aida', 'Centum', 'Fedora', 'Figaro', 'Opera' and 'Phantom' series, and some new ones. They were grown in both steamed and non-steamed soil in Spanish tunnels in order to compare their performance in both situations. The flowers were regarded as of impressive quality. The most obvious finding was the variation in stem weight and length, and spike length, between cultivars. The effects of growing in steamed or non-steamed soil depended on the variable being measured, with a strong beneficial effect of steaming on stem weight but commercially insignificant effects on stem and spike length. In terms of stem length, more than half the cultivars benefited from planting into steamed soil, while a smaller group showing little or no benefit.

There has been increasing concern among growers about the poor establishment and growth, and lack of flower uniformity, in column stocks. No single factor had been identified as responsible for these unsatisfactory results. As a result, separate HDC-funded projects (PO 005 and 005a) were carried out to survey cultural practices and investigate the role of *Pythium* and, in particular, *Fusarium* in these findings (PO 005) and to consider the possibly of remedial effects of soil amendments (PO 005a). Details of these findings are given in the project final report .

Due to the ongoing interest in the 'Katz' series as a summer or late crop, varietal comparisons were continued in 2013 with a range of cultivars grown in a Spanish tunnel at the Centre. Additionally, the full range of Combinations Young Plants and Florensis Cut Flowers column stocks were planted under glass at a commercial nursery in Terrington St Clement, Norfolk, for testing for susceptibility to fusarium wilt. As a result of requests from growers, spare plants from the main trials were used to plant a purely observational trial of all the Combinations and Florensis varieties, varieties from the 'Katz' series and some new, coded lines, also at the commercial nursery.

Also in 2013 a herbicide screen was carried out at the Centre by Angela Huckle, John Atwood and Jessica Sparkes (ADAS), part of an HDC/HTA/EMR Fellowship (HDC project CP 86). Only a limited range of herbicides is known to be safe to column stocks, and, as some of the more desirable, new cultivars have relatively weak growth, they are more susceptible to herbicide damage. The primary focus of the project was phytotoxicity rather than weed challenge, so the trial was better hosted at the Centre than at a commercial nursery. The cultivars used were 'Fedora Deep Rose' and 'Figaro Lavender', representing the stronger and weaker varieties, respectively, and a range of pre- and post-planting herbicide treatments was applied. An interim summary is available in the Centre's 2013 Open Day handout and full results should be available early in 2014.

2013 ‘Katz’ variety trial in tunnel

In week 24 plug-plants of ‘Katz’ varieties ‘Apricot’, ‘Bright Rose’, ‘Cherry Blossom’, ‘Lavender Blue’, ‘Light Lavender’, ‘Pink’, ‘White ‘ and ‘Yellow’ were transplanted at 64 plants/m^2 into duplicate *ca* 1m-long plots in the Centre’s ‘Pro-Tech’ tunnel bay 1.

The plants grew well, though their stem strength was not as good as in previous years, possibly due to hot weather throughout most of the life of the crop Figure 30. However, their quality was far superior to that in the commercial glasshouse trial, which was mostly unmarketable because of the weakness of the stems.

Figure 30. Examples of column stocks ‘Katz’ growing at the Centre in 2013 (6 August).

Cropping began in week 30 and continued until week 32. Stem and spike lengths were recorded for double-flowered plants and are shown in Figure 31, with analysis of variance in Table 15 and Table 16. Mean stem length varied from 80cm (‘Light Lavender’) to >90cm (‘Bright Rose’, ‘Pink’ and ‘Yellow’), and the analysis of variance confirmed that the effect of

cultivar was statistically highly significant (P<0.01). However, the differences between cultivars in spike length were small and not statistically significant.

Figure 31. Overall stem and spike lengths of double-flowered flowered plants of eight 'Katz' cultivars of column stocks from the 2013 trial in a Spanish tunnel. The figures are means of twelve sampled stems from each of two replicate plots. LSD (5%) = 2.9 for stems and 2.3 for spikes.

Table 15. Analysis of variance for the stem length data of Figure 31.

Source of variation	DF	SS	MS	F	P
Cultivar	7	350.79	50.11	7.995	0.004 **
Residual	8	50.142	6.27		
Total	15	400.93	50.11		

The values of P (probability) indicate the statistical significance of the different sources of variation (e.g. of cultivar). *, ** 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 (i.e. P>0.05).

Table 16. Analysis of variance for the spike length data of Figure 31.

Source of variation	DF	SS	MS	F	P
Cultivar	7	88.08	12.58	3.263	0.060 NS
Residual	8	30.85	3.86		
Total	15	118.9			

See footnote to previous table

2013 Varietal susceptibility to fusarium wilt

Plots of the full range of Combinations and Florensis varieties (the latter including 'Katz' varieties and also a number of coded lines supplied by Florensis from PanAmerican Seeds' breeding lines) were planted at 64 plants/m^2 in week 24 in a commercial glasshouse that had a history of fusarium wilt (Figure 32). The trial followed a commercial crop of column stocks and the soil was not sterilised before the trial was planted. There were four replicate plots of each variety and 16 plants per plot.

Figure 32. Examples of column stocks 'Katz' growing under glass in the commercial evaluation (30 August 2013).

The numbers of stems with obvious fusarium wilt, and the number of any other remaining unmarketable stems, were assessed in week 31 after the marketable stems had been cropped. The numbers of stems with fusarium wilt and the number of stems harvested are shown in Figure 34 (Combinations varieties) and Figure 35 (Florensis varieties). In these Figures the varieties have been ranked from left to right according to increasing incidence of fusarium wilt symptoms, enabling the relatively resilient cultivars (on the left of the histogram) to be picked out and, of those, the varieties that gave a greater-than-average yield of marketable stems. In the case of the Combinations varieties, the resilient and productive varieties were 'Fantasy Red Imp', 'Fantasy Red', 'Avalanche White', 'Phantom Cream Imp' and 'Phantom Red'. In the case of the Florensis varieties, many more of those tested fell into this category: 'Anytime' varieties 'Red', 'Pink', 'Sea Blue', 'White', 'Apple Blossom' and 'Yellow', 'Katz' varieties 'Pink', 'Bright Rose', 'Cherry Blossom', 'Light Lavender' and 'Yellow', 'Figaro Lavender' and some of the coded lines, 'T0681P', 'T0311P' and 'T6340P'. Figure 33 gives a similar breakdown, but with varieties grouped into series. It

confirms the resilience and productivity of the 'Katz' and 'Anytime' series, while 'Opera' varieties have the opposite characteristics. Despite designing the trial with four replicate plots of each variety, the results should be interpreted with caution due to the uneven occurrence of the pathogen in the soil and the unpredictable nature of disease expression.

The information on this trial can also be found in the National Cut Flower Centre/HDC Information Sheet 4 (Summary of the Cut Flower Centre (CFC) trial examining the susceptibility of a wide range of different varieties of column stocks (*Matthiola incana*) to fusarium wilt).

The other main findings were:

- None of the currently available range of varieties showed total resistance to fusarium wilt
- Some varieties, such as 'Centum' (especially 'Deep Blue'), 'Opera Deborah' and 'Fedora' were highly susceptible to fusarium wilt, although in this trial the Florensis range of 'Centum' seemed more susceptible than the Combination range, a result which needs further investigation
- The 'Katz' series was the least susceptible to fusarium wilt, but this could be partially due to the high number of plants with single flowers, which from previous experience rarely express disease symptoms
- The Combinations varieties 'Fantasy Red' and 'Fantasy Red Improved' seem worthy of further investigation because they achieved a high percentage of marketable stems with a low level of disease expression
- As a series, 'Anytime' (with the exception of 'Anytime Lavender') showed low susceptibility to fusarium wilt and a high proportion of marketable stems
- Some varieties showed a low level of fusarium wilt, but also a low number of marketable stems (usually less than 50%), including 'Aida White' and 'Figaro Lavender' This is as a result of production in unsteamed soil which has been observed regularly on commercial plantings in recent years.
- Some of the new, coded Florensis varieties, such as T0311P and T1266P, showed promise, expressing a low level of disease whilst having a high number of marketable stems; whereas others (such as T7796P and T8784P) appeared to be highly susceptible to fusarium wilt.

Fusarium oxysporum is still the single most troublesome problem of column stocks, resulting in very high crop losses in some situations. It is a very aggressive pathogen and in cases of extreme disease pressure it is likely to attack all the current commercially available

varieties. However this trial has confirmed earlier grower observations that there is a considerable variation in varietal susceptibility.

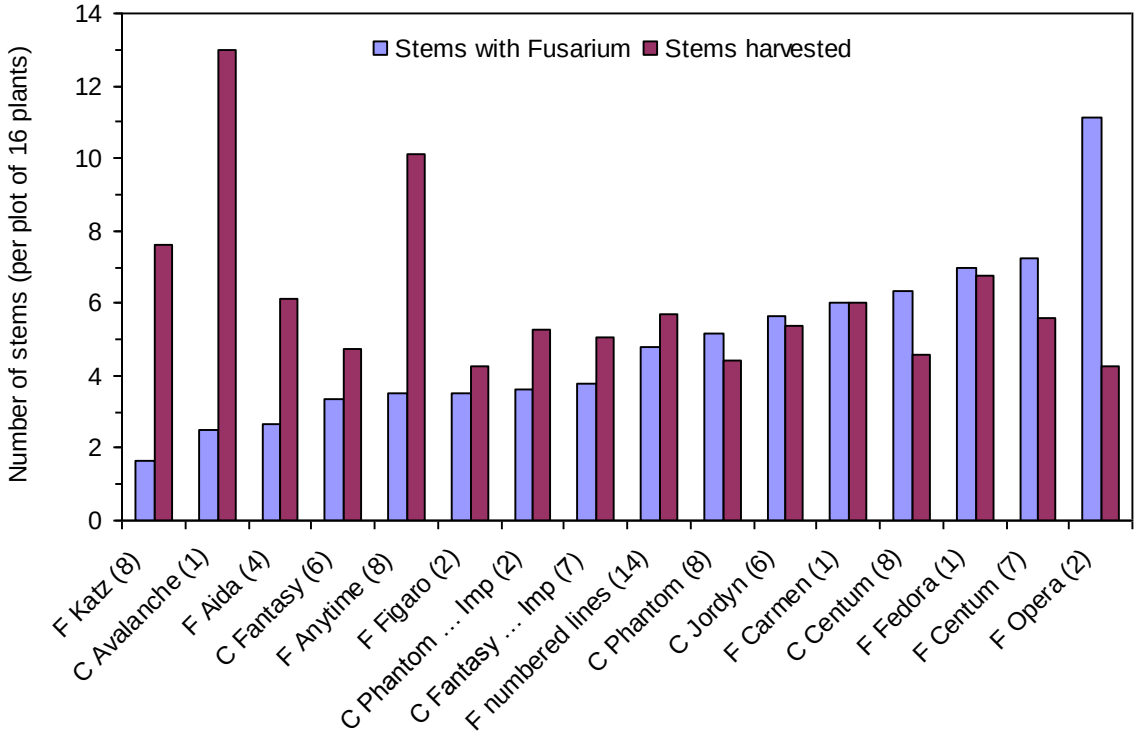

Figure 33. Column stocks in the fusarium wilt susceptibility trial in a commercial glasshouse, showing results for the different series arranged by increasing incidence of fusarium wilt (blue bars) ranked from left to right, also showing the number of stems harvested (red bars). The values are the means of each series, with the number of varieties in each series in parenthesis.

2013 Variety trial

Using spare plug-plants from the fusarium wilt trial above, additional single plots of each of the Combinations and Florensis varieties were planted at 64 plants/m^2 in week 24 in a steamed area of the commercial glasshouse. The hot weather brought the plants on much quicker than anticipated and some of the 'Anytime' varieties and coded lines were ready for cropping in week 30. Despite the hot weather during this period, all the varieties (except 'Katz') produced marketable stems. This demonstration was very popular at the Open Day, with growers spending a lot of time looking through the varieties and making decisions about their own programmes. This was an additional trial to those agreed in the original work-plan and as such there was not enough resource to undertake any assessments but growers appreciated the opportunity to view all of the commercially available varieties on one site.

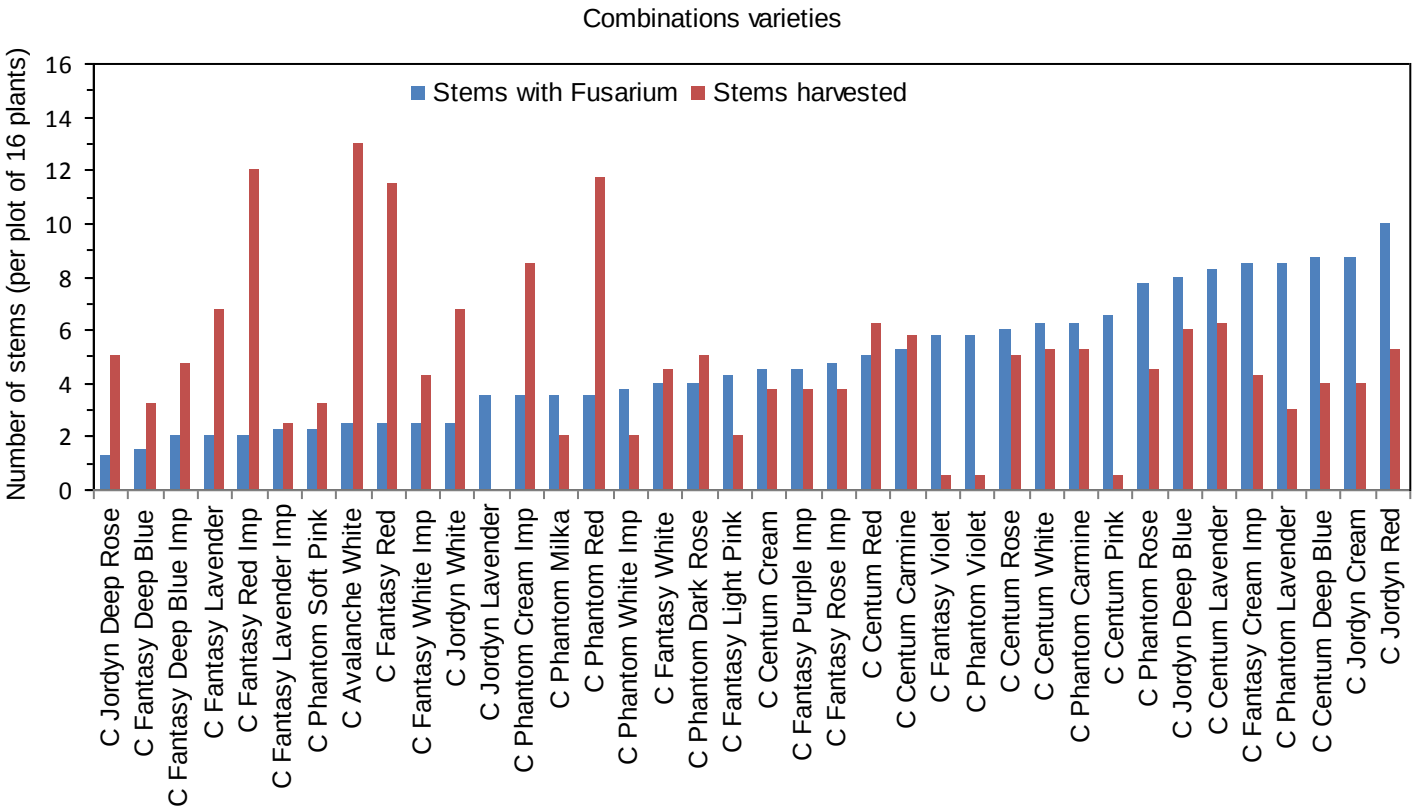

Figure 34. Combinations varieties of column stocks in the fusarium wilt susceptibility trial in a commercial glasshouse: varieties arranged by increasing incidence of fusarium wilt (blue bars) from left to right, also showing number of stems harvested (red bars). The figures are means of four replicate plots.

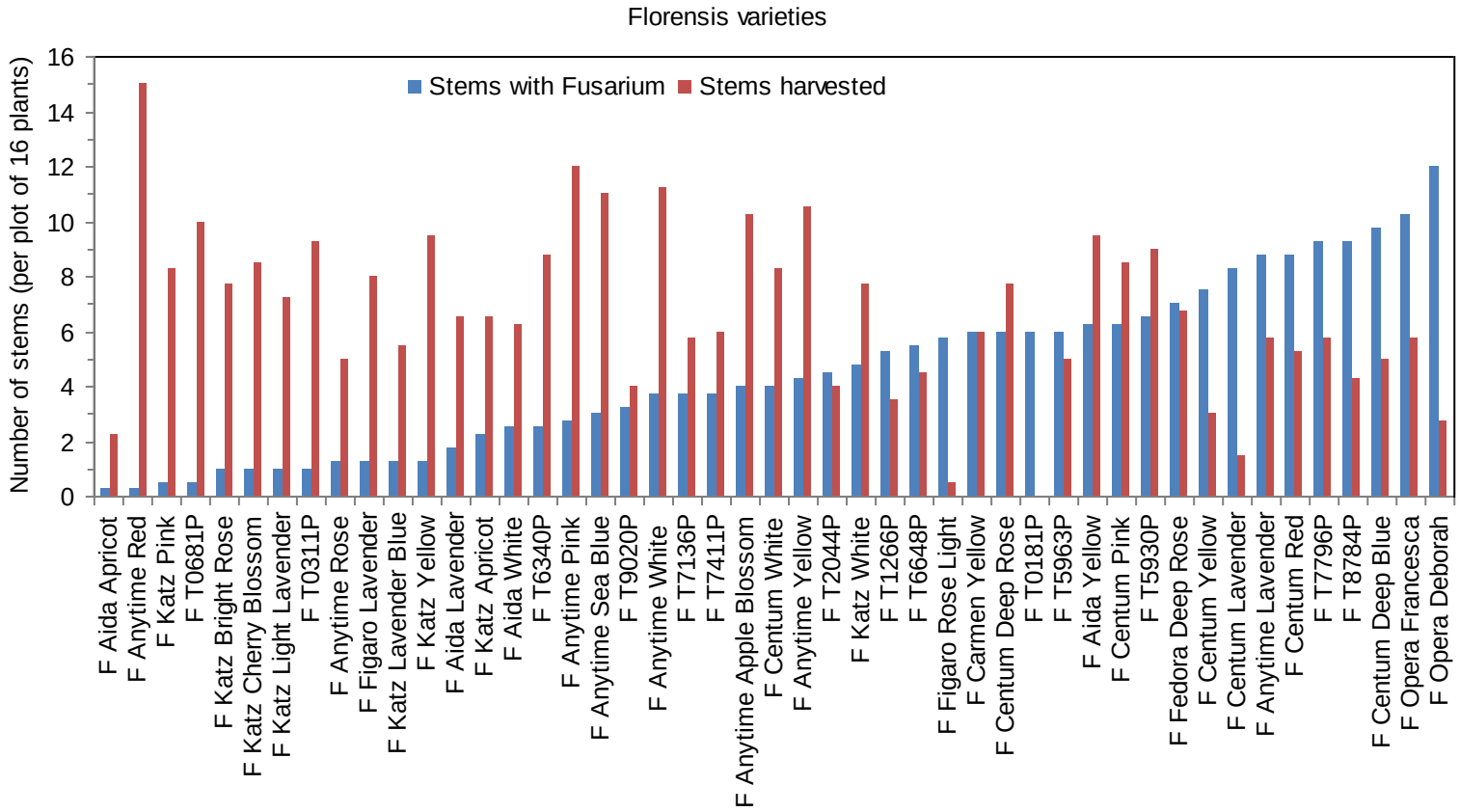

Figure 35. Florensis varieties of column stocks in the fusarium wilt susceptibility trial in a commercial glasshouse: varieties arranged by increasing incidence of fusarium wilt (blue bars) from left to right, also showing number of stems harvested (red bars). The figures are means of four replicate plots.

8. Sunflower (*Helianthus annuus*)

Background

Perhaps unexpectedly, sunflowers became a fashionable cut-flower in the early-2000s, and this popularity has been maintained despite a number of problems. Significant quantities are now field-grown in the UK. Sunflowers have been included in the Centre's trials since 2010. The main needs are to reduce the resources needed in harvesting and handling, and this includes evaluating new dwarf cultivars and using plant growth regulators on standard cultivars.

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

Figure 36. Outside sunflower at the Centre in 2013: left, germination after direct-drilling (4 June); right, at flowering (22 July).

2013 cultivar trial

In 2013 seeds of cultivars 'Galilee Adami', 'Galilee Miracle', 'Galilee Orange', 'Helios Flame', 'Tanya', 'Tavor Flash Bicolour', 'Tavor Joy' and 'Tavor Lemon', and of five numbered lines (CF 100, 639, 652 and 654, and KB 198) were obtained from KBS Consulting. They were sown by hand into 5 × 1 m plots made up of four rows 30cm apart with seeds 10cm apart within the rows in outdoor beds in weeks 15 and 23 (Figure 36), and into 1.5m-long plots in 'Pro-Tech' tunnel bay 2 in week 30. Insufficient seeds of three cultivars (CF 100, 'Galilee Orange' and 'Tanya') remained for the last sowing, but plots of the remaining ten cultivars were duplicated in adjacent beds.

Despite the dry weather of 2013, some cultivars started to produce marketable stems from mid-June onwards, with the second planting coming into flowering in time for the Open Day in early August when growers could make their own judgments. Mean overall stem lengths and flower-head diameters for the outdoor sowings (weeks 15 and 23) are shown in Figure 37, with analyses of variance in Table 17 and Table 18**Error! Reference source not found.**. 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 (Figure 39). The analysis of variance confirmed that differences between cultivars in stem length and flower-head diameter were statistically significant ($P<0.001$), while the effect of planting date was not significant.

The corresponding means and analysis for the ten cultivars sown both outdoors (weeks 15 and 23) and in the tunnel (week 30) are shown in Figure 38, Table 19 and Table 20. For simplicity (and as a check of uniformity) the duplicated beds in the tunnel were analysed as separate plantings.

'Galilee Miracle' and 'Tavor Lemon' were much shorter than the other cultivars, whether grown outside or in the tunnel (unfortunately it was not possible to include the dwarf variety 'Tanya' in the tunnel plantings). Overall, growing in the tunnel produced much taller plants than growing outside, as was the case in previous years. Analysis of variance showed that the effects of both cultivar and plantings were significant ($P<0.001$). Flower-head diameters varied somewhat between cultivars, but the cultivars did not fall into two groups ('normal' and 'dwarf') as they did regarding stem lengths; analysis of variance showed that these between-cultivar differences were highly significant ($P<0.01$). Almost without exception, flower-head diameters were significantly ($P<01001$) smaller in the tunnel than outside but most still met the current disc diameter spec of between 5 and 7cm. . The analysis of variance suggested that measurements were consistent between the two replicated tunnel plantings.

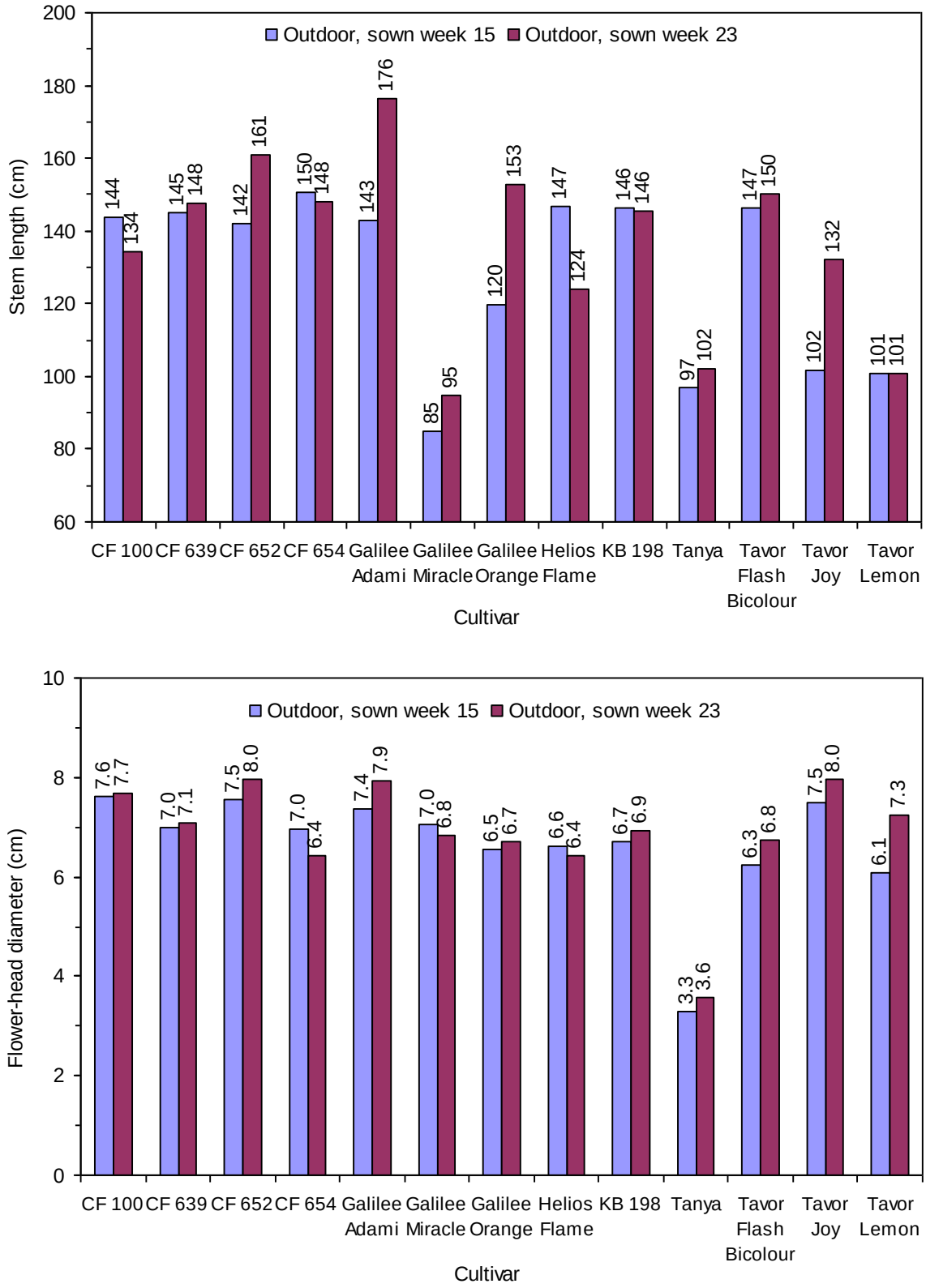

Figure 37. Stem length (above) and flower-head diameter (below) of 13 sunflower cultivars sown outdoors in week 15 or 23.

Table 17. Analysis of variance for the stem length data of Figure 37 (13 sunflower cultivars sown at two dates outdoors)

Source of variation	DF	SS	MS	F	P	
Cultivar	12	12436.1	1036.3	7.109	<0.001	***
Planting date	1	390.4	390.4	2.678	0.128	NS
Residual	12	1749.2	145.8			
Total	25	14575.8				

The values of P (probability) indicate the statistical significance of the sources of variation (in this case cultivar and planting date). *, ** 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 (i.e. P>0.05).

Table 18. Analysis of variance for the flower-head diameter data of Figure 37 (13 sunflower cultivars sown at two dates outdoors)

Source of variation	DF	SS	MS	F	P	
Cultivar	12	29.595	2.466	27.164	<0.001	***
Planting date	1	0.327	0.327	3.604	0.082	NS
Residual	12	1.089	0.091			
Total	25	31.011				

See footnote to previous table.

Table 19. Analysis of variance for the stem length data of Figure 38 (10 sunflower cultivars with four ‘plantings’ (i.e. sown outdoors in week 15 or 23, or in a Spanish tunnel in two replicated beds in week 30)).

Source of variation	DF	SS	MS	F	P	
Cultivar	9	17329.29	1925.48	12.407	<0.001	***
Planting	3	45329.00	15109.67	97.361	<0.001	***
Residual	27	4190.20	155.19			
Total	39	66848.48				

The values of P (probability) indicate the statistical significance of the sources of variation (in this case cultivar and planting). *, ** 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 (i.e. P>0.05).

Table 20. Analysis of variance for the flower-head diameter data of Figure 38 (10 sunflower cultivars with four ‘plantings’ (i.e. sown outdoors in week 15 or 23, or in a Spanish tunnel in two replicated beds in week 30)).

Source of variation	DF	SS	MS	F	P	
Cultivar	9	6.140	0.682	4.109	0.002	**
Planting	3	10.982	3.661	22.048	<0.001	***
Residual	27	4.483	0.166			
Total	39	21.605				

See footnote to previous table.

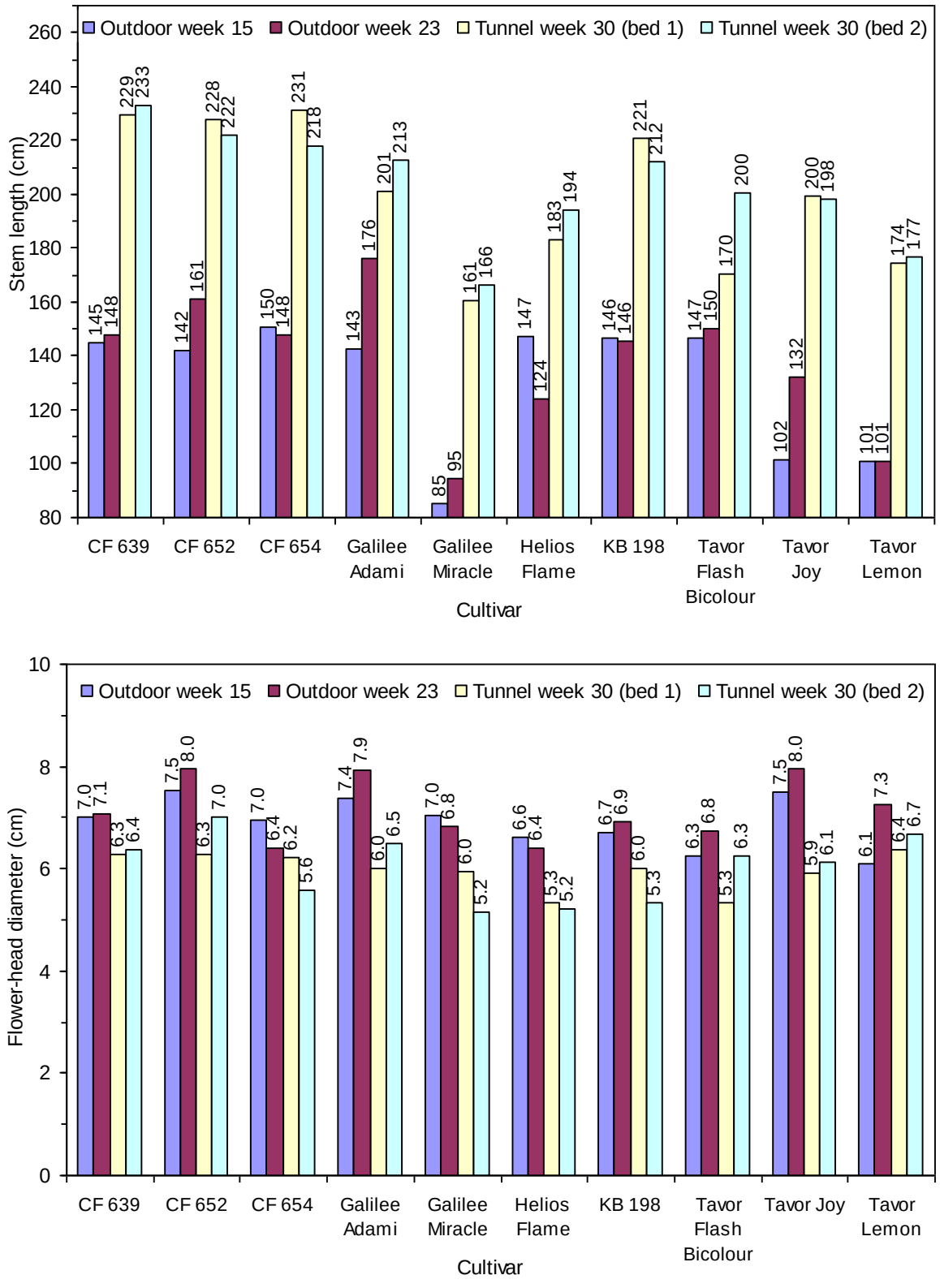

Figure 38. Stem length (above) and flower-head diameter (below) of ten sunflower cultivars sown outdoors in week 15 or 23 or in a tunnel in week 30. LSD (5%) for stem lengths = 11.4 (between cultivars) and 18.1 (between plantings) and for flower-head diameters = 0.37 (between cultivars) and 0.59 (between plantings).

‘Galilee Adami’ ‘Tavor Flash Bicolor’ ‘CF 652’ ‘Galilee Orange’

‘Tavor Lemon’ ‘CF 100’ ‘Galilee Miracle’ ‘CF 639’

‘Tanya’ ‘KB 198’ ‘CF 654’ ‘Helios Flame’

Figure 39. Sunflower cultivars grown outside at the Centre in 2013 (no picture of ‘Tavor Joy’ available) (18 August). In some photos (eg Tavor Lemon) both the stage of harvesting and more mature stage is shown.

9. Herbaceous perennial cut-flowers

Dahlia (*Dahlia hybrida*) - ‘Karma’ series

Dahlias are generally considered to have a poor vase-life, and the ‘Karma’ series was developed with a view to a longer vase-life. In 2009 demonstration plots of 18 cultivars (from Keep Smiling) were planted at the Centre in outdoor beds and in the ‘Pro-Tech’ tunnel. The cultivars were ‘Lagoon’, ‘Choc’, ‘Prospero’, ‘Amanda’, ‘Bon Bini’, ‘Thalia’, ‘Ying Yang’, ‘Sangria’, ‘Maarten de Zwaan’, ‘Ventura’, ‘Royal’, ‘Serena’, ‘Fiesta’, ‘Red Corona’, ‘Corona’, ‘Pink Corona’, ‘Irene’ and Naomi’. The crops grew vigorously, especially under protection, and the blooms were striking. However, the results of vase-life tests were disappointing, with the flowers failing to reach the minimum 11 days vase-life considered necessary for a commercial proposition, with the vase-water becoming very cloudy. The MG has confirmed supermarket interest in sourcing dahlias as a cut-flower, but this is currently being resisted until the vase-life issues are resolved.

Some plots were retained in the ‘Haygrove’ tunnel as material for further post-harvest trials, but tests carried out by Emma Bradford (Floralife) in 2013 did not identify any better

conditioning or vase treatments. The idea of developing a research project to examine the post-harvest qualities of dahlia blooms at a more strategic level has been discussed.

Rudbeckia (*Rudbeckia* cultivars)

Rudbeckia is another potential cut-flower crop, and its inclusion in the programme was suggested by a supermarket representative. Initial demonstrations with seed-raised annuals of *Rudbeckia hirta* were carried out in 2011 and 2012 but, although the flowers were attractive in themselves, the stems were too vigorous and unruly to be considered practical for commercial use.

More robust perennial varieties, *R. laciniata* 'Herbstsonne' and 'Goldquelle' (from Kolster), were planted in 2012. They showed some market potential, but many of the stems were weak and, as is the case with most perennial crops, their true potential is likely to show up in later years. In 2013 it was agreed that these varieties of perennial rudbeckia were probably not sustainable as cut-flower crops, because they were far too vigorous and produced stems that were unmanageable (Figure 40).

Figure 40. Perennial rudbeckia, planted 2012, flowering at the Centre (6 August 2013).

Sedum (*Sedum* cultivars)

In 2010 three sedum cultivars, *Sedum spectabile* 'Brilliant', 'Matrona' and 'Herbstfreude' (from Kolster) were planted as a demonstration in outside beds. Growth was weak in the first year, but once established subsequent growth was very vigorous, with impressive stem counts, length and weight and a demonstration of their quality as cut-flowers (with at least a 7-day vase-life) suggesting the demonstration should be extended. In 2011 plants of cultivars 'Mr Goodbud', 'Magical Bon Bon', 'Magical Lizzy' and 'Magical Twist' (Kolster) were added. In 2012 the Centre's sedum plots probably generated more attention than any of the other crops. The numerous and substantial stems could be cropped at a range of stages, from relatively tight to wide-developed, and they have potential uses in a range of bouquets as well as straight lines. Numerous samples were been made available to the industry for information and promotion, and it is known that, as a result, significant commercial plantings have been made. Consequently no further trials on sedum are planned.

10. Hardy foliage

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

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

Many of the plantings are now becoming well established, and there was distinct interest from the industry in 2013 (Figure 41). Substantial commercial plantings of *Hypericum, Symphoricarpos* and other hardy foliage have been made on local nurseries.

In 2012 stems of *Cotinus*, *Hypericum* and *Symphoricarpos* were sampled for vase-life testing. After simulated storage, etc., taking 5 days, the vase-life of *Cotinus* cultivars varied from 1 to 7 days, depending on the hydrating solution used. The vase-life of *Hypericum* cultivars also varied from 1 to 7 days, while *Symphoricarpos* cultivars achieved 6 days. Considerable foliar wilting was seen during testing, so there appears to be a problem with water uptake, despite flower foods being used. As these results were so variable, they need to be repeated, especially as they may conflict with comments from local growers who considered *Hypericum*, but not Cotinus, to have a very good vase-life. More attention also needs to be paid to achieving uniform stems.

Now that the plantings are established and industry interest has been confirmed, stem counts will be recorded. In 2013 the plants of *Hypericum* cultivars 'Magical Green Fall', 'Magical Tropical Fall' and 'Magical White Fall' yielded between 20 and 25 stems per plant per annum.

Figure 41. General view of the hardy foliage area at the Centre (22 July 2013).

Non-crop-specific trials

1. Green-waste container growing medium

Background

The increasing availability of green-waste has raised interest in using it as a growing medium for container-grown plants. It is known that one local grower using green-waste for lily production has suspected it has been responsible for some growth retardation, suggesting the medium might be contaminated with herbicide residues. Similar instances with pot-grown ornamentals are also known. With the increasing use of green-waste, this

issue could become important, so the potential for herbicide contamination is being investigated.

2013 trial

A sample of the batch of green-waste used in this trial was bio-assayed at Stockbridge Technology Centre (STC) by growing field beans, a sensitive species, in the material. The results clearly showed that the growing medium was contaminated.

Further tests were carried out at the Centre, growing a range of species in the same green-waste. Seeds, plugs or bulbs of annual dianthus, antirrhinum, aster, carnation, chrysanthemum, column stock, lily, lisianthus, sunflower, tanacetum and zinnia, and of the indicator plants tomato and field beans, were sown or planted in 7.5L pots of green-waste. The pots, nine of each species, were placed in 'Pro-Tech' tunnel bay 1 arranged as randomised, replicated plots of three pots each.

Plant growth and development were checked at least weekly. No crop damage was observed in any of these pots (Figure 42**Error! Reference source not found.**). In view of the result from STC, this was surprising. One explanation is that the herbicide may have been washed out of the pots, or broken-down in the pots, as a result of the large amount of irrigation water was applied to the crops because of the very hot weather. This was disappointing because it was hoped that this trial would provide an indication of the susceptibility of the different varieties. As this was not possible, growers must continue to use quality checked green compost with caution until additional information is available.

Figure 42. The green-waste pot-trial at the Centre (22 July 2013).

2. Spectral filters

Background

The increasing popularity of Spanish tunnels has provided opportunities to incorporate another technology into cut-flower production – spectral filters. There has been previous HDC-funded work investigating the potential for manipulating cut-flower crops by spectral filters, primarily project PC 168 (Cut-flowers: evaluation and development of plastic films and low-cost growing structures). In that project spray carnations, godetia, column stocks and spray carnations were grown for two years under a wide range of the films then available (1999 to 2000). 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). From a coordinated survey of the numbers of pest insects in these tunnels during 2000 (HDC project PC 170, Protected crops: the potential of spectral filters for pest control), there was insufficient evidence to recommend spectral filters as a cost-effective method of reducing pest numbers (e.g. aphid vision has been shown to depend on the presence of UV light). 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 (e.g. to affect insect populations), should the use of a more expensive specialist film be considered. Since the work described was done several years ago, there was scope to re-visit this issue using currently available films and applying the experience gained in the interim period.

2013 spectral filters trials

Two trials were carried out on commercial nurseries, on column stocks at a nursery in Terrington St Clement, Kings Lynn, Norfolk, and on bloom chrysanthemum at a nursery in Pinchbeck, Spalding, Lincolnshire.

Column stocks spectral filters trial

Commercial 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 (Haygrove) or 'SteriLite SuperThermic' film (XL Horticulture). The latter film combines the total blocking of UV light (the 'SteriLite' element) with the diffusion of light and reflection of IR (the 'SuperThermic' element) and it was hoped that this would enhance the growth of the stocks leading to the production of longer stems.

The crop was planted in week 20. Records were taken of stems cropped on 14 July 2013 (week 28), which corresponded to the main picking period of the 'Figaro' cultivars, but it was a late pick for 'Deborah' and 'Figaro', which showed more symptoms of fusarium wilt by this time. In each case the overall stem length and spike length were recorded for a random sample of 35 stems which were taken across the whole crop as harvested by nursery staff.

Stem and spike lengths are shown in Figure 43, and analysis of variance in Table 21 and Table 22. Stem lengths were consistently greater under the specialist film (which is possibly due to a slight delay in flowering owing to the lower temperatures) than under clear film, by between 1 and 9cm in the different varieties. The analysis of variance showed that the effect of film was statistically significant (at P=0.04), while 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 showed that the effects of film and cultivar were not significant. The two most representative varieties were 'Figaro Light Rose' and 'Figaro Lavender' because these were picked at the ideal harvest stage and showed very little sign of fusarium wilt. The difference between the stem length of these varieties grown in different tunnels was very small (5 and 1cm, respectively), but in a poor growing year (unlike 2013) this could have made the difference between their meeting the required specification or not.

Table 21. Analysis of variance for the stem length data of Figure 19 (four column stock cultivars grown under a clear and a specialist film).

Source of variation	DF	SS	MS	F	P	
Cultivar	3	18.805	6.268	1.139	0.459	NS
Film	1	62.720	62.720	11.398	0.043	*
Residual	3	16.509	5.503			
Total	7	98.034				

The values of P (probability) indicate the statistical significance of the sources of variation (in this case cultivar and film). *, ** 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 (i.e. P>0.05).

Table 22. Analysis of variance for the spike length data of Figure 19 (four column stock cultivars grown under a clear and a specialist film).

Source of variation	DF	SS	MS	F	P	
Cultivar	3	3.520	1.173	1.012	0.496	NS
Film	1	2.000	2.000	1.725	0.280	NS
Residual	3	3.478	1.159			
Total	7	8.998				

See footnote of previous table.

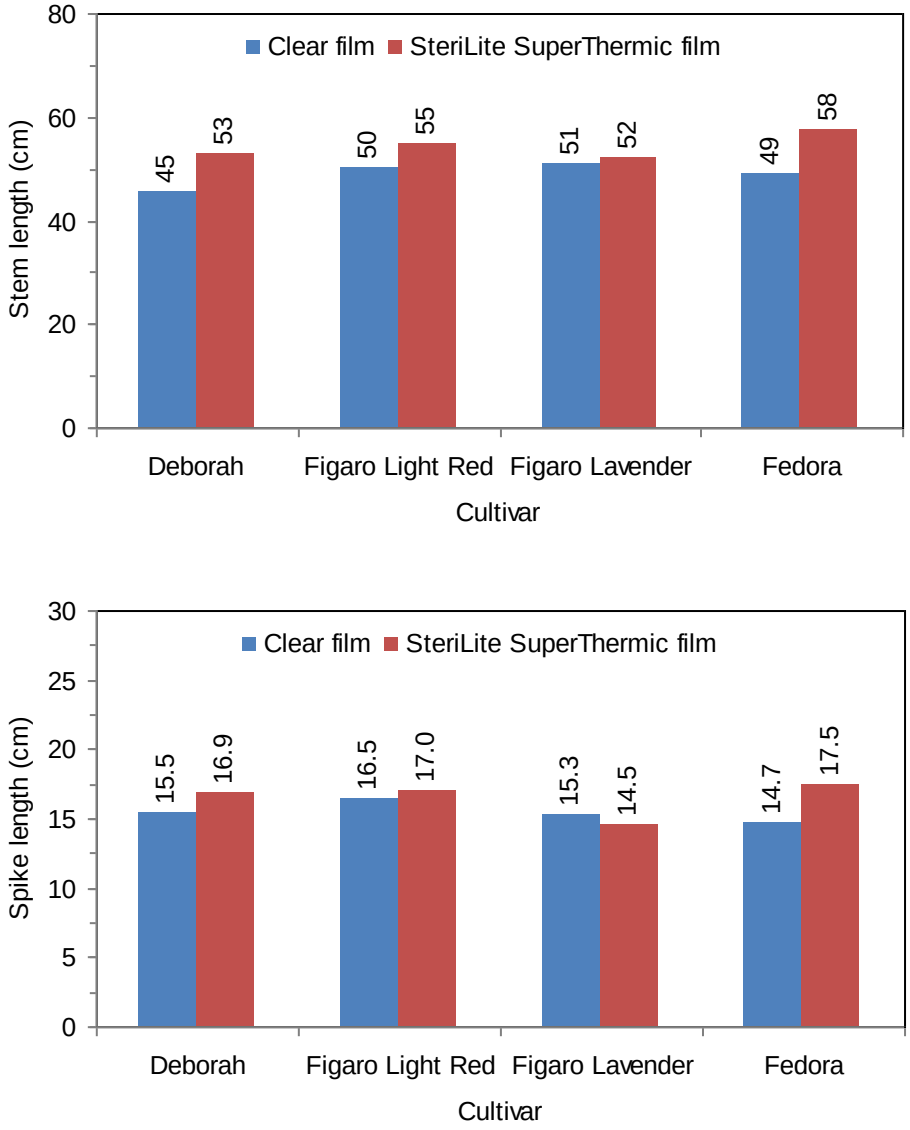

Figure 43. Stem length (above) and spike length (below) of four column stocks cultivars growing under clear or 'SteriLite SuperThermic' film. LSD (5%) for stem lengths = 5.3 (between cultivars) and 7.5 (between films) and for spike length = 2.42 (between cultivars) and 3.43 (between films).

Bloom chrysanthemum spectral filters trial

Commercial areas of bloom chrysanthemum ‘Hanenburg Red’ were grown in two similar Spanish tunnels, covered with either ‘Aster TR’ (Sotrafa) or ‘SunMaster Smart Blue’ (XL Horticulture) (Figure 44). ‘Aster TR’ is a standard polythene film with high light transmission and some light diffusing, properties. ‘Smart Blue’ is a blue polythene film which alters the balance of light between the near- and far-red regions of the spectrum (so reducing the stem elongation trigger), is UV-open and reduces light and heat levels in the tunnel. Blocks were planted in week 19 and pinched to three leaves after 21 days. Daminozide (as ‘B-Nine SG’) was applied to half each tunnel, the other halves being untreated. Conditions in the tunnels and the quality of the crops were recorded Table 23.

Figure 44. The tunnels with control, clear film (left) and ‘Smart Blue’ film (right), used in the bloom chrysanthemum spectral filters trial at a commercial nursery.

The temperature in the ‘Smart Blue’ tunnel was, on average, 3.9°C lower than in the standard tunnel on a hot day, while in cool, dull conditions there was no temperature difference noted. The plants under ‘Smart Blue’ film bloomed 2 weeks later than under the standard film, perhaps because of the lower temperatures there.

The appearance of the blooms was superficially similar under both films. However, under the standard film the stems were noticeably thicker and stronger than under the ‘Smart Blue’ film. Under the former, the petals and leaves were slightly lighter in colour, though probably not to the extent that the average consumer would notice; under the ‘Smart Blue’ film the petals and leaves were slightly darker in colour and the leaves appeared thinner.

The average, minimum and maximum stem lengths were slightly shorter under ‘Smart Blue’ film than under standard film, and slightly shorter when daminozide was used than when plants were not treated with growth retardant, but mostly these differences amounted only to some 2 to 5cm. Average stem weights (after trimming to 60cm-length) were slightly greater under the standard film and slightly greater when retardant was used, but again these differences amounted to only 2 to 5g. There did not appear to be an interaction

between film type and retardant treatment. The average width of the lead bud, both at picking (8cm) and at the end of vase-life (14cm), was the same in all four treatment combinations.

Importantly, the crop-out was only 54% under the 'Smart Blue' film, but 84% under the standard clear film: under the former there were more unmarketable stems because they were too thin and light to reach the desired specification. There were also less marketable stems in the 'Smart Blue' tunnel as a higher proportion of the crop produced only 1 to 2 usable stems compared with 2 to 3 in the control crop. The post-harvest life of the stems was not affected by the film type, being 22 days in all cases.

Overall the results indicated that the 'Smart Blue' film was not suitable for growing cut-flower bloom chrysanthemum 'Hanenburg Red'. It caused the crop to grow more slowly, with a smaller percentage of the crop suitable for market, compared to the standard. The usual rider, about reaching conclusions based on one cultivar being tested in one season, applies.

Table 23. Tunnel temperatures and crop assessment for bloom chrysanthemum 'Hanenburg Red' grown in Spanish tunnels with 'Smart Blue' or standard film and with or without a growth retardant treatment.

Tunnel film	Retard-ant	Stem length(cm)			Crop-ping date	Planting to harvest (weeks)	Avg, stem weight (g) (trimmed to 60cm)	Crop-out (5)
		Avg.	Min.	Max.				
'Smart blue'	None	99	90	104	16 Oct.	24	45	54
'Smart blue'	'B-Nine'	96	90	96	16 Oct.	24	49	54
Standard	None	99	90	105	02 Oct.	22	50	84
Standard	'B-Nine'	94	85	100	02 Oct.	22	53	84

Discussion

Information gathering

A database of companies supplying seeds and planting material for cut-flower production was compiled and proved useful in identifying sources of novel crops. New cut-flower crops were researched using the 'HA' database and compiled into a report that was a valuable source of information on novel cut-flower crops. Cut-flower trials programmes worldwide were summarised from Internet resources and brought together a wealth of information that might otherwise be hard to find. Many information sheets on cut-flower growing are available on the Internet, largely from American universities, and these were compiled into a database. Finally, a start was made to collect statistics on cut-flower production worldwide, which is considered useful in determining developing trends within the industry.

This information, which will be made available on the Centre's website, will be expanded during the life of the project. Information on trials programmes is particularly extensive and dispersed (e.g. on the Internet and in reports of research organisations, rather than in the recognised scientific literature), and the search will be concentrated on countries matching the UK climatically.

New crops

Basil (*Ocimum basilicum*) has been included in major cut-flower trials in the USA, and can provide fragrance (and in some cases variegated leaves) to mixed bunches and bouquets. Four cultivars were included in the Centre's 2013 demonstrations both outdoors and in a tunnel. They were productive but had poor vase-life, and might be more successful if grown under harder conditions and treated with a flower conditioner straight from picking. In some American trials the cultivar 'Aramato' was outstanding and could be tested.if it can be obtained.

Cosmos (*Cosmos bipinnatus*) is better known as a garden flower, but has also been included – with mixed results – in American trials programmes. Cultivars from several series were tested outdoors and in a tunnel at the Centre in 2013, where they were vigorous if somewhat unruly. Looking for a context, supermarkets require a variety of novel flowers to use in 'monthly bouquets', and cosmos might fit this role if grown cheaply as an outside, drilled crop picked over a short season. Representative cultivars should be compared on this basis in 2014. There are a number of varieties available with stem legth that could be long enough to be used as a cut flower. Some of these will be sourced and tested in 2014.

Leonotis leonurus (Lion's Ear) is a South African plant being introduced to cultivation, with research programmes in Poland, Italy, Israel and probably elsewhere. It has attractive orange flowers, is aromatic and easy to grow in various regions. *Leonotis* 'Staircase' is an easily available variety and was investigated as a tunnel crop in 2013. As a vigorous 2m-high plant it would be difficult to handle in this format. Other research suggests they should be cut-back over winter to produce more manageable growth. Other cultivars of *L. leonurus* (e.g. 'Alba') and shorter species (such as *L. mollis*) will be evaluated on a small scale in 2014.

Lupins were also tested at the Centre in 2013. *Lupinus harvardii* and *L. densifolius* have been researched as new flower crops in the USA, and some selections and hybrids are being commercialised, but we were unable to source any of these. However, the 'Gallery' and 'Russell' series (*Lupinus polyphyllus*) are tall and have a good colour range, and were planted outdoors and in a tunnel at the Centre in 2013, anticipating a full evaluation in 2014. Further attempts are being made to source new material from the USA, while some other interesting lines have also been found that could be tested at some point depending on the success of the 'Gallery' and 'Russell' lupins.

Trachelium caeruleum is not well known in the UK, though widely grown in the Netherlands. In 2013 seed of several cultivars was obtained for trialling, but failed to germinate. Subsequently it was grown successfully from plugs as a tunnel crop. With its colour and form *Trachelium* may have potential in the UK, so trial will be repeated in 2014 using plug-plants exclusively. Samples of the 'Lake Collection', sold as a cut-flower *Trachelium*, will also be included.

Zinnia (*Zinnia elegans*) have been grown previously at the Centre, but further work was suspended until cultivars with better post-harvest characteristics became available. In contrast, trials in the USA rated zinnia as very dependable, if the appropriate cultivars were used. In 2013 cultivars from the 'Oklahoma' and 'Benary's Giant' series were tested as outside and tunnel-grown crops. They were assessed as far superior to the zinnia cultivars previously grown for flower colour and quality. Vase-life testing showed that 'Benary's Giant' cultivars showed potential for commercialisation as there was relatively little stem bending, the main fault with those previously tested, but further vase-life tests and testing conditioning solutions will be needed in 2014.

For the new crops programme in 2014, the MG suggested the following be considered: *Ranunculus asiaticus*, *Capsicum annuum* ornamental peppers, *Gomphrena globosa*, *Phytostegia virginianum*, *Eremurus* cultivars and *Spirea cantonensis*. Other suggestions

have included rosemary (*Rosmarinus officinalis*) and saponaria (*Saponaria officinalis*) as aromatic and easily-grown fillers, respectively.

Aster, September-flowering (*Aster ericoides*)

The blackout trial showed that the flowering of September-flowering *A. ericoides* can be successfully manipulated using this method. However, in order to obtain two flushes the first needs to be much earlier than week 32, as used in 2013. It is planned to continue this experiment in 2014, with the use of blackout covers beginning when the shoots are 40 to 50cm-long (compared with 60 to 70cm-long in 2013).

These *A. ericoides* varieties are considered to have potential both in bouquets and as a straight line, over a short period. Numerous samples were distributed from the Centre and were well received by growers and buyers, though none would commit to taking up the crop at this stage. The difficulties include a short (four week) season for the natural-season crop, poor consistency at the end of the season, mildew (also at the end of the season), uncertainty over the yield of stems/m^2 (which also needs to be addressed in the 2014 programme), and having to compete with cheap imports.

Annual (or China) aster (*Callistephus chinensis*) ('bloom asters')

Despite the large numbers of series and cultivars tested at the Centre over several years, none has been found that approach the quality of the 'Krallen' varieties. Due to the large numbers of China aster cultivars available and their variable performance, further cultivar evaluations are needed for both outside and tunnel production in 2014. The vigour of some types suggests that growth regulator treatments might also be beneficial, and this method will also be tested.

No progress has been reported on the prevention of petal disorders in 'Krallen', and they are no longer supplied by Florensis. R&D on this topic is a priority, and although no research strategies have been suggested so far, the MG could encourage a call for proposals.

The lack of consistency in growth and development, seen in several potential cut-flower crops besides bloom asters, may reflect their origin as garden plants, where some variability may be beneficial. Selection for greater uniformity and the availability of standard seed may be a prerequisite for growing better commercial crops of many cut-flowers being used as cut-flowers.

Dianthus, annual (*Dianthus barbatus*), 'Breanthus' range

The current trial with 'Breanthus' is on-going. HilverdaKooij are still working on the genetics of this crop. Some varieties are clearly better than others, for example 'Findis' produced premature buds and appears to have been dropped from the catalogue. It is important that, in the early stages of breeding, hybridisers need to liaise closely with growers to ensure their new varieties match the grower's requirements.

These improved cultivars generated keen interest from packers and supermarkets. However, it is thought that a grower might struggle to make adequate returns (say 20p per stem at the current time), partly because of the cost of planting material, and consequently there has been little or no commercial uptake. To achieve commercial viability, 'Breanthus' needs to be perceived as a high-quality product that is distinct from 'cheap and cheerful' sweet william. Unfortunately, recent enquiries have confirmed that unrealistic returns are still being offered.

Dianthus, spray (*Dianthus caryophyllus*), 'Star' and 'Solomio'

As was the case for 'Breanthus', dianthus 'Star' and 'Solomio' generated definite interest from packers and supermarkets. However, once again, a grower may struggle to make adequate returns, partly because of the cost of planting material, so they need to be sold as a premium product that is distinct from the standard imported stems. 'Breanthus' yields would need to be boosted by a productive second flush of flowers, and Hilverdakooij state that a second flush should be obtained, this should be investigated through making scheduled plantings, though it may be possible only in a heated glasshouse. The current tunnel crop is still on-going, in order to assess its productivity in its second year – will it be early enough to produce a second flush?

Eryngium (Sea Holly) (*Eryngium* cultivars)

Despite the disappointing and weather-dependent results in the demonstration in 2013, samples sent to packers and supermarkets generated considerable interest - the form of the flower-head is consistently regarded as appealing. There is considerable variability in winter hardiness of the outdoor crop, at least in the first year after planting, while they may be too vigorous in tunnels. It is planned to continue the trial of eryngium cultivars in 2014, with the aims of identifying the best hardy cultivars and how they can be grown to produce reliable and regular stems.

Lily (*Lilium* cultivars)

Lilies are a well-established line with the advantage that new cultivars and inter-specific hybrids are coming along all the time, providing freshness to the product. The new cultivars in this trial included some stunning and very impressive flower sizes and forms. However, the general view of growers was that this quality was too good for a supermarket product – a victim of their success? - and that they would be suitable only for high-end outlets such as florists. It was therefore proposed suggests that that any further trials ought to be conducted with the established cultivars currently being grown for the supermarkets (e.g. Dynamite), rather than with relatively novel ones.

The trial was successful in stimulating debate amongst the industry as to the need for alternative growing medium, and showed that it was possible to produce good quality stems whether grown in peat, green-waste or a mix of the two, although growing in peat produced the longest stems (even though the other treatments still exceeded the 60cm spec for stem length). Further alternative growing media trials will be undertaken in 2014 on a commercial nursery using established varieties.

Stocks, column (*Matthiola incana*)

Trials at the Centre have addressed a number of practical issues of column stock production, and especially the possibility of using cultivars of the relatively heat-resistant 'Katz' series as a summer crop or late tunnel crop. Variety comparisons, including the 2013 trial of 'Katz' cultivars, all stressed the importance of varietal selection (both between and within series) for a number of characteristics, such as stem length and weight, response to growing in steamed or non-steamed soil, ability to select for double-ness, and the percentage of double-flowered plants produced.

The stocks trials in this project, in PO 005 and in two associated grower trials, were viewed by some 95% of the UK's column stock growers. The large variety trial at the commercial nursery was viewed by growers as part of the 2013 Open Day and is cited as an example of how the Centre is able to respond proactively to requests from the industry. The findings will help determine the choice of varieties for individual nurseries, and will influence the direction of future breeding work.

Work at the Centre in conjunction with project PO 005, has gone some way to explaining the issues experienced by growers in recent years, especially in demonstrating the clear connection between the poor performance of some cultivars – especially the 'Figaro' and 'Aida' series – and the type of sterilisation used.

Fusarium wilt remains the single most troublesome problem of column stocks. It is an aggressive pathogen and under extreme disease pressure it is likely to attack all the current available varieties, but work described above confirmed there is a considerable variation in this susceptibility. The findings will help growers to plan their future cropping programmes based on their individual nursery disease risk, the sterilisation technique used, time of year, etc. The Centre will continue to liaise with both the industry and plant propagators in order to develop further these findings, especially in relation to some of the more promising coded varieties not yet commercially available.

Suggestions from industry have also indicated that some of the traditional older varieties - such as 'Anthony' and 'Cleopatra' - should be re-examined to determine their susceptibility to the disease, and this will be an area of further work for the Centre in 2014.

Sunflower (*Helianthus annuus*)

An obvious means of reducing the costs of handling sunflowers would be the use of relatively short or dwarf cultivars, and in the 2013 trials 'Galilee Miracle', 'Tavor Lemon' and, particularly, 'Tanya' were promising in this respect. The production of sunflowers under protection can successfully extend the season, and is already of interest to some growers, especially those with older cold glass that has limited potential for other crops. However, production under protection does produce significantly taller stems (even in the shorter cultivars) and smaller flower-heads.

Herbaceous perennial cut-flowers

Dahlia (*Dahlia hybrida*) have a poor vase-life, and the 'Karma' series was developed as a dahlia with a longer vase-life. Crops of 18 cultivars have previously been trialled at the Centre, but, although growing vigorously and attracting much admiration for their striking blooms, the results of vase-life tests were disappointing. Although the MG has confirmed supermarket interest in sourcing dahlias as a cut-flower, this is being resisted until the vase-life issues are resolved. Further tests on 'Karma' varieties grown at the Centre were carried out by Emma Bradford (Floralife) in 2013 but did not identify any better conditioning or vase treatments. The idea of developing a research project to examine the post-harvest qualities of dahlia blooms at a more strategic level has been discussed.

The inclusion of rudbeckia cultivars (*Rudbeckia* species) in trials was suggested by a supermarket representative. Initial demonstrations with seed-raised annuals of *R. hirta* showed that the stems were too vigorous and unruly to be suitable for commercial growing,

and trials in 2012 – 2013 with more robust perennial varieties of *R. laciniata* also showed they were far too vigorous and produced stems that were unmanageable.

Sedum cultivars were initially planted as a demonstration in outside beds. Once established growth was very vigorous. There were high stem counts, lengths and weights, plus adequate vase-life almost irrespective of picking stage. Numerous samples were been made available to the industry and it is known that, as a result, significant commercial plantings have been made, and consequently no further trials are planned.

Hardy foliage

A wide range of hardy foliage was planted outside in 2010 and 2011 and has now become established. There was distinct interest from the industry in 2013. It is know that substantial commercial plantings of *Hypericum*, *Symphoricarpos* and other hardy foliage have been made on local nurseries.

Green-waste container growing medium

With the increasing availability and interest in green-waste as a growing medium, concerns have been raised, including the potential for herbicide contamination. This was tested using a range of cut-flowers and two 'indicator' species (tomato and field beans, which are sensitive to herbicide residues) grown in peat or green-waste or a mixture of each. It failed to show any sign of herbicide contamination in green-waste. Growers should still exercise caution using green-waste. If in doubt, it may be possible to check batches using a simple pot test.

Spectral filters

Two trials were undertaken in 2013, with column stocks and bloom chrysanthemums.

In the column stocks trial four cultivars were grown under clear polythene film or 'SteriLite SuperThermic', a film that diffuses light, blocks UV and reflects IR. Stem lengths were consistently greater under the specialist film than under clear film, but only by a few cm, and no other adverse effects were seen.

In the bloom chrysanthemum trials, the one cultivar grown under a standard film or a 'Smart Blue' film, the blue film was unsuitable because the stems produced under it were significantly later, somewhat thinner, weaker, shorter and lighter in weight and had a much reduced percentage crop-out (54% compared with 84% under standard film), though petal and leaf colour appeared slightly lighter when grown under the standard film. Vase-life and lead bud width were the same with either film.

Knowledge and technology transfer

Knowledge and technology transfer are major objectives of this project, and while progress in these areas is covered below in a specific section, it is important to note that the demonstrations, trials and experiments reported above have hard-to-quantify outputs other than the data that have been reported. In particular, the Centre provides a point of contact and discussion around the opportunity to see a wide range of trials and plant material gathered at one site, in which not only growers, but also seed and plant suppliers, packers, technologists and retailers, participate. Further, substantial samples of cut-flowers have been made available to the industry at large, providing further stimulus to the UK industry to consider growing or sourcing a wider range of cut-flowers in the UK.

How the objectives were achieved

The Centre has now successfully developed its role as an information hub and cohesive voice for the UK cut-flower industry. This has been achieved by holding a number of grower events throughout the year, including a tulip study day, lily and spectral filter study day and an Open Day to look at the CFC trials on both growers' holdings and the main site at Rookery Farm. The project continues to produce appropriate technical literature including a review of cut flower trials worldwide and a summary of the Centre's column stock fusarium wilt susceptibly variety trial. A number of crops that have been trialled at the Centre have now been planted commercially, including antirrhinum, sedum, hardy foliage and a summer spot-crop of lisianthus. In addition to the main trials, the Centre, in its role as a crop association, has facilitated additional trials including herbicides on column stocks and sweet william as well as a review of hydroponic use for cut flowers.

Conclusions

- The information gathering exercise revealed the extent of activity worldwide on investigating new cut-flower crops, and of trials programmes that can add greatly to our knowledge of current and novel crops. There is an appetite for novelties and the cut-flower industry should respond to this opportunity.
- The new flower review provided many ideas for testing at the Centre. The priorities decided for 2014 were *Ranunculus asiaticus*, *Capsicum annuum* ornamental peppers, *Gomphrena globosa*, *Phytostegia virginianum*, *Eremurus* cultivars and *Spirea cantonensis*.
- Four basil cultivars were grown to assess their suitability as an aromatic, attractive foliage for use in mixed bunches and bouquets. They are not recommended at present as vase-life was poor, but this may improve with the use of harder growing conditions, other cultivars and flower conditioners.
- Several cosmos cultivars were assessed as novel cut-flowers and had a good range of colours and flower forms but a vigorous and untidy habit. In the context of a 'monthly bouquet' they may be useful as a cheap, drilled crop cut over a short season, but this awaits vase-life testing and assessing new cut-flower varieties.
- *Leonotis leonurus* – lion's ear – was another novelty assessed, but the cultivar grown ('Staircase') was excessively tall and flowered at the end of summer. Tests of cutting-back tall types for a further year's growth, and of shorter species, are needed before a recommendation can be made.
- Lupins of the 'Gallery' and 'Russell' series established well and their suitability as novel cut-flowers will be assessed in their second year.
- A trial to assess cultivars of *Trachelium caeruleum* as a novel cut-flower failed due to the non-germination of seeds, but one cultivar grown from plug-plants grew well, so plugs will be tested in 2014.
- Zinnias of the 'Oklahoma' and 'Benary's Giant' series were grown and their quality (stem strength, flower colour and form) were far superior to other cultivars previously tested at the Centre as cut-flowers. Stem bending in the vase was far less than it had been with the varieties tested previously.
- New double varieties of September-flowering *Aster ericoides* show potential as a straight line or in bouquets, if production costs can be trimmed – which is partly determined by whether a second flush can be obtained. An experiment with blackout covers showed that flowering time can be manipulated, and this will be developed in 2014.

- Trials continued in 2013 to find alternatives to ‘Krallen’ China asters (‘bloom asters’), varieties that were demonstrated at the Centre and taken up by growers until petal disorders became evident. This work will continue as no alternatives or solutions to the petal disorders have been found. Growth restriction treatments will also be investigated because of the vigour of some cultivars.
- The ‘Breanthus’ range of improved annual dianthus was demonstrated by the Centre in 2012 and generated keen interest from the industry which, however, has not taken them on as they may fail to make adequate returns, partly because regular sweet william are perceived as a cheap flower.
- The ‘Solomio’ and ‘Star’ ranges of spray dianthus, also introduced in 2012, fall into the same category as ‘Breanthus’, with packers and supermarkets interested, growers concerned about making adequate returns, and a popular perception that they are no different to cheap, imported stems. In 2014 work at the Centre will concentrate on scheduling for a second flush which would improve the economics.
- Centre trials found that eryngium cultivars generated much interest amongst packers and supermarkets with their interesting flower form, but their uptake has been hindered by poor reliability and establishment and variable winter-hardiness. Work on these aspects will continue in 2014.
- New cultivars of lilies were demonstrated in 2013, and, although the blooms were striking, led to the conclusion that they were too exotic for regular supermarket sales and more suited for florists. Future trials should concentrate on the established (and cheaper) cultivars.
- The lily trial was combined with a trial of using green-waste as an alternative growing medium. The results were good, though there was a small reduction in stem length compared with growing in a conventional peat mix.
- Column stocks varieties of the heat-resistant ‘Katz’ series have potential as a summer or late tunnel crop. The results stressed the importance of careful varietal selection, not only for stem length and weight, but also for response to steamed or non-steamed soil, the ability to select for double-ness, and the percentage of double flowers produced. ‘Figaro’ and ‘Aida’ were especially sensitive to the type of sterilisation used.
- The ‘Anytime’ series of column stocks can be considered for late production as it is quick to crop, less susceptible to fusarium wilt (except for ‘Anytime Lavender’), and less prone to blindness in hot weather.
- Fusarium wilt is the major problem of column stocks, and although under high disease pressure it is likely to affect all cultivars, there is a considerable variation to

their susceptibility, so cropping programmes can be based in the individual nursery's disease risk.

- Using relatively short or dwarf sunflower cultivars reduces handling costs, and 'Galilee Miracle' and 'Tavor Lemon', and the truly dwarf 'Tanya', were the best of those tested in 2013.
- Seasonal extension can be obtained by growing sunflowers under protection, but at the expense of taller growth (even in 'Tanya') and somewhat smaller flower-heads.
- 'Karma' dahlias produced high quality stems and attractive flowers, but their vase-life was disappointing and trials with conditioning and vase treatments failed to improve it.
- Although attractive as flowers, cultivars of both annual and perennial rudbeckia were too vigorous and unruly in their growth to be practical as cut-flowers.
- A range of sedum cultivars demonstrated at the Centre showed vigorous growth, tall, heavy and prolific stems and long vase-life almost irrespective of picking stage. Sedum have been picked up by growers and significant commercial areas have been planted.
- In a demonstration of a range of hardy foliage, cultivars of *Hypericum* and *Symphoricarpos* have performed well, and it is known that substantial commercial plantings have been made locally.
- Because of concerns over herbicide residues in green-waste used as a growing medium, this was tested by growing a range of cut-flower species in green-waster in a pot trial. No evidence for herbicide-related damage was seen, though caution should still be exercised and tests should be made before beginning to use it.
- Investigating the effects of spectral filters, column stocks were grown under clear polythene or a specialist film that diffuses light, blocks UV and reflects IR ('SteriLite SuperThermic'). Stem lengths were consistently but only slightly increased when growing under the specialist film. Growing a bloom chrysanthemum cultivar under a standard film or a 'Smart Blue' film showed that product quality was better under the standard film, the crop under the 'Smart Blue' having many more unmarketable stems.

Knowledge and Technology Transfer

Events

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

- HDC/CFC Forced Tulip Flower Event. Winchester Growers, Nocton, Lincolnshire, 19 April 2013 (handout available).
- National Cut Flower Centre Open Day, JA Collison & Sons, Terrington St Clement, Norfolk and Rookery Farm, Holbeach St John, Lincolnshire, 1 August 2013 (handout available).
- HDC/CFC Lily Technical Event, Winchester Growers, Pinchbeck, Lincolnshire, 11 September 2013 (handout available).

The Open Day attracted about 80 attendees, a high number for this type of event. As well as the interest in the trials themselves, the formt of the event also provided a significant opportunity for networking. This year the Open Day included viewing trials of column stocks from this project and from PO 005 at the collaborating nursery, and it is estimated that some 95% of the UK's column stock growers were in attendance. Set up in response to industry concerns, the stocks trials were an example of how the Centre can respond proactively to the industry's requests. The findings will help determine the choice of varieties for individual nurseries, as well as influencing the direction of future breeding work.

Website

The Centre's website http://www.thecutflowercentre.co.uk/ was further expanded during 2013. Annual project reports and the specialist reviews and leaflets cited in this section are available for downloading from the website, along with relevant EAMUs and Centre news.

Articles published

Three articles on the Centre's work were published during 2013:

- *Firm future for cut flower R&D.* HDC News, 194, 16-18. Lyndon Mason (2013).
- *Cut Flower Centre* [Open Day report]. HDC News, 196, 10-11. (2013).
- *Crops and techniques for UK flowers.* HDC News, Supplement, Ornamentals Review 2013, 25. (2013).
- *World of flowers on trial.* HDC News, 199. 22. (2013/2014).
- *New breeding in trials at Cut Flower Centre.* The Commercial Greenhouse Grower, September 2013.

Reports and databases

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

- Field- and tunnel-grown cut-flowers with potential for UK exploitation: a review of trials programmes and research in 'novel' subjects. [Includes sources of information on cut-flower crops.] National Cut-Flower Centre/HDC. Gordon Hanks (2013).
- *A database of seed and young plant suppliers for the cut-flower industry.* National Cut-Flower Centre/HDC. Gordon Hanks (written 2013, awaiting publication).

Leaflets

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

- Summary of the Cut Flower Centre (CFC) trial examining the susceptibility of a wide range of different varieties of column stock (Matthiola incana) to fusarium wilt. Information Sheet 4, National Cut-Flower Centre/HDC. Lyndon Mason (2013).
- The National Cut-Flower Trials Centre & UK Cut-flower Growers' Association. Flyer, National Cut-Flower Centre/HDC. Gordon Hanks (2014).
- Snapdragons (including 'Trumpet' or peloric cultivars) as a cut-flower grown in tunnels. Information Sheet, National Cut-Flower Centre/HDC. Gordon Hanks (2014).
- *Lisianthus as a cut-flower grown in tunnels.* Information Sheet, National Cut-Flower Centre/HDC. Gordon Hanks (2014).

Other examples of technology and knowledge transfer

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

In summer 2013 the Project Leader visited about 100 growers across the British Isles. At more than half of these businesses the growers initiated discussions on the work of the Centre, seeking further information about the results obtained and the future trials programme.

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