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Project leader(s):	Lyndon Mason Director, Cut Flower Centre Ltd
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Key worker(s):	Lyndon Mason (Director, Cut Flower Centre Ltd) Lucy Markova (R Robinson & Son) David Robinson (R Robinson & Son) Elaine Robinson (R Robinson & Son)
Location:	Cut Flower Centre Ltd, c/o Rookery Farm, Joys Bank, Holbeach St Johns, Spalding, Lincolnshire PE12 8SG Commercial nurseries in Lincolnshire Flower Packers' facilities in Lincolnshire
Project co-ordinator(s):	Gordon Hanks (Consultant) 2 Malvern Close Spalding Lincolnshire PE11 2DQ
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AUTHENTICATION

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

Lyndon Mason
Director
Cut Flower Centre Ltd

Signature ..... Date .....

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GROWER SUMMARY

Headlines

- Lisianthus grown in ‘Spanish tunnels’ have been identified as producing a very high quality crop in terms of stem weight and vigour, and should be considered as a new production opportunity for UK flower growers.
- Further trials have confirmed opportunities for UK growers to exploit new ‘trumpet’ cultivars of antirrhinums which now have a good colour range and acceptable spread of flowering.
- Trials with hardy foliage have clearly demonstrated that they can be produced successfully in UK conditions and some species such as Sedum have generated considerable market interest.
- Numerous column stocks trials have been undertaken which have demonstrated that the use of large block produced plants does not produce a better autumn crop, mechanical gapping up at the propagation stage does not increase the incidence of uneven flowering and that the new ‘Katz’ range has potential from autumn flowering. In addition to this a large variety trial in 2012 has helped growers and the breeder/propagator to make informed decisions about future varietal choices.
- German cultivars of China asters grown in Spanish tunnels have shown great market potential but problems with commercial crops of the ‘Krallen’ series mean that additional variety selection is required especially of the blue flowered varieties.
- Modern cultivars of double flowering *Aster ericoides* have shown significant market potential, but further work is needed to look at scheduling.
- Trials of dwarf sunflowers have demonstrated potential candidates which can be adopted by growers in the future.
- As in previous years phlox have shown considerable potential as tunnel crops in the UK.
- Initial trials in 2012 have shown the potential for the new varieties of annual Dianthus (’Breanthus’) and new spray carnations (’Star’ and ‘Solomio’) but more work is needed in 2013.

Background and expected deliverables

Outdoor cut-flower production in the UK has long consisted of the production of a limited range of mostly natural-season flowers. UK production has remained at a more-or-less static level for many years, despite a huge increase in sales of imported cut-flowers and the increase in *per capita* purchases. There is a perception that, overall, UK growers have not responded to these imports by boosting their own production. It has been suggested that this has been partly due to a shortage of appropriate cultural information, set against a bewildering range of species and unaided by conservative attitudes over what is possible under UK conditions and the apparently 'superior' level of production abroad. But production in the UK can deliver freshness without air-miles, an opportunity boosted by the current popularity of a range of summer annual flowers - often 'cottage garden' types - that can be grown to a high standard in this country either outdoors or in relatively low-cost 'Spanish tunnels'. Tunnels offer protection from weather and assist production over an expanded season, and ensure crops of high quality can be picked seven days a week irrespective of the prevailing weather.

Recognising this need to generate know-how for UK conditions, and that there was no independent trials centre for the cut-flower sector in the UK, a cut-flower group convened by the HDC in 2007 proposed setting-up a trials centre for cut-flowers, which was then established at Kirton. The 'Cut-flowers Trials Centre' was to be an industry-led, commercially oriented, independent trials site where a range of species and varieties could be assessed objectively and critically under the eyes of growers. The trials ground would include demonstration plots of newer or novel cut-flower species and variety trials of modern cultivars of established cut-flowers, as well as 'agronomic' trials to solve problems and develop the best husbandry protocols, all under typical UK climatic, cultural and economic conditions. This would reduce the sector's dependence on less satisfactory sources such as anecdotal information, promotional material from seed-houses, *ad hoc* 'look-see' trials and US texts on 'speciality flowers'. Guidance for the Centre was to be provided by a Management Group (MG) representing growers, packers and retailers, ensuring the relevance of its work to the industry. This report covers the Centre's continuing work over the years 2010 to 2012.

As well as the knowledge transfer activities that enhance the production and quality of UK-grown cut-flowers generally, an important deliverable by the Centre is the identification of potential new products for UK growers that would increase product range and provide new business opportunities.

Summary of the project and main conclusions

1. Antirrhinum (*Antirrhinum majus*) - 'trumpet' cultivars

In 2009 and 2010 the Centre grew demonstration plots of new 'trumpet' cultivars of antirrhinum that were quite distinct in flower form from the typical 'snapdragon'. They impressed the industry with their novel form, vigour and quality. In 2010 plugs of 'Ivory White', 'Red' and 'Yellow' lines from the 'Peloric' series were transplanted to plots in a tunnel in week 14. They cropped around week 22 with an average stem length of 66 cm, a six-stem bunch weight of 310 to 320 g, and longevity in standard vase life (VL) testing of up to 15 days from picking. There was a second flush of flowers around week 28 with shorter and lighter stems though still marketable. Commercialising 'trumpet' varieties requires changes in expectations and handling: their novel flower shape is not obvious unless displayed at a later stage of development than is normal for snapdragons, the colour range available at the time was limited, not enough was known of their post-harvest qualities after relatively late picking and no information was available about planting dates and season extension. All these issues were addressed in trials during 2011 and 2012.

In a further cultivar trial in 2011 plugs of 'Ivory White Peloric', 'Trumpet Pink' and 'Yellow Peloric' were transplanted in week 17 to plots in a tunnel. The first flush was in week 25. Stem weights and spike lengths varied considerably between cultivars, though all were satisfactory. 'Yellow Peloric' gave the heaviest stems and longest flower spikes. Trimmed (60 cm) stem weights in 'Ivory White Peloric' and 'Yellow Peloric' were about 50 g. A second flush produced many more stems, though these were lighter - just under 30 g for a 60 cm stem. Samples were picked in week 25 for standard VL testing: after simulated storage, transport and retail store phases, all bunches had a similar performance in the vase, and on vase-day six most of the lower buds were withering and there was slight discolouration of the stems. 50% failure occurred in all bunches on vase-day 10, bunches being terminated for browning or withering of half of the flower-heads.

To investigate seasonal extension, further trumpet antirrhinums were grown as late planted crops in tunnels in 2011. Plugs of 'Tangerine' were transplanted in week 27. Despite late planting, stem length, trimmed weight and flower spike length were about the same as the best from the earlier planting, though there was insufficient time for a second flush. Seasonal extension was further examined in 2012; plugs of the 'Apollo' series ('Cinnamon', 'Ivory', 'Ivory White', 'Purple', 'Trump' and 'Yellow') and 'Trumpet Tangerine' were planted as a late-season crop in plots in a tunnel in week 28. They were ready for cropping in weeks 34

to 35. Stem length, spike length and numbers of flowers far exceeded any minimum supermarket specification. For comparison, plugs of traditional cultivars, 'Potomac Rose' and 'Potomac White', were transplanted to plots in a tunnel as a mid-season crop (week 22). Flowers were ready for cropping in weeks 34 to 35. They produced tall stems with long flower spikes and trimmed stem weights of about 60 g, similar to the 'Peloric' plantings.

There was positive feedback from the industry for 'trumpet' antirrhinums. Basic information was gained about varietal performance and a reasonable range of colours is now available. There was some scope for seasonal extension via planting dates, and through the second flush where the crop was planted early enough. Their VL was reasonable though not exceptional, the relatively late stage of cropping necessary to show the flowers to advantage probably being a contributory factor, since VL testing at a less mature stage in 2010 had given a VL of 15 days. Sufficient agronomic information is now available for the industry to decide about commercialising these attractive new lines.

2. *Aster ericoides* (September-flowering)

In early trials at the Centre (2007) the potential of new, mainly double-flowered cultivars of *Aster ericoides* was demonstrated as a pinched crop for September to October flowering in polythene tunnels. In 2010 a wider range of *A. ericoides* cultivars was grown: 'Blue Tail', 'Cape Town', 'Cassy', 'Chicago', 'Coldwater', 'Double Fun White', 'Flameback', 'Flamingo', 'Milka Dark' and 'Parrot'. Plugs were transplanted to plots in a tunnel in week 18 and to outdoor plots in week 20. The plants were grown both as single stems and pinched crops. The outdoor grown plants were more manageable but of poorer quality than tunnel-grown crops. Single-stem crops grew excessively tall. In tunnels, pinched plants yielded numerous strong stems ready for cropping from around week 36. The industry responded that these lines showed real potential, and numerous sample bunches were provided to potential packers and buyers. In 2011 and 2012 further cultivars were trialled as early- and late-planted crops, observations were made on the plants over-wintered in tunnels and VL was evaluated.

In 2011 an early-season crop of 'Blue Tail', 'Cape Town', 'Cassandra', 'Cassy', 'Chicago', 'Cirina Dark', 'Double Fun Blue', 'Double Fun Pink', 'Double Fun White' and 'Linda' was transplanted to plots in a tunnel in week 19. The crop was pinched two weeks later. Most cultivars produced strong plants, cropping around week 42, four to six weeks later than the equivalent plants in 2010. This had implications for crop programming since the unusually early stems in 2010 may have been due to the hot summer weather experienced then. The average stem length varied from 77 to 159 cm, stem weight from 35 to 62 g, and the number of stems cropped per plot from about 100 to just over 200, so careful varietal selection would

be necessary. Ranking the cultivars by aspects of performance ‘Cassy’, ‘Linda’ and ‘Cirina Dark’ produced above-average numbers of longer-than-average stems, but they were low in weight. In contrast ‘Blue Tail’, ‘Cape Town’ and ‘Cassandra’ produced the heaviest stems but these were relatively low in number as well as shorter.

In 2011 a late-crop was also set up with the objective of following on from a crop of column stocks. Plugs of ‘Blue Tail’, ‘Cairo’, ‘Cape Town’, ‘Chicago’ and ‘Dark Mark’ were pinched in week 24 and allowed to break before transplanting to plots in a tunnel in week 28. ‘Cairo’, ‘Cape Town’ and ‘Chicago’ cropped in week 41, but their stem lengths and weights were about half those of the early-planted crop. The other three cultivars either failed to flower or produced stems too short to crop.

Of the plots planted in a tunnel in 2010 and left down, part was pinched in week 21 and part left intact. The non-pinched, over-wintered plants grew out of control. This shows that the first flush should be cut-back to produce a late flush.

In 2012 stems of ‘Blue Tail’, ‘Cape Town’, ‘Cassandra’, ‘Chicago’, ‘Cirina Dark’, ‘Coldwater’, ‘Double Fun Blue’, ‘Double Fun Pink’, ‘Double Fun White’, ‘Flamingo’ and ‘Parrot’, largely from the week 19 planting, were subjected to standard VL testing. Between cultivars, VL varied from five to 11 days for the 20%-florets-dead stage, and was much longer when assessed at the 50%-florets-dead stage. In general, stems were too long, often with widely spread branches, and would require significant trimming before packing, which could be addressed through improved husbandry and varietal selection. Overall, the ‘Double Fun’ series were the best performers for weight and flower presentation and had a satisfactory VL. In addition, samples from ten plots, seven cultivars from the 2011 trials and three from the over-wintered crop, were picked in week 39 for VL testing. VL varied between seven and 21 days, so reaching or exceeding the current requirement for a five or seven day VL in mixed bouquets.

The trials generated increased market interest in these cultivars, but a longer cropping period was required. In 2012 a new trial involved planting a new crop both in tunnels and outdoors and cropping the plants over-wintered from 2011. The new crop consisted of plugs of ‘Blue Tail’, ‘Capetown’, ‘Cassandra’, ‘Cassy’, ‘Chicago’, ‘Cirina Dark’, ‘Double Fun Blue’, ‘Double Fun Pink Dark’, ‘Double Fun White’, ‘Linda’, ‘Milka Dark’, ‘Milka Karmin’ and ‘Pretty Wendy’ transplanted into plots in a tunnel and outdoors in week 25, deliberately planted later than in the previous year in an attempt to curb excessive growth. The same cultivars (less ‘Milka Dark’ and ‘Milka Karmin’) that had been planted in 2011 in a tunnel and outdoors and over-wintered were used for comparison. The results confirmed the considerable differences between cultivars and the superior yields of second-year crops and of tunnel-

growing, though yields of the new plantings may have been adversely affected by the poor summer in 2012. Stems were sampled in weeks 39 and 42 for VL testing, and, after simulated storage, transport and retail store phases, all achieved a five day VL at the consumer stage.

Numerous samples were again supplied to technologists, supermarket managers and packers, some being sent to the Netherlands. Their general quality and stem weight were considered very satisfactory and VL reasonable. Although in 2012 the main emphasis had been to find a longer cropping season, even with the range of planting combinations used it was still not possible to spread cropping over more than four weeks. The earliest picking was from the over-wintered tunnel crop, which flowered seven to 10 days earlier than the outdoor crop. In 2013 it is planned to use blackouts in an attempt to spread the season and obtain two flushes.

3. Carnation, spray (*Dianthus caryophyllus*)

'Solomio' and 'Star' are new ranges of 'novelty' spray carnations recently introduced by Hilverda Kooji. In 2012, plots were set up to assess their market potential and collect basic data for these cultivars. Rooted plugs of 'Solomio Fen', 'Solomio Sem', 'Solomio Vin' and 'Star Cherry' were delivered in week 14, when the unusually wet weather precluded immediate planting-out, so they were transplanted to 9 cm-diameter pots and transplanted to plots in a tunnel in week 18 and plots outdoors in week 21. Plants were pinched to five or six leaves three weeks after planting. In the very wet weather of 2012 the performance of the outside crop was poor and it was not worthwhile making any formal assessments. There was considerable variation in performance between the remaining cultivars: 'Sem' was the earliest to flower, with first stems picked in week 37; two weeks later 'Vin' and 'Fen' started to flower but growth was very slow and by week 45 the plants were cut-back to the ground to make way for de-skinning the tunnel, and even then many stems were not ready for picking while a number (especially in the case of 'Fen') were blind. 'Sem' produced stronger stems than 'Vin' and 'Fen', though this may have been due to poor light levels and low temperatures throughout October when the last two cultivars were being picked. Overall stem lengths were adequate at 60 to 70 cm. A selection of stems was sampled in week 39 for VL testing, and after simulated storage, transport and retail store phases, all achieved a six day VL at the consumer stage.

This new range of dianthus received positive market feedback from the industry due to its unusual flower form. It was thought these novel cultivars could be marketed at a more developed stage of development than traditional spray carnations, being branded accordingly. Unfortunately only 'Sem' had finished flowering by the time it was necessary to

de-skin the tunnel: had the crop been grown in a glasshouse the picking season could have been extended, though in better weather it would probably have been cropped two or three weeks earlier anyway. Further trials are planned for 2013.

4. China asters (*Callistephus chinensis*) - 'German' varieties

The evaluation of these striking new cultivars of large headed China aster, principally the 'Krallen' and 'Gala' series, was started at the Centre in 2007 and because of the interest shown, has continued into 2012. In 2010 a large multi-variate trial was carried out, and information from it is set out below under cultivar comparisons, comparisons of plug- and block-raised plants, effects of planting date, and use of a plant growth regulator (PGR) to control the excessive growth of the more vigorous cultivars. Demonstration plots of 26 cultivars from the 'Benary Princess', 'Matador' and 'Standby' series were also grown in 2010. In 2011 the PGR work was continued and VL testing carried out, while in 2012 alternatives to the 'Krallen' series were trialled ('Meteor' and 'Ribbon') as well as 'Bonita' which is a new "Matsumoto" type of aster.

Plugs of two 'Gala' cultivars ('Lavender' and 'Purple') and six 'Krallen' cultivars ('Chinchilla', 'Golden', 'Kameo', 'Karthauser', 'Lux' and 'Perser') were transplanted into beds in a tunnel in week 16. Mean stem lengths for the different cultivars ranged from 90 to 110 cm, with 'Gala' cultivars taller than the shorter, more variable 'Krallen' cultivars. However, the 'Gala' cultivars were conspicuously light in weight, about 20 g/stem, confirming earlier observation. In contrast the 'Krallen' cultivars were heavier, especially 'Kameo' and 'Karthauser' whose stems weighed nearly 80 g each. With the exception of 'Golden', a cultivar atypical in several respects, 'Krallen' cultivars had larger, more impressive flowers which are largely responsible for the greater stem weights. Picking dates were the same for all cultivars, except 'Golden' which was a few days later.

'Krallen' cultivars 'Chinchilla', 'Golden', 'Kameo', 'Karthauser' and 'Lux' were raised as blocks in the UK and as plug-plants in the Netherlands. They were planted in plots in a tunnel in weeks 16, 18 and 20 (plugs) and 17, 19 and 21 (blocks). The block-raised plants performed as well or better than conventional Dutch plugs. In the case of stem lengths, no consistent differences between cultivars, propagation method or planting date could be seen, though 'Chinchilla', 'Golden' and 'Lux' gave consistently long stems. Stem weight showed more distinct results, with plug-raised plants giving heavy stems from the earliest planting, decreasing later, and block-raised plants giving heavy stems from both the early and middle plantings, with lighter stems later on. Despite their length, stems of 'Chinchilla', 'Golden' and 'Lux' were light in weight. Stem diameter and the number of side-shoots were reasonably

consistent across the cultivar-treatment combinations, with the exception that ‘Golden’ in the three heavier sets (plugs from week 16 and blocks from weeks 17 and 19) had thicker stems and more side-shoots. Flower size varied between cultivars, but, overall, the same three heavier plantings also produced larger flowers. Within plantings, picking dates were generally similar, except that cultivar ‘Golden’ was slightly later to crop.

‘Krallen’ cultivars (‘Chinchilla’, ‘Kameo’, ‘Karthauser’, ‘Lux’, ‘Orient’ and ‘Perser’) and ‘Gala’ cultivars (‘Lavender’ and ‘Purple’) were raised as blocks in the UK for comparison with standard Dutch-raised plugs. The blocks were planted in plots in a tunnel in week 23. Mean stem lengths were reasonably consistent at about 105 cm across all cultivars, as were stem weights and diameters. In contrast to plug-raised plants there were no consistent differences between the cultivars of the two series tested. There were small (probably commercially insignificant) differences in the numbers of side-shoots per plant. Flower sizes too were consistent and all cultivars reached the picking stage together (around week 36).

To determine the earliest practical planting date for UK block-raised ‘Krallen’ in tunnels, blocks of ‘Chinchilla’, ‘Golden’, ‘Kameo’, ‘Karthauser’, ‘Lux’, ‘Orient’ and ‘Perser’’ were raised in the UK and planted in plots in a tunnel in week 16 through to 23. Except for ‘Karthauser’, which had shorter stems than the other cultivars tested, average stems lengths for the cultivars did not vary greatly and were mostly in the range 105 to 115 cm. For each cultivar there was no clear trend for stems to be longer or shorter following progressively later planting: generally stem length was satisfactory at the earliest planting date (week 16 or 17). As expected from previous results, stem weight was much more variable than stem length; with the exception of ‘Golden’, weights were heavier from the earlier plantings and fell away with later plantings, and in several cases the weights of stems from plantings in weeks 17 to 19 were double those of plantings in week 21 or later. The effects of cultivar on stem length and weight were not significant, while the effect of planting date on stem weight was significant.. Stem diameter was greater for earlier plantings of ‘Chinchilla’ and ‘Golden’ than for later plantings, but this trend was not seen in the other cultivars, and the number of side-shoots per plant varied in a similar way. For flower size too, with the exception of ‘Golden’, there was a clear trend for smaller size following progressively later planting. There were significant effects of cultivar on flower diameter and on the number of side-shoots but not on stem diameter or picking date. Flower diameter and side-shoot number and stem diameter were all significantly diminished by later planting. Essentially, these findings showed that the earlier plantings of all these cultivars produced heavier stems and larger flowers.

In order to determine the earliest practical planting date for plug-raised ‘Krallen’ and ‘Gala’ in tunnels, plugs of ‘Krallen’ cultivars (‘Chinchilla’, ‘Golden’, ‘Kameo’, ‘Karthauser’ and ‘Lux’) and ‘Gala’ cultivars (‘Lavendar’ and ‘Purple’) were transplanted to plots in a tunnel in weeks

16 to 22. Stem length in ‘Kameo’ and ‘Karthauser’ was shorter than average, while that of the ‘Gala’ cultivars was longer. There was a clear trend for the middle plantings (weeks 18 or 20) to produce longer stems. Except for the ‘Gala’ cultivars there was a clear trend for stem weight to decrease following progressively later plantings, an effect conspicuous in the case of ‘Golden’, ‘Kameo’, ‘Karthauser’ and ‘Lux’. The effect of cultivar was significant on stem length and weight as was planting date on stem length and weight; the effects of planting date on numbers of side-shoots and stem diameter were not significant. In terms of flower size, there appeared to be a striking result that flower diameters were greater from the first planting (week 16) for the four cultivars that produced heavier stems from this early planting (‘Golden’, ‘Kameo’, ‘Karthauser’ and ‘Lux’). As with the block-raised plants there was the expected later cropping from later plantings (week 20 or 22), with only minor differences between cultivars from the same planting date. However, the two ‘Gala’ cultivars were exceptional in that flower cropping was considerably delayed even following planting at week 18.

Since early plantings of these cultivars can produce vigourous growth and excessively long stems, an application of plant growth regulator would be useful. Plug-raised ‘Krallen’ cultivars ‘Kameo’ and ‘Karthauser’ and ‘Gala’ cultivars ‘Lavender’ and ‘Purple’ were transplanted in week 16, 18 and 20 to plots in a tunnel. The plots were treated with two rates of daminozide (as ‘B-Nine SG’) or were left un-treated as controls. The ‘B-Nine’ rates were 3 and 6 g/L, with split-dose applications made as foliar drenches to run-off on 2 June and 3 July 2010. The higher rate of product resulted in only a 10% reduction in stem length compared with un-treated controls, but only following the early planting date (week 16). Treatments to the later plantings were ineffective. There were no or only minimal effects of the treatment on the other variables measured – stem weight, stem diameter, number of side-shoots, flower diameter and picking date.

Plugs of 25 cultivars of the ‘Standby’, ‘Benary Princess’ and ‘Matador’ series were planted to plots in a tunnel in week 20. While these supplied an additional range of shades, the general view of the growers and buyers who examined them was that none was of the quality of the ‘Krallen’ series, though some might find a limited market.

In 2011 a further plant growth regulator trial was carried out. Plugs of ‘Gremlin’ cultivars (‘Donker Paars’, ‘Donker Rose’, ‘Geel’, ‘Lincht Rose’, ‘Paarsblauw’ and ‘Rood’ and ‘Krallen’ cultivars (‘Birma’, ‘Chinchilla’, ‘Karthauser’, ‘Lux’ and ‘Perser’) were transplanted to beds in a tunnel in week 25. Half of each bed was treated with ‘B-Nine SG’ at 6 g of product per litre twice, sprayed to ‘run-off’, in weeks 32 and 34. With the ‘Krallen’ varieties applying ‘B-Nine SG’ gave a fairly consistent, but only 3% overall, reduction in stem length compared with the controls. In contrast the result of using ‘B-Nine SG’ with the ‘Gremlin’ varieties was

unconvincing, inconsistent and resulted in an overall less than 2% reduction in length. Late in the season (week 39) samples of four cultivars – 'Bonita Scarlet', 'Chinchilla', 'Lux' and 'Perser' - were picked for standard VL testing in 2011. 'Chinchilla' gave a VL of nine days and 'Perser' and 'Lux' seven days.

Alternative large-headed annual aster cultivars were sought for a trial in 2012. These were from the 'Meteor' and 'Ribbon' series, and cultivars of the 'Bonita' series were also included as they are marketed as being complementary to 'Matsumoto', the most commonly grown spray variety. Plugs of 'Meteor Carmine Red', 'Meteor Violet Blue', 'Meteor Yellow', 'Ribbon Dark Pink', 'Ribbon Lavender', 'Ribbon Lilac Rose' and 'Ribbon Violet' were transplanted to plots in a tunnel during weeks 27 and 28, and plugs of the 'Bonita' series 'Pink', 'Blue', 'Scarlet' and 'Rose' in weeks 30 and 31 (the planting dates were much later than originally planned but they were unfortunately delayed due to supply issues with the seed-house). Despite the application of prophylactic sprays against thrips, a severe attack of Tomato Spotted Wilt Virus (TSWV) appeared early in the life of the crop. The problem was particularly serious on the 'Meteor' series but was present only at low levels in the 'Ribbon' series with virtually no symptoms on the 'Bonita' series. As a result of the late planting and subsequent poor weather, and the TSWV infection, the stems were of such poor quality that no assessments were made. None of the cultivars tested appeared to have prospects as an alternative to 'Krallen', but the trial will be repeated in 2013 using an earlier planting date and additional new varieties. The 'Bonita' range generated interest from growers of the traditional 'Matsumoto' varieties, but the range did not attain its full potential owing to late planting and poor weather. It appears likely that growers will undertake their own trials in 2013.

The series of trials with 'German asters' at the Centre showed there is potential for exploiting these vibrant cultivars in the UK. The 'Krallen' series produces a large head and strong stems of superior quality compared with the 'Benary Princess', 'Gala', 'Matador' and 'Standby' series, but there is still scope for further cultivar trials to eliminate poor or inconsistent 'Krallen' cultivars such as 'Golden', which often behaves in an atypical manner and produces weak stems of poor quality. Earlier trials showed that 'Krallen' cultivars also showed better tolerance to pests and disease. Throughout the project many samples were supplied to supermarkets, packers and local florists, some being sent to the Netherlands. They were well received, with the 'blue' cultivars – 'Karthauser' and 'Perser' - identified as having probably the most market potential.

The results of the later trials on the effects of planting date confirmed and extended the earlier findings. For plug-raised plants (generalising somewhat across cultivars), later plantings led to the production of lighter stems with smaller flowers, while stem length, stem

diameter and the number of side-shoots were less from either the early or the late plantings and maximal from middle plantings. In most cases later planting (in weeks 20 to 22) led to poorer quality stems, whereas early or middle plantings were satisfactory. While earlier findings had suggested that these cultivars should not be planted later then week 26, the issues of lightweight stems and smaller flowers obtained from the week 22 and 23 plantings implies that production of marketable stems from a week 26 planting seems unlikely. Subsequent commercial planting have shown that week 24 to 25 is perhaps the latest that 'Krallen' can be planted and an adequate crop obtained.

UK block-propagated plants performed as well or better than conventional Dutch plugs. The former gave heavier plants with larger flowers from the early and middle plantings, while the latter gave heavier stems and larger flowers only from the early planting. Block-propagated plants may be more robust than plugs, and appeared to make more consistent stems. A subsidiary trial showed that block-raised plants could simply be laid on the ground, as in AYR chrysanthemum growing; the blocks did not need to be buried in the soil, provided they were kept well watered.

Only a weak response to daminozide has been seen in these trials, and earlier and perhaps repeated applications at a higher dose appear to be needed. Once optimal treatments rates have been defined these could be used to bolster stem weight in cultivars and planting dates that need it.

The 'Krallen' series were grown by local producers in commercial quantities in 2009 and 2010, and 'Karthauser' and 'Perser' were in great demand by the supermarkets. Numerous VL tests were undertaken by the packer on batches being sold through the supermarkets, and their VL was found consistently to meet or exceed the guarantee of five days. Despite its great commercial potential, however, VL subsequently became an issue when a problem with petal-spotting and flower-tip browning became apparent. The cause of the disorder has unfortunately not been identified, despite extensive investigations both in the Netherlands and the UK. Losses became so severe that 'Krallen' is unlikely to be grown again on any large scale until the cause can be identified and rectified. Petal-spotting was less severe, but still present, on other cultivars. In 2013 further variety trials will be undertaken to try and identify potential alternatives to 'Krallen'.

5. Dianthus, annual ('Breanthus')

'Breanthus' is a new range of annual dianthus developed by Hilverda Kooji. In 2012, plots were set up to assess their market potential and collect basic data for four of these cultivars. 'Duke Breanthus' ('Hilbreduk'), 'Earl Breanthus', 'King Breanthus' and 'Queen Breanthus' were propagated from cuttings and delivered as rooted plugs in week 14. The unusually wet

weather at the time precluded immediate planting, and they were transplanted to 9 cm diameter pots and when appropriate transplanted to plots in a tunnel (week 18) and outdoors (week 21). One half of each plot was pinched (week 21 in tunnel, week 23 outside) and the other half-plot left non-pinched. In the very wet weather of 2012 the performance of the outdoor crop was very poor and it was not considered worthwhile to make any formal assessments. In the tunnel the first flush occurred in weeks 29 and 30 and the second began in week 36. Good quality stems were harvested, but the growth of the four cultivars was very different in yield, stem strength and second-flush vigour. 'Duke' gave a very heavy first flush of strong stems, but failed to produce a marketable second flush. 'Queen' produced a large number of much weaker stems in both first and second flushes. The total yield of stems for 'King' and 'Queen' were of the order expected by the propagator (>100 stems/m^2). Some stems failed to mature, probably due to the unusually poor weather and very late season. It is not yet known whether this year's behaviour of 'Duke' was typical of the cultivar, or caused by seasonal factors. 'Queen' produced substantially lighter stems and slightly shorter stems, though still sufficiently long enough for trimming to 45 cm. Compared with the non-pinched controls, pinching reduced overall stem length (except in the less vigorous 'Queen') and gave lighter stems in the otherwise vigorous 'King'.

This demonstration of 'Breanthus' received a positive market response from retailers and growers. The tight, spherical head was considered especially appealing. However, the crop was planted unavoidably late due to wet weather, and the poor season probably had a negative effect on crop performance, so the results should be interpreted cautiously and further trials are needed before these cultivars can be recommended by the Centre. In 2013 it is planned to investigate staggered planting for continuity of supply, as well as differences between pinched and non-pinched plants and between the flowers of the first and second flushes. The crop planted in 2012 will be over-wintered and (if it survives) will be assessed in more detail in 2013.

6. Lisianthus (Eustoma grandiflorum)

Cut-flowers of lisianthus have now achieved considerable popularity in the UK as a rather 'exotic' crop. Its longer growing season than many other flowers, and high heat and light requirements, restrict the number of rounds that can be accommodated in a year, but the possibility of growing a short summer 'spot' crop in Spanish tunnels was raised in discussions in 2009. In 2010 plugs were transplanted to plots in a 'Haygrove tunnel', fitted with side skirts and doors, in weeks 18, 19 and 20. Cropping started in week 30 and continued past week 34. It was acknowledged by Open Day visitors that the results were impressive, with high-quality blooms, good stem strength and no pest and disease problems. Many sample bunches were provided to packers and buyers for assessment. But it was also

noted that the trial had coincided with warm, dry weather that would be very favourable for the crop, so the trial was repeated in 2011 when further cultivars were tested, planting date was investigated and growth compared in a 'closed' 'Haygrove tunnel' (fitted with side skirts and doors) and an 'open' 'Pro-Tech tunnel' (without end-doors or skirted sides). The work was extended in 2012 to study the effects of soil sterilisation and growing through black mulch.

In 2011, 30 lisianthus cultivars were included in trials. Plugs of 10 cultivars were transplanted to plots in the closed tunnel in each of weeks 18, 19 and 20, with further plugs of the 10 varieties planted in week 20 transplanted to plots in the open tunnel in week 21. Despite the wetter, cooler season of 2011, as in 2010 the plots grown in the closed tunnel produced strong, high quality stems and only inconsequential levels of pest or disease were seen, with little evidence of root diseases. In contrast, growth of the late planting in the open tunnel was weak and significant amounts of *Fusarium* were seen along with some *Pythium.* This crop was abandoned after the cover was damaged in a gale, but before this a long-established lisianthus grower visited the Centre and commented that, while the crop was not as strong and vigorous as in the closed tunnel, it was still better than his equivalent glasshouse crop, and so it would be well worth repeating in 2012 but using a slightly earlier planting date. Since the difference in pest and disease levels between the two tunnels may have related to either their different microclimates or to the means of soil sterilisation used - the closed tunnel had been treated with Basamid (dazomet) in autumn 2010 and left sheeted-down over winter, while the open tunnel had not been sterilised until spring 2011 – soil sterilisation would also need to be further investigated.

There were considerable varietal differences in cropping dates, stem lengths and trimmed weights, some cultivars evidently being more suited to cultivation in tunnels. Most cultivars planted in weeks 18 and 19 cropped in weeks 32 and 33, with the odd cultivar later. The week 20 plantings cropped over weeks 32 to 36. Of the 28 plantings, eight failed to reach the average length of 70 cm needed for trimming to specification, but only six had a trimmed stem weight of less than 80 g each. Untrimmed stem lengths and trimmed stem weights, averaged across the cultivars, showed no clear trend with later planting, although stems from the middle planting date were shorter and lighter (each by about 10%) than either the earlier or later plantings.

Samples of cultivars 'ABC 2-3 Blue Rim', 'Dream Blue', 'Dream Lavender', Dream White', 'Mariachi Lime Green', 'Piccolo 2 Rose Pink' and 'Rosita Blue' were picked in week 32 for standard VL testing and a second batch ('ABC 2-3 Blue Rim', 'Dream Blue', 'Dream

Lavender', 'Mariachi Lime Green', 'Piccolo 2 Rose Pink' and 'Piccolo 2 Deep Blue') in week 33. Amongst the different cultivars VL varied from seven to 14 days in batch one and from seven to 13 days in batch two. The main reasons for failure were flower-head damage due to *Botrytis* or drooping of the flowers and stems. The VL guarantee for straight lisianthus is usually nine days. In batch one only 'Dream White', 'Mariachi Green' and 'Piccolo Rose' achieved this, while in batch two all cultivars except 'ABC 2-3 Blue Rim' and 'Dream Lavender' did so; overall, about half the bunches picked met the nine day requirement. Lisianthus is also commonly used in mixed bouquets that are generally guaranteed for five or seven days. For the latter criterion, all bunches tested would meet the required guarantee.

A multi-factorial trial in 2012 addressed three issues:

As a result of the long growing period of lisianthus, planting densities greater than 64 plants/m^2 are used in the Netherlands to achieve commercial viability and therefore planting densities of 64, 80 or 96 plants/m^2 were tested.

To investigate the different results obtained in 2011 in the two types of tunnel – which besides their physical differences also had different dates for soil sterilisation – plantings were made into separate areas of the closed tunnel that had been sterilised with steam or Basamid in November 2011 (and then left covered with polythene over winter) or had been left un-sterilised as a control, and into an area of an open tunnel that had been steam-sterilised in November 2011.

As the possible benefits of growing lisianthus through polythene mulch had been raised in discussions by growers at the 2011 Open Day, both mulched and non-mulched plots were included in both the closed and open tunnels. The material used was a thin, micro-perforated black polythene film.

Plugs of 13 cultivars were transplanted to plots in weeks 21 (closed tunnel) or 22 (open tunnel). Cropping started in week 33. As in the previous two years, overall the stems were of exceptional quality being strong with very little disease in the closed tunnel. However, some root problems were evident in the open tunnel, though this did not result in significant crop losses in this case. The main results were:

Using a mulch did not increase stem length or weight compared with planting directly into the soil, though there was a suggestion that some cultivars were more responsive to the mulch than others.

Stem lengths were broadly consistent across the whole range of combinations of mulch or no mulch, planting rate, and soil sterilisation method. Stem weights were greatest when planted at the lowest density (64 plants/m^2), the size of this response varying between the three cultivars ('Piccolo 2 Rose Pink' was particularly responsive), but apparently irrespective of whether mulch or soil sterilisation was used.

Comparing growth in the open and closed tunnels was hampered because the plants in the open tunnel were very slow growing, many stems failing to reach maturity and flower before it was time to de-skin the tunnels in November. This was likely due to low light levels and unseasonably low temperatures in the poor summer of 2012. It was not felt that a direct comparison of crops in the two tunnels would be valid. These results and those of the 2011 trial showed that unless there is a very warm summer, the production of lisianthus can only be considered in tunnels that have a facility for their doors and sides to be closed, ensuring an adequate temperature can be maintained if the outside temperature is too low.

The last three years of trials have shown that the Centre's closed 'Haygrove tunnel' provided a superb environment for the production of high-quality, strong-stemmed lisianthus of a wide range of cultivars. Production in an open tunnel is much more risky, and was not successful during the last two years of trials. Perhaps surprisingly the 2012 trial did not show any real advantage of sterilised over non-sterilised plots, but lisianthus are known to be susceptible to so many different stem and root diseases that it would be very risky to produce a commercial crop with no soil sterilisation. As would be expected, wider spacing tends to produce stronger stems but, from the results of the 2012 trial, some cultivars seemed to respond more positively then others. Viewing the trials in 2011, representatives of a propagator and a supermarket commented that these were some of the strongest-stemmed lisianthus they had ever seen. Samples of lisianthus were supplied widely to technologists and managers of supermarkets and packers and were very enthusiastically received and as a result, some growers were being approached to produce a tunnel grown crop in 2013. With this quality in a home-grown product, it was considered the crop could generate a good return if the supermarkets would pay a premium price for it: the main obstacle was the long time the crop is in the ground. However, the Centre's trials have demonstrated the potential of the production of the crop in closed 'Spanish tunnels' in the UK and it now up to the industry to develop it further.

7. Ornamental brassicas (*Brassica oleracea*)

For economic success ornamental brassicas need to be grown on as low-cost a basis as practical, and this is likely to involve direct-drilling as increasingly practiced in the Netherlands. In 2009 a small trial was set-up to compare the production of ornamental

brassicas by direct-drilling with traditional plug planting, but, owing to extreme dry weather, germination was erratic and no meaningful results were obtained. Since ornamental brassicas appear to be very sensitive to poor soil conditions, when the trial was repeated in 2010, it was located on a commercial nursery with more a appropriate soil type. The direct-drilled crop performed well, and as a result management at this nursery intends to direct-drill most its ornamental brassicas for routine cropping in the future. Cultivar trials were also conducted in co-operation with the Centre at the same nursery in 2011.

In 2010 fifteen numbered lines of new ornamental brassicas were grown and assessed in the field and then subjected to standard VL testing. Between cultivar differences in leaf colour and form were high, as was plant height (from 20 to 53 cm). VL after a simulated storage, transport and retail period varied between 10 and 16 days. Seven of the lines were assessed as promising novelties or as alternatives to 'Crane' cultivars. Other cultivars were rejected on the basis of being 'too cabbage-like', having a tendancy to bolt, being too short, being flat-topped and collecting water on the head, not having clear colours, a tendancy to leaf browning and producing many side-shoots. Unfortunately, owing to a change of staff at the seed supplier, it was not possible to source these exact cultivars in 2011.

In 2011 ten further lines were evaluated. Seed was sown in plugs in week 22 and transplanted to field plots in week 27. Stems were harvested in week 40 and samples were subjected to VL testing. None of the varieties presented any issues over their growing, though 'Sunny Bright' consisted of mixed seed, consequently resulting in a mixture of head sizes. The overall selection produced a good range of head colour, from white to purple/pink, while many produced attractive heads, notably 'Snow Bright' with white veining in the pink/white/green leaves. Average stem length varied from 40 cm (for 'Kohju No. 2', which was considered too short) to 62 cm (for 'Dream White', possibly too tall). The percentage of stems cropped varied much between varieties – from only 5 or 10% with 'Sunny Bright' and 'Kohju No. 2', to 90% or more (in the case of tall varieties like 'Dream White', 'Lake Swan' and 'Suruga Hatshi'). VL, after a simulated storage, transport and retail period, ranged from a satisfactory 12 days (with 'Dream Light', 'Lake Swan', 'Sunny Bright' and 'Suruga Hatshi') to 23 days (with 'Dream White', 'Hakuju' and 'Moon Light').

Work in the project confirmed that direct-drilling in the field was suitable for producing ornamental brassicas, and in order to reduce costs this is likely to be the way forward in field-scale production in the future. A number of new lines was identified as suitable for commercialisation, particularly 'Dream Red', 'Moon Light' and 'Snow Bright', and these may well be futher exploited by growers after more field-scale trials undertaken by individual producers. It was observed in these trials that plots of ornamental brassicas sometimes showed a distinct 'edge effect', the outside plants developing a 'true cabbage' appearance

rather than producing a typical ornamental head, and the reasons for this need to be investigated.

8. Phlox (Phlox paniculata)

Plots of phlox cultivars ‘Icecap’, ‘Magical Dream’, ‘Magical Fragrance’, ‘Magical Surprise’, ‘Miss Fiona’, ‘Miss Marple’ and ‘Sugar Missy’ were established in 2009 in plots in a tunnel. They were grown-on mainly to provide a resource to flower packers and supermarket buyers. The crop produced blooms which were far superior to an outdoor crop. Stems were picked over the period week 27 to 31. Associated tests showed a variable but generally acceptable VL, though grower observations have indicated that, by the time of marketing, there may be a natural petal drop from the first opened florets that detracts from the appeal of the stems, an area where further cultivar selection and post-harvest studies are needed. The ‘Magical’ series showed outstanding resistance to powdery mildew, but had to be withdrawn from the trial in 2010 as a result of commercial issues.

In 2011, the plots started to crop in early-July, again giving stems of far superior quality than those on an outdoor crop. Average trimmed stem weights varied from 32 to 38 g. The number of stems cropped varied from a low 31/m^2 for ‘Sugar Missy’ to 104/m^2 for ‘Miss Fiona’. The second flush was still developing when the polythene cover had to be removed from the tunnel due to deteriorating weather. Samples of several lines were picked in week 24 for standard VL testing. ‘Sugar Missy’ had an extremely good performance with a 14 day VL, and was the only variety not to drop any flower heads during the trial. Between vase-days four and six flower drop started on all other bunches and, although the level was significant, a substantial amount of flowers still remained to open, giving the product the appearance of continuous flowering. In these cultivars VL varied between nine and 11 days. In further VL tests in 2012 a selection of stems was sampled in weeks 34, and all achieved a seven day VL at the consumer stage.

Although no further trials work was carried out in 2012, the phlox were grown-on and, produced another crop much superior to that obtained outdoors, was used to provide high-quality samples to demonstrate to supermarket buyers. This trial has shown that phlox is a good candidate for production in ‘Spanish tunnels’ or cold glass and that the production of high-quality stems is possible, although there is still a potential issue with flower drop in the vase. However, as with so many other potential cut-flower lines, production needs to be developed in conjunction with the market outlets, and as such the Centre feels it cannot take these trials any further. It is now up to the industry to commercialise this crop further. It must also be pointed out that many of the varieties trialled at the Centre have been superseded by new introductions which may (or may not) be less prone to flower drop.

Growers should work closely with the propagator to choose varieties that are best suited to their needs.

9. Sedum (Sedum spectabile)

In 2010 initial plots of three sedum cultivars, *Sedum spectabile* 'Brilliant', 'Herbstfreude' and 'Matrona' grew poorly, with no flowers produced in the first year. After establishment, however, their growth in the second year was vigorous. Reports of their impressive stem count, length, weight and quality as cut-flowers suggested the original planting should be extended, and in 2011 plants of cultivars 'Magical Bon Bon', 'Magical Lizzy', 'Magical Twist' and 'Mr Goodbud' were transplanted into outdoor beds in week 24. In 2012 average stem lengths across the seven cultivars ranged from 41 ('Mr Goodbud') to 81 cm ('Matrona'). After one or two years' establishment, they produced prodigious stem counts. Standard VL tests showed a long post-harvest life and the ability to crop flowers over a wide range of developmental stages.

In 2012 this demonstration generated probably more attention at the Centre than any of the other crops. The 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 commercial plantings are now being made.

10. Stocks (column) (*Matthiola incana*)

Column stocks for autumn-flowering were included in the Centre's programme in 2009, when the suggested advantage of using block-raised plants (a more robust plant which would establish more easily than plugs) was tested, with transplanting in weeks 26, 28 and 33. This showed that there was no advantage using blocks over plugs, and, in any case, the plants did not flower until after the tunnel's polythene had to be removed for the winter. These trials ensured that growers did not waste time and money by using this unsuccessful technique on a commercial scale and the technique has now been totally discounted by the industry. Further trials on column stocks were carried out in 2011 (variety demonstrations and investigating issues of gapping-up and summer flower failures) and 2012 (demonstration of the non-selectable 'Katz' lines and the effects of soil sterilisation).

In producing selectable stocks, propagators use automated gapping-up to replace single-flowered plants in the plug-tray with doubles, and this process has sometimes been seen to cause apparent damage to the plants. To investigate this issue, two plots were planted in week 27 in a tunnel with 'Centrum Pink', one using selected plugs from a non-gapped-up tray, the second from a tray previously gapped-up automatically. Flower quality was

assessed and compared across the two plots, and showed minimal differences in stem length and weight and spike length. Although this was only a small test, it may indicate there is no disadvantage in using automated gapping-up in this case hence enabling growers to continue to receive trays with a high number of double plants which results in reduced transport costs.

In 2011 samples of three column stocks cultivars, 'Anytime Yellow', 'Centrum Pink' and 'Figaro Lavender' were transplanted to plots in a tunnel in week 27. The main aim was to assess 'Anytime Yellow', a new line. Cut-stems were harvested in week 35. Overall stem and spike lengths were similar in the three cultivars, the main differences being in untrimmed stem weight which varied from just under 50 g with 'Anytime Yellow' to over 75 g in 'Centrum Pink'. On the basis of this small sample, 'Anytime Yellow' appeared to be of average stem length but with a long spike, and relatively light in weight. Grower trials also demonstrated the potential for 'Anytime Yellow' to supplement the current range of commercial varieties available.

Stocks are prone to failing or abnormal flower initiation when grown in summer temperatures. However, the 'Katz' series of column stocks was bred for resilience to higher temperatures, so work was planned to investigate summer cropping of 'Katz' varieties at the Centre in 2011. The plugs did not arrive at the Centre until late-August, but nevertheless were planted in plots in a tunnel which by then had had its cover removed. The plants 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 raised the question of whether, irrespective of its advantages as a crop in a warm summer, this series might be suitable as a late tunnel crop. Unlike many stocks varieties, the 'Katz' series is selectable for double flowers 'only with difficulty' and automated methods are not sufficiently sensitive, so it has been suggested that selection in this case is not economic. However, in the right circumstances a profitable crop might still be possible if a reasonable percentage of double flowers can be obtained when grown in a 'Spanish tunnel' or under minimally heated or unheated glass. For this reason records were kept of the numbers of double and single flowers obtained. The overall percentage of plants producing double flowers varied from 32 to 57% in different lines, or from 40 to 62% if plants with non-opening flowers were excluded (in which case about half of the eight lines yielded around 60% of doubles). Further tests would be needed to determine if the performance of the different 'Katz' lines is consistent year-on-year, and this was investigated further in 2012. Plugs of cultivars 'Cherry Blossom', 'Lavender Light', 'Pink' and 'Yellow' were transplanted to plots in a tunnel in week 28. After a weak start in which the plants lodged badly, they went on to produce some strong, long stems ready for cropping in weeks 34 and 35. The plants were severely grazed by rabbits,

destroying over a third of the plants overall, with ‘Cherry Blossom’ and, especially, ‘Lavender Light’ being especially grazed.

In 2012, 48 cultivars of column stocks, representing a number of series and including many numbered lines were delivered as plugs and their performance assessed in plots of both steamed and non-steamed soil. They were transplanted to plots in both areas of a tunnel in week 21. Flowers were cropped mostly in week 30 and in general were regarded as of impressive quality. The most obvious finding was the considerable 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: there was a strong beneficial effect of steaming on stem weight, a smaller (and commercially irrelevant) positive effect on stem length, and no significant effect on spike length. In terms of increased stem weight, more than half of the cultivars benefited from planting into steamed soil, with a smaller group showing little or no benefit.

Although the ‘Katz’ cultivars started poorly, they produced some long, strong stems that provoked quite positive feedback. It is for the market to decide whether there is a place for ‘Katz’, considering their variability, the numbers of single flowers, and the atypical leaf form. The large cultivar trial also produced generally good quality stems and positive feedback, but varietal selection is important since most do better on sterilised soil. This trial also demonstrated that some varieties, such as the ‘Figaro’ series, performed very poorly on non-steamed soil (see also HDC project PO 005). The results of this trial, along with two associated grower variety trials, were viewed by about 95% of the UK column stock growers, and will help to determine variety choice for individual nurseries in 2013 and beyond. The grower opinions of the varieties viewed at the trials will also influence the direction of the breeding work in future years.

11. Sunflowers (*Helianthus annuus*)

In 2010 sunflowers were included in the Centre’s trials for the first time. Although sunflowers are already a well-established crop in the UK, their size means that harvesting and handling require significant resources. To facilitate handling, and perhaps mechanical harvesting, it was planned to investigate new dwarf cultivars as well as the use of plant growth regulators on standard cultivars. The standard cultivar ‘Sunrich Orange’ and a number of others including: ‘Galilee Adami’, ‘Premier Lemon’, ‘Premier Light Yellow’ and ‘Zohar Yellow’ were direct-drilled by hand to outdoor plots in weeks 24, 25 and 26. It was planned to treat the standard cultivar with growth regulator, but the extremely dry weather that followed resulted in poor germination and establishment, especially for the last two sowings. This was followed by wet, windy weather that adversely affected establishment and growth. Stem

lengths were recorded at the picking stage for each cultivar from the first sowing. The average stem lengths of the standard cultivars were 151, 129 and 109 cm (for 'Galilee Adami', 'Sunrich Orange' and 'Zohar Yellow', respectively) and 48 and 45 cm for 'Premier Lemon' and 'Premier Light Yellow'. The later sowings, and the 'Premier Lemon' and 'Premier Light Yellow', failed to produce stems of marketable quality so the trial needed to be repeated. Cultivar and growth regulator trials were continued in 2011 and 2012.

In 2011 eight cultivars, some available only with code numbers, were sourced from various seed-houses and sown by hand to plots in outdoor beds in weeks 19 and 22. Percentage germination varied from 38 to 100% depending on the variety. This showed that further work is needed by breeders to ensure commercially viable germination rates. Cropping took place in weeks 32 to 35 for cultivars sown in week 19, and in weeks 33 to 35 for the sowing in week 22. For the earlier sowing 'Early Sunrise' (KB 114), 'Jua Maya' and 'Stellar Sun' (KB 105) were faster to crop than the other varieties. The cropping dates for the later sowing were more uniform, with the exception of 'Stellar Sun' (KB 105) which was again quick to crop. Flower diameters varied from 15 to 19 cm for the various cultivars. The flowers of 'Jua Maya' were relatively small from both sowings. For most, but not all, cultivar stem lengths were greater from the later sowing, but this was not always accompanied by increased stem weight (there appearing to be no obvious relationship between the two). 'Happy Face' (KB 116) was the most dwarf cultivar trialled, from both sowings, and produced a relatively high stem weight. Bunches of cultivars 'Galilee', 'Happy Face', 'KB105', 'Sunrich' and 'Dafna' were cropped in week 35 and subjected to standard VL testing. The outstanding result was the quality and long VL of cultivar 'Dafna'.

Seed of the standard sunflower 'Sunrich Orange' were sown by hand in an outdoor bed in each of weeks 19, 22 and 26. The plant growth regulator 'B-Nine SG' (daminozide) was applied as a foliar spray to 'run-off' on part of each bed, using a rate of 6 g product/L, in week 32 and again in week 33. As it was visually obvious that the treatment had had no effect on plant height, no measurements were made.

Three novel cultivars were evaluated in 2012: 'Vincent's Fresh', 'Vincent's Choice' and a new line, VV10-4. They were direct-sown by hand into plots outdoors in week 23 and plots in a tunnel in week 31. In the tunnel 'Vincent's Choice' averaged 1.9 m-tall stems weighing 0.2 kg, with a flower diameter of nearly 18 cm, while 'Vincent's Fresh' was shorter and lighter (1.6 m, 0.15 kg), with a similar head size. 'VV 10-4' was only a little shorter than 'Vincent's Fresh', but had much lighter stems (0.11 kg) and smaller heads (12 cm) and therefore showed potential as a more cost-effective product. The very wet weather this year was not favourable to outdoor sunflowers, resulting in a combination of poor germination and damage to the petals from wind and rain. However, with an average height of 1.1 m for

'Vincent's Choice', 1.2 m for 'Vincent's Fresh' and 0.75 cm for 'VV 10-4', for stems cropped in week 43 it would appear as if the new coded variety does have potential as a truly dwarf variety of good appearance and manageable dimensions.

The variety trials gave the opportunity for growers to view a wide range of the recent sunflower introductions and compare this with their own trials of some of the same varieties. It is for growers themselves to determine the most appropriate variety for their situation, but 'Dafna' looked very promising from the 2011 trials, with VV 10-4 from the 2012 trial showing potential as a truly dwarf variety for both outdoor and protected production.

12. Sweet peas (*Lathryus odoratus*)

Recurring expressions of interest in developing a low-input system of sweet pea production led to trials at the Centre in 2011. A metal 'A' frame with netting was erected along the length of a tunnel. Seeds were germinated in small, individual pots and transplanted in rows along either side of the framework in week 22 at each of 30 or 50 cm spacings. The 50 cm spaced plants were pinched once, while the 30 cm spaced plants were not pinched. The first stems were picked in mid-July, cropping continuing for an extended period. The initial results were very encouraging, with a large number of long, high quality stems being produced from both growing formats. The average length of stems approached 30 cm, with slightly longer stems from the 50 cm, pinched plots. However, floret numbers were consistently low, with 3.3 to 3.8 florets per stem. Between 1,000 and 2,000 stems were obtained for each 5 m-long plot. Bunches of 'Valerie Harrod' and 'Gwendoline' were picked in week 34 for standard VL testing, and all bunches had a similar performance irrespective. Stems started to fail from vase-day two onwards, and all bunches showed 50% stem failure on vase-day five due to bud drop.

This investigation was originally instigated as a result of a request from a supermarket to develop a lower specification, and therefore a lower price point, for the product. The trial produced a large number of good quality stems, but the average floret count was only three or four and this was not received favourably by the supermarkets. As a result, the trial was not repeated in 2012: it is likely that sweet peas will remain a small-scale, high-value niche product.

13. Preliminary assessments

<u>Amaranthus (Amaranthus caudatus)</u>

After a specific request from a grower, a small selection of amaranthus cultivars was grown in 2011 to assess their potential as a cut-flower. Plugs of 'Caudatus Red', 'Green Thumb',

'Oeschberg', 'Pygmy Torch' and 'Red Cathedral' were transplanted to plots in a tunnel in week 21. Cropping started in week 30. The length and form of the inflorescences varied considerably, though all were vigorous. The smaller-flowered types were thought to have potential as cut-flowers for supermarket sales, whereas the larger types have scope for a specialist grower, for example, for architectural displays in larger settings. From comments received from the industry, it would be useful to look at an earlier cropping stage that might be more appropriate to develop their commercial potential. It was hoped to continue with a variety demonstration in 2012 and use the material to investigate cropping stages and VL, but there were difficulties in obtaining the plugs and the trial could not be repeated.

Campanula (*Campanula* species)

Campanula was considered by the MG to have some potential, and an initial assessment was carried out in 2012. Three cultivars, 'Champion Lavender', 'Champion Pink' and a numbered line 135 5005, were delivered as plugs and transplanted to plots in a tunnel in week 22. All varieties cropped in week 31, producing stem counts of 98, 96 and 99 stems/plot, respectively. There was a positive response from growers, and samples were taken to show interested parties and for VL testing. This has resulted in a renewed interest in the crop amongst some growers.

Celosia (Celosia cristata)

Although celosia has been tried as a cut-flower in the UK before, there does not seem to be a demand at the present time. Plugs of celosia cultivars 'Bombay Flora' and 'Bombay Fire' were planted in plots in a tunnel in week 23. This gave a very good quality product creating a good market reaction, though there would be only limited scope to sell any volume.

Dahlia (*Dahlia hybrida*) - 'Karma' series

More than one member of the MG has confirmed the supermarkets' interest in sourcing dahlias as a cut-flower, but this is currently being resisted since VL issues are still unresolved. Dahlias are generally considered to have a poor VL, but the 'Karma' series was developed to deal with this shortcoming. In 2009 a demonstration of 18 'Karma' cultivars was grown. Cuttings were planted in week 28 in both outdoor beds and in plots in a tunnel, the cultivars being 'Amanda', 'Bon Bini', 'Choc', 'Corona', 'Fiesta', 'Irene', 'Lagoon', 'Maarten de Zwaan', 'Naomi', 'Pink Corona', 'Prospero', 'Red Corona', 'Royal', 'Sangria', 'Serena', 'Thalia', 'Ventura' and 'Ying Yang'. Although the crops grew vigorously, especially under protection, and the blooms were eye-catching, the results of VL tests were disappointing. The flowers failed to reach the minimum of 11 days VL considered necessary to be a commercial proposition, while the vase-water became highly contaminated. Despite these

disappointing results, productivity and flower quality were so impressive that the plants were maintained as a demonstration, and there was a proposal to develop an HDC-funded project to examine the post-harvest qualities of dahlia blooms on a more strategic level.

Delphinium (Delphinium elatum)

Although delphinium was trialled in the early work of the Centre (in 2007 and 2008), some new cultivars from Hilverda Kooij suggested a fresh demonstration would be worthwhile. In 2012 plugs of cultivars 'Tango Dark Blue', 'Trick', 'Trick Pink', 'Sky Waltz' and 'Yellow Trick' were planted in plots in a tunnel and outdoors in week 25. This year the weather proved unsuitable for producing stems of any quality.

Eryngium (*Eryngium* species)

Responding to a grower's request, in 2011 a small selection of new eryngium cultivars was grown to assess the varieties available and their potential as a crop in the UK. Plugs of cultivars 'Arabian Dawn', 'Blue Bell', 'Deep Blue', 'Magical Blue Falls', 'Magical Cloud', 'Magical Purple Falls' and 'Marbella' were transplanted into plots in a tunnel and outside in week 32. Few flowers were produced in 2011. Although marketable stems were produced in 2012, owing to plant losses as result of the cold weather and the effect of the wet summer and autumn of 2012, it was not possible to record any meaningful yields. However, the samples sent to the packers and supermarkets generated considerable interest in this crop and as a result a new planting will be made in 2013. Stems were sampled in week 34 for VL testing (by Butters Group Ltd). After simulated storage, transport and retail store phases, all achieved a seven day VL with the consumer.

Hardy foliage

A wide range of hardy foliage plants was planted in outdoor plots in the spring of 2010 and 2011:

- *Calicarpa bodiniera* 'Profusion'
- *Cornus alba* 'Flaviramea'
- *C. alba* 'Kesselringil'
- *C. alba* 'Sibirica'
- *Corylus avellana* 'Contorta'
- *Cotinus* 'Magical Green Fountain'
- C. 'Royal Purple'
- *Hedera helix* 'Arborescens'
- *Hypericum inodorum* 'Magical Green Fall'
- *H. inodorum* 'Magical Tropical Fall'

- *H. inodorum* ‘Magical White Fall’
- *Philadelphus* ‘Snowbelle’
- *Photinia* ‘Purple Peter’
- *P.* ‘Red Robin’
- *Quercus palustris*
- *Q. rubra*
- *Salix alba* ‘Darts Snake’
- *S.* ‘Caradoc’
- *S*. *udensis* ‘Sekka’
- *Symphoricarpos* ‘Bright Fantasy’
- *S.* ‘Charm Fantasy’
- *S.* ‘Magical ‘Avalanche
- *S*. ‘Magical ‘Pride’
- *Viburnum opulus* ‘Compactum’
- *V. opulus* ‘Roseum’
- *V. tinus*
- *V. tinus* ‘Red Spirit’

Most subjects have established well and the number of marketable stems will be assessed in 2013. Commercial plantings of foliage subjects are now taking place as a result of these demonstration plots.

Rudbeckia (Rudbeckia hirta)

Rudbeckia is another potential cut-flower crop, and its inclusion in the programme of the Centre was suggested by a supermarket representative. Initial demonstrations with seed-raised annuals were carried out in 2011 and 2012. In 2011, cultivars ‘Hirta Green Eye’ and ‘Hirta My Joy’ were transplanted into plots in a tunnel in week 21. Although the flowers were attractive, the stems were too vigorous and unruly to be considered practical for commercial use. More robust perennial varieties were tested in 2012. These were cultivars ‘Goldquelle’ and ‘Herbstsonne’ supplied as 7 cm pots and planted in plots in a tunnel in week 25. While the crop did show some market potential, many of the stems were quite weak and as is the case with most perennial crops, their true potential is likely to show up in the second year and beyond.

Financial benefits

The project has identified a number of crops such as tunnel-grown lisianthus, ‘trumpet’ antirrhinum, hardy foliage and sedum as having potential for UK production. Other novel crops have also been developed and are at a stage where they could be tested on a small

commercial scale. Two or three new products would help to maintain a significant number of larger or medium-sized businesses. Now that the CFC is developing a clear market potential for 'new' crops, it is proposed that the preparation of basic costings will be an integral part of its remit in the future. The basic costings will include as much information as possible including planting costs, yield, basic production costs etc. but clearly it will be difficult to provide accurate labour figures owing to the issue of scaling up small scale trial plots to a realistic commercial situation. This information will be disseminated to industry in the form of technical bulletins available on the CFC website.

Action points for growers

Growers looking for new opportunities might consider the case for growing new cultivars of 'trumpet' antirrhinums, lisianthus and annual dianthus as tunnel crops, and new cultivars of dwarf sunflowers, hardy foliage and ornamental brassicas as field crops.

Antirrinum

The planting density of 'trumpet' antirrhinums should be around 64 plants/m^2. Early plantings in week 14 to 17 produce two flower flushes in early to late summer and a week 27 planting produces an early autumn crop demonstrating that continuity of cropping is possible with these new varieties. Very few pest and disease problems were experienced in the trials but aphids can be a problem, so application of a suitable insecticide may be required. Pollination by bees can also be in issue in some situations but this can be overcome by netting of the doors and vents.

Aster ericodes

The new double varieties of *Aster ericoides* can be planted both indoors and outdoors from a planting date of mid-April to early May. A planting density of 16 plants/m^2 should be used. The crop is usually then pinched two to three weeks later. If grown under protection the crop needs to be cut back in mid to late May otherwise the stems become unmanageable by the time of flowering. Powdery mildew is a major problem with *Aster ericoides* and a regular fungicide spray programme needs to be adhered to.

'Breanthus' annual dianthus

Planting in week 18 was successful with this crop, pinching can be undertaken which will produce slightly shorter and lighter stems. Flowering from this planting date will occur around week 30 with a second flush in week 36, although there is considerable variation in the performance of the different cultivars.

China aster

Young plants can be bought in grown in plugs or peat blocks with the blocks tending to produce a heavier crop from later plantings. The optimum planting density is 64 plants/m^2 and they can be planted under protection from about week 16 up to about week 25. (Earlier plantings may result in excessive growth whereas the later plantings may be too short if the autumn weather is not favourable to good growth).

Whole plants are harvested and made into bunches of between three and five stems. The central flower bud can be removed to enhance vase life but this will result in a significance reduction in weight.

Column stocks

In terms of starting material there is no advantage in using plants produced in peat blocks as opposed to plugs. Using product which has been gapped up provides trays with a higher number of double plants which results in reduced transport costs. The 'Anytime' series has potential for later plantings; whilst the new range of 'Katz' cultivars may have potential for autumn production in Spanish tunnels. Soil steaming is important with the performance of many varieties not least the 'Aida' and' Figaro' series.

Lisianthus

This crop can be successfully produced in a closed Spanish tunnel. Planting time should be between weeks 18 to 21 producing a marketable crop between weeks 32 and 36. The planting density can range from 64 to 86 plants/m^2. The lower density will yield slightly stronger stems. As the crop is prone to a number of root and stem diseases it should be produced in sterilised soil. Care needs to be taken to ensure that the humidity level does not build up inside production tunnels as this will provide a favourable environment for the development of downy mildew.

Ornamental brassicas

Direct-sowing of ornamental brassica is a possible way to reduce production costs. A number of new cultivars show promise for commercialisation including: 'Dream Red', 'Moon Light' and 'Snow Bright'.

Phlox

Powdery mildew is a serious problem on this crop and a regular prophylactic fungicide spray programme needs to be maintained through the life of the crop. The crop can be produced in polythene tunnels or under cold glass; in the latter structure a second flower flush may occur. Growers should liaise with the propagators to ensure that they are planting the best varieties currently available to minimise flower drop during shelf life.

Sedum

The main planting period is spring or autumn at a density of 10 to 12 plants/m^2 in 1m wide beds. Cropping can be expected from the second year onwards. Harvesting can occur when the heads are green, through flower bud stage and ultimately when in full flower. Vase life was shown to be very good at all stages of cropping.

'Solomio' and 'Star' spray carnations

Exact planting dates and production structures still need to be verified for the cultivars examined. The 'Star' series is very attractive to rabbits and precautions need to be taken to protect the crop from rabbit feeding.

Sunflowers

Cropping times can be staggered by sowing from weeks 19 to 26 outdoors and week 31 in a Spanish tunnel (cropping times ranged from week 32 to 35 outdoors and week 44 in the tunnel). The variety 'Dafna' had an outstanding vase life.

SCIENCE SECTION

Introduction

The National Cut-Flower Centre (CFC) is a project funded by the Horticultural Development Company (HDC, formerly the Horticultural Development Council) for the benefit of the UK cut-flower industry. For its first two years the CFC was funded jointly by the EU Lincolnshire Fenlands LEADER+ programme and the HDC. HDC funding is through the HDC Bulbs & Outdoor Flowers (BOF)[1] and Protected Ornamentals (PO)[2] Panels.

Since 2009 the Centre has been located at Rookery Farm, Holbeach St Johns, having moved from the Kirton Research Centre where the project was successfully initiated in 2007. Currently, its facilities consist of some 600m^2 of outdoor plots, a 7.9 x 38.1m single-span 'Haygrove' Spanish tunnel, and a 22.7 x 38.1m triple-span 'Pro-Tech' Spanish tunnel.

The CFC exists to help the UK cut-flower industry as a whole, and is run "by the industry, for the industry". Its strategic direction is driven by a Management Group (MG) made up of individuals representing a cross-section of the cut-flower business, from growers through packers to multiple and other retailers. Further information can be found on the Centre's web-site, http://www.thecutflowercentre.co.uk/about-us/

The technical aims of the Centre are:

- To carry out demonstrations, trials and problem-solving experiments relevant to UK cut-flower production, covering current crops and, especially, potential crops new to the UK;
- To evaluate promising, newer cut-flower crops on a commercial scale;
- To publish the results of these findings and help establish 'Best Practice' for the crops and cultivars promoted;
- To act as a forum to identify and facilitate further R&D projects relevant to UK cut-flower production;
- To provide a source of samples to enable growers, packers and supermarkets to test consumer reaction to new cut-flower lines.

[1] see http://www.hdc.org.uk/sectors/BOFindex.asp
[2] see http://www.hdc.org.uk/sectors/POindex.asp

In more general terms the Centre aims:

- To provide information about cut-flower crops and growing formats that are new to UK production, enabling UK growers to make informed choices about new marketing opportunities
- To identify a small number of definite new opportunities for UK cut-flower growers
- To enhance the perception of UK cut-flowers and flower growers.

Reports of earlier projects can be found in the reports for 2007 and 2008 (annual and final reports for HDC project PC/BOF 268) and 2009 (final report for HDC project PC/BOF 268a). The present report describes all the work carried out under HDC project PO/BOF 002 (2010 to 2012); although this report describes all three years' work, if further details of the 2010 and 2011 trials are required those years' annual reports should be consulted. HDC members may obtain full reports of earlier reports on request to the HDC. An index to the crops trialled each year is given at the end of this report (Appendix 3).

Materials and methods

Facilities at the Centre

The facility at Rookery Farm, Joys Bank, Holbeach St Johns, Spalding, Lincolnshire comprised a single-span 'Haygrove' tunnel[3] (7.9m wide x 38.1m long), a triple-span 'Pro-Tech' tunnel[4] (overall 22.7m wide x 38.0m long) 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 were provided at each end of the 'Pro-Tech' tunnel. Typical of the area, the soil was heavy silt.

Crop husbandry – pre-planting

Protocols were agreed between Rookery Farm's management and the Centre's Management Group (MG): the aim was good commercial practice adapted, as necessary, to suit small trial plots requiring frequent or detailed records to be kept and some individual pesticide applications to be made.

The growing areas were sterilised as required by the trials programme. Prior to the 2010 season the soil in the tunnels was steam-sterilised in spring 2010. For the 2011 season the 'Haygrove' tunnel was sterilised with dazomet (as 'Basamid') in autumn 2010 and left sheeted-down through winter, while the 'Pro-Tech' multi-span was also sterilised with dazomet but in spring 2011. For the 2012 season 'Pro-Tech' tunnel bay 1 and the southern half of bay 2 were steamed in November 2011, with the other half of bay 2 left non-sterilised for the column stocks trial and bay 3 also non-sterilised as it was planted with perennials; the 'Haygrove' tunnel was split to three areas – dazomet- or steam-sterilised (November 2011) or left non-sterilised – as specifically required for a lisianthus trial.

Prior to the start of planting each year, several separate soil samples were taken across the trials site for standard glasshouse soil analysis. Fertiliser applications were calculated to bring nutrient indices to standard levels for cut-flowers: 2 for N, 5+ for P, 4 for K and 4 for Mg. In 2011 a 20:10:10 compound fertiliser, 'Root to Shoot'[5] (or straights as appropriate) was applied at 10g/m^2 before planting Aster ericoides (week 25), column stocks (week 27), eryngium in 'Pro-Tech' tunnel bay 2 (week 32) and sunflowers (week 22). In 2012 'Root to Shoot' was applied at 10g/m^2 across 'Pro-Tech' tunnel bays 1 (week 15) and 2 (week 30), 'Root to Shoot' and sulphate of potash were applied at 10 and 100g/m^2, respectively, across

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

bay 3, and sulphate of potash and nitrate of ammonium were each applied at 100g/m^2 across the 'Haygrove' tunnel. Later, 'Root to Shoot' was replaced by a proprietary 'Growmore' fertiliser (7:7:7 N:P:K) used at an equivalent rate. It is not possible to give a base fertiliser recommendation for all minor cut flower crops and in the aim was to bring the base levels up to those required for column stocks which are an index of 2 for N, 6 for P, 4 for K and 4 for Mg

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 provided for each bed and divided half-way along the tunnels to provide two separate irrigation zones per bed. Unless otherwise stated, the beds were covered with 1.2m-wide, 120-gauge, micro-perforated black polythene film; the column stocks and sunflower trials were planted directly into the border soil to more accurately mirror commercial practice, and lisianthus trials included plots with and without polythene film as part of the trials.

Crop husbandry – planting

All planting was carried out through the polythene film or directly into the border soil as appropriate. Many crops were planted using 5" x 5" (12.5 x 12.5cm) wire mesh as a planting guide, giving eight plants across the bed. Some less densely planted crops were planted using 20.0 x 16.7cm wire mesh, giving five plants across the bed. Most crops were obtained as plug-plants and were transplanted into the beds at a density of 64 plants/m^2. Aster ericoides was obtained as un-rooted cuttings, rooted in plugs, and transplanted at 16 plants/m^2, and phlox were planted at the same spacing. Dahlia cuttings were planted at 9 plants/m^2. Sweet peas were germinated in small pots and transplanted into rows at the required spacing (30 or 50cm apart) along the base of 'A-frame' support netting. Sunflowers were sown by hand 10cm apart in rows, with four rows 35cm apart across the bed (ca36 seeds/m^2). Hardy foliage plants were obtained as either pot-grown or bare-root plants and planted as per the supplier's recommendations which varied from 30 to 100cm apart (details under 'Results'). Crops were watered with a hand-lance immediately after planting.

Crop husbandry – post-planting

Once plants were established most water was applied through the lay-flat irrigation lines. Once in growth, plants received a weekly liquid feed (e.g. 'Universal Violet', 10:10:30, The Scotts Company), with application increased to twice per week on vigorous crops (such as lisianthus) later in the growing season.

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[5] J & H Bunn Ltd, Yarmouth, Norfolk, UK

Beds were usually provided with support netting that was 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 vigour of the crop. In some cases plants were stopped (pinched) or a growth regulator was applied, in which case the details are given in the text under 'Results'.

Pesticide advice was given by a BASIS-qualified agronomist who visited the trials regularly throughout the growing season, and pesticides were applied as needed and according to recommendations. Details of pesticide applications are given in Appendix 1. In 2012 a phosphate fertiliser/growth stimulant 'Nutri-Grow'[6] 4:30:8 N:P:K was applied at 0.45kg/ha to lisianthus and column stocks on 25 June.

Trials and trials design

The species and cultivars trialled are given in the text under 'Results', with the names of suppliers, dates of planting, transplanting or direct-drilling, plot sizes, details of any special treatments, and whether grown in the 'Haygrove' or 'Pro-Tech' tunnels or in outdoor beds. The plots were typically 3m-long, with 1m-long unplanted 'guard areas' between plots and at the ends of the tunnels to guard against 'end effects'. Appropriate to the more practical nature of the project, treatment plots were not generally replicated, but, where appropriate, factorial analysis of variance without replication[7] was used to assess the significance of 'main effects' such as cultivar, planting density or planting date (this analysis does not allow interactions between the main effects to be assessed formally).

Crop assessments

Stems were picked at an appropriate commercial stage for each crop, taking samples close to the peak cropping date. Usually the number of stems picked was recorded (the numbers of stems/m^2 were calculated using exact plot lengths), along with (for a sample of ten stems per plot) picking dates, lengths and weights of stems (stem weights after trimming to length, if required) and other measurements (such as spike length or head size) as appropriate. Other than where a trimmed length is referenced, under 'Results' stem lengths and weights always refer to the total weights and lengths of the whole stem, including buds, flowers and 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, notes and grower comments.

[6] http://www.plantsyence.com/
[7] using the data analysis tool within Microsoft Excel

Trials at commercial nurseries

From observations of previous trials of ornamental brassicas at the Centre and elsewhere it is known this crop is particularly sensitive to soil conditions, the soil at Rookery Farm being considered too heavy. Therefore ornamental brassica trials were grown and evaluated at a commercial nursery (by Winchester Growers Ltd) in 2010 and 2011.

Vase Life trials

For subjects where post-harvest quality and vase life (VL) were an issue, or if their VL were unknown, samples of freshly harvested stems were subjected to standard VL testing for the Centre by commercial growers/packers. The exact protocol used at each site varied (see below), but typically consisted of initial holding in a hydrating solution (such as 'Chrysal Clear Professional 2') followed by simulated periods of cold-storage, transport, retail display and home display, typically with a universal flower food sachet added to the vase.

The companies carrying out the tests are indicated under 'Results'. They were:

- Winchester Growers Ltd, Herdgate Lane, Pinchbeck, Spalding, Lincolnshire PE11 3UP: ornamental brassica in 2010 and 2011
- JZ Flowers International Ltd, 51A Cowbit Road, Spalding, Lincolnshire PE11 2RJ (formerly Fast Track Flowers Ltd): Aster ericoides and sunflowers, 2011
- Intergreen (UK) Ltd, Washway Road, Fleet, Holbeach, Spalding, Lincolnshire PE12 8LT: antirrhinum, Aster ericoides, 'German asters', lisianthus, phlox and sweet peas
- Butters Group Ltd, Kellett Gate, Spalding, Lincolnshire PE12 6EH: all testing in 2012 (see Appendix 2).

For 2010 and 2011 testing, details were as given in the Annual Reports. For testing in 2012 the process was: storage/hydration (in plain water), 'transport phase' (with 'Chrysal Clear Professional 2', 'CVBN' or 'eZ Dose' conditioner), 'depot phase' (2cm trimmed from stem base, sleeved, 12 hours at 5±1°C), 'retail phase' (4 or 5 days at 20±2°C and 1000lux) and 'consumer's VL period' (de-sleeved, 3cm trimmed from stem base, universal flower food added, 20±2°C and 1000lux). Depending on the species, most cut-flowers would be expected to provide a minimum of 5 to 7 days VL with the consumer, following the *ca* six days of the pre-consumer phases.

Results

1. ANTIRRHINUM (*ANTIRRHINUM MAJUS*) - 'TRUMPET' CULTIVARS

Introduction

In 2009 and 2010 the Centre grew demonstration plots of new 'trumpet' cultivars of antirrhinum from Florensis B.V., quite distinct in flower form from the typical 'snapdragon', these flowers have a pronounced trumpet shape. They consistently impressed growers, packers and supermarket technologists because of their novel form, vigour and quality. In 2010 plugs of 'Ivory White', 'Red' and 'Yellow' lines from the 'Peloric' series were transplanted in week 14 at 64 plants/m^2 in the Haygrove tunnel. They cropped around week 22 with an average stem length of 66cm, bunches of six stems weighing 310 to 320g, and standard VL testing showing a longevity of up to 15 days from picking. There was a second flush of flowers around week 28, stems being shorter and lighter than the first flush but nevertheless of marketable quality: bunches of six stems of length 55cm weighed 285 to 305g. Throughout the 2010 flowering season significant quantities of bunches were supplied to interested parties for monitoring by their buyers and account managers, this involving at least six major packers and assessments in both the UK and the Netherlands.

Commercialising 'trumpet' varieties would require some changes in expectations and handling: for example, their novel flower shape is not obvious unless displayed at a later stage of development than is normal for snapdragons. Additionally, the colour range available was rather limited, not enough was known of their post-harvest qualities after picking at a later-than-usual stage, and there was no information available about planting dates and the possibility of season extension. These issues were addressed in trials in 2011 and 2012.

Figure 1: *Trumpet antirrhinums flowering week 23, 2010 (Photos: Cut Flower Centre Ltd)*

2011 (1) Cultivar assessment

Plugs of cultivars 'Yellow Peloric', 'Trumpet Pink' and 'Ivory White Peloric' (Florensis B.V.) were transplanted in week 17 into 3m-long beds in the 'Haygrove' tunnel at 64 plants/m^2.

Stem weights and spike lengths varied considerably between the three cultivars, though all were judged satisfactory (Table 1). 'Yellow Peloric' gave the heaviest stems and long flower spikes. Consistent with the three weeks later transplanting than in 2010, the first flush was in week 25 (week 22 in 2010). Trimmed (60cm) stem weights in 'Yellow Peloric' and 'Ivory White Peloric' in 2011, about 50g, were similar to those obtained in 2010 (just over 50g for a 66cm-trimmed stem). Samples of all three cultivars were taken in week 25 for VL testing (see below). A second flush produced many more stems, though these were lighter than in 2010 (just under 30g for a 60cm-stem, compared with nearly 50g for a 55cm-stem in 2010).

Table 1: Flowering performance of tunnel-grown 'trumpet' *antirrhinum* cultivars, cropped and recorded in weeks 25 (first flush) and 33 (second flush). The figures are means of 30 stems/plot (first flush) or 20 stems/plot (second flush) shown with standard deviations (SD); 'trimmed weight' refers to stems trimmed to 60cm length.

Cultivar	*First flush*										*Second flush*		
	Untrimmed stem length (cm)		*Trimmed stem weight (g)*		*Flower spike length (cm)*		*Stem diameter (mm)*		*Number of side-shoots*		*Number stems cropped*	*Trimmed stem weight (g)*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*		*Mean*	*SD*
'Yellow Peloric'	94.4	3.3	50.5	878	25.0	2.1	7.1	1.3	8.9	3.5	270	28.4	7.9
'Trumpet Pink'	91.0	4.0	36.0	6.5	29.3	3.1	6.6	1.1	10.4	2.5	390	26.9	6.3
'Ivory White Peloric'	82.6	5.4	48.8	11.6	19.9	3.6	7.0	1.4	8.3	4.0	470	28.0	4.8

2011 (2) Late-planting in two types of tunnel

To investigate seasonal extension, further trumpet antirrhinums were grown as late-planted crops in both types of tunnel. Plugs of cultivar 'Tangerine' (Florensis B.V.) were transplanted into 4m-long beds in the 'Haygrove' tunnel and 'Pro-Tech' tunnel bay 1 in week 27 at 64 plants/m^2.

Table 2 shows that, despite the late planting, stem length, trimmed weight and flower spike length were about the same as the best from the earlier planting. However this left insufficient time for a second flush.

Table 2: Flowering performance of 'trumpet' *antirrhinum* 'Tangerine' following late transplanting (week 27) into the 'Haygrove' and 'Pro-Tech' tunnels, cropped and recorded in week 35. The figures are means of 20 stems/plot shown with standard deviations (SD); 'trimmed weight' refers to stems trimmed to 60cm length.

Tunnel	*Total no. stems cropped*	*Untrimmed stem length (cm)*		*Trimmed stem weight (g)*		*Flower spike length (cm)*	
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
'Haygrove'	195	94.4	3.3	50.5	8.8	25.0	2.1

‘Pro-Tech’	230	82.6	5.4	48.8	11.6	19.9	3.6

Figure 2: Antirrhinum cultivars in 2011, left to right: 'Yellow Peloric', 'Ivory White Peloric' and 'Trumpet Pink'; first flush (top) and second flush (bottom) (Photos: Cut Flower Centre Ltd)

2011 (3) VL testing

Samples of 'Yellow Peloric', 'Trumpet Pink' and 'Ivory White Peloric' were picked in week 25 for standard VL testing (by Intergreen (UK) Ltd). The greater stem weights of 'Yellow Peloric' and 'Ivory White Peloric' compared with 'Trumpet Pink' were noted, confirming the earlier results. After simulated storage, transport and retail store phases, all bunches had a similar performance in the vase, with changes occurring within the same time-frame on all bunches. On vase-day 6 most of the lower buds were withering in all cultivars, and there was also a slight discolouration of stems (it was suggested that this was possibly a reaction to the flower food used). Fifty per cent failure occurred in all bunches on vase-day 10, with all bunches being terminated for browning or withering of 50% of the flowers heads.

2012 (1) Cultivar demonstration of traditional *antirrhinum* (mid-season)

Plugs of further cultivars - 'Potomac Rose' and 'Potomac White' (Florensis B.V.) - were planted into 3m-long plots in 'Pro-Tech' tunnel bay 1 in week 22 at 64 plants/m^2. Flowers were ready for cropping and recording in weeks 34 to 35. The results (Table 3) show the production of tall stems with long flower spikes and trimmed stem weights of about 60g, similar to those from the 'Peloric' plantings in 2011.

Table 3: Flower measurements for tunnel-grown 'trumpet' *antirrhinum cultivars*, 2012. The figures are means of 10 stems/plot shown with standard deviations (SD); 'trimmed weight' refers to stems trimmed to 70cm length.

Cultivar	*Untrimmed stem length (cm)*		*Trimmed stem weight (g)*		*Flower spike length (cm)*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
'Potomac White'	121.3	4.7	55.1	7.3	29.8	3.7
'Potomac Rose'	123.0	3.1	61.5	8.2	24.9	2.0

2012 (2) Cultivar demonstration (late-season)

Plugs of cultivar 'Trumpet Tangerine' and of the 'Apollo' series (Florensis B.V.) were planted in week 28 into 3m-long plots in Pro-Tech tunnel bay 1 at 64 plants/m^2. The 'Apollo' cultivars (some with trial numbers) comprised 'Yellow' (PS 1546), 'Trump' (PS 1865), 'Ivory White', 'Ivory', 'Purple', 'Yellow' and 'Cinnamon'. They were ready for cropping in weeks 34 to 35 and were left in place as a demonstration for the Open Day (week 37). Because of the advanced stage of the flower development by the Open Day, no formal measurements were taken, but it was visually obvious that the stem length, spike length and numbers of flowers far exceeded any minimum supermarket specification, as confirmed by participants at the Open Day.

Summary and outcomes

In general there was positive feedback from the industry for the 'trumpet' antirrhinums trialled at the Centre. Basic information has been gained about varietal performance and a reasonable range of colours is now available. There was some scope for seasonal extension via planting dates and through the second flush where the crop was planted early enough. Their VL life was reasonable, though not exceptional, and the relatively late stage of cropping necessary to show the flowers to advantage may be a contributory factor: VL testing at a less mature stage in 2010 gave a superb VL of 15 days, as described earlier. Sufficient agronomic information is now available – and will be summarised in a project fact-

sheet in 2013 - for the industry to decide whether or not to develop these attractive new lines. It is up to the industry to pursue this crop further and move it on to commercialisation both at the grower and retailer level.

2. ASTER ERICOIDES (SEPTEMBER-FLOWERING)

Introduction

In early trials at the Centre (2007) the potential of new, mainly double-flowered cultivars of *Aster ericoides* was demonstrated as a pinched crop for September/October flowering in tunnels.

In 2010 a wider range of *A. ericoides* cultivars was grown: 'Chicago' ('Moergo'), 'Coldwater', 'Flameback', 'Flamingo', 'Milka Dark', 'Parrot', 'Blue Tail', 'Cape Town' ('Moertown'), 'Cassy' ('Morecas') and 'Double Fun White' (Armada Young Plants). Plugs were planted into 3m-long plots in the ProTech tunnel in week 18 and in outdoor plots in week 20, all at 16 plants/m^2, and grown as single stems and as a pinched crop. The trial showed that outdoor-grown plants, while more manageable (owing to them being less vigorous and producing shorter stems) were of poorer quality, and that single-stem crops became excessively tall. Under tunnels, pinched plants yielded numerous strong stems ready for cropping from around week 36. The response of the industry was that these lines showed real potential, and numerous sample bunches were provided to potential packers and buyers.

In 2011 and 2012 further cultivars were trialled as early- and late-planted crops, observations were made on the plants over-wintered in tunnels, and VL testing was carried out.

2011 (1) Early-planted crop (week 19)

Plugs of cultivars 'Chicago' ('Moergo'), 'Linda', 'Cirina Dark', 'Blue Tail', 'Double Fun Pink', 'Double Fun Blue', 'Double Fun White', 'Cassy' ('Morecas'), 'Cassandra' and 'Cape Town' ('Moertown') (Armada Young Plants) were transplanted into 3m-long plots in 'Pro-Tech' tunnel bay 3 in week 19 at 16 plants/m^2. The crop was pinched 2 weeks later (week 21).

Most varieties produced strong plants which cropped around week 42, 4 to 6 weeks later than the equivalent plants in 2010. Clearly this has implications for crop programming, and was looked at again in 2012 to see if the 2010 results were unusually early owing to the hot weather experienced over the summer. This did in fact seem to be the case. Among these cultivars, the average stem length varied from 77 to 159cm, stem weight from 35 to 62g, and

the number of stems cropped per plot from about 100 to just over 200 (Table 4), so careful varietal selection would be necessary.

Ranking the varieties by aspects of performance, ‘Cassy’, ‘Linda’ and ‘Cirina Dark’ produced above-average numbers of longer-than-average stems, but these were of low weight. ‘Blue Tail’, ‘Cape Town’ and ‘Cassandra’ produced the heaviest stems, but these were relatively low in number as well as being shorter.

2011 (2) Late-planted crop (week 28)

This trial was conceived as a late-crop to follow a round of column stocks in Spanish tunnels. Plugs of six cultivars, ‘Chicago’ (‘Moergo’), ‘Dark Mark’, ‘Blue Tail’, ‘Cassy’ (‘Morecas’), ‘Cairo’ (‘Moerci’) and ‘Cape Town’ (‘Moertown’) (Armada Young Plants) were pinched in week 24 and allowed to break before transplanting into 3m-long beds in Pro-Tech tunnel bay 2 in week 28 at 16 plants/m^2.

Three varieties, ‘Cairo’, ‘Cape Town’ and ‘Chicago’, cropped in week 41, but with stem lengths and weights about half that of the better, early-planted crop (Table 5). The other three cultivars, ‘Blue Tail’, ‘Cassy’ and ‘Dark Mark’ either failed to flower or the stems were too short to crop.

Table 4: Flowering performance of ten *A. ericoides* cultivars transplanted to tunnel in week 19, with stem lengths and weights recorded in week 42, 2011. The figures are means of 30 stems/plot shown with standard deviations (SD). The numbers of stems cropped and the cropping date are also shown.

Cultivar	*Stem length (cm)*		*Stem weight (g)*		*Stems cropped per plot*	
	Mean	*SD*	*Mean*	*SD*	*Number*	*Weeks*
‘Chicago’ (‘Moergo’)	110.9	18.5	41.3	23.5	120	41 – 42
‘Linda’	149.1	9.1	34.7	12.0	200	42 – 43
‘Cirina Dark’	127.7	10.6	35.3	12.0	173	41 – 43
‘Blue Tail’	79.5	11.6	62.0	25.6	100	41
‘Double Fun Pink’	91.8	9.3	39.0	17.3	215	41 – 43
‘Double Fun Blue’	95.8	8.3	36.3	13.8	200	41 – 43
‘Double Fun White’	77.0	5.3	48.0	20.9	160	41 – 42
‘Cassy’ (‘Moercas’)	159.0	9.2	38.3	11.8	180	42 - 43
‘Cassandra’	108.4	13.4	48.7	18.3	142	41 - 42
‘Cape Town’ (‘Moertown’)	107.8	12.6	54.7	29.1	100	41

Table 5: Flowering performance of six *A. ericoides* cultivars following transplanting into tunnel in week 28. Stem lengths and weights recorded in week 41, the figures are means of 20 stems shown with standard deviations (SD).

Cultivar	*Stem length (cm)*		*Stem weight (g)*		*Notes*
	Mean	*SD*	*Mean*	*SD*	
'Blue Tail'	na[1]		na		Stems too short, not cropped
'Cairo' ('Moerci')	88.3	10.1	81.0	29.9	
'Cape Town' ('Moertown')	69.0	5.5	86.5	25.8	
'Cassy' ('Moercas')	na		na		No flowers produced
'Chicago' ('Moergo')	73.3	5.5	81.0	31.4	
'Dark Mark'	na		na		Stems too short, not cropped

[1]na, not available or not applicable

2011 (3) Plants over-wintered from 2010

Of the varieties planted in 2010 and left down in Pro-Tech tunnel bay 3, part was pinched in week 21 and part left intact. The over-wintered plots that were not pinched in the spring grew out of control: the first flush needed to be cut-back to give a late flush. The pinched crop was much more manageable and more akin with the newly planted crop.

2011 (4) VL test 1

Stems of cultivars 'Blue Tail', 'Cassandra', 'Chicago', 'Cape Town', 'Cirina Dark', 'Coldwater', 'Double Fun Blue', 'Double Fun Pink', 'Double Fun White', 'Flamingo' and 'Parrot', largely from the week 19 planting, were subjected to standard VL testing (by JZ Flowers International Ltd/Fast Track Flowers Ltd) after the stems were trimmed to 62cm long. VL varied between varieties, from 5 to 11 days (for the 20%-florets-dead stage) and much longer when assessed when 50% of the florets were dead. However, the sample was considered relatively advanced for testing, so these figures should represent the VL very conservatively. A general comment was that the stems were too long, and often the branches too wide, and would require a significant amount of trimming before packing; this should be addressed by improving crop husbandry and varietal selection. The 'Double Fun'

series were the best performers overall for weight and flower presentation and had a satisfactory VL.

2011 (5) VL test 2

Samples from ten plots, comprising seven cultivars from the 2011 trials and three from the over-wintered crop, were picked in week 39 and supplied for VL testing (by Intergreen (UK) Ltd). VL varied between 7 and 21 days, agreeing with the figure of 8 to 16 days seen in the first test (see above). The main reasons for failure were yellowing or brown flower heads or leaves, and in some varieties the colour faded towards the end of VL. All samples tested would therefore have reached or exceeded the current requirement for a VL of 5 or 7 days in mixed bouquets.

2012 (1) Seasonal extension using late-planting and second-year crops

The previous year's trials generated much market interest in these cultivars, but a longer window of cropping was required. This trial involved planting a new crop in tunnels and outside, as well as cropping the plants over-wintered from 2011

Plugs of cultivars 'Blue Tail', 'Capetown' ('Moertown'), 'Cassandra', 'Cassy' ('Moercas'), 'Chicago' ('Moergo'), 'Cirina Dark', 'Double Fun Blue', 'Double Fun Pink Dark', 'Double Fun White', 'Linda', 'Milka Dark', 'Milka Karmin' and 'Pretty Wendy' (Armada Young Plants) were transplanted into 2m-long plots in 'Pro-Tech' tunnel bay 3 and outdoors in week 25 at 16 plants/m^2. The same cultivars (less 'Milka Dark' and 'Milka Karmin') that had been planted in 2011 in 'Pro-Tech' tunnel bay 3 and in outdoor plots and over-wintered (for details see 2011(1)) were also used for comparison. The 2012 plantings had been planted later than those of the previous year (planted in week 21) in an attempt to curb excessive growth. Central $1m^2$ areas of plots were cropped in week 42 through 45 and graded into marketable bunches of five stems.

The yields are given in Table 6. As well as confirming the considerable differences between cultivars, the superior productivity of second-year crops and of tunnel-growing is shown. However, to a large extent the yields of the new plantings may have been adversely affected by the poor summer weather in 2012. Stems were sampled in weeks 42 to 44 for VL testing (by Butters Group Ltd). After simulated storage, transport and retail store phases, all achieved at least a 5-day VL with the consumer (see Appendix 2 for results).

Table 6: 2012 flower yields at the dates shown of *A. ericoides* cultivars planted in 2011 or 2012 in a tunnel of outdoors (not all combinations were available). The figures are marketable stems per $1m^2$ sample areas.

Picking date (week no.)	*Cultivar*	2011		2012		*Overall cultivar averages*
		Outdoor	*Tunnel*	*Outdoor*	*Tunnel*	
42-43	'Blue Tail'	75		50	40	*55.0*
42-43	'Cape Town'			45	50	*47.5*
42-44	'Cassandra'			55	90	*72.5*
44-45	'Cassy'				45	*45.0*
42-43	'Chicago'	85		30		*57.5*
42-43	'Cirina Dark'	65		50	40	*51.7*
43-44	'Double Fun Blue'	115	85		25	*75.0*
44-45	'Double Fun Pink'				30	*30.0*
43-44	'Double Fun White'	50	60		95	*68.3*
43-45	'Linda'	95				*95.0*
44	'Pretty Wendy'		165			*165.0*
Overall year/ location averages		*80.8*	*103.3*	*46.0*	*51.9*	

Summary and outcomes

In 2011 numerous samples of these varieties were again supplied to technologists and managers of supermarkets and packers, some being sent to the Netherlands. Their general quality and stem weight were considered very satisfactory, and VL reasonable, though samples had often been picked at too late a stage, a factor to remember in future trials. In 2012 the main emphasis was to seek a longer cropping season: however, even with the range of planting combinations used, it was still not possible to spread cropping over more than 4 weeks. The earliest picking was from the over-wintered tunnel crop, which flowered 7 to 10 days earlier than the outdoor crop. In 2013 it is planned to use blackouts to spread the season and attempt to obtain two flushes.

3. Carnation, spray (*Dianthus caryophyllus*)

Introduction

'Solomio' and 'Star' are new ranges of 'novelty' spray carnations recently introduced by HilverdaKooji. In 2012, plots were set up to assess their market potential and collect some basic data for four of these cultivars.

2012 Initial assessment

Rooted plugs of cultivars 'Solomio Sem', 'Solomio Vin', 'Solomio Fen' and 'Star Cherry' were delivered in week 14. The unusually wet weather at the time precluded immediate planting-out, and they were transplanted to 9cm-diameter plant pots. They were planted into 2m-long plots in 'Pro-Tech' tunnel bay 2 in week 18 and outside in week 21. Planting was through 20.0 x 16.7cm mesh, one plant per square, giving 30 plants/m^2. The plants were pinched to 5 or 6 leaves three weeks after planting.

In the very wet weather of 2012 the performance of the outside crop was very poor and it was not considered worthwhile to make any formal assessments. One cultivar, 'Star Cherry', proved very attractive to rabbits, despite the trials site being surrounded by rabbit netting, which meant that very few flowers were produced and no information is available for this cultivar.

There was considerable variation in performance between the remaining cultivars. ‘Sem’ was the earliest to flower, with the first stems picked in week 37. Two weeks later ‘Vin’ and ‘Fen’ started to flower, but growth was very slow and by week 45 the plants were cut back to the ground to make way for de-skinning the tunnel; even then, many stems of these cultivars were not ready for picking, while a number (especially in ‘Fen’) were blind. Stem yields are shown in Table 7. ‘Sem’ produced stronger stems than ‘Vin’ and ‘Fen’, though this may have been due to poor light levels and low temperatures throughout October when the last two cultivars were being picked. Overall stem lengths were adequate at 60 to 70cm. Stems were sampled in week 39 for VL testing (by Butters Group Ltd). After simulated storage, transport and retail store phases, all achieved at least a 6 -day VL with the consumer (see Appendix 2 for results).

Table 7

Stem yield and length for new ‘Solomio’ spray carnations in tunnel, 2012. Stem lengths are the means of 10 stems, shown with SD.

Cultivar	*Stems/plot*	*Stems/m^2*	*Stems/plant*	*Total stem length (cm) with (SD)*
‘Sem’	385	175	5.8	63.0 (5.2)
‘Vin’	503	229	7.6	70.2 (4.7)
‘Fen’	333	151	5.0	70.6 (3.0)

Summary and outcomes

This demonstration received positive market feedback from the industry, owing to the unusual flower form of this new range. It was thought these novel cultivars could be marketed at a more developed stage of development than traditional spray carnations and branded accordingly. Unfortunately, only ‘Solomio Sem’ had finished flowering by the time it was necessary to de-skin the tunnel. Had the crop been grown in a glasshouse the picking season could have been extended somewhat, though in better weather it would probably have been cropped two or three weeks earlier anyway. Further trials are needed. In 2013, weather permitting, earlier plantings will be tested. The plots planted in 2012 will be over-wintered to follow performance in a second year.

4. CHINA ASTERS (*CALLISTEPHUS CHINENSIS*) - 'GERMAN' VARIETIES

Introduction

The evaluation of these striking cultivars of China aster, principally the 'Krallen' and 'Gala' series, was started at the Centre in 2007 and, because of the interest shown, have continued to 2012.

In 2010 a large multi-variate trial was carried out, and information is set out below under the headings of cultivar comparisons, comparisons of plug- and block-raised plants, effects of planting date and effects of using a growth retardant to control the excessive growth that can occur in vigorous cultivars. Also in 2010 demonstration plots of 26 cultivars from the 'Standby', 'Benary Princess' and 'Matador' series were grown. In 2011 the growth retardant work was continued and VL testing carried out. In 2012 alternatives to the 'Krallen' series were trialled: 'Meteor', 'Bonita' and 'Ribbon'.

2010 (1) Cultivar comparison: plug-raised 'Krallen' and 'Gala'

Plugs of six 'Krallen' cultivars ('Chinchilla', 'Golden', 'Kameo', 'Karthauser', 'Lux' and 'Perser') (Ball Holland) and two 'Gala' cultivars ('Lavender' and 'Purple') (Combinations) were transplanted to 3m-long beds in 'Pro-Tech' tunnel bays 1 and 2 in week 16 at 64 plants/m^2.

Mean stem lengths for the different cultivars ranged from about 90cm to about 110cm, with the 'Gala' cultivars notably taller than the shorter but more variable 'Krallen' cultivars (Figure 1). However, the tall 'Gala' cultivars were conspicuously light in weight, about 20g/stem, confirming earlier observations that 'Gala' produced tall, but very thin, weak stems. In contrast the 'Krallen' cultivars were heavier, especially 'Kameo' and 'Kartthausen' whose stems weighed nearly 80g each (Figure 1). With the exception of 'Golden', a cultivar atypical in several respects (see below), 'Krallen' cultivars had larger, more impressive flowers which must largely be responsible for the greater stem weights. Picking dates were the same in all cultivars, except for 'Golden' which was a few days later to picking.

2010 (2) Cultivar comparison: block-raised 'Krallen' and 'Gala'

Six 'Krallen' cultivars ('Chinchilla', 'Orient', 'Kameo', 'Karthauser', 'Lux' and 'Perser') (Ball Holland) and two 'Gala' cultivars ('Lavender' and 'Purple') (Combinations) were raised as blocks in the UK for comparison with the standard, Dutch-raised plugs. The blocks were planted into 3m-long plots in 'Pro-Tech' tunnel bays 1 and 2 in week 23 at 64 plants/m^2.

Mean stem lengths were reasonably consistent, at about 105cm, across all cultivars, as were stem weights (Figure 2). In contrast to plug-raised plants (see above) there were no consistent differences between the cultivars of the ‘Krallen’ and ‘Gala’ series tested. Stem diameters were equally consistent. There were small, but probably commercially non-significant, differences in the numbers of side-shoots per plant. Flower sizes too were consistent across the cultivars and they all reached the picking stage together (average date, 1 September).

Figure 1

Comparison of eight cultivars of 'German aster' 'Krallen' and 'Gala' series, grown from plugs transplanted to a tunnel in week 16, 2010. Data are the means of 10 stems/plot. Top: stem length; bottom: stem weight

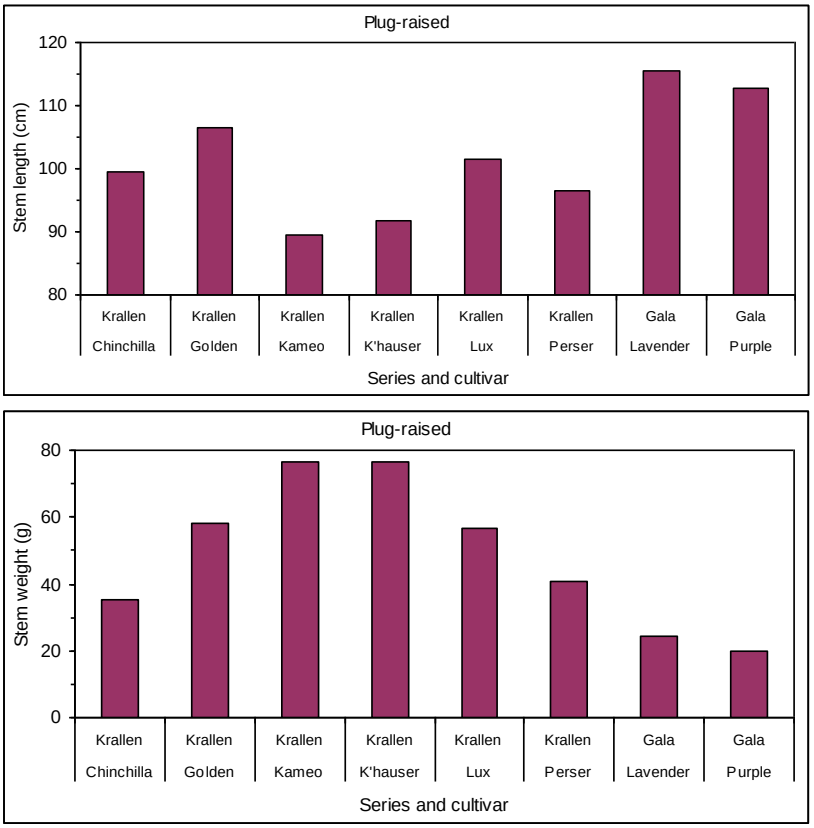
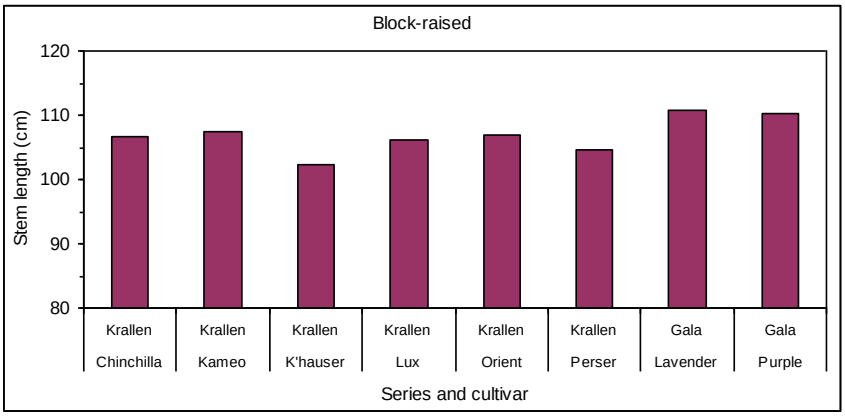
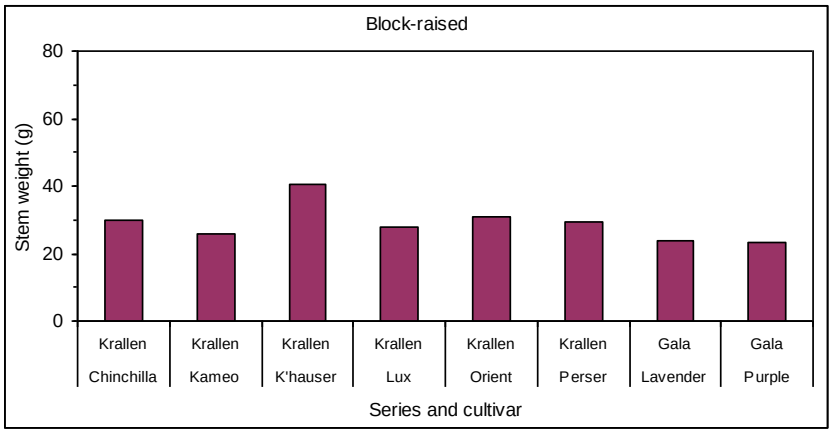


Figure 2

Comparison of eight cultivars of 'German aster' 'Krallen' and 'Gala' series, grown from blocks transplanted to a tunnel in week 23, 2010. To assist comparisons, the vertical scales of histograms are the same as in Figure 1. Data are the means of 10 stems/plot. Top: stem length; bottom: stem weight





2010 (3) Comparison of UK block- and Dutch plug-raised 'Krallen'

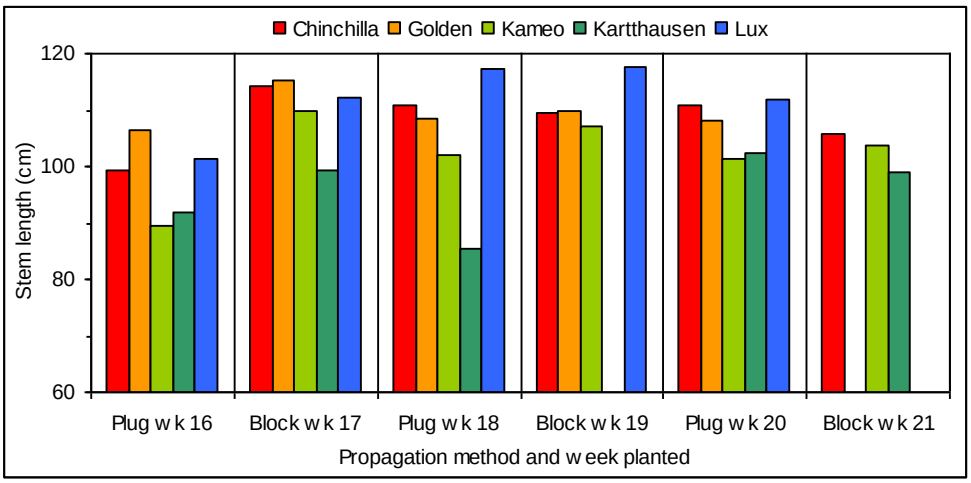
Five 'Krallen' cultivars ('Chinchilla', 'Golden', 'Kameo', 'Karthauser' and 'Lux') (Ball Holland) were raised as blocks in the UK and as plug-plants in the Netherlands. They were planted into 3m-long plots in 'Pro-Tech' tunnel bays 1 and 2 in weeks 16, 18 and 20 (plugs) and weeks 17, 19 and 21 (blocks), all at 64 plants/m^2.

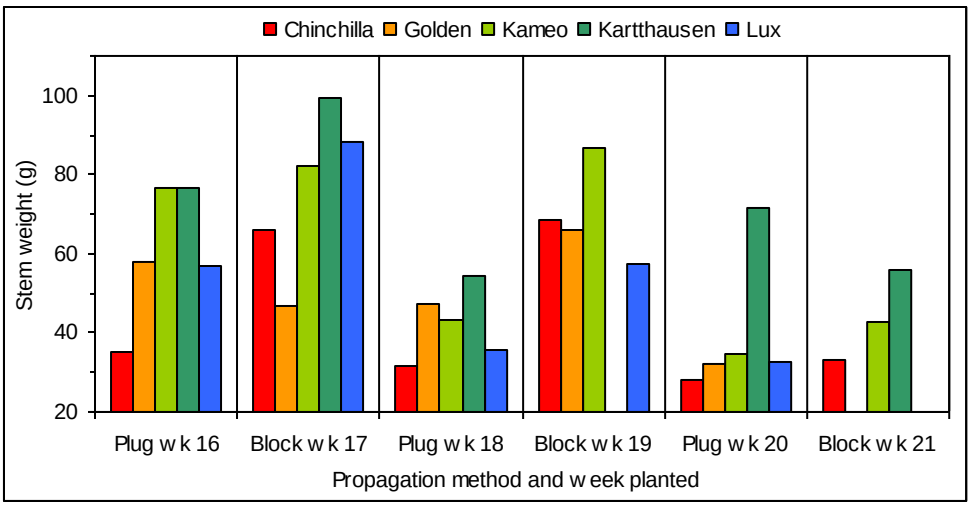
The UK block-propagated plants performed as well as or better than conventional Dutch plugs. For stem lengths, no consistent differences between cultivars, propagation method or planting date could be seen, though 'Chinchilla', 'Golden' and 'Lux' gave consistently long stems (Figure 3). Stem weight showed more distinct results: plug-raised plants gave heavy stems from the earliest planting, decreasing later, while block-raised plants gave heavy stems from both the early and middle plantings, with lighter stems later. Despite their long stems, plants of 'Chinchilla', 'Golden' and 'Lux' produced light-weight stems.

Stem diameter and the number of side-shoots were reasonably consistent across the cultivar-treatment combinations, with the exception that 'Golden' in the three heavier plantings (plugs at week 16, and blocks at weeks 17 and 19) had thicker stems and more side-shoots. Flower size varied between cultivars, but, overall, the same three heavier plantings also produced larger flowers. Within plantings, picking dates were generally similar, except that cultivar 'Golden' was slightly later to crop.

Figure 3

Comparison of five 'Krallen' cultivars of 'German aster' grown from plugs or blocks and transplanted from week 16 to week 21, 2010. Due to missing or failed plants, three cultivar-treatment combinations are missing. Data are the means of 10 stems/plot. Top: stem length; bottom: stem weight





2010 (4) The effect of planting date on UK block-raised 'Krallen'

In order to determine the earliest practical planting date for UK block-raised 'Krallen' in tunnels, seven cultivars ('Chinchilla', 'Golden', 'Kameo', 'Karthauser', 'Lux', 'Perser' and 'Orient') (Ball Holland) were raised as blocks in the UK and planted into 3m-long plots in 'Pro-Tech' tunnel bays 1 and 2 in weeks 16 to 23 (not all cultivars were available at all planting dates), all at 64 plants/m^2. The results are shown in Figure 4.

Except in the case of 'Karthauser', which had shorter stems than the other cultivars included, average stems lengths for the cultivars did not vary greatly and were largely in the range of 105 to 115cm. For each cultivar, there was no clear trend for stems to be longer or shorter following progressively later planting. Generally, stem length was satisfactory at the earliest planting date (week 16 or 17). As expected from the results above, stem weight was much more variable than stem length. With the exception of 'Golden', stem weights were markedly heavier from the earlier plantings and fell with later plantings: in several cases the weights of stems from plantings in weeks 17 to 19 were double those of plantings in week 21 or later. A balanced sub-set of the data (four cultivars x three planting dates) was subjected to two-factor analysis of variance, showing that the effects of cultivar on stem length and weight

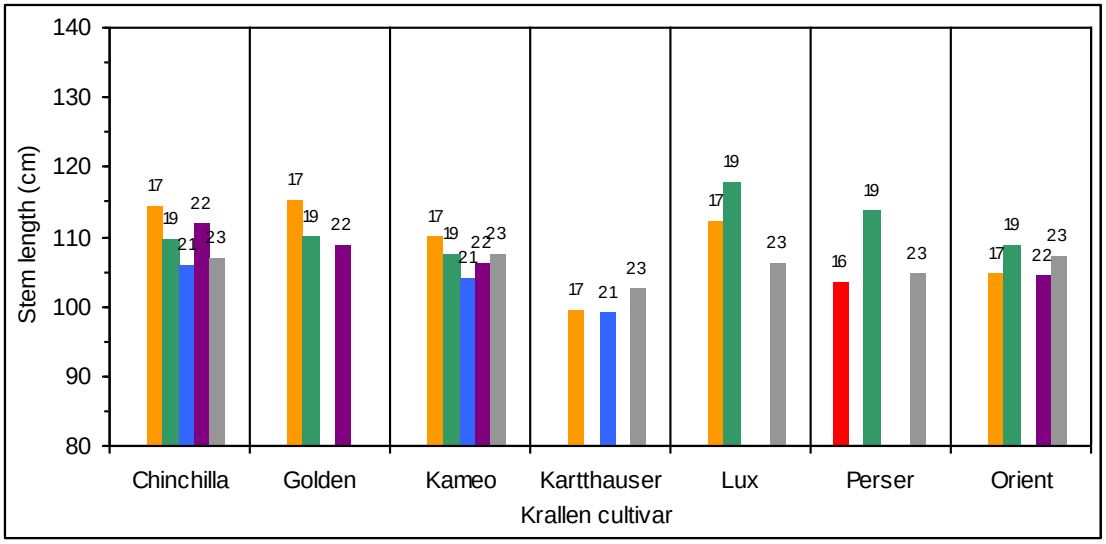
were not statistically significant, but that the noted effect of planting date on stem weight was significant ($p<0.05$).

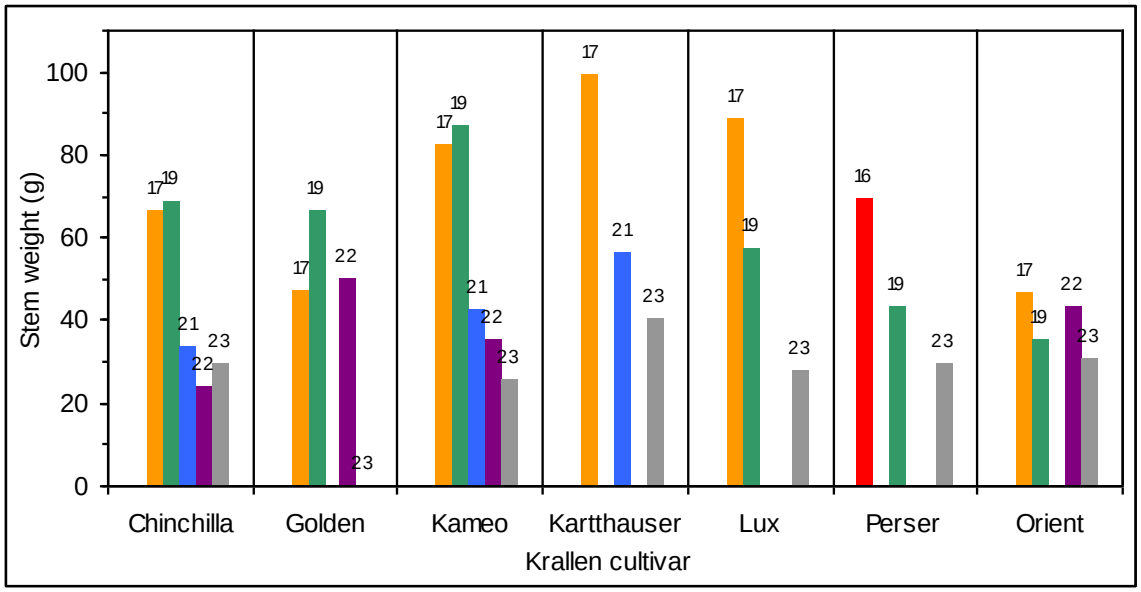
Stem diameter was notably greater for earlier plantings of ‘Chinchilla’ and ‘Golden’ than for later plantings, but this trend was not seen in the other cultivars tested, and the number of side-shoots per plant varied in a similar way. For flower size, too, with the exception of ‘Golden’ there was a very clear trend for smaller size following progressively later planting. AOV showed there were statistically significant effects of cultivar on flower diameter and on the number of side-shoots (both at $p<0.05$), but not on stem diameter or picking date. Flower diameter ($p<0.001$) and side-shoot number and stem diameter (both $p<0.05$) were all significantly diminished by later planting.

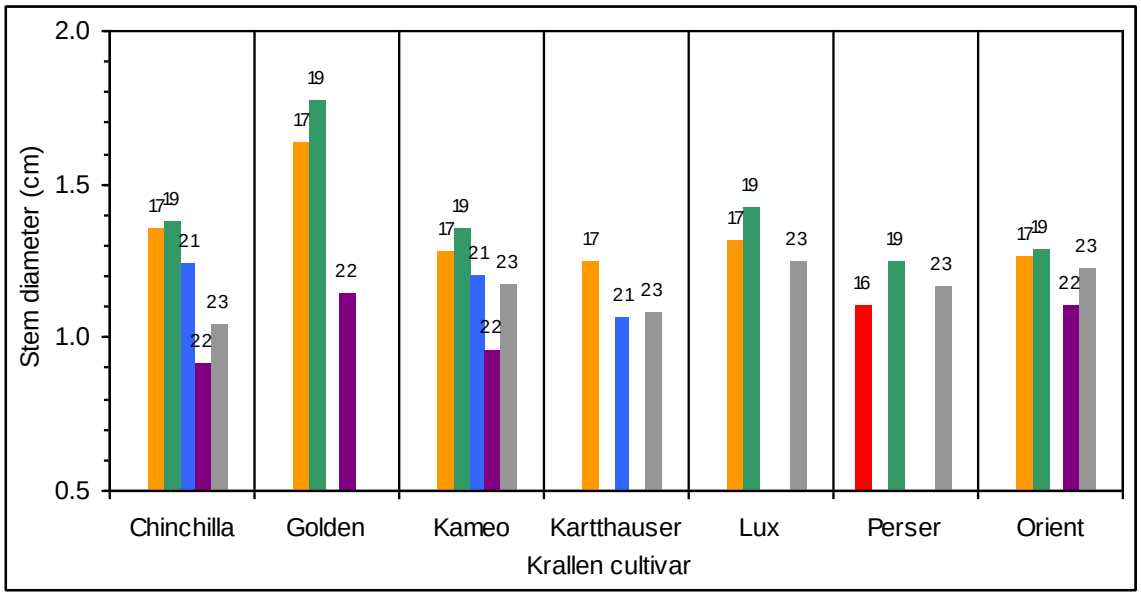
Essentially, these findings showed that the early plantings of all tested cultivars produced heavier stems and larger flowers, performance lessenning with later plantings.

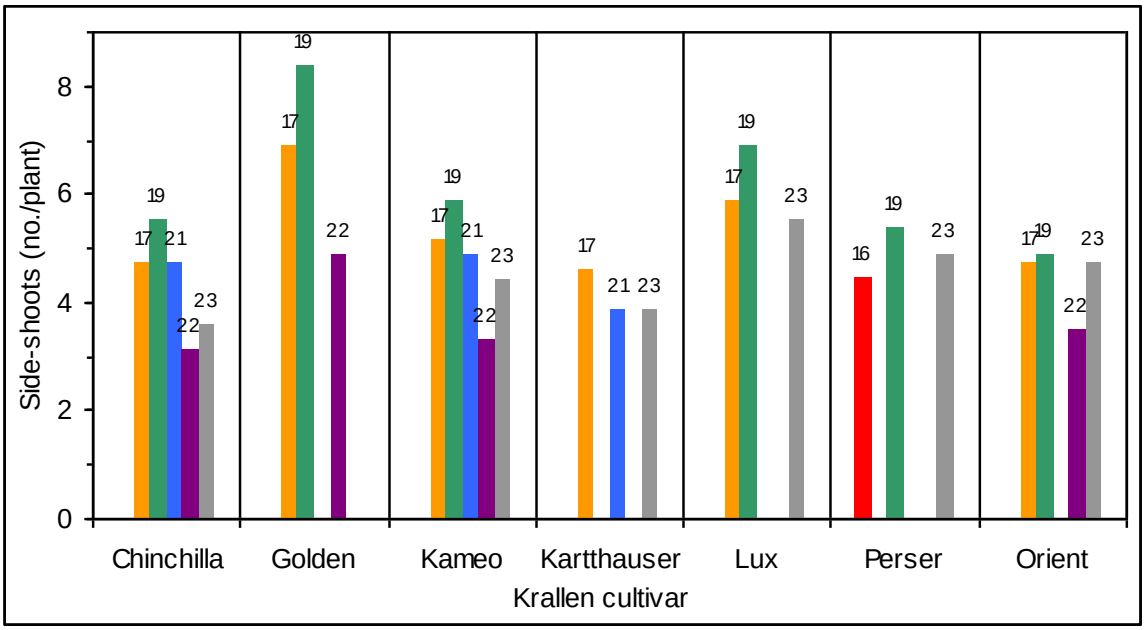
Figure 4

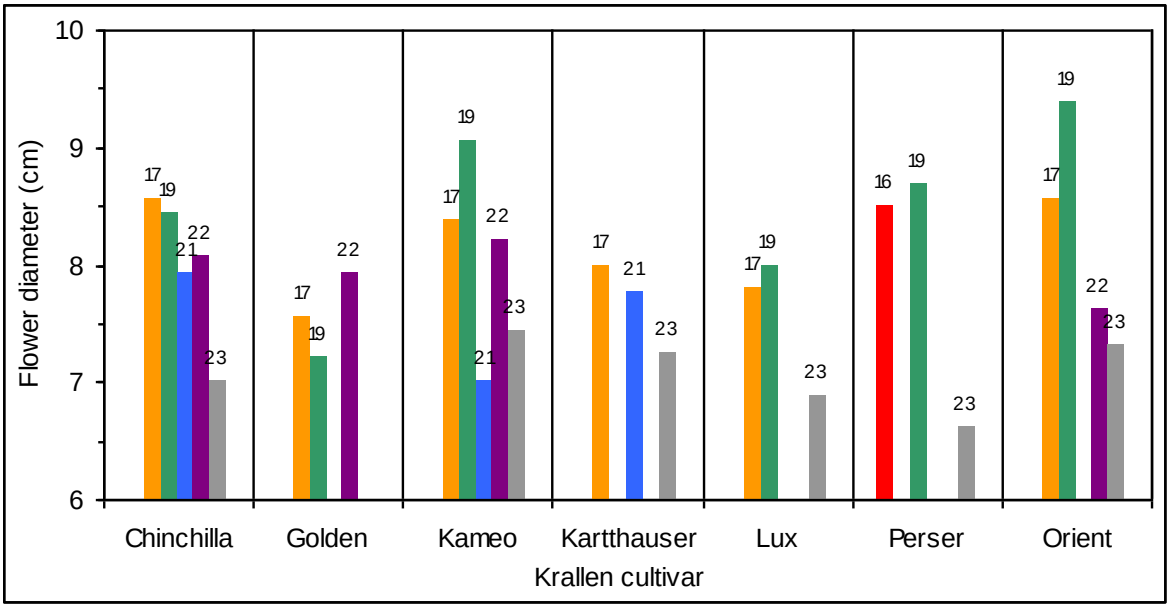
Comparison of seven ‘Krallen’ cultivars of ‘German aster’ grown from blocks and transplanted into a tunnel between weeks 16 to 23 (the planting date is indicated above each coloured block). Not all cultivars were available for all planting dates. Data are the means of 10 stems/plot. From top to bottom: stem length, stem weight, stem diameter, number of side-shoots, flower diameter and picking date.

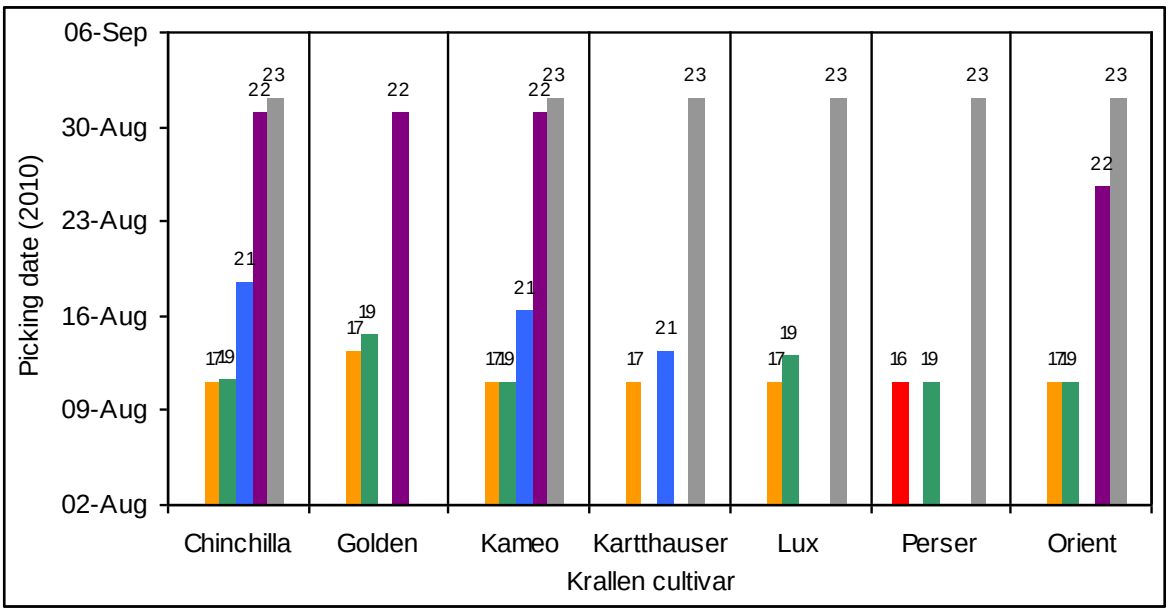












2010 (5) The effect of planting date on Dutch plug-raised 'Krallen' and 'Gala'

In order to determine the earliest practical planting date for plug-raised 'Krallen' and 'Gala' in tunnels, seven plug-raised cultivars ('Krallen' cultivars 'Chinchilla', 'Golden', 'Kameo', 'Karthauser' and 'Lux' (Ball Holland) and 'Gala' cultivars 'Lavendar' and 'Purple' (Combinations)) were planted into 3m-long plots in 'Pro-Tech' tunnel bays 1 and 2 in weeks 16 to 22 (not all cultivars were available at all planting dates), all at 64 plants/m^2.

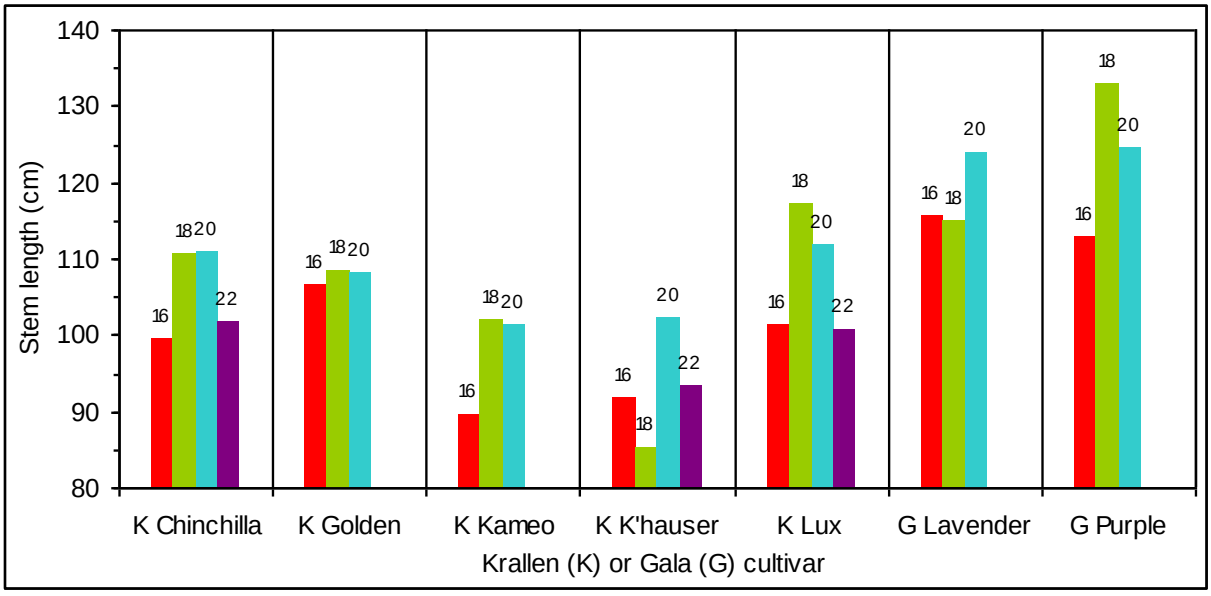
Stem length in plug-raised 'Kameo' and 'Karthauser' was shorter than average, while that of the two 'Gala' cultivars was longer than average (Figure 5). There was a clear trend for the middle plantings (weeks 18 or 20) to produce longer stems. Except for the 'Gala' cultivars,

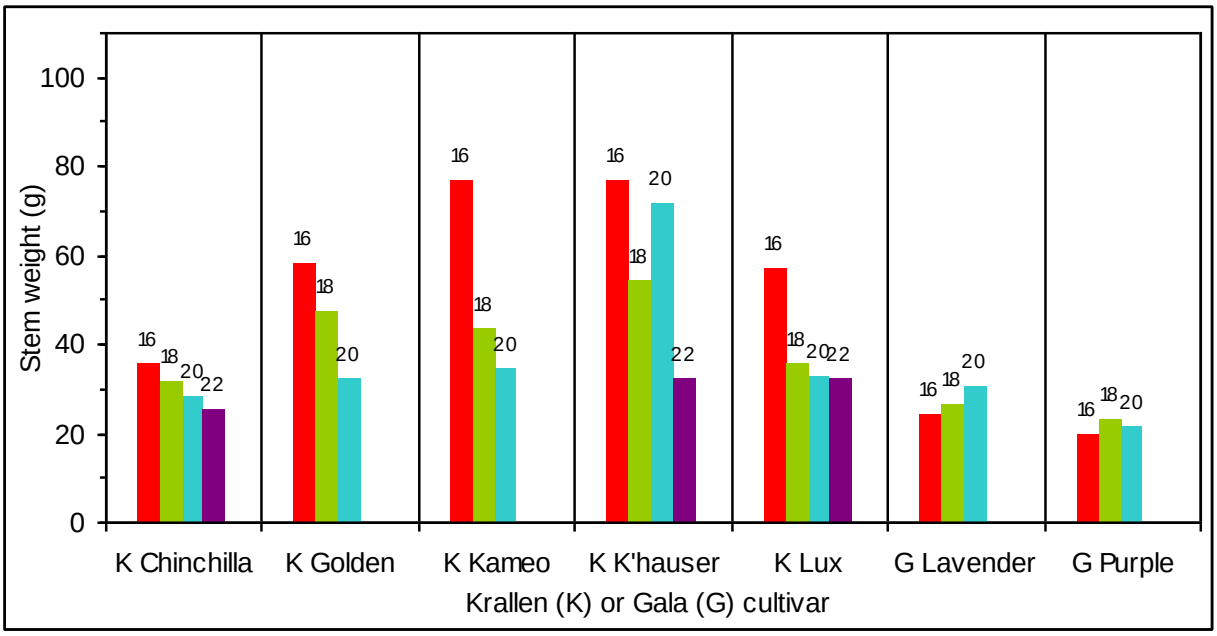
there was a clear trend for stem weight to decrease following progressively later plantings, and this effect was conspicuous in the case of cultivars ‘Golden’, ‘Kameo’, ‘Karthauser’ and ‘Lux’. There was also the suggestion of a tendancy for thicker stems and more side-shoots with the middle plantings. A balanced sub-set of the data (seven cultivars x three planting dates) was subjected to two-factor AOV. This confirmed the statistical significance of the effect of cultivar on stem length ($p<0.001$) and weight ($p<0.01$) and of planting date on stem length and weight (both $p<0.05$); the effect of planting date on numbers of side-shoots and on stem diameter was not statistically significant.

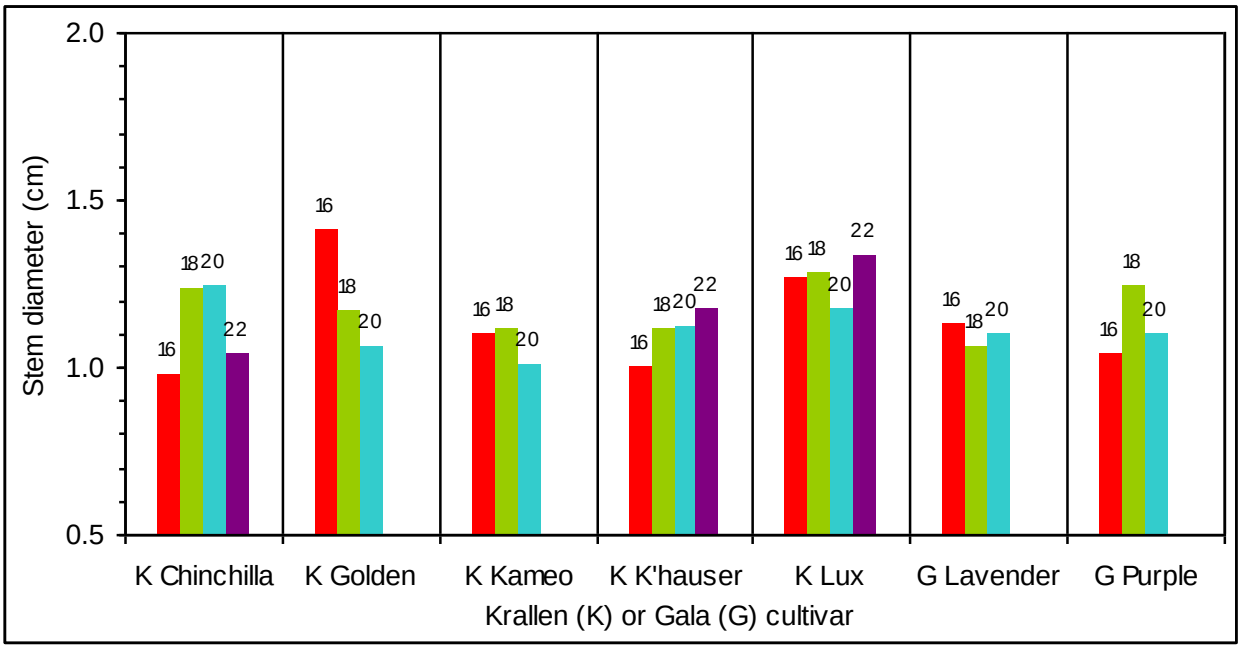
For flower size, there appeared to be a striking result that flower diameters were greater from the first plantings (week 16) of the four cultivars that produced heavier stems from this early planting - ‘Golden’, ‘Kameo’, ‘Karthauser’ and ‘Lux’; however, AOV showed the effect of planting date on flower size failed to make statistical significance at the $P=0.05$ level. As with the block-raised plants (see above) there was the expected later cropping from later plantings (say week 20 or 22), with only minor difference between cultivars from the same planting date. However, the two ‘Gala’ cultivars were exceptional in that flower cropping was considerably delayed even following planting at week 18. AOV confirmed the cultivar effect on picking date as statistically significant ($p<0.01$).

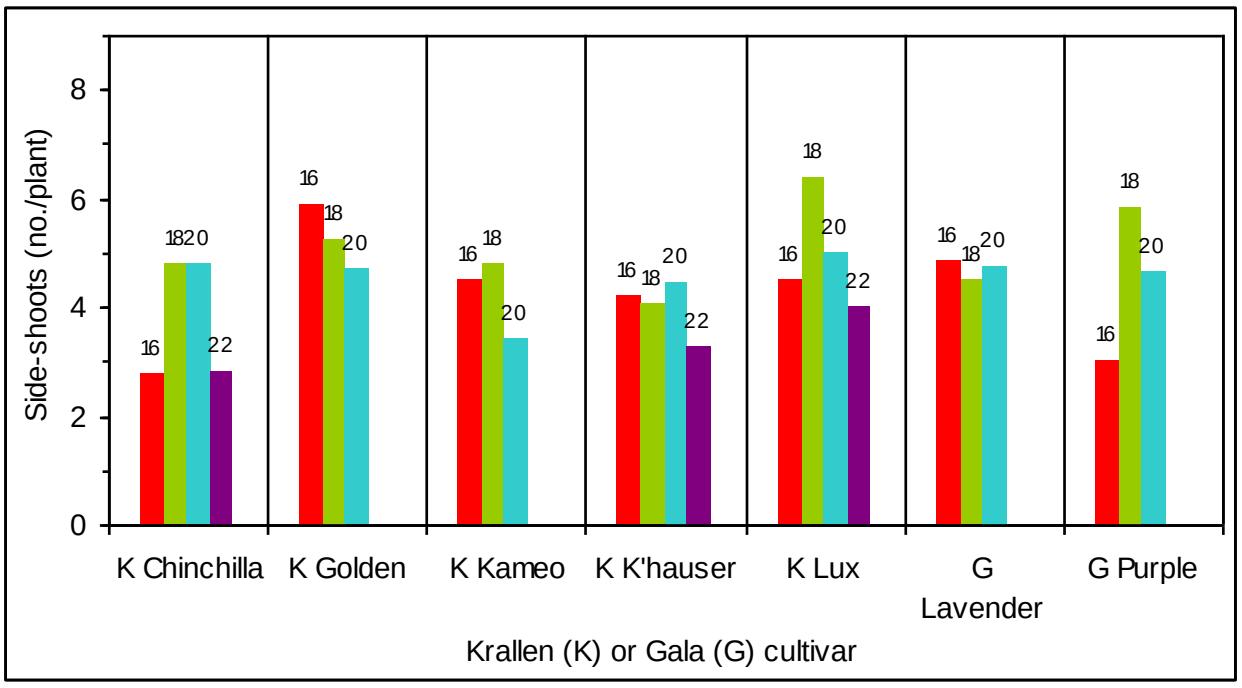
Figure 5

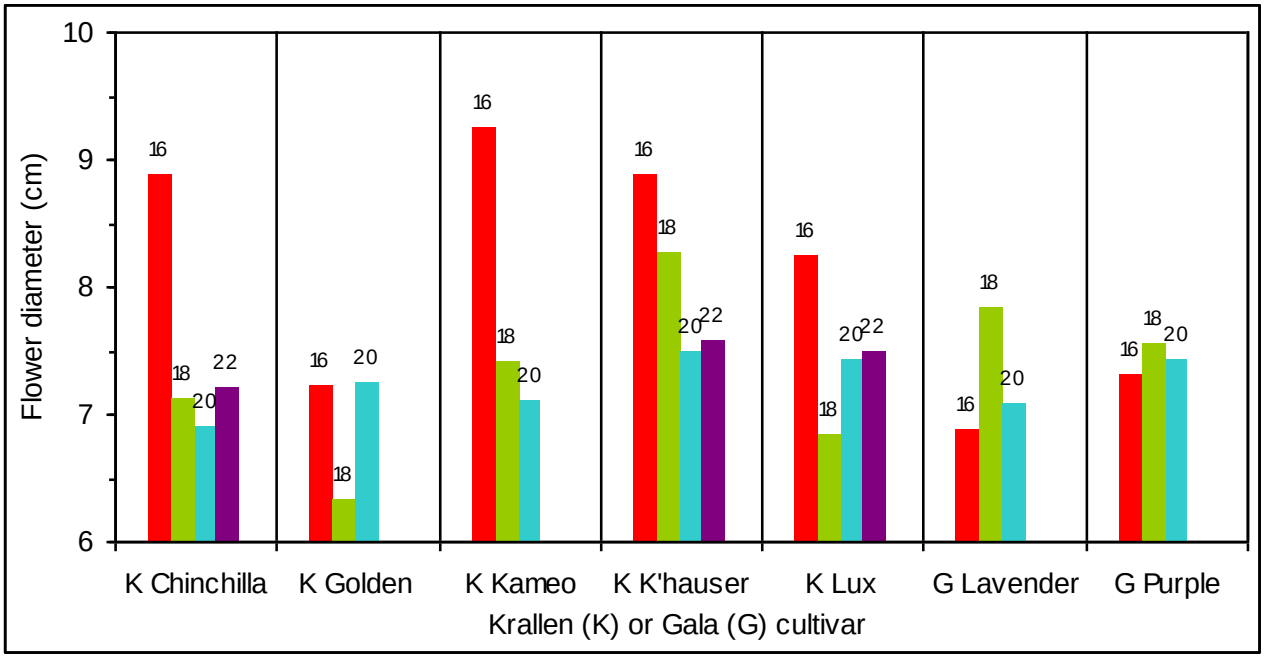
Comparison of seven ‘Krallen’ and ‘Gala’ cultivars of ‘German aster’ grown from plugs and transplanted between weeks 16 to 22 (the planting date is indicated above each coloured block). Not all cultivars were available for all planting dates. To assist comparisons, the vertical scales of histograms are the same as in Figure 4. Data are the means of 10 stems/plot. From top to bottom: stem length, stem weight, stem diameter, number of side-shoots, flower diameter and picking date.

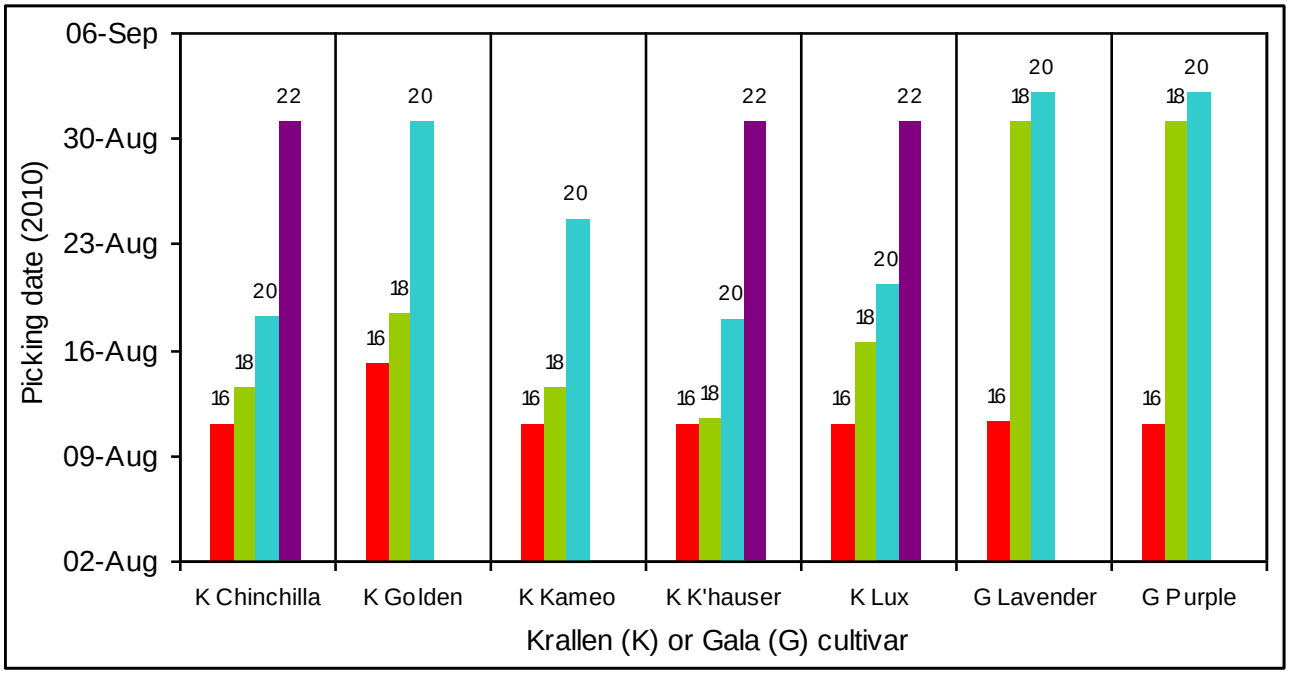












2010 (6) The effect of plant growth regulator on stem length

As confirmed above, early plantings of these cultivars can produce vigourous growth and excessively long stems, so possibly treatment with a growth retardant would be useful.

Plots of plug-raised 'Krallen' cultivars 'Kameo' and 'Kartthouser' (Ball Holland) and 'Gala' cultivars 'Lavender' and 'Purple' (Combinations) were planted in week 16, 18 and 20 into 3m-long plots in 'Pro-Tech' tunnel bays 1 and 2, all at 64 plants/m^2. The plots were treated

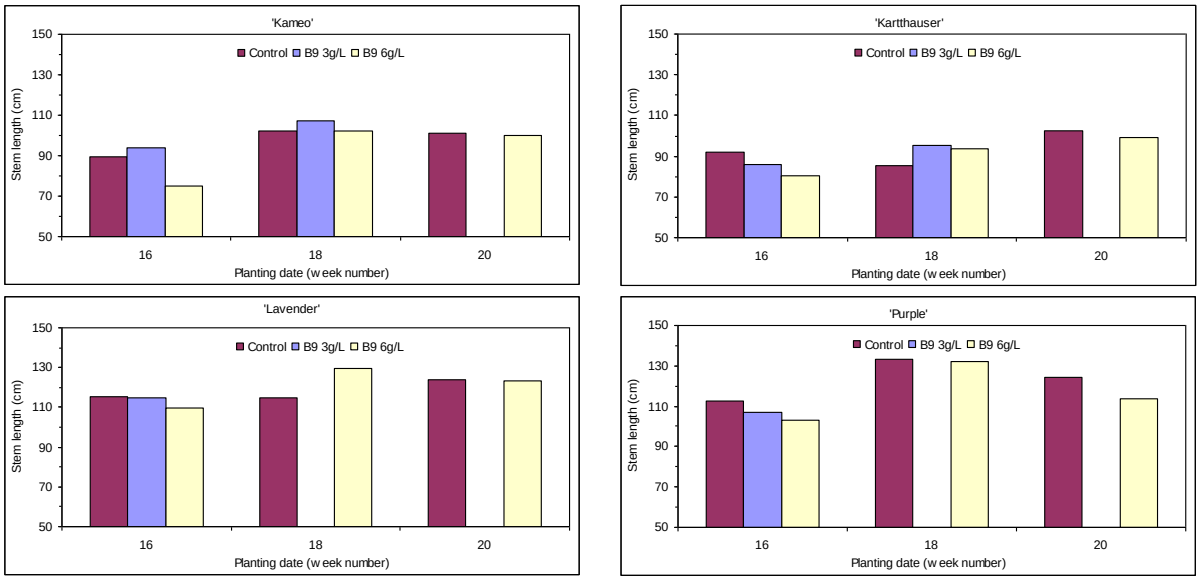
with two rates of daminozide (as ‘B-Nine SG’) or were left un-treated as controls. The ‘B-Nine’ rates were 3 and 6g/L, with split-dose applications made as foliar drenches to run-off on 02 June and 03 July 2010 when the crop was approximately 50cm tall.

Stem length at picking is shown in Figure 6. The higher rate of retardant resulted in only a small reduction in stem length – by not more than about 10%, compared with un-treated controls – in all cultivars but only following the early planting date (week 16). Treatments of the later plantings were ineffective. There were no or only minimal effects of retardant treatment on the other variables measured – stem weight, stem diameter, number of side-shoots, flower diameter or picking date (data not presented).

Four balanced sub-sets of the data (two or three ‘B-Nine’ treatments x three planting dates for each of four cultivars) were subjected to two-factor AOV. This confirmed that the effects of growth regulator treatment were effective and statistically significant (at $p<0.05$) for plantings of week 16, but were not significant for plantings of weeks 18 or 20. This weak and inconsistent effect of ‘B-Nine’ confirmed the observed impressions.

Figure 6

The effect of ‘B-Nine’ growth regulator treatments on stem length of ‘German aster’ ‘Krallen’ cultivars ‘Kameo’ and ‘Karthauser’ and ‘Gala’ cultivars ‘Lavender’ and ‘Purple’ grown from plugs and transplanted in weeks 16, 18 and 20 to tunnels. Data are the means of 10 stems/plot. Not all plantings received the lower rate of ‘B-Nine’.



2010 (7) Cultivar demonstration – ‘Standby’, ‘Benary Princess’ and ‘Matador’ series

Plugs (supplied by Florensis B.V.) of 25 cultivars of the ‘Standby’, ‘Benary Princess’ and ‘Matador’ series were planted into 3m-long plots in the ‘Haygrove’ tunnel in week 20, at 64 plants/m^2.

A selection of these cultivars is shown in the picture below. While these supplied an additional range of shades, the general view of the gowers and buyers who examined them was that none was of the quality of the ‘Krallen’ series. Some might find a more limited market.

Some ‘German asters’ of the ‘Standby’, ‘Benary Princess’ and ‘Matador’ series (Photos: Cut Flower Centre Ltd)

2011 (1) Growth retardant trial

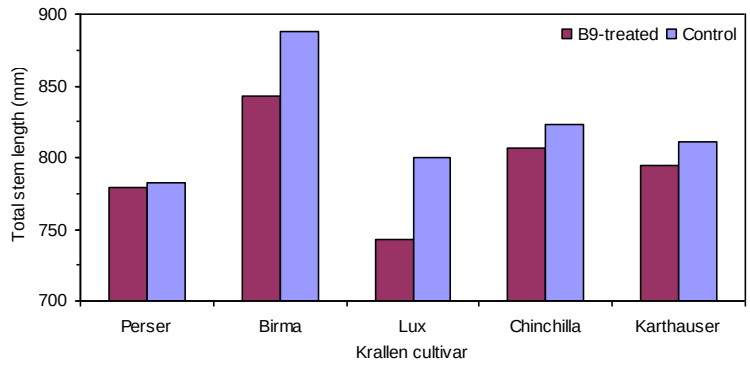
Plugs of five ‘Krallen’ cultivars (‘Perser’, ‘Birma’, ‘Lux’, ‘Chinchilla’ and ‘Karthauser’) (Florensis B.V.) and six ‘Gremlin’ cultivars (‘Geel’, ‘Paarsblauw’, ‘Lincht Rose’, ‘Donker Rose’, ‘Rood’ and ‘Donker Paars’) (seed from Hem Zaden, plugs from Florensis B.V.) were planted into 3m-long beds in ‘Pro-Tech’ tunnel bay 2 in week 25, all at 64 plants/m^2. Half of each bed was treated with ‘B-Nine SG’ at 6g of product per litre twice, sprayed to ‘run-off’, in weeks 32 and 34.

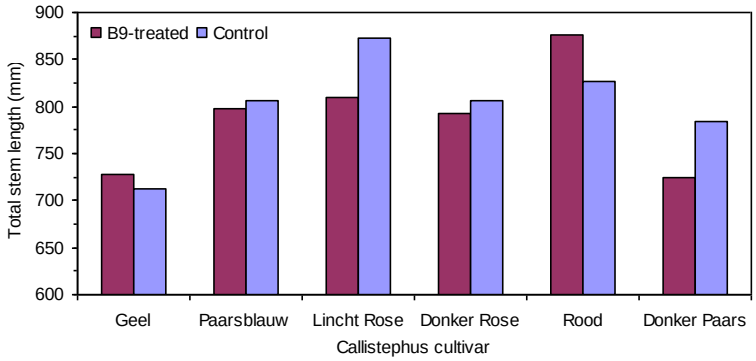
The effects of ‘B-Nine SG’ treatment on total stem length are shown in Figure 7. In the ‘Krallen’ varieties applying ‘B-Nine SG’ gave a fairly consistent, but only 3% overall, reduction in stem length compared with the controls. In contrast, in the ’Gremlin’ varieties the result of using ‘B-Nine SG’ was unconvincing, inconsistent and resulted in an overall less than 2% reduction in length. Analysis of variance showed that, while varietal differences in stem length were significant at the 5% level of probability in both cultivar groups, the effect of ‘B-Nine SG’ was not.

As in previous years many samples were supplied to supermarkets, packers and local florists, some being sent to the Netherlands. They were well received, with the ‘blue’ cultivars – ‘Karthauser’ and ‘Perser’ being identified as having the most market potential.

Figure 7

Total stem length of ‘Krallen’ (above) and ’Gremlin’ series (below) of ‘German asters’ in plots treated with ‘B-Nine SG’ growth regulator or left untreated as controls.





2011 (2) VL testing

Late in the season (week 39) samples of four cultivars – 'Bonita Scarlet', 'Chinchilla', 'Perser' and 'Lux' - were picked in for VL testing (By Intergreen (UK) Ltd). VL lasted up to 9 days, the main reason for failure being yellowing or browning flower-heads or leaves. 'Chinchilla' gave a VL of 9 days and 'Perser' and 'Lux' 7 days.

2012 (1) Cultivar demonstration – alternatives to 'Krallen'

Some alternative large-headed annual aster cultivars were demonstrated in this trial from the 'Meteor' series (Kieft Pro Seeds) and 'Ribbon' series (Seeds of Success International). Cultivars of the 'Bonita' series (Sakata) were also included, as they are marketed as being complementary to 'Matsumoto', the most commonly grown spray variety.

Plugs of 'Meteor Carmine Red', 'Meteor Yellow', 'Meteor Violet Blue', 'Ribbon Violet', 'Ribbon Lilac Rose', 'Ribbon Lavender' and 'Ribbon Dark Pink' were planted in 2m-long beds in 'Pro-Tech' tunnel bay 1 in week 27 and 28. Plugs of the 'Bonita' series 'Pink', 'Blue', 'Scarlet' and 'Rose' were planted in 4m-long beds in 'Pro-Tech' tunnel bay 1 in week 30 and in bay 2 in week 31. All plantings were at a density of 64 plants/m^2. The planting date was much later than originally planned but was unfortunately delayed due to supply issues with the seed.

Despite the application of prophylactic sprays against thrips, a virus vector, severe symptoms of Tomato Spotted Wilt Virus (TSWV) appeared very early in the life of the crop. The presence of TSWV was confirmed by FERA. The problem was particularly severe in the 'Meteor' series and only present at low levels in the 'Ribbon' series with virtually no symptoms on the 'Bonita' series.

Because of the late planting (and subsequent poor weather) and TSWV infection, the stems were of such poor quality that no assessments were made of the bloom varieties. From this late planting date none of the cultivars tested appeared to have prospects as an alternative to the 'Krallen' cultivars, but the trial will be repeated in 2013 using an earlier planting date

and additional new varieties. The ‘Bonita’ range generated interest from growers of the traditional ‘Matsumoto’ varieties, but did not attain its full potential owing to the late planting and poor weather in 2012. It would appear likely that growers will undertake their own commercial trials in 2013.

Summary and outcomes

The series of trials with ‘German asters’ at the Centre showed there is potential for exploiting these vibrant cultivars in the UK. The ‘Krallen’ series produces a large head and strong stems of superior quality compared with the ‘Gala’, ‘Standby’, ‘Benary Princess’ and ‘Matador’ series, but there is still scope for further cultivars trials to eliminate poor or inconsistent cultivars such as ‘Golden’, which often behaves in an atypical manner and produces weak stems of poor quality. Earlier trials showed that ‘Krallen’ cultivars also showed better tolerance to pests and disease.

The results on the effects of planting date confirmed and extended the findings from earlier trials at the Centre. For plug-raised plants, and generalising somewhat across cultivars, later planting led to the production of lighter stems with smaller flowers, while stem length, stem diameter and the number of side-shoots were less from either the early or the late plantings and maximal from middle plantings. In most cases later planting (say in weeks 20 to 22) led to poorer quality stems, whereas early or middle plantings were satisfactory. While earlier findings had suggested that these cultivars should not be planted later then week 26, the issues of lightweight stems and smaller flowers obtained from the week 22 and 23 plantings implies that production of marketable stems from a week-26 planting seems unlikely. Subsequent commercial planting have shown that week 24 to 25 is perhaps the latest that ‘Krallen’ can be planted and an adequate crop still be obtained.

UK block-propagated plants performed as well or better than conventional Dutch plugs. The former gave heavier plants with larger flowers from the early and middle plantings, while the latter gave heavier stems and larger flowers only from the early planting. Block-propagated plants may be more robust than plugs, and appeared to make more consistent stems (see above). A subsidiary trial showed that block-raised plants could simply be laid on the ground, as in AYR chrysanthemum growing; the blocks did not need to be buried in the soil, provided they were kept well watered.

Only a weak response to growth retardant has been seen in these trials, and earlier and perhaps repeated applications at a higher dose appear to be needed. Once optimal growth retardant treatments have been defined these could be used to bolster stem weight in cultivars and planting dates that need it.

The ‘Krallen’ series were grown by local producers in commercial quantities in 2009 and 2010, and the ‘blue’ varieties ‘Karthauser’ and ‘Perser’ were in great demand by the supermarkets. Numerous VL tests were undertaken by the packer on batches being sold through the supermarkets, and their VL was found consistently to meet or exceed the guarantee of 5 days. Despite its great commercial potential, however, VL subsequently became an issue when a problem with petal-spotting and flower-tip browning became apparent. The cause the disorder has unfortunately not been identified, despite extensive investigations both in the Netherlands and the UK. Losses became so severe that ‘Krallen’ is unlikely to be grown again on any large scale until the cause can be identified and rectified. Petal-spotting, was less severe, but was still present, on other cultivars. In 2013 further variety trials will be undertaken to try and identify potential alternatives to ‘Krallen’.

5. DIANTHUS, ANNUAL (‘BREANTHUS’)

Introduction

‘Breanthus’ is a new range of annual dianthus developed by HilverdaKooji. In 2012, plots were set up to assess their market potential and collect basic data for four of these cultivars.

2012 Initial assessment

Cultivars ‘Duke Breanthus’ (‘Hilbreduk’) (white), ‘Earl Breanthus’ (‘Hilbreearl’) (pink), ‘Queen Breanthus’ (‘Hilbrequeen’) (burgundy) and ‘King Breanthus’ (‘Hilbreking’) (purple with white eye) were propagated from cuttings and delivered as rooted plugs in week 14. The unusually wet weather at the time precluded immediate planting, and they were transplanted to 9cm-diameter plant-pots. When appropriate they were planted to 2m-long plots in ‘Pro-Tech’ tunnel bay 2 in week 18 and outside in week 21 at a density of 30 plants/m^2. One half of each plot was pinched (week 21 in tunnel, week 23 outside) and the other half-plot left non-pinched.

In the very wet weather of 2012 the performance of the outside crop was very poor and it was not considered worthwhile to make any formal assessments.

In the tunnel the first flush occurred in weeks 29 to 30 and the second beginning week 36 (picking was held over until the Open Day, week 37). Good quality stems were harvested, but the growth of the four cultivars was very different in yield, stem strength and second-flush vigour. ‘Duke’ gave a very heavy first flush of strong stems, but failed to produce a marketable second flush. ‘Queen’ produced a large number of much weaker stems in both first and second flushes. The total yields of stems are shown in Table 8, and, for ‘King’ and ‘Queen’, were of the order expected by the propagator (>100 stems/m^2). Some stems failed

to mature, probably due to the unusually poor weather and very late season. It is not known whether this year's behaviour of 'Duke' was typical of the cultivar, or caused by seasonal factors.

Table 8

Total stem yield of 'Breanthus' annual dianthus cultivars in tunnel, 2012.*

Cultivar	*Stems/plot*	*Stems/m^2*	*Stems/plant*
'Duke'	116	50	1.7
'Earl'	168	70	2.3
'King'	328	143	4.8
'Queen'	221	116	3.9

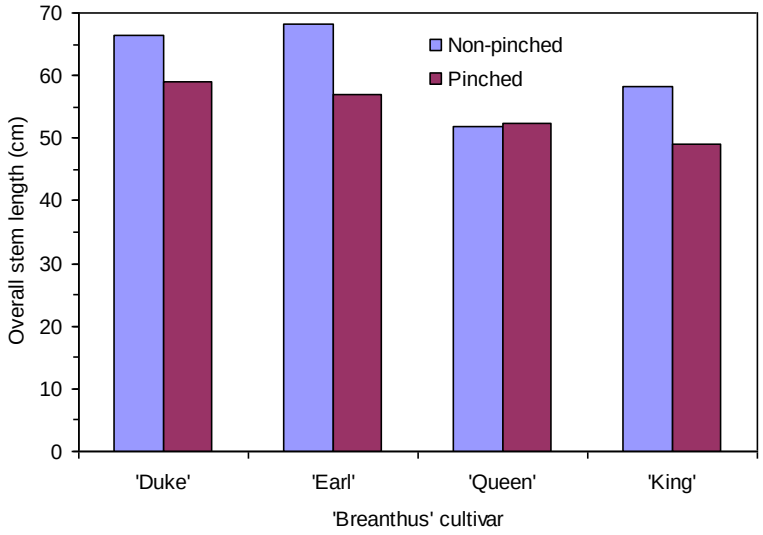
* Totals across pinched and non-pinched plants and including both flushes

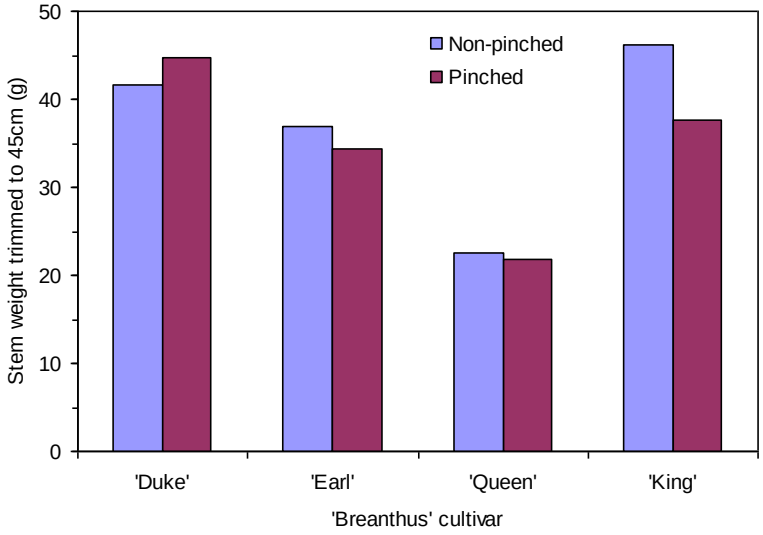
Figure 8 shows the overall stem lengths and weights of stems (trimmed to 45cm) for the four cultivars, pinched and non-pinched. 'Queen' produced substantially lighter stems and (in general) slightly shorter stem lengths, though still sufficiently long for trimming to 45cm. Compared with the non-pinched controls, pinching was seen to (a) reduce overall stem length (except in the less vigorous 'Queen') and (b) give lighter stems in the otherwise vigorous 'King'.

Stems were sampled in weeks 34 - 35 for VL testing (by Butters Group Ltd). After simulated storage, transport and retail store phases, all achieved a 7-day VL with the consumer (see Appendix 2 for results). The end of VL was a result of flower senescence. Where 'Professional 2' had been used as the conditioner, but not where CVBN had been used, the water was cloudy at this stage.

Figure 8

Overall stem length and weight of stem trimmed to 45cm in tunnel-grown 'Breanthus' (annual dianthus) cultivars either pinched or non-pinched, 2012.





Summary and outcomes

This demonstration received a positive market response from retailers and growers. The tight, spherical head was considered especially appealing. However, the crop was planted unavoidably late due to wet weather, and the poor season probably had a negative effect on crop performance, so the results should be used cautiously and further trials are needed before they can be recommended by the Centre. In 2013 it is planned to investigate staggered planting for continuity of supply, as well as differences between pinched and non-pinched plants and between the flowers of the first and second flushes. The crop planted in 2012 will be over-wintered and (if it survives) will be assessed in more detail in 2013.

6. LISIANTHUS (*EUSTOMA GRANDIFLORUM*)

Introduction

Cut-flowers of lisianthus have now achieved considerable popularity in the UK as a rather 'exotic' crop. Its longer growing season than many other flowers, and high heat and light requirements, restrict the number of rounds that can be accomodated in a year, but the possibility of growing a short summer 'spot' crop in Spanish tunnels was raised in discussions in 2009. As a result, in 2010 plugs were planted in beds in the 'Haygrove' tunnel, fitted with side skirts and doors, in weeks 18, 19 and 20. Stems were broken in windy weather if the doors were not kept shut. Cropping started in week 30 and continued past week 34 when the Centre's Open Day was held and when the images below were taken. It was acknowledged by visitors that the results were impressive, with high-quality blooms, good stem strength and no pest and disease problems, and many sample bunches were provided to packers and buyers for assessment. But it was also noted that the trial had coincided with warm, dry weather that would be very favourable for the crop, and so the trial was repeated the following year, when further cultivars were tested, planting date was investigated and growth in 'closed' and 'open' tunnels compared. The work was extended in 2012 to study the effects of soil sterilisation and growing through black mulch.

Lisianthus growing at the Centre, week 34, 2010 (Photos: Cut Flower Centre Ltd)

2011 (1) Lisianthus cultivar trial over three planting dates in ‘open’ and ‘closed’ tunnels

In 2011 thirty cultivars (Florensis B.V.) were included in trials (see Table 9 for details). Plugs of ten cultivars were planted in the ‘Haygrove’ (closed) tunnel in each of weeks 18, 19 and 20, and further plugs of the ten varieties planted in week 20 were planted in ‘Pro-Tech’ (open) tunnel bay 1 (without end-doors or skirted sides) in week 21. All plantings were at a density of 64 plants/m^2 in beds 3m long.

As in 2010 the plots grown in the closed tunnel produced strong, high quality stems and only inconsequential levels of pest or disease were seen, with little evidence of root diseases. In contrast, growth of the late planting in the open tunnel was weak and significant amounts of *Fusarium* were seen along with some *Pythium.* The crop was abandoned after the cover was damaged in a gale. However, before this event a long-established lisianthus grower visited the Centre and commented that, while the crop was not as strong and vigorous as in the ‘Haygrove’ tunnel, it was still better than his equivalent glasshouse crop, and so it would be well worth repeating in 2012 but using a slightly earlier planting date. Since the difference in pest and disease levels between the two tunnels may have related to their different microclimates or means of soil sterilisation - the ‘Haygrove’ tunnel was treated with dazomet in autumn 2010 and left sheeted-down over winter, while the ‘Pro-Tech’ bays were not sterilised with dazomet until spring 2011 – soil sterilisation should also be further investigated.

Cropping dates, stem lengths and trimmed weights are summarised for the main plots in the ‘Haygrove’ tunnel in Table 9. There were considerable varietal differences, some cultivars evidently being more suited to cultivation in tunnels. Most cultivars planted in weeks 18 and 19 were cropping in weeks 32 to 33, respectively, with the odd cultivar later; the week-20 plantings cropped over weeks 32 to 36. Of the 28 plantings, eight failed to reach the average length of 70cm needed for trimming to specification, but only six had a trimmed stem weight of less than 80g each. Untrimmed stem lengths and trimmed stem weights, averaged across the cultivars, showed no clear trend with later planting, although stems from the middle planting date were shorter and lighter (each by about 10%) than either the earlier or later plantings.

Lisianthus, L to R: ‘ABC 2-3 Blue Rim’, ‘Dream White’ and ‘Rosita Blue’ (Photos: Cut Flower Centre Ltd)

Table 9

Flowering performance of lisianthus cultivars following transplanting at weeks 18, 19 and 20 into the 'Haygrove' tunnel. Stem lengths and weights recorded on the dates shown, usually corresponding to peak cropping time. The figures are means of 20 stems shown with standard deviations (SD); trimmed stem weight refers to weight after trimming stems to 70cm-length.

Cultivar	*Planting week*	*Recording date*	*Total stem length (cm)*		*Trimmed stem weight (g)*	
			Mean	*SD*	*Mean*	*SD*
'ABC 2-3 Blue Rim'	18	08 Aug	86	18.7	93	21.0
'Arena Rose'	18	08 Sep	97	5.1	96	43.9
'Dream White'	18	08 Aug	62	2.1	52	19.9
'Excalibur Green'	18	08 Aug	84	3.4	101	30.6
'Kyoto Purple'	18	08 Aug	72	2.7	78	22.4
'Mariachi Lime Green'	18	08 Aug	73	3.7	77	19.6
'Minuet Dark Purple'	18	08 Aug	74	3.8	134	31.6
'Papillon Flash Pink'	18	17 Aug	80	5.4	164	56.4
'Rosita Blue'	18	08 Aug	82	17.9	88	22.8
'Arena III Red'	19	26 Aug	91	2.6	87	18.8
'Dream Lavender'	19	08 Aug	59	12.6	73	15.9
'Excalibur Pure White'	19	17 Aug	73	3.2	118	73.4
'Mariachi Lavender'	19	17 Aug	57	4.9	74	25.0
'Mariachi White Pure'	19	08 Aug	72	4.6	87	36.7
'Minuet Apricot'	19	17 Aug	61	13.4	95	27.4
'Piccolo 2 Rose Pink'	19	08 Aug	92	3.4	87	25.8
'Revolution Green'	19	17 Aug	60	3.2	85	21.1
'Revolution White'	19	17 Aug	64	6.6	96	38.6
'ABC 2-3 Blue Rim'	20	17 Aug	88	3.9	121	23.5
'Arena White'	20	31 Aug	89	2.8	88	19.7
'Ceremony Blue Flush'	20	31 Aug	90	3.5	94	18.5
'Dream Blue'	20	08 Aug	68	3.4	73	14.7
'Excalibur Yellow'	20	31 Aug	89	4.4	80	17.5
'Mariachi Blue'	20	17 Aug	70	4.5	97	22.7
'Minuet White'	20	31 Aug	76	3.6	94	17.8
'Papillon Rose Pink'	20	08 Sep	66	7.2	101	49.5
'Piccolo 2 Deep Blue'	20	31 Aug	79	4.2	110	29.5
'Rosita 3 Yellow'	20	17 Aug	79	4.5	142	36.6

2011 (2) Lisianthus VL trials

Samples of 'ABC 2-3 Blue Rim', 'Dream Blue', 'Dream Lavender', Dream White', 'Mariachi Lime Green', 'Piccolo 2 Rose Pink' and 'Rosita Blue' were picked in week 32 for VL testing (By Intergreen (UK) Ltd). A second batch of 'ABC 2-3 Blue Rim', 'Dream Blue', 'Dream Lavender', 'Mariachi Lime Green', 'Piccolo 2 Rose Pink' and 'Piccolo 2 Deep Blue', was picked in week 33 and treated in the same way. Amongst the different cultivars VL varied from 7.5 to 14.0 days in batch 1 and from 7.0 to 13.3 days in batch 2. The main reasons for failure were flower-head damage due to Botrytis or drooping of the flowers and stems. The VL guarantee for straight lisianthus is usually 9 days. In batch one only 'Dream White', 'Mariachi Green' and 'Piccolo Rose' achieved this, while in batch 2 all cultivars except 'ABC

2-3 Blue Rim' and 'Dream Lavender' did so; overall, about half the bunches picked met the 9-day requirement. Lisianthus is also commonly used in mixed bouquets that are generally guaranteed for 5 or 7 days. Following the latter criterion, all bunches tested would meet the required guarantee.

2012 (1) Lisianthus planting density, black mulch, open and closed tunnels, and sterilisation method

For ease of interpretation, this trial is described in three sections:

- Because of the long growing period of lisianthus, planting densities greater than 64 plants/m^2 are used in the Netherlands to achieve commercial viability and in this trial planting densities of 64, 80 or 96 plants/m^2 were included.
- To investigate the different results obtained in 2011 in the two types of tunnel, which besides their physical differences also had different dates for soil sterilisation, plantings were made into separate areas of the closed ('Haygrove') tunnel that had been sterilised with steam or Basamid in November 2011 (and then left covered with polythene over winter) or had been left un-sterilised as a control, and into an area of an open tunnel ('Pro-Tech' tunnel bay 1) that had been steam-sterilised in November 2011.
- Finally, as the possible benefits of growing lisianthus through polythene mulch had been raised in discussions at the 2011 Open Day, both mulched and non-mulched plots were included in both the closed and open tunnels. The material used was a thin, micro-perforated black polythene film ('Blackflame').

Plugs of 13 cultivars (Florensis B.V.; see Figure 9 for cultivar codes) were planted into 2m-long beds in week 21 (closed, 'Haygrove' tunnel) or week 22 (open, 'Pro-Tech' tunnel). Because of space restrictions a 'fully balanced' experimental design was not practical, and Figures 9 -13 should be consulted to determine the treatment combinations used.

Cropping started in week 33, with some stems being held back for the Open Day in week 37. As in the previous 2 years, overall the stems were of exceptional quality, with strong stems and very little disease in the 'Haygrove' tunnel. However, some root problems were evident in the open tunnel, though this did not result in significant crop losses in this case.

Figure 9 shows the effects of using a black mulch on the stem length and weight of ten cultivars in the closed tunnel (with means and analyses of variance in Table 10 and 11). Using the mulch did not increase stem length and weight compared with planting directly into the soil. There were significant differences between cultivars in length ($P<0.05$) and height ($P<0.01$). There was also a suggestion that some cultivars were more responsive to a mulch than others. Figure 10 (and Tables 12 and 13) show the equivalent data for nine cultivars in

the open tunnel. In this case there was a small ($P<0.05$) positive benefit of using mulch on stem length, but not on weight, and there was also a significant difference between cultivars in length ($P<0.001$) but not in weight. Overall, then, there was little or no benefit of using mulch on stem quality, which confirmed the visual observations made during the 2012 Open Day.

Figures 11 and 12 show the effects on the three cultivars of black mulch, planting rate and soil sterilisation method on stem lengths and weights, respectively. Stem lengths were broadly consistent across the whole range of treatment combinations. Stem weights, however, were greatest when planted at the lowest rate (64 plants/m^2), the size of this response varying between the three cultivars (cultivar C, 'Piccolo 2 Rose Pink', was particularly responsive), but apparently irrespective of whether a mulch or soil sterilisation was used; this was despite the steamed plots producing visually slightly better stems. These conclusions are confirmed by the marginal means, the overall means for each of the experimental factors shown in Figure 13, where the greater vigour of cultivar C and the heavier stems at the lowest planting rate can be seen, along with a suggestion that Basamid-sterilisation had an adverse effect.

Further plots of ten cultivars each were grown at 80 plants/m^2 in steam-sterilised soil in the closed and open tunnels and with or without mulch. This data has been presented above – separately for each tunnel – in order to compare the effect of using a mulch. It was also intended that this would be a comparison of the two tunnel types, but the plants in the open tunnel were very slow growing and many stems failed to reach maturity and flower before it was time to de-skin the tunnels in November. This was likely due to low light levels and unseasonably low temperatures in the poor summer of 2012. Growth was variable. For these reasons a direct comparison of crops in the two tunnels would not be valid. These results and those of the 2011 trial showed that unless there is a very warm summer, the production of lisianthus can only be considered in tunnels that have a facility for their doors and sides to be closed, ensuring an adequate temperature can be maintained if the outside temperature is too low.

In general these lisianthus data showed very high levels of variance, possibly masking some underlying effects: sample sizes should be increased in future trials.

Stems were sampled in weeks 35 to 39 for VL testing (by Butters Group Ltd). After simulated storage, transport and retail store phases, with one exception (due to early wilting of the stems) they achieved a 6 or 7-day VL with the consumer (see Appendix 2 for results).

Summary and outcomes

The last three years of trials have shown that the Centre's 'Haygrove' tunnel provided a superb environment for the production of high-quality, strong stems across a wide range of lisianthus varieties. However production in an open tunnel is much more risky, and was not successful during the last two years (2011 and 2012) of these trials.

Perhaps surprisingly the 2012 trial did not show any real advantage of sterilised over non-sterilised plots, but lisianthus are known to be susceptible to so many different stem and root diseases that it would be very risky to produce a commercial crop with no sterilisation.

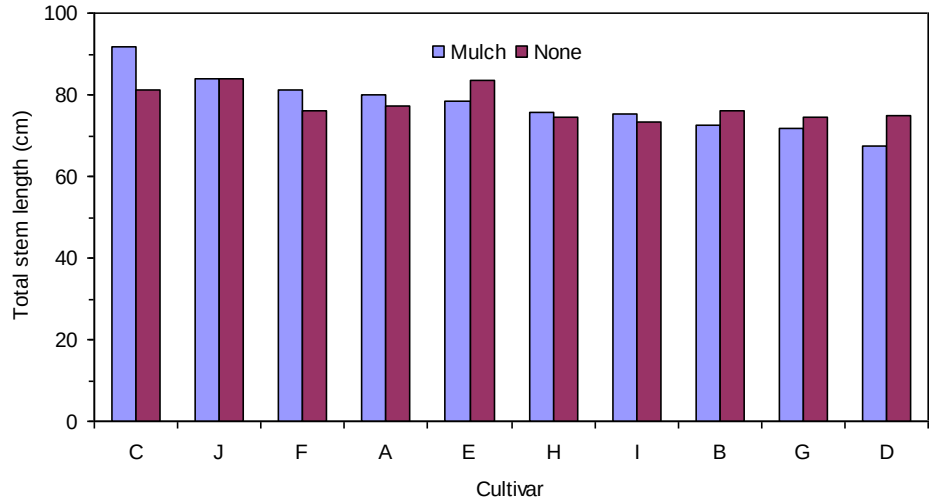
As would be expected, wider spacing tends to produce stronger stems but, from the results of the 2012 trial, some cultivars seemed to respond more positively then others.

Viewing the trials in 2011, a representative of Florensis B.V. and one of the supermarket technologists said these were some of the strongest-stemmed lisianthus they had ever seen. Samples of lisianthus were again supplied widely to technologists and managers of supermarkets and packers and were very enthusiastically received and as a result, some growers have been approached to produce a crop in 2013. With this quality in a home-grown product, it was considered the crop could generate a good return if the supermarkets would pay a premium price for it: the main obstacle was the long time the crop is in the ground. However, the Centre's trials have demonstrated the potential of the production of the crop in closed Spanish tunnels in the UK and it now up to the industry to develop it further.

Figure 9

Total stem length (above) and weight of stem trimmed to 70cm (below) of ten lisianthus cultivars grown at 80 plants/m^2 in steam-sterilised soil in a closed tunnel with or without a black mulch, 2012. Cultivars are ranked in descending order of length or weight when grown with mulch. Each value is the mean of ten stems. In this figure and those following, cultivars are coded by the following letters:

A 'Charm White Blue'
B 'Velvet Purple Summer'
C 'Piccolo 2 Rose Pink'
D 'Arena Yellow'
E 'Ceremony Blue Flash'
F 'Excalibur Green'
G 'Magic Lilac'
H 'Mariachi Blue'
I 'Minuet Dark Purple'
J 'Rosita 3 Pink'
K 'Papillon Flash Pink'
L 'Vulcan 1 Green'
M 'Piccolo 2 White Pure'



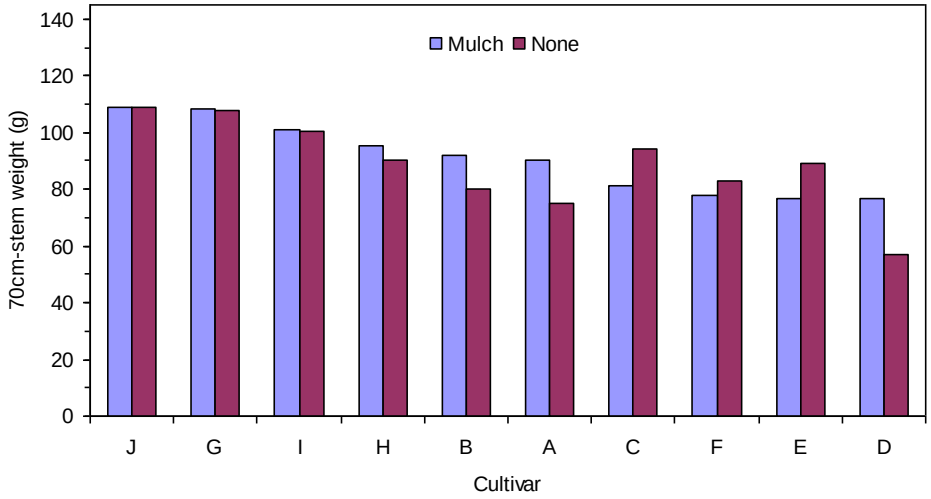


Table 10

Total stem lengths (cm) of ten lisianthus cultivars grown at 80 plants/m^2 in steam-sterilised soil in a closed tunnel with or without a black mulch, 2012: treatment and marginal means and LSD values (above) and analysis of variance (below).

Cultivar	*Mulch*	*No mulch*	*Cultivar means*	
A	80.1	77.1	78.6	
B	72.7	76.3	74.5	
C	91.6	81.3	86.4	
D	67.4	74.9	71.2	
E	78.3	83.4	80.8	LSD (5%) = 3.76
F	81.0	76.2	78.6	
G	71.6	74.4	73.0	
H	75.6	74.6	75.1	
I	75.3	73.2	74.3	
J	83.9	83.9	83.9	
Treatment means	77.7	77.5		
	LSD (5%) = 8.40			

Analysis of variance

Source of Variation	*SS*	*Df*	*MS*	*F*	*P*	*Significance*
Cultivar	439.975	9	48.8862	3.5462	0.0366	*
Mulch	0.253	1	0.2531	0.0184	0.8952	ns
Residual	124.069	9	13.7855			
Total	564.298	19				

Table 11

70cm-trimmed stem weights (g) of ten lisianthus cultivars grown at 80 plants/m^2 in steam-sterilised soil in a closed tunnel with or without a black mulch, 2012: treatment and marginal means and LSD values (above) and analysis of variance (below).

Cultivar	*Mulch*	*No mulch*	*Cultivar means*	
A	90.1	74.8	82.5	
B	91.8	80.3	86.0	
C	81.2	94.4	87.8	
D	76.7	57.2	66.9	
E	77.0	88.9	83.0	LSD (5%) = 7.77
F	78.0	82.8	80.4	
G	108.3	107.8	108.0	
H	95.5	90.0	92.8	
I	101.3	100.7	101.0	
J	108.8	108.8	108.8	
Treatment means	90.8	88.6		
	LSD (5%) = 17.38			

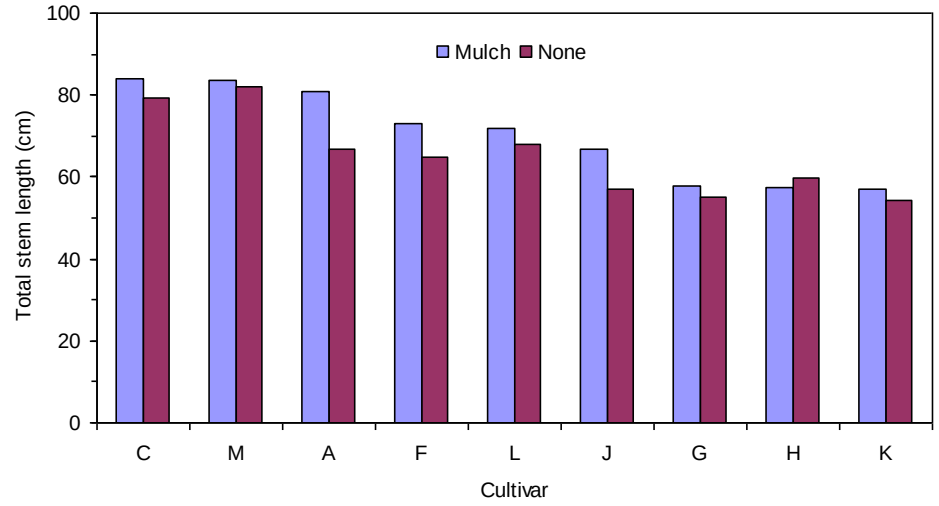
Analysis of variance

Source of Variation	*SS*	*Df*	*MS*	*F*	*P*	*Significance*
Cultivar	3112.92	9	345.8808	5.8592	0.0073	**
Mulch	25.98	1	25.9816	0.4401	0.5237	ns
Residual	531.29	9	59.0326			
Total	3670.20	19				

Figure 10

Total stem length (above) and weight of stem trimmed to 70cm (below) of nine lisianthus cultivars grown at 80 plants/m^2 in steam-sterilised soil in an open tunnel with or without a black mulch, 2012. Cultivars are ranked in descending order of length or weight when grown with mulch. Each value is the mean of ten stems. In this figure and those following, cultivars are coded by the following letters:

A 'Charm White Blue'
B 'Velvet Purple Summer'
C 'Piccolo 2 Rose Pink'
D 'Arena Yellow'
E 'Ceremony Blue Flash'
F 'Excalibur Green'
G 'Magic Lilac'
H 'Mariachi Blue'
I 'Minuet Dark Purple'
J 'Rosita 3 Pink'
K 'Papillon Flash Pink'
L 'Vulcan 1 Green'
M 'Piccolo 2 White Pure'



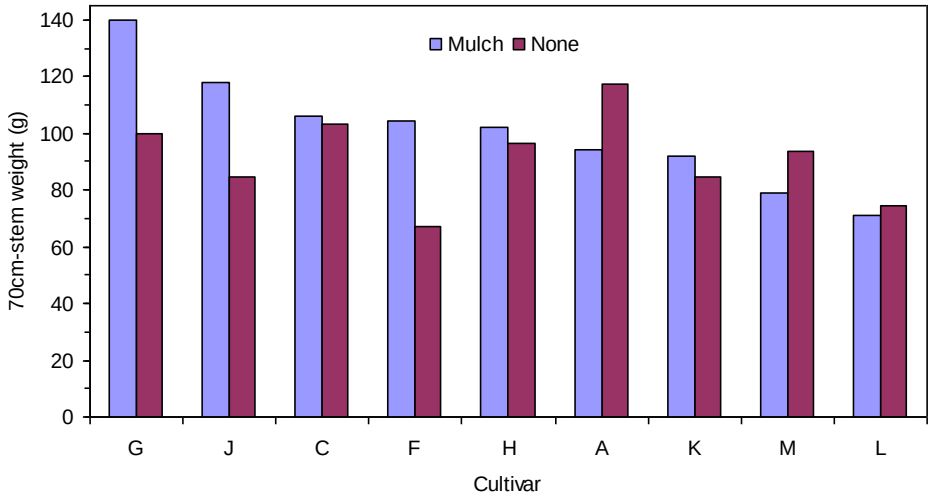


Table 12

Total stem lengths (cm) of nine lisianthus cultivars grown at 80 plants/m^2 in steam-sterilised soil in an open tunnel with or without a black mulch, 2012: treatment and marginal means and LSD values (above) and analysis of variance (below).

Cultivar	*Mulch*	*No mulch*	*Cultivar means*	
A	80.8	66.9	73.9	
C	84.1	79.3	81.7	
F	73.0	64.9	69.0	
G	57.8	55.0	56.4	
H	57.3	59.7	58.5	LSD (5%) = 3.76
J	66.8	57.0	61.9	
K	57.0	54.3	55.7	
L	71.7	67.8	69.8	
M	83.4	82.0	82.7	
Treatment means	70.2	65.2		
	LSD (5%) = 7.97			

Analysis of variance

Source of Variation	*SS*	*Df*	*MS*	*F*	*P*	*Significance*
Cultivar	1711.51	8	213.9397	17.9254	0.0002	***
Mulch	112.50	1	112.5000	9.4261	0.0153	*
Residual	95.48	8	11.9350			
Total	1919.49	17				

Table 13

70cm-trimmed stem weights (g) of nine lisianthus cultivars grown at 80 plants/m^2 in steam-sterilised soil in an open tunnel with or without a black mulch, 2012: treatment and marginal means and LSD values (above) and analysis of variance (below).

Cultivar	*Mulch*	*No mulch*	*Cultivar means*	
A	94.3	117.2	105.8	
C	106.1	103.1	104.6	
F	104.4	67	85.7	
G	140.2	99.7	120.0	
H	102.4	96.3	99.4	LSD (5%) = 17.45
J	117.7	84.7	101.2	
K	92.1	84.7	88.4	
L	71.2	74.3	72.8	
M	79.1	93.4	86.3	
Treatment means	100.8	91.2		
	LSD (5%) = 37.02			

Analysis of variance

Source of Variation	*SS*	*df*	*MS*	*F*	*P*	*Significance*
Cultivar	3160.72	8	395.0906	1.5326	0.2799	ns
Mulch	421.47	1	421.4672	1.6350	0.2369	ns
Residual	2062.28	8	257.7847			
Total	5644.47	17				

Figure 11

Total stem length of three lisianthus cultivars grown at 64, 80 or 96 plants/m^2 in steam-sterilised, Basamid-sterilised or non-sterilised soil in a closed tunnel with or without a black mulch, 2012. Each value is the mean of ten stems. See Figure 9 for key to cultivars.

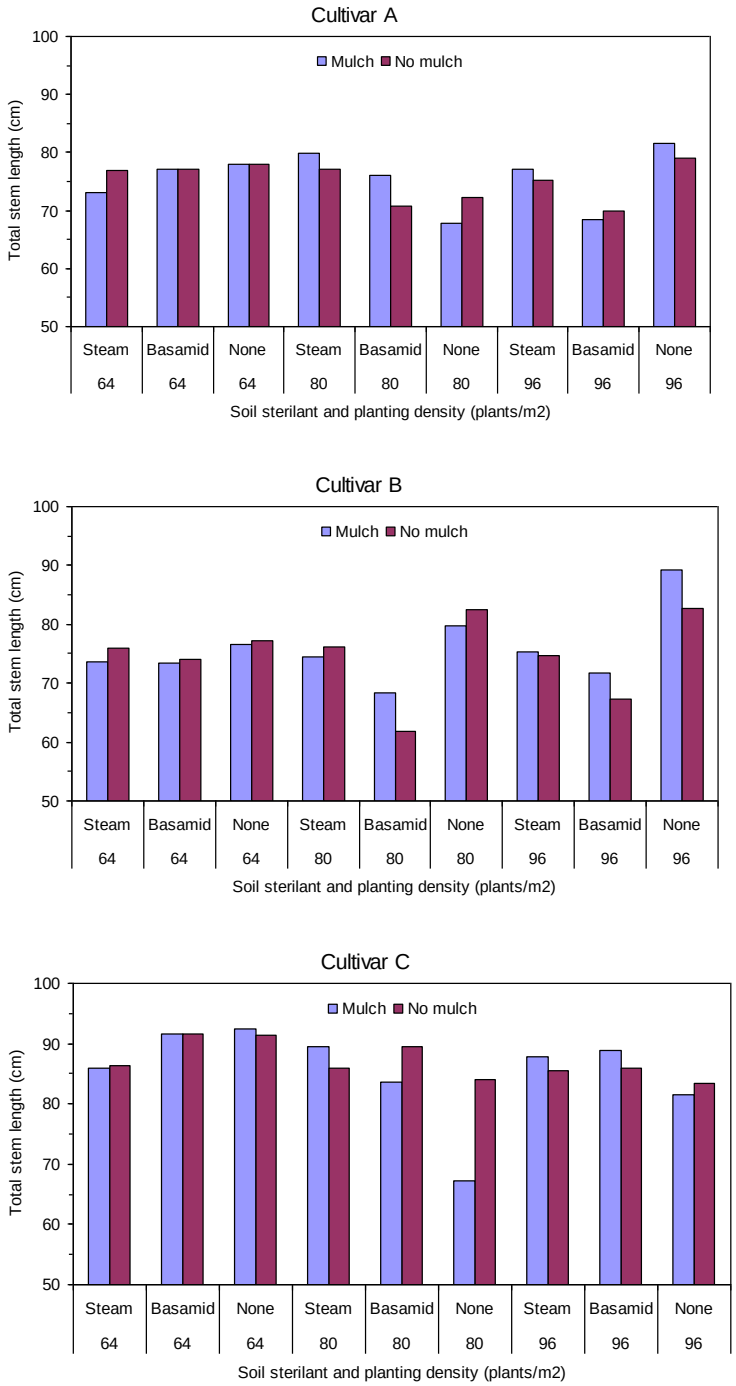


Figure 12

Weight of stem trimmed to 70cm of three lisianthus cultivars grown at 64, 80 or 96 plants/m^2 in steam-sterilised, Basamid-sterilised or non-sterilised soil in a closed tunnel with or without a black mulch, 2012. Each value is the mean of ten stems. See Figure 9 for key to cultivars.

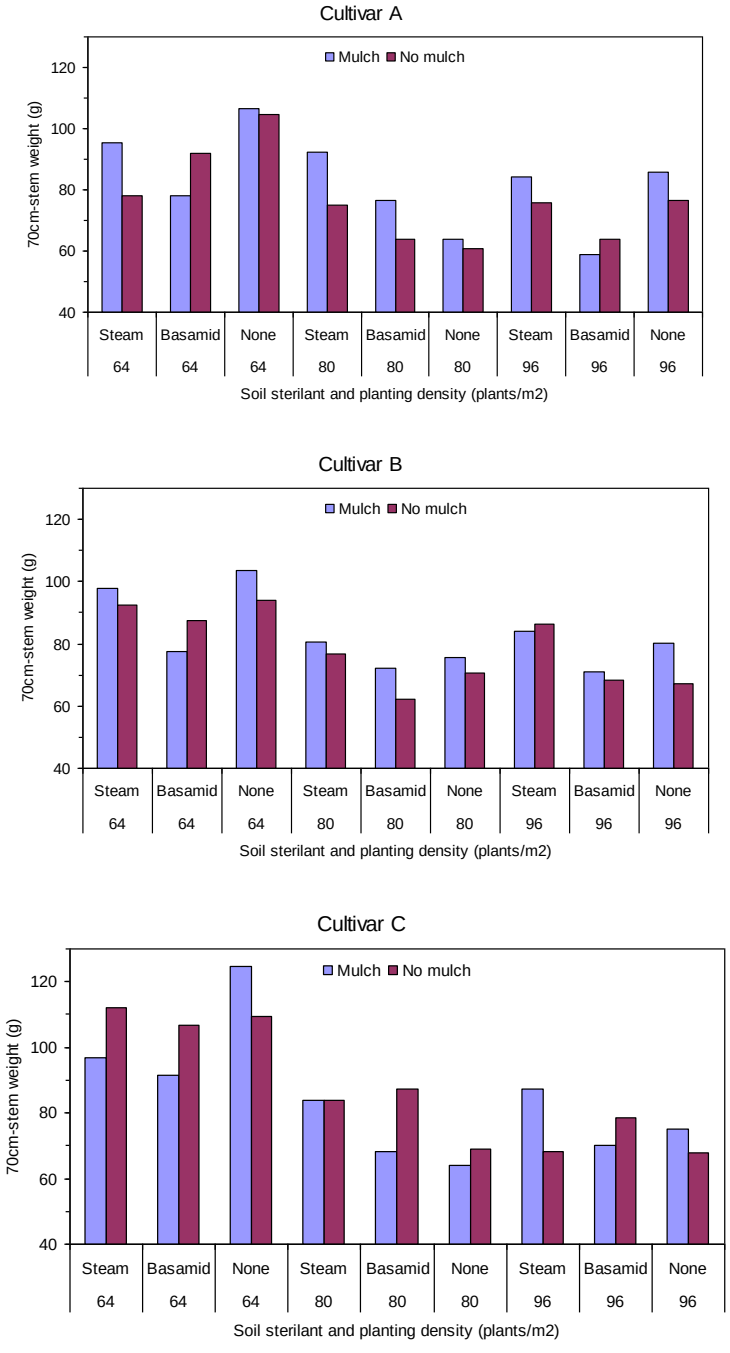
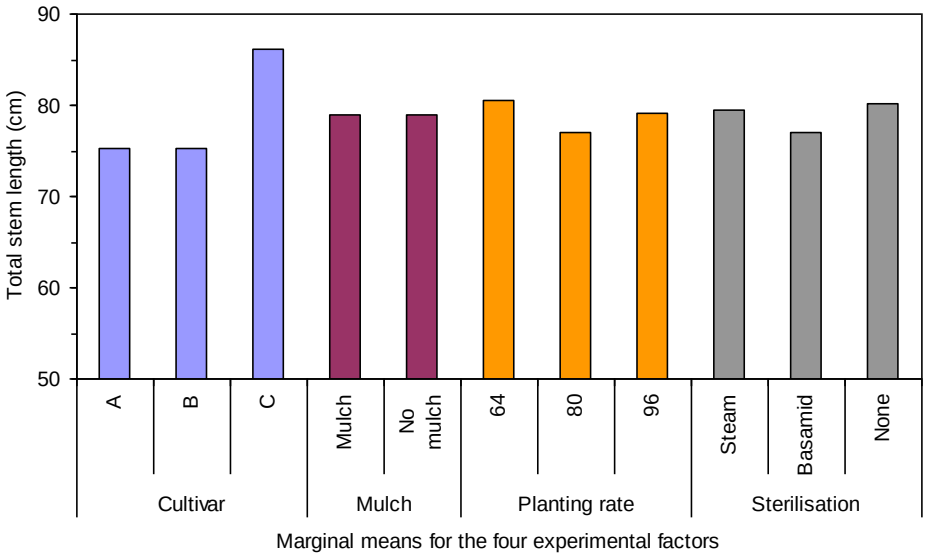
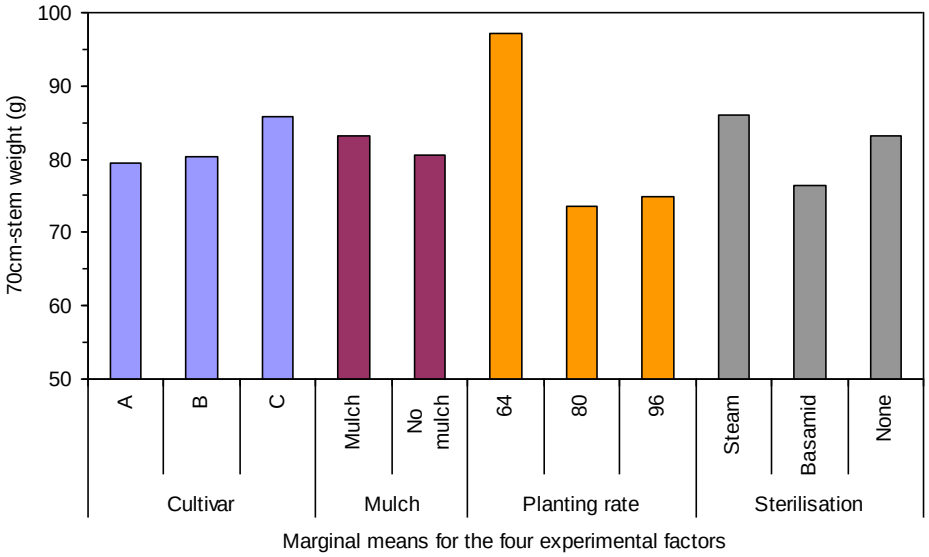


Figure 13

Total stem length (above) and 70cm-trimmed stem weight (below) of three lisianthus cultivars grown at 64, 80 or 96 plants/m^2 in steam-sterilised, Basamid-sterilised or non-sterilised soil in a closed tunnel with or without a black mulch, 2012. The values are marginal means for the four experimental factors – cultivar, planting density, soil sterilisation method and mulch. See Figure 9 for key to cultivars.





7. ORNAMENTAL BRASSICAS (*BRASSICA OLERACEA*)

Introduction

For economic success ornamental brassicas need to be grown on as low-cost a basis as practical, and this is likely to involve direct-drilling as increasingly practiced in the Netherlands. In 2009 a small trial was set-up to compare the production of ornamental brassicas by direct-drilling with traditional plug planting, but, owing to extreme dry weather, germination was erratic and no meaningful results were obtained. Since ornamental brassicas appear to be very sensitive to poor soil conditions, when the trial was repeated in 2010 it was located on a commercial nursery with more appropriate soil. The direct-drilled crop performed well, and as a result management at this nursery intends to direct-drill all its ornamental brassicas for routine cropping in future. Cultivar trials were also conducted in co-operation with the Centre at the same nursery in 2011.

2010 Cultivar trial and VL testing

Fifteen coded lines of new ornamental brassicas were grown and assessed in the field and then subjected to VL testing (By Winchester Growers Ltd). Between-cultivar differences in leaf colour and form were high, as was plant height, with average heights varied from 20 to 53cm. VL (after a simulated storage, transport and retail period) varied between 10 and 16 days. On this basis, seven were assessed as being promising as novelties or as alternatives to 'Crane' cultivars (see photographs). Other cultivars were rejected on the basis of being "too cabbage-like", having tendancy to bolt, being too short, being flat-topped (and collecting water on the head), not having clear colours, tendancy to leaf browning and producing many side-shoots. Unfortunately, owing to a change of staff at the seed supplier, it was not possible to source these exact cultivars in 2011.

(Photos: Winchester Growers Ltd)

A

B

E

F

H

I

J

2011 Cultivar trial and VL testing

Ten further lines (Florensis B.V.) were evaluated at the same nursery as the 2010 trials (Winchester Growers Ltd). Seed was sown in plugs in week 22 and transplanted to field plots in week 27, plug-plants being used rather than direct-drilling as only small batches of seed were available. Stems were harvested in week 40 and samples were subjected to VL testing.

None of the varieties presented any issues over their growing, though ‘Sunny Bright’ consisted of mixed seed, with some being white/pink and some rose, consequently resulting in a mix of head sizes. The overall selection produced a good range of head colour, from white to purple/pink, while many produced attractive heads, notably ‘Snow Bright’ with white veining in the pink/white/green leaves (see photographs below). Average stem length varied from 40cm (for ‘Kohju No. 2’, which was considered too short) to 62cm (for ‘Dream White’, possibly too tall). The percentage of stems cropped varied much between varieties – from only 5 or 10% in ‘Sunny Bright’ and ‘Kohju No. 2’, to 90% or more (in the tall varieties, ‘Lake Swan’, ‘Suruga Hatshi’ and ‘Dream White’). Overall the most promising varieties were ‘Moon Light’, ‘Snow Bright’ and ‘Dream Red’.

VL (after a simulated storage, transport and retail period) ranged from a satisfactory 12 days (in ‘Sunny Bright’, ‘Dream Light’, ‘Suruga Hatshi’ and ‘Lake Swan’) to 23 days (in ‘Moon Light’, ‘Hakuju’ and ‘Dream White’). All stems showed re-growth of the head while in the VL room.

(Photos: Winchester Growers Ltd)

‘Kohju No. 2’

‘Dream Red’

‘Moon Light’

‘Dream Light’

‘Hakuju’

‘Dream White’

‘Snow Bright’

‘Suruga Hatshi’

‘Sunny Bright’

‘Lake Swan’

Summary and outcomes

Work in the project confirmed that direct-drilling in the field was suitable for producing ornamental brassicas, and in order to reduce costs this is likely to be the way forward in field-scale prodcutuon in the future. A number of new lines was identified as suitable for commercialisation, particularly ‘Moon Light’, ‘Snow Bright’ and ‘Dream Red’, and these may well be futher exploited by growers after more field-scale trials undertaken by individual producers.

It was observed in these trials that plots of ornamental brassicas sometimes showed a distinct ‘edge effect’, the outside plants developing a ‘true cabbage’ appearance rather than producing a typical ornamental head, and the reasons for this need to be investigated.

8. PHLOX (*PHLOX PANICULATA*)

Introduction

Plots of phlox cultivars 'Icecap', 'Miss Marple', 'Miss Fiona' and 'Sugar Missy' (Bartels Stek) and 'Magical Dream', 'Magical Fragrance' and 'Magical Surprise' (Kolster B.V.) were established in 2009 in 'Pro-Tech' tunnel bay 3 at 16 plants/m^2. They were grown-on mainly to provide a resource to flower packers and supermarket buyers. The crop produced blooms far superior to an outdoor crop. Stems were picked over the period week 27 to 31. Associated tests showed a variable but generally acceptable VL, though grower observations have indicated that, by the time of marketing, there may be a natural petal drop from the first opened florets that detracts from the appeal of the stems, an area where further cultivar selection and post-harvest studies are needed.

The 'Magical' series showed outstanding resistance to powdery mildew. Unfortunately a disagreement between the propagator and breeder meant that they had to be withdrawn from the trial in 2010.

L to R: Phlox 'Magical Dream', Magical Fragrance' and 'Magical Surprise' in 2009 (Photos: Cut Flower Centre Ltd)



2011 (1) Crop performance

In 2011 the plots started to crop in early-July, again giving stems of far superior quality than an outdoor crop. Stem production is summarised in Table 14. Average trimmed stem weights varied from 32 to 38g. The number of stems cropped varied from a low 31/m^2 for 'Sugar Missy' to 104/m^2 for 'Miss Fiona'. The second flush was still developing when the polythene cover had to be removed from the tunnel due to deteriorating weather.

Table 14

Flowering performance in 2011 of four phlox cultivars planted in 2009 in 'Pro-Tech' bay 3. Stem weights recorded on the dates shown, usually corresponding to peak cropping time; the figures are means of 20 stems shown with standard deviations (SD) and stems were trimmed to 60cm before weighing.

Cultivar	*Recording date*	*Plot size (m^2)*	*Stems cropped*	*Stems cropped*	*Trimmed stem weight (g)*

			(no./plot)	*(no./m^2)*	*Mean*	*SD*
'Miss Marple'	06 July	9.0	780	87	35	8.6
'Miss Fiona'	06 July	4.5	466	104	32	10.2
'Ice Cap'	11 July	4.5	185	41	38	9.1
'Sugar Missy'	11 July	9.0	283	31	34	9.8

Clockwise from top left: Phlox 'Icecap' 'Miss Marple', 'Sugar Missy' and Miss Fiona' in 2012 (Photos: Cut Flower Centre Ltd)




2011 (2) VL testing

Samples of several lines, ten bunches of five stems each, were picked in week 24 for VL testing (By Intergreen (UK) Ltd). 'Sugar Missy' had an extremely good performance with a 14-day VL, and was the only variety not to drop any flower heads during the trial. Between vase-days 4 and 6 flower drop started on all bunches (except for 'Sugar Missy'), and, although the amount of flowers dropping was significant, a substantial amount of flowers still had the potential to open, giving the product continuous flowering. In these cultivars VL varied between 9 and 11 days. For all bunches the reason for failure was the development of withered stems, leaves and flower-heads.

2012 (1) VL testing

A selection of stems was sampled in weeks 34 for VL testing (by Butters Group Ltd). After simulated storage, transport and retail store phases, all achieved a 7-day VL at the consumer stage (Appendix 2). By the end of VL flowers and leaves were beginning to senesce and the water was becoming cloudy.

Summary and outcomes

Although no further trials work was carried out in 2012, the phlox were grown-on and, producing another crop much superior to that obtained outdoors, was used to provide high-quality samples to demonstrate to supermarket buyers.

This trial has shown that phlox is a good candidate for production in Spanish tunnels or cold glass and that the production of high-quality stems is possible, although there is still a potential issue with petal drop in the vase. However, as with so many other potential cut-flower lines, production needs to be developed in conjunction with the market outlets and as such the Centre feels it cannot take these trials any further. It is now up to the industry to commercialise this crop further. It must also be pointed out that many of the varieties trialled at the Centre have been superseded by new introductions which may (or may not) be less prone to petal drop. Growers should work closely with the propagator to choose varieties that are best suited to their needs.

9. SEDUM (*SEDUM SPECTABILE*)

Introduction

In 2010 five-plant outdoor rows of three sedum cultivars, *Sedum spectabile* 'Brilliant', 'Matrona' and 'Herbstfreude' (Kolster B.V.) were planted as a demonstration. They grew poorly, with no flowers being produced in the first year. After establishment, however, their subsequent growth was very vigorous (Table 15). Reports of their impressive stem count, length, weight and quality as cut-flowers suggested the original planting should be extended, and in 2011 plants of cultivars 'Mr Goodbud', 'Magical Bon Bon', 'Magical Lizzy' and 'Magical Twist' (Kolster B.V.) were transplanted (week 24) into outside beds, spaced at 25 x 25cm (a planting density of 16 plants/m^2). Both plantings were assessed in 2012.

L to R: Sedum spectabile 'Brilliant', S. 'Matrona' and S. 'Herbstfreude (Photos: Cut Flower Centre Ltd)



2012 Cultivar assessments

In 2012 stem counts and lengths were recorded and samples of stems taken for VL testing. The sedums planted in rows in 2010 had by now spread outwards to form substantial clumps, producing many dozens of stems per plant with average stem lengths of 70 to 80cm (Table 15). For the four cultivars planted in beds in 2011, the mean stem counts varied from 2.4 to 6.9 per plant, and mean stem lengths of 40 to 60cm were consistently shorter than in the 2010 plantings (Table 15).

Table 15

Stem counts and lengths in 2012 for sedum cultivars planted in 2010 (five-plant rows at 6 plants/m^2) or 2011 (ca 4m-long beds at 16 plants/m^2). Stem lengths based on a sample of 10 stems per plot.

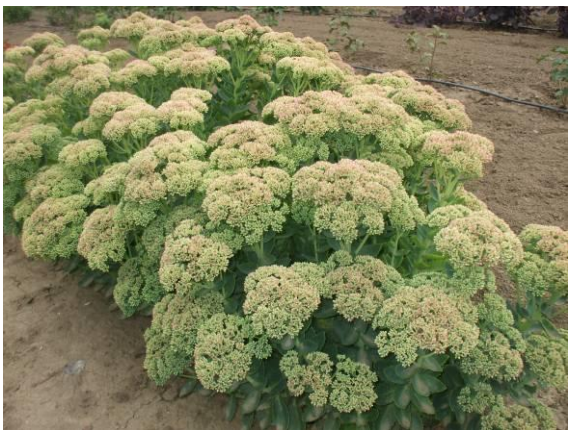
Cultivar and planting year	Stem length (cm)		Counts		Plot length (m)
	Average	SD	Per m^2	Per plant	
'Brilliant' 2010	72.5	4.09	-	89.6	-
'Herbstfreude' 2010	72.0	2.79	-	78.8	-
'Matrona' 2010	80.7	5.52	-	38.2	-
'Magical Twist' 2011	58.8	2.94	111	6.9	3.6
'Magical Lizzy' 2011	57.3	5.29	63	3.9	3.3
'Magical Bon Bon' 2011	56.8	2.44	49	3.1	4.6
'Mr Goodbud' 2011	40.7	2.87	39	2.4	3.7

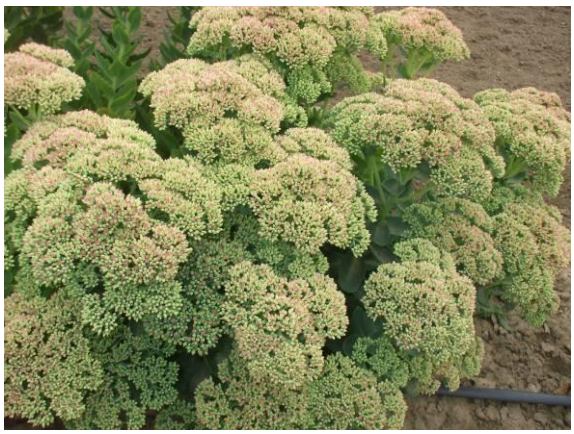
Stems were sampled in weeks 34 for VL testing (by Butters Group Ltd). After simulated storage, transport and retail store phases, all achieved at least a 7-day VL with the consumer, mostly remaining in good condition after 7 days (see Appendix 2 for results).

Summary and outcome

In 2012 this demonstration generated probably more attention at the Centre 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 commercial plantings are now being made.

Sedums, clockwise from top left: 'Magical Twist', 'Magical Lizzy', 'Magical Bon Bon' and 'Mr Goodbud' (Photos: Cut Flower Centre Ltd)





10. STOCKS (COLUMN) (*MATTHIOLA INCANA*)

Introduction

Column stocks for autumn-flowering were included in the Centre's programme in 2009, when the suggested advantage of using block-raised plants (i.e. a more robust plant which would establish more easily than plugs) was tested, with transplanting in weeks 26, 28 and 33. This showed that there was no advantage due to using blocks over plugs, and, in any case, the plants did not flower until after the tunnel's polythene had to be removed for the winter. These trials ensured that growers did not waste time and money by using this unsuccessful technique on a commercial scale. The technique has now been totally discounted by the industry.

2011 (1) Effect of gapping-up

In producing selectable stocks, propagators use automated gapping-up to replace single-flowered plants in the plug-tray by doubles, and this process has sometimes been seen to cause apparent damage to the plants. To investigate this issue, two plots were planted in week 27 in 'Pro-Tech' tunnel bay 2 with 'Centrum Pink', one using selected plugs from a non-gapped-up tray (hence less plants available to plant in the trial), the second from a tray previously gapped-up automatically. Flower quality was assessed and compared across the two plots, and showed minimal differences in stem length and weight and spike length (Table 16). Although this was only a small test, it may indicate there is no disadvantage in using automated gapping-up in this case. This finding has been confirmed in a more extensive trial undertaken at Greenmount College, Northern Ireland.

Table 16

Flowering performance of gapped-up and non-gapped up column stock 'Centrum Pink' following transplanting at week 27 into 'Pro-Tech' bay 2. Cropped and recorded in week 35, the figures are the means

of the indicated number of stems, with standard deviations (SD).

Treatment	*No. of stems*	*Untrimmed stem length (cm)*		*Untrimmed stem weight (g)*		*Flower spike length (cm)*	
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Gapped-up	100	46.4	2.24	79.0	16.0	14.1	2.58
Not gapped-up	47	47.6	1.98	75.0	12.2	12.9	2.77

2011 (2) Variety demonstration

In 2011 samples of three column stocks cultivars, 'Figaro Lavender', 'Anytime Yellow' and 'Centrum Pink' (Florensis B.V.) were transplanted to 2m-long beds in 'Pro-Tech' tunnel bay 2 in week 27 at 80 plants/m^2. The main aim was to assess 'Anytime Yellow', a new line. Cut-stems were harvested in week 35 and the main features are summarised in Table 17. Overall stem and spike lengths were similar in the three cultivars, the main differences being in (untrimmed) stem weight which varied from just under 50g in 'Anytime Yellow' to over 75g in 'Centrum Pink'. On the basis of this small sample, 'Anytime Yellow' appeared to be of average stem length but with a long spike, and relatively light in weight. Grower trials also demonstrated the potential for 'Anytime Yellow' to supplement the current range of commercial varieties available.

Table 17

Flowering performance of column stock cultivars following transplanting at week 27 into 'Pro-Tech' bay 2. Cropped and recorded in week 35, the figures are means of 30 stems shown with standard deviations (SD).

Cultivar	*Untrimmed stem length (cm)*		*Untrimmed stem weight (g)*		*Flower spike length (cm)*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
'Figaro Lavender'	52.1	2.22	58.5	11.52	15.3	2.93
'Anytime Yellow'	47.8	2.98	47.5	8.19	18.5	3.13
'Centrum Pink'	46.4	2.14	76.3	16.4	13.6	3.01

Column stocks, L to R: 'Figaro Lavender', 'Anytime Yellow' and 'Centrum Pink (Photos: Cut Flower Centre Ltd)

2011 (3) Summer flower failures in column stocks

Stocks are prone to failing or abnormal flower initiation when grown in summer temperatures. However, the 'Katz' series of column stocks was bred for resilience to higher temperatures, so work was planned to investigate summer cropping of 'Katz' varieties at the Centre in 2011.

The plugs (Florensis B.V.) did not arrive at the Centre until late-August 2011, but nevertheless they were planted in 'Pro-Tech' tunnel bay 2, which by then had had its cover removed. The plants 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 raised the question of whether, irrespective of its advantages as a crop in a warm summer, this series might be suitable as a late tunnel crop. Unlike many stocks varieties, the 'Katz' series is selectable for double flowers "only with difficulty" and automated methods are not sufficiently sensitive, so it has been suggested that selection in this case is not economic. However, in the right circumstances a profitable crop might still be possible if a reasonable percentage of double flowers can be obtained growing in a Spanish tunnel or under minimally heated or unheated glass. For this reason records were kept of the numbers of double and single flowers obtained (Table 18). The overall percentage of plants producing double flowers varied from 32 to 57% in different lines, or from 40 to 62% if plants with non-opening flowers

were excluded (in which case about half of the eight lines yielded around 60% of doubles). Further tests would be needed to determine if the performance of the different ‘Katz’ lines is consistent year-on-year, and this was investigated further in 2012.

Table 18

The percentage of 'Katz' column stocks cultivars with double flowers assessed without selection in the 'Pro-Tech' tunnel in 2011, based on samples of about 100 plants each.

'Katz' cultivar	*Number of sampled plants with different categories of flowers*			*Double plants as % of all plants*	*Double plants as % of all opening plants*
	Double	*Single*	*Non-opening*		
001 Red	33	26	30	37.1	55.9
002 Pink	38	57	13	35.2	40.0
003 Soft Pink	60	41	9	54.5	59.4
006 Light Mauve	68	41	9	57.6	62.4
007 Light Pink	68	46	11	54.4	59.6
008 Dark Mauve	58	55	7	48.3	51.3
009 White	40	44	38	32.8	47.6
010 Cream	29	29	27	34.1	50.0

2012 (1) Further demonstration of the 'Katz' range

Following on from the work in 2011 summer-flowering, non-selectable 'Katz' cultivars were grown to examine the proportion of single and double flowers. Plugs of four cultivars, 'Cherry Blossom', 'Pink', 'Yellow' and 'Lavender Light' (Florensis B.V.), were transplanted to 5m-long plots in 'Pro-Tech' tunnel bay 1 (week 28), planting at 64 plants/m^2.

After a weak start in which the plants lodged badly, they went on to produce some strong, long stems ready for cropping in weeks 34 and 35 (though they were held-over until week 37 for the Open Day). The plants were severely predated by rabbits, destroying 38% of the plants overall, with 'Cherry Blossom' and, especially, 'Lavender Light' being the favourite meals. The numbers of surviving plants with single and double inflorescences were recorded (Table 19). In the four cultivars the percentage of double plants varied relatively little, between 46 and 57% (overall average, 52%) of the non-predated plants.

Table 19

The number of 'Katz' column stocks cultivars that were predated and which produced flowers (double or single) in 2012. Results based on sampling plots of about 400 plants each.

'Katz' cultivar	*Number of sampled plants with different categories of flowers*			*Double plants as % of all plants that flowered*
	Double	*Single*	*Predated*	
Yellow	176	135	99	56.6
Pink	187	155	71	56.7
Lavender Light	85	90	295	48.6
Cherry Blossom	102	119	186	46.2

2012 (2) Variety trial in steamed and non-steamed soil

Forty-eight cultivars of column stocks, representing a number of series and including many numbered lines (Florensis B.V., for codes and colours see Table 20), were delivered as plugs and their performance assessed in both steamed and non-steamed soil. They were transplanted to 0.6m-long plots in steamed and non-steamed beds in 'Pro-Tech' tunnel bay 2 in week 21, planting at 64 plants/m^2.

Flowers were cropped mostly in week 30 and in general were regarded as of impressive quality. The overall stem lengths, weights of trimmed stems and spike lengths are given in Tables 20 - 22. The most obvious finding is the considerable variation in stem weight and length, and spike length, between cultivars, effects shown by the analysis of variance to be significant at a probability level of $P<0.01$ or better. The effects of growing in steamed or non-steamed soil depended on the variable being measured: there was a strong beneficial effect of steaming on stem weight ($P<0.001$; see Figure 14), a smaller (and commercially irrelevant) positive effect on stem length ($P<0.01$), and no significant effect on spike length. In terms of increased stem weight, more than half of the cultivars benefited from planting into steamed soil, with a smaller group showing little or no benefit (Table 21).

Summary and outcomes

The earlier work with column stocks demonstrated that there was no advantage in producing a late flowering crop from blocks rather than plugs. Blocks are much more expensive to buy and this piece of work was a good example of how a negative result can be advantageous to growers: it can prevent them from trying an unsuccessful production technique on a commercial scale, with all of the associated costs that they will then incur.

The trials looking at the mechanical gapping up of the plugs (and the results of the Greenmount trials) have shown that this technique is probably not contributing to the increased variability of cropping that has been seen in recent years.

Although the 'Katz' cultivars started poorly, they produced some long, strong stems that provoked quite positive feedback at the 2012 Open Day. It is for the market to decide whether there is a place for 'Katz', considering their variability, the numbers of single flowers, and the atypical leaf form.

The large cultivar trial also produced generally good quality stems and positive feedback, but varietal selection is important since most do better on sterilised soil. This trial also demonstrated the finding of HDC project PO 005 (Column stocks: an investigation into the

causes(s) of poor establishment, growth and flower uniformity in commercial crops) that some varieties, such as the ‘Figaro’ series, performed very poorly on non-steamed soil. The results of this trial, along with two associated grower variety trials, were viewed by about 95% of the UK column stock growers, and will help to determine variety choice for individual nurseries in 2013 and beyond. The grower opinions of the varieties viewed at the trials will also influence the direction of the breeding work in future years.

Figure 14

Stem weights (trimmed to 45cm length) of column stocks cultivars grown in steamed and non-steamed soil in 2012, based on samples of ten stems per plot. Cultivars ordered from left to right by decreasing benefit (in terms of stem weight) of using sterilised soil.

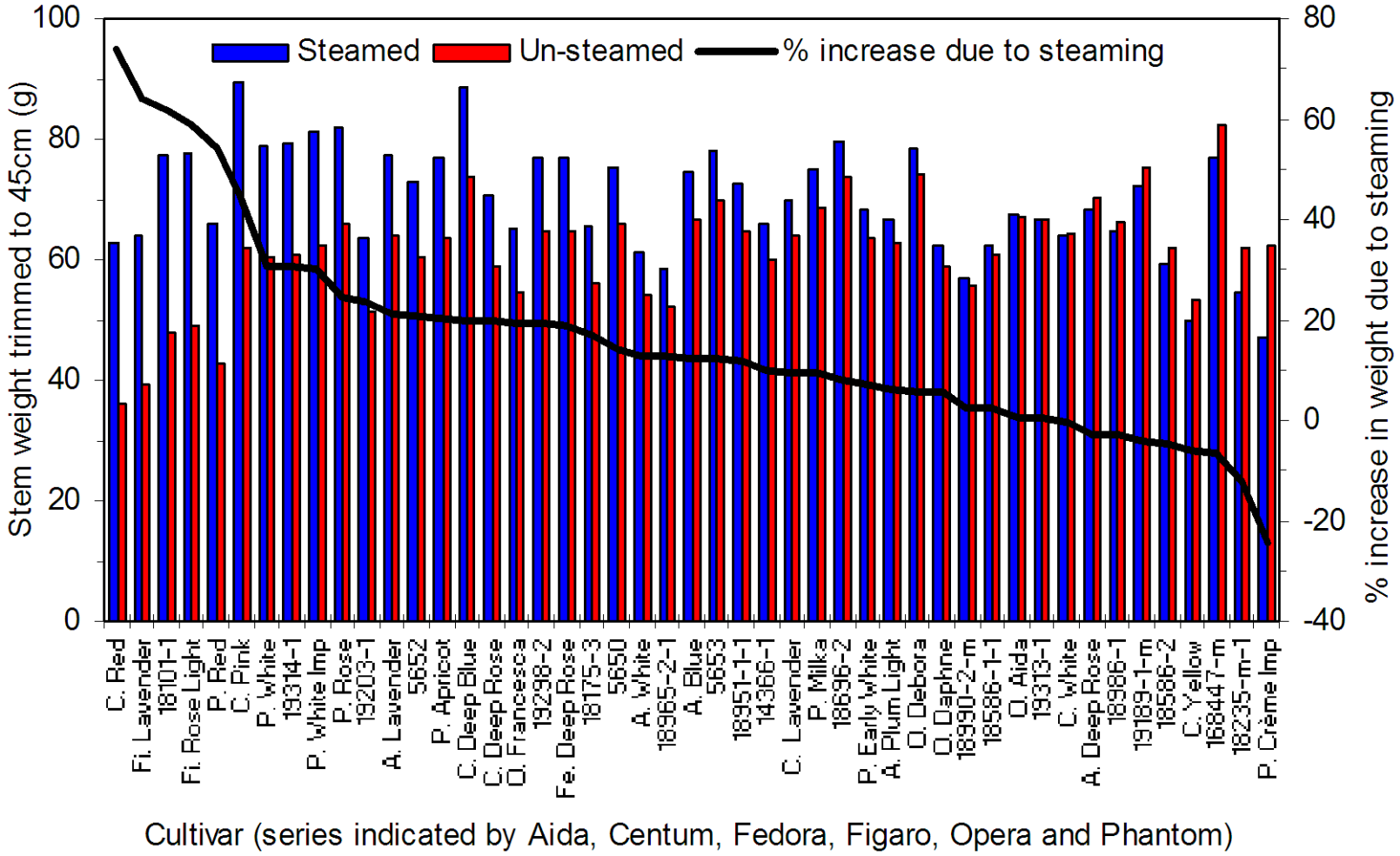


Table 20

Overall stem lengths (cm) of column stocks cultivars grown in steamed and non-steamed soil in 2012: treatment and marginal means and LSD values (above) and analysis of variance (below); based on samples of ten stems per plot, data for cultivar 19103-1 excluded from analysis of variance.

Cultivar	*Flower colour*	*Steamed*	*Non-steamed*	*Cultivar means*	
5650	White	46.2	44.7	45.5	
5652	White	45.6	44.0	44.8	
5653	White	47.7	46.6	47.2	
14366-1	Pink	51.8	44.9	48.4	
168447-m	White	40.8	44.4	42.6	
18101-1	Lavender	52.7	41.6	47.2	
18175-3	Peach	51.4	42.4	46.9	
18235-m-1	Cream	40.2	44.9	42.6	
18586-1-1	Blue/purple	60.8	61.2	61.0	
18586-2	Blue/purple	61.2	62.2	61.7	
18696-2	White	43.0	43.5	43.3	
18951-1-1	Peach	50.9	42.7	46.8	
18965-2-1	Lavender	50.9	44.2	47.6	
18986-1	Cream	44.7	51.5	48.1	
18990-2-m	White	39.9	40.8	40.4	
19103-1	Red	53.3	n.a.*	n.a.	
19189-1-m	White	48.5	46.5	47.5	
19203-1	Blue/pink	54.0	52.2	53.1	
19298-2	White	47.9	45.4	46.7	
19313-1	White	46.2	46.5	46.4	
19314-1	White	47.7	48.7	48.2	
Aida Blue	Blue/purple	49.8	48.0	48.9	
Aida Deep Rose	Pink	53.6	48.9	51.3	
Aida Lavender	Lavender	48.4	45.6	47.0	LSD (5%)
Aida Plum Light	Pink	52.7	49.3	51.0	= 1.31
Aida White	White	43.3	46.3	44.8	
Centum Lavender	Lavender	46.0	42.3	44.2	
Centum Deep Blue	Blue/purple	46.8	48.7	47.8	
Centum Deep Rose	Pink	43.5	42.2	42.9	
Centum Pink	Pink	44.3	40.4	42.4	
Centum Red	Red	49.1	40.0	44.6	
Centum White	White	38.9	43.0	41.0	
Centum Yellow	Cream	36.3	42.4	39.4	
Fedora Deep Rose	Pink	45.9	42.6	44.3	
Figaro Lavender	Lavender	46.8	35.9	41.4	
Figaro Rose Light	Pink	45.6	39.6	42.6	
Opera Aida	White	49.8	48.5	49.2	
Opera Daphne	Pink	48.8	41.9	45.4	
Opera Debora	Blue/purple	46.2	44.0	45.1	
Opera Francesca	Red	48.8	44.2	46.5	
Phantom Apricot	Apricot	48.9	40.6	44.8	

Phantom Crème Imp	Cream	35.5	42.6	39.1
Phantom Early White	White	44.5	47.3	45.9
Phantom Milka	Blue/purple	49.0	48.1	48.6
Phantom Red	Red	45.6	42.3	44.0
Phantom Rose	Pink	43.6	40.2	41.9
Phantom White	White	46.2	47.6	46.9
Phantom White Imp	White	47.2	46.0	46.6
Treatment means		47.2	45.3	
		LSD (5%) = 6.34		

Analysis of variance

Source of Variation	*SS*	*df*	*MS*	*F*	*P*	*Significance*
Cultivar	1799.16	46	39.1121	3.9281	<0.0001	***
Steaming	85.79	1	85.7877	8.6158	0.0052	**
Residual	458.02	46	9.9570			
Total	2342.97	93				

* n.a., data not available (insufficient plants)

Table 21

Stem weights (trimmed to 45cm length) (g) of column stocks cultivars grown in steamed and non-steamed soil in 2012: treatment and marginal means and LSD values (above) and analysis of variance (below); based on samples of ten stems per plot, data for cultivar 19103-1 excluded from analysis of variance.

Cultivar	*Steamed*	*Non-steamed*	*Cultivar means*
5650	75.1	65.9	70.5
5652	73.0	60.5	66.8
5653	78.1	69.7	73.9
14366-1	65.9	60.1	63.0
168447-m	76.8	82.4	79.6
18101-1	77.2	47.8	62.5
18175-3	65.5	56.1	60.8
18235-m-1	54.4	62.1	58.3
18586-1-1	62.2	60.9	61.6
18586-2	59.1	62.1	60.6
18696-2	79.6	73.8	76.7
18951-1-1	72.6	64.9	68.8
18965-2-1	58.6	52.1	55.4
18986-1	64.6	66.4	65.5
18990-2-m	56.9	55.6	56.3
19103-1	64.9	n.a.*	n.a.
19189-1-m	72.0	75.1	73.6
19203-1	63.4	51.3	57.4
19298-2	77.0	64.6	70.8
19313-1	66.8	66.6	66.7
19314-1	79.3	60.8	70.1
Aida Blue	74.6	66.5	70.6
Aida Deep Rose	68.2	70.1	69.2
Aida Lavender	77.4	63.8	70.6

Aida Plum Light	66.5	62.7	64.6	LSD (5%) = 2.94
Aida White	61.3	54.3	57.8	
Centum Lavender	69.9	64.0	67.0	
Centum Deep Blue	88.6	73.9	81.3	
Centum Deep Rose	70.5	58.9	64.7	
Centum Pink	89.4	61.9	75.7	
Centum Red	62.9	36.2	49.6	
Centum White	64.1	64.4	64.3	
Centum Yellow	50.0	53.3	51.7	
Fedora Deep Rose	77.0	64.8	70.9	
Figaro Lavender	64.1	39.1	51.6	
Figaro Rose Light	77.8	49.0	63.4	
Opera Aida	67.5	67.2	67.4	
Opera Daphne	62.2	59.0	60.6	
Opera Debora	78.5	74.2	76.4	
Opera Francesca	65.2	54.7	60.0	
Phantom Apricot	76.7	63.7	70.2	
Phantom Crème Imp	47.1	62.3	54.7	
Phantom Early White	68.2	63.6	65.9	
Phantom Milka	74.9	68.6	71.8	
Phantom Red	65.9	42.8	54.4	
Phantom Rose	81.8	65.8	73.8	
Phantom White	79.0	60.4	69.7	
Phantom White Imp	81.2	62.5	71.9	
Treatment means	70.0	61.4		
	LSD (5%) = 14.25			

Analysis of variance

Source of Variation	*SS*	*df*	*MS*	*F*	*P*	*Significance*
Cultivar	5376.33	46	116.8767	2.3259	0.0025	**
Steaming	1720.05	1	1720.0469	34.2303	<0.0001	***
Residual	2311.47	46	50.2493			
Total	9407.84	93				

* n.a., data not available (insufficient plants)

Table 22

Flower spike length (cm) of column stocks cultivars grown in steamed and non-steamed soil in 2012: treatment and marginal means and LSD values (above) and analysis of variance (below); based on samples of ten stems per plot, data for cultivar 19103-1 excluded from analysis of variance.

Cultivar	*Steamed*	*Non-steamed*	*Cultivar means*
5650	14.6	12.5	13.6
5652	14.3	11.6	13.0
5653	13.9	11.7	12.8
14366-1	18.6	15.2	16.9
168447-m	14.3	15.9	15.1
18101-1	19.5	17.7	18.6
18175-3	21.0	17.1	19.1

18235-m-1	14.4	17.7	16.1	
18586-1-1	18.4	22.9	20.7	
18586-2	16.9	23.6	20.3	
18696-2	13.6	14.5	14.1	
18951-1-1	21.0	17.0	19.0	
18965-2-1	18.4	18.4	18.4	
18986-1	14.9	17.4	16.2	
18990-2-m	25.1	26.5	25.8	
19103-1	17.5	n.a.*	n.a.	
19189-1-m	16.1	18.6	17.4	
19203-1	17.0	18.2	17.6	
19298-2	13.2	11.4	12.3	
19313-1	12.4	12.0	12.2	
19314-1	12.2	14.0	13.1	
Aida Blue	16.3	16.5	16.4	
Aida Deep Rose	18.2	17.7	18.0	
Aida Lavender	17.3	19.3	18.3	
Aida Plum Light	18.2	19.9	19.1	LSD (5%) = 0.75
Aida White	13.2	14.0	13.6	
Centum Lavender	18.2	20.1	19.2	
Centum Deep Blue	13.2	15.5	14.4	
Centum Deep Rose	16.5	15.8	16.2	
Centum Pink	17.3	15.1	16.2	
Centum Red	21.6	15.6	18.6	
Centum White	11.8	14.6	13.2	
Centum Yellow	11.1	13.6	12.4	
Fedora Deep Rose	19.1	16.2	17.7	
Figaro Lavender	16.7	12.8	14.8	
Figaro Rose Light	16.6	13.0	14.8	
Opera Aida	13.9	13.3	13.6	
Opera Daphne	19.3	17.2	18.3	
Opera Debora	16.9	14.3	15.6	
Opera Francesca	18.9	18.9	18.9	
Phantom Apricot	17.4	15.4	16.4	
Phantom Crème Imp	11.3	14.0	12.7	
Phantom Early White	13.5	14.7	14.1	
Phantom Milka	16.3	16.0	16.2	
Phantom Red	18.1	18.4	18.3	
Phantom Rose	16.9	14.6	15.8	
Phantom White	14.4	16.0	15.2	
Phantom White Imp	15.4	15.6	15.5	
Treatment means	16.3	16.2		
		LSD (5%) = 3.66		

Analysis of variance

Source of Variation	*SS*	*df*	*MS*	*F*	*P*	*Significance*
Cultivar	692.25	46	15.0488	4.5405	<0.0001	***
Steaming	0.31	1	0.3102	0.0936	0.7610	NS
Residual	152.46	46	3.3143			

Total	845.02	93

* n.a., data not available (insufficient plants)

11. SUNFLOWERS (*HELIANTHUS ANNUUS*)

Introduction

In 2010 sunflowers were included in the Centre's trials for the first time. Although sunflowers are already a well-established crop in the UK, their size means that harvesting and handling require significant resources. To facilitate handling, and perhaps mechanical harvesting, it was planned to investigate new dwarf cultivars as well as the use of plant growth regulators on standard cultivars.

The standard cultivar 'Sunrich Orange' and a number of dwarf varieties, 'Galilee Adami', 'Zohar Yellow', 'Premier Light Yellow' and 'Premier Lemon' (sourced by Simon Crawford, Flowers by Design) were direct-drilled by hand to outside beds in weeks 24, 25 and 26, sown 12.5cm apart in rows with four rows 35cm apart across the bed (*ca* 32 seeds/m^2). It was planned to treat the standard cultivar with growth regulators, but the extremely dry weather that followed resulted in poor germination and establishment, especially for the last two sowings. This was followed by wet, windy weather that adversely affected establishment and growth.

Stem lengths were recorded at picking stage for 30 stems of each cultivar from the first sowing. The average stem lengths of the standard cultivars were 151, 129 and 109cm for 'Galilee Adami', 'Sunrich Orange' and 'Zohar Yellow', respectively, and 48 and 45cm for 'Premier Light Yellow' and 'Premier Lemon'. The later sowings, and the Premier Light Yellow and Lemon, failed to produce stems of marketable quality. This trial therefore needed to be repeated.

2011 (1) Trial of dwarf cultivars

Eight cultivars, some available only with code numbers, were sourced by Simon Crawford (Flowers by Design) from various seed-houses (see Table 23). They were sown by hand 10cm apart in rows, with four rows 35cm apart across the bed (*ca* 36 seeds/m^2) into outdoor beds (weeks 19 and 22).

Percentage seed germination varied from 38 to 100, depending on the variety and sowing date (Table 23). While some were trial varieties, this showed that further work is needed by the breeder to ensure germination rates are commercially viable. Stem lengths and weights and flower diameters were recorded at peak cropping.

Cropping dates varied from 10 August to 1 September across the cultivars sown in week 19, and from 18 August to 2 September for the sowing in week 22 (Figure 15). In the earlier

sowing ‘Early Sunrise’ (KB 114), ‘Jua Maya’ and ‘Stellar Sun’ (KB 105) were faster to crop than the other varieties, whereas cropping dates for the later sowing were more uniform with the exception of ‘Stellar Sun’ (KB 105) which was again quick to crop. Flower diameters varied from 15 to 19cm for the various cultivars (Figure 15). The flowers of ‘Jua Maya’ were relatively small from both sowings.

Total stem lengths and weights are shown in Figure 16. For most, but not all, cultivars, stem lengths were greater from the later sowing, but this was not always accompanied by increased stem weight, there appearing to be no obvious relationship between the two. ‘Happy Face’ (KB 116) was the most dwarf cultivar trialled, from both sowings, and produced a high stem weight.

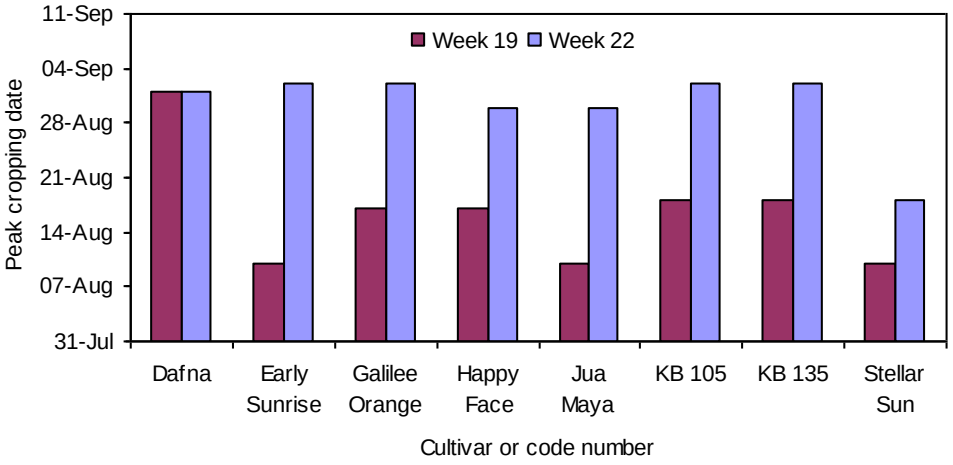
Table 23

Seed germination and flowering performance of eight sunflower cultivars following sowing at the weeks shown into outdoor beds. The lengths and weights are means of 30 stems shown with standard deviations (SD).

Cultivar (and code number, if appropriate)	*Sowing week*	*% germin-ation*	*Date recorded*	*Total stem length (cm)*		*Total stem weight (g)*		*Flower diam. (cm)*	
				Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
‘Dafna’	19	100	01-Sep	112.9	6.70	366	91.5	16.5	1.01
‘Early Sunrise’ (KB 114)	19	67	10-Aug	127.3	10.09	398	89.9	14.9	1.17
‘Galilee Orange’	19	81	17-Aug	149.5	8.36	574	121.5	17.9	1.50
‘Happy Face’ (KB 116)	19	38	17-Aug	87.2	5.62	688	177.9	19.0	1.77
‘Jua Maya’	19	64	10-Aug	125.9	21.95	430	107.1	14.9	1.30
KB 105	19	69	18-Aug	118.4	7.95	347	123.1	14.3	1.29
KB 135	19	42	18-Aug	111.9	8.51	511	173.4	17.2	1.72
‘Stellar Sun’ (KB 105)	19	42	10-Aug	109.9	11.23	728	140.3	17.9	2.21
‘Dafna’	22	86	01-Sep	112.4	6.04	367	90.9	16.4	1.00
‘Early Sunrise’ (KB 114)	22	72	02-Sep	152.8	13.64	482	208.6	19.2	1.66
‘Galilee Orange’	22	100	02-Sep	164.8	7.82	526	109.0	19.3	1.37
‘Happy Face’ (KB 116)	22	88	30-Aug	91.8	5.80	392	72.6	16.2	1.77
‘Jua Maya’	22	93	30-Aug	122.6	5.65	209	56.1	15.3	1.47
KB 105	22	81	02-Sep	152.6	8.49	653	150.7	19.2	1.42
KB 135	22	97	02-Sep	162.0	11.86	676	237.4	19.2	1.79
‘Stellar Sun’ (KB 105)	22	63	18-Aug	127.1	6.45	509	121.6	15.0	3.12

Figure 15

Main cropping periods (above) and flower diameter (below) for eight sunflower cultivars following sowing at week 19 or 22 in outdoor beds



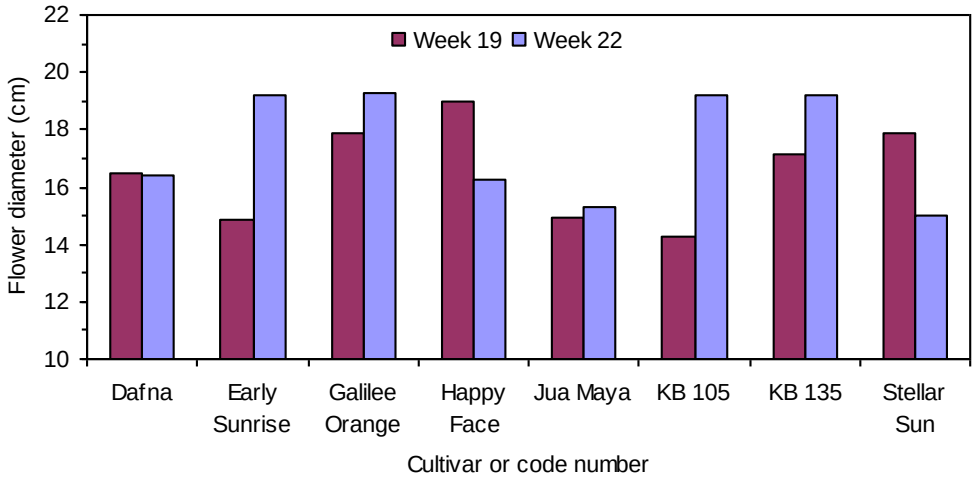
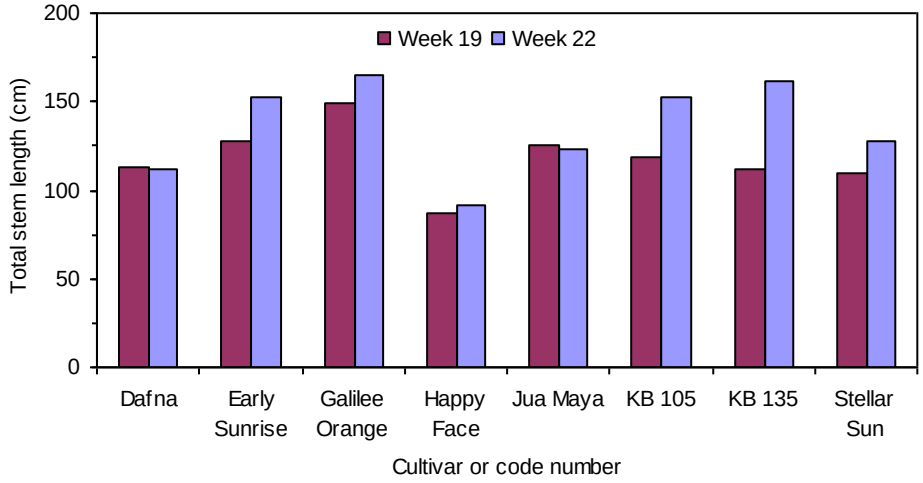
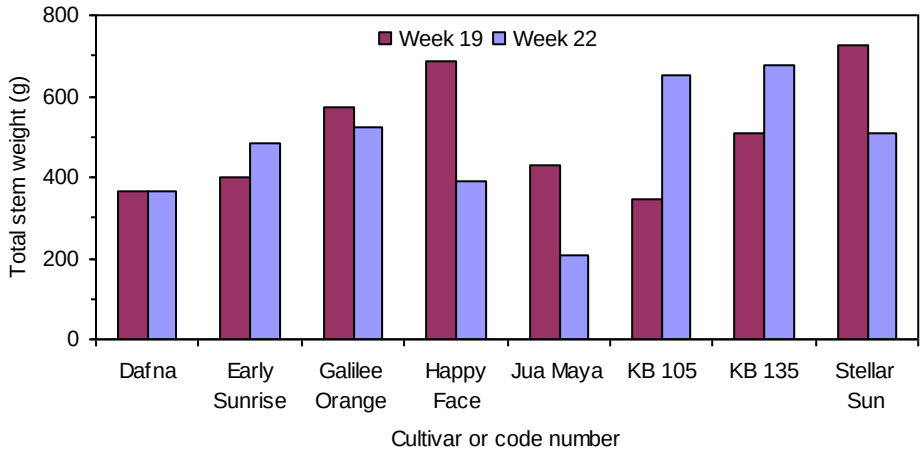


Figure 16

Total stem lengths (above) and weights (below) for eight sunflower cultivars following sowing at week 19 or 22 in outdoor beds.





2011 (2) Growth regulator treatments

Seed of standard sunflower ‘Sunrich Orange’ were sown, using the same methods as above, in one outside bed in each of weeks 19, 22 and 26. The growth retardant ‘B-Nine SG’ was applied as a foliar spray to ‘run-off’ on part of each bed, using a rate of 6g product/L, in week 32 and again in week 33. This was applied when the plants were about half a metre tall. B9 was chosen because sunflower belong to the compositae family i.e. the same as chrysanthemums for which the use of B9 is the industry standard. As it was visually obvious that the retardant application had had no effect on plant height, no further observations were made.

2011 (3) VL testing

Bunches of a selection of promising cultivars ie ‘Galilee’, ‘Happy Face’, ‘KB105’, ‘Sunrich’ and ‘Dafna’ were subjected to standard VL testing (by JZ Flowers). Stems were harvested to

buckets and placed in a cold store on 31 August 2011, moved to a VL test room the next day, and placed in vases after a further 4 days. The outstanding result was the quality and long VL of cultivar ‘Dafna’.

2012 (1) New cultivar testing

In 2012 three novel cultivars were evaluated. Seed of sunflowers ‘Vincent’s Fresh’ and ‘Vincent’s Choice’ (Sakata) and a new line, VV10-4 (Simon Crawford, Flowers by Design) were direct-seeded by hand 10cm apart in rows with four rows 35cm apart across the bed (*ca* 36 seeds/m^2) into 15m-long plots outdoors (week 23) and in ‘Pro-Tech’ tunnel bay 2 (week 31).

In the tunnel ‘Vincent’s Choice’ averaged 1.9m-tall stems weighing 0.20kg, with a flower diameter of nearly 18cm, while ‘Vincent’s Fresh’ was shorter and lighter (1.6m, 0.15kg), with a similar head size (Table 24). ‘VV 10-4’ was only a little shorter than ‘Vincent’s Fresh’, but had much lighter stems (0.11kg) and smaller heads (12cm) and therefore showed potential as a more cost-effective product.

Table 24

Flowering performance of novel tunnel-grown sunflower cultivar; figures are means of 5 stems per plot, shown with standard deviations (SD). Stems trimmed to 65cm for weighing.

Cultivar	*Overall length (cm)*		*65cm-stem weight (g)*		*Flower diameter (cm)*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
'Vincent's Fresh'	157.6	6.02	155.0	6.08	17.8	0.84
'Vincent's Choice'	191.6	3.85	207.0	17.52	17.6	0.55
'VV 10-4'	149.6	4.51	116.0	26.75	12.0	0.71

The very wet weather of 2012 was not favourable to the Centre’s outdoor sunflower crop, as was the case with many commercial crops, resulting in a combination of poor germination and damage to the petals from wind and rain. However, with an average height of 1.1m for ‘Vincent’s Choice’, 1.2m for ‘Vincent’s Fresh’ and 0.75cm for ‘VV 10-4’ (stems cropped week 43) it would appear as if the new coded variety does have real potential as a truly dwarf variety. A grower assessment of the three cultivars judged ‘VV 10-4’ as the best of the three, having a bright but not too big flower-head, a good VL and having the advantage, compared with standard sunflower varieties, of manageability.

Summary and outcomes

The 2011 variety trial gave the opportunity for growers to view a wide range of the recent sunflower introductions and compare this with their own trials of some of the same varieties. It is for growers themselves to determine the most appropriate variety for their situation, but

‘Dafna’ looked very promising from the 2011 trials, with VV 10-4 from the 2012 trial showing potential as a truly dwarf variety for both outdoor and protected production.

12. SWEET PEAS (*LATHRYUS ODORATUS*)

Introduction

Recurring expressions of interest in developing a low-input system of sweet pea production led to trials at the Centre in 2011.

2011 (1) Testing a low-input system

A metal 'A' frame with netting was erected along the length of 'Pro-Tech' bay 1. Seed was sourced from various seed-houses (Simon Crawford, Flowers by Design). Seeds were germinated in small, individual pots that were transplanted as required. Five varieties were planted in rows along either side of the framework in week 22 at each of 30 or 50cm-spacings, with each plot *ca* 5m-long. The 50cm-plants were pinched once, while the 30cm-plants were not pinched.

(Photos: Cut Flower Centre Ltd)

The first stems were picked in mid-July, cropping continuing for an extended period. The initial results were very encouraging, with a large number of long, high-quality stems being produced from both growing formats. Data are summarised in Table 25. The average length of stems approached 30cm, with slightly longer stems from the 50cm, pinched plots. However, floret numbers were consistently low, with 3.3 to 3.8 florets per stem. Table 25 also shows the very high yields obtained with sweet peas – usually between 1,000 and 2,000 per 5m-long plot.

2011 (2) VL testing

Two bunches of 'Valerie Harrod' and 'Gwendoline' were picked in week 34 for VL testing (By Intergreen (UK) Ltd). All bunches had a similar performance irrespective of cultivar and whether a powder or liquid formulation of Chrysal Universal flower food. Stems started to fail from vase-day 2 onwards, and all bunches showed 50% stem failure on vase-day 5 due to bud drop.

Table 25

Flowering performance in 2011 of sweet pea cultivars sown in 'Pro-Tech' bay 1, either as a non-pinched crop spaced 30cm apart, or a pinched crop spaced 50cm apart. Stem lengths and floret counts recorded as the trial progressed; the figures are means of 50 stems shown with standard deviations (SD).

Cultivar	*Growing system*	*Total number of stems cropped**	*Stem length (mm)*		*Floret count (no./stem)*	
			Mean	*SD*	*Mean*	*SD*
'Bristol'	30cm, non-pinched	1610	24.0	3.68	3.6	0.53
'Gwendoline'		1939	26.4	3.02	3.8	0.43
'Our Harry'		661	28.6	3.73	3.6	0.57
'Valerie Harrod'		1751	27.0	3.71	3.6	0.49
'White Supreme'		2279	25.7	3.00	3.7	0.44
'Bristol'	50cm, pinched	1208	27.7	4.73	3.4	0.61
'Gwendoline'		808	31.3	3.79	3.6	0.50
'Our Harry'		1126	27.9	4.21	3.4	0.53
'Valerie Harrod'		1798	29.4	4.12	3.7	0.46
'White Supreme'		1775	26.1	3.95	3.3	0.63

* until 30 September 2011

Examples of sweet peas grown in 2011; left-hand picture shows (L to R) 'Gwendoline', 'Valerie Harrod' and 'White Supreme' (Photos: Cut Flower Centre Ltd)


Summary and outcomes

This investigation was originally instigated as a result of a request from a supermarket to develop a lower specification, and therefore a lower price point, for the product. The trial produced a large number of good quality stems, but the average floret count was only three or four and this was not received favourably by the supermarkets at the 2011 Open Day. As

a result, the trial was not repeated in 2012: it is likely that sweet peas will remain a small-scale, high-value niche product.

13. PRELIMINARY ASSESSMENTS

Introduction

In addition to the main subjects trialled, a number of possibly more speculative flower crops was included as smaller assessments in order to gauge their potential and determine grower interest.

Amaranthus (Amaranthus caudatus)

After a specific request from a grower, a small selection of amaranthus cultivars was grown in 2011 to assess their potential as a cut-flower crop for the UK. Plugs of 'Caudatus Red', 'Pygmy Torch', 'Oeschberg', 'Red Cathedral' and 'Green Thumb' (Florensis B.V.) were planted in week 21 to 3m-long plots in 'Pro-Tech' tunnel bay 1 at a planting density of 64 plants/m^2. Cropping started in week 30. As can be seen from the photographs below, the length and form of the inflorescences varied considerably, though all were vigorous. The smaller-flowered types were thought to have potential as cut-flowers for supermarket sales, whereas the larger types have scope for a specialist grower, for example, for architectural displays in larger settings. From comments received from the industry, it would be useful to look at an earlier cropping stage than the photos below that might be more appropriate to develop their commercial potential. It was hoped to continue with a variety demonstration in 2012 and use the material to investigate cropping stages and VL, but there were difficulties in obtaining the plugs and the trial was therefore not repeated.

Amaranthus 2011, clockwise from top left: 'Green Thumb', 'Red Cathedral', 'Pygmy Torch', 'Oeschberg' and 'Caudatus Red' (Photos: Cut Flower Centre Ltd)



Campanula (*Campanula* spp.)

(Photos: Cut Flower Centre Ltd)

Campanula was considered by the MG to have some potential some background, and an initial assessment was carried out in 2012. Three cultivars, ‘Champion Lavender’, ‘Champion Pink’ and a numbered line 135 5005 (Florensis B.V.), were delivered as plugs and transplanted to 1.65m-long plots at a density of 80 plants/m^2 in ‘Pro-Tech’ tunnel bay 1 in week 22.

The three varieties cropped in week 31, producing stem counts of 98, 96 and 99 stems/plot, respectively. There was a positive response from growers, and samples were taken to show interested parties and for VL testing. This has resulted in a renewed interest in this crop amongst some growers.

L to R: Campanula 'Champion Lavender', 'Champion Pink' and Florensis '135 5005' in 2012 (Photos: Cut Flower Centre Ltd)



Celosia (Celosia cristata)

Although celosia has been tried as a cut-flower in the UK before, there does not seem to be a demand at the present time. Plugs of celosia cultivars 'Bombay Flora' and 'Bombay Fire' (Florensis B.V.) were planted in 1.65m-long beds in 'Pro-Tech' tunnel bay 1 in week 23, at 64 plants/m^2. This gave a very good quality product and there was a good market reaction, especially at the Open Day, though there would be only limited scope to shift any volume.

Stems were sampled in week 34 for VL testing (by Butters Group Ltd). After simulated storage, transport and retail store phases, they achieved only a 2-day VL with the consumer (see Appendix 2 for results). They showed rapid yellowing of the foliage, senescence of flowers, and rotting of the neck.

L to R: Celosia 'Bombay Fire' and 'Bombay Flora' in 2012 (Photos: Cut Flower Centre Ltd)


Dahlia (*Dahlia hybrida*) - 'Karma' series

More than one member of the MG has confirmed the supermarkets' interest in sourcing dahlias as a cut-flower, but this is currently being resisted since VL issues are still unresolved. Dahlias are generally considered to have a poor VL, and this series was developed to deal with this shortcoming. In 2009 a demonstration of 18 'Karma' cultivars (Keep Smiling BV) was grown. Cuttings were planted in week 28 to outdoor beds and in 'Pro-Tech' tunnel bay 3 at 9 plants/m^2. 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'. Although the crops grew vigorously, especially under protection, and the blooms were eye-catchingly striking, the results of VL tests were disappointing. The flowers failed to reach the minimum of 11 days VL considered necessary to be a commercial proposition, while the vase-water became highly contaminated.

Despite these disappointing results, productivity and flower quality were so impressive that the plants were maintained as a demonstration, and there was a proposal to develop an HDC-funded project to examine the post-harvest qualities of dahlia blooms on a more strategic level.

Delphinium (Delphinium elatum)

Although delphinium was trialled in the early work of the Centre (2007 and 2008), some new cultivars from Hilverda suggested a fresh demonstration would be worthwhile. Plugs of cultivars 'Sky Waltz', 'Trick Pink', 'Trick', 'Tango Dark Blue' and 'Yellow Trick' were planted in 1.65m-long beds in 'Pro-Tech' tunnel bay 3 and outdoors in 2012 in week 25, at a density of 16 plants/m^2. The weather in 2012 proved unsuitable for producing stems of quality, also noted by other growers this year.

Eryngium (*Eryngium* spp.)

Responding to a grower's request, in 2011 a small selection of new eryngium cultivars was grown to assess the varieties available and their potential as a crop in the UK. Plugs of cultivars 'Marbella', 'Blue Bell' and 'Arabian Dawn' (Armada Young Plants), 'Deep Blue' (Hem Zaden and Florensis B.V.) and 'Magical Purple Falls', 'Magical Blue Falls' and 'Magical Cloud' (Kolster B.V.) were transplanted into 4m-long plots in 'Pro-Tech' tunnel bay 2 (week 28) and outside (week 32). Planting was at 64 plants/m^2. Few flowers were produced in 2011 and the plantings were grown-on for assessment in 2012.

Marketable stems were produced in the second year but the owing to plant losses as result of the cold weather and the effect of the wet summer / autumn of 2012, it was not possible to record any meaningful yields.

However, the samples sent to the packers and supermarkets generated considerable interest in this crop and as a result a new planting will be made in 2013. Stems were sampled in week 34 for VL testing (by Butters Group Ltd). After simulated storage, transport and retail store phases, all achieved a 7-day VL with the consumer (see Appendix 2 for results).

Eryngium in 2011, L to R: 'Arabian Dawn', 'Blue Bell' and 'Marbella' (courtesy Armada Young Plants)



Eryngium in 2011, L to R: 'Magical Purple Falls', 'Magical Cloud' and 'Magical Blue Falls' (courtesy Kolster B.V.)



Hardy foliage

A wide range of hardy foliage plants (Kolster B.V.) was planted in outside beds (at spacings of 100 x 100cm unless otherwise noted) in spring 2010:

- *Calicarpa bodiniera* 'Profusion'
- *Cornus alba* 'Flaviramea', C. alba 'Kesselringil' and C. alba 'Sibirica'
- *Corylus avellana contorta* (80 x 80cm)
- *Cotinus* 'Magical Green Fountain' and C. 'Royal Purple' (both 80 x 75cm)
- *Hedera helix arborescens* (50 x 50cm)
- *Philadelphus* 'Snowbelle' (70 x 70cm)
- *Photinia* 'Purple Peter' and P. 'Red Robin' (both 70 x 70cm)
- *Quercus palustris* and *Q. rubra* (both 60 x 50cm)
- Salix alba 'Darts Snake', S. 'Caradoc' and S. udensis 'Sekka'
- *Symphoricarpos* 'Bright Fantasy', *S.* 'Charm Fantasy' and *S.* 'Magical Pride' (all 90 x 90cm)
- *Viburnum opulus* 'Compactum' (80 x 80cm), *V. opulus* 'Roseum' (80 x 80cm), *V. tinus* (60 x 60cm) and *V. tinus* 'Red Spirit' (60 x 60cm)

Some examples of *Hypericum* and further varieties of *Symphoricarpos* (also from Kolster B.V.) were added in spring 2011:

- *Hypericum inodorum* 'Magical Green Fall', *H. inodorum* 'Magical Tropical Fall' *and H. inodorum* 'Magical White Fall' (all 60 x 70cm)
- *Symphoricarpos* 'Magical Pride' and *S*. 'Magical Avalanche' (both 90 x 90cm)

Stems of *Cotinus*, *Hypericum* and *Symphoricarpos* were sampled in weeks 35 to 39 for VL testing (by Butters Group Ltd). After simulated storage, transport and retail store phases, the VL achieved with the consumer varied from 1 to 7 days for the different subjects (see Appendix 2 for results). From the extent of foliage wilting there appeared to be a problem of water uptake despite vase-chemicals being used. Now that the plantings are established and industry interest is confirmed, in future years foliage yields will be recorded.

Examples of hardy foliage plants at the Centre, photographed in 2011

L to R: Symphoricarpos, Photinia and Hedera (Photos: Cut Flower Centre Ltd)



L to R: Calicarpa, Viburnum and Philadelphus (Photos: Cut Flower Centre Ltd)



L to R: Cornus and Cotinus (Photos: Cut Flower Centre Ltd)

L to R: Corylus and Salix (Photos: Cut Flower Centre Ltd)

Rudbeckia (Rudbeckia hirta)

Rudbeckia is another potential cut-flower crop, and its inclusion in the programme of the Centre was suggested by a supermarket representative. Initial demonstrations with seed-raised annuals were carried out in 2011 and 2012. In 2011, cultivars 'Hirta My Joy' and 'Hirta Green Eye' (Florensis B.V.) were transplanted into two 4m-long plots in 'Pro-Tech' tunnel bay 1 in week 21 at 8 plants per m^2. 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 were tested in 2012. These were cultivars 'Herbstsonne' and 'Goldquelle' supplied as 7cm pots (Kolster B.V.) and were planted in 2m-long beds in 'Pro-Tech' tunnel bay 3 at a density of 8 plants/m^2 in week 25. While the crop did show some market potential, many of the stems were quite weak and as is the case with most perennial crops, their true potential is likely to show up in year 2 and beyond, so assessment must await 2013.

Discussion

Summary of findings

Since its inception, the Centre's demonstrations and trials have involved some 32 main types of cut-flower as well as some ornamental grasses and a good selection of hardy foliage species. On the basis of the results, the species tested can be divided into five groupings, as follows.

(a) Many of the subjects, despite their inherent attractiveness and usefulness in other areas of horticulture, have failed to impress cut-flower specialists as having sufficient potential for being more widely grown as commercial cut-flowers in the UK to justify their continuing in trials. These include ageratum, caryopteris, cynara, echinops, godetia, larkspur, lychnis, solidago, veronica and the ornamental grasses.

(b) Several other types have impressive flowers but have only been trialled for one or two years and no definite decision about them can yet be made (some are herbaceous perennials where a two- to three-year period of establishment is needed): these include campanula, eryngium, rudbeckia and the hardy foliage crops.

(c) Yet others are attractive and sometimes vigorous, but need to find a market niche since they cannot be seen as cut-flowers grown on a large-scale, including amaranthus, celosia and sweet pea.

(d) Some other striking species appear to present intractable issues that are unlikely to be resolved without dedicated research: thus dahlia and zinnia have a brilliant colour range and flower form but have poor lasting qualities in the vase.

Although some of the above examples might be dismissed as 'negative information', that can be useful in saving growers the expense of test-growing them themselves.

(e) As previously stated by the MG, to stimulate the expansion of the UK cut-flower sector through the take-up of novel species, the Centre needs to identify only a relatively small number of potential alternative species. This the Centre has achieved through presenting encouraging results with lisianthus, delphinium scheduling, ornamental brassica, phlox, sedum, column stocks and dwarf sunflower as well as with new cultivars of 'older' crops - antirrhinum, *Aster ericoides*, spray carnation, China aster and 'Breanthus' annual dianthus. The state of progress with these types will now be summarised.

Trumpet cultivars of antirrhinum are quite distinct in flower form from the typical snapdragons. They are novel, vigorous and exotic-looking. Grown in tunnels they produce stems in sufficient quantities and of sufficient length, weight and VL, though they may need to be marketed at a later stage of development than conventional snapdragons in order to display their unusual form. A flowering period from week 25 to week 35 was practical through manipulating planting times and making use of the second flush. As a result of the Centre's trials, sufficient agronomic information is now available about trumpet cultivars for the industry to make a decision about commercialising them.

Some new, mainly **double-flowered cultivars of *Aster ericoides*** were first demonstrated as a pinched crop for September and October flowering in tunnels. Grown in tunnels, a disadvantage is that their vigour means adequate support and trimming are needed, but tunnel-grown pinched plants yield numerous strong stems ready for cropping from around week 36 to 38 depending on variety and weather conditions. Outdoor-grown plants were more manageable, but of poorer quality. The industry responded well to these lines, taking numerous sample bunches for demonstration to potential packers and buyers. A wide range of attractive cultivars has been trialled as early- and late-planted crops and crops over-wintered in tunnels. The availability of so many varieties means that careful selection is needed, and it may prove difficult to find cultivars with all the right characteristics: for example, in one trial 'Cassy', 'Linda' and 'Cirina Dark' produced above-average numbers of longer-than-average stems but they were low in weight, while 'Blue Tail', 'Cape Town' and 'Cassandra' produced the heaviest stems but these were relatively low in number as well as shorter. The VL of these cultivars was also quite variable, from 5 to 11 days for a 20%-florets-dead stage, and in general the stems were too long and often had widely spread branches requiring significant trimming before packing. Overall, the 'Double Fun' series were the best performers for weight and flower presentation, with a satisfactory VL between 7 and 21 days (easily reaching or exceeding the requirement for a 5 or 7 day VL in mixed bouquets). One important goal is achieving a longer cropping season, but even with the range of planting combinations tested at the Centre it was not possible to spread cropping over more than 4 weeks without some form of daylight manipulation. The earliest picking

was from the over-wintered tunnel crop, which flowered 7 to 10 days earlier than the outdoor crop. Consequently some further work is needed, and in 2013 it is planned to use blackouts in an attempt to spread the season and obtain flowers in two flushes.

'Solomio' and 'Star' are recently introduced ranges of **'novelty' spray carnations** and they were tested at the Centre in 2012. Adverse weather this year prevented them reaching their full potential, but nevertheless they received positive feedback from the industry due to the unusual form of their flower. It was suggested that these novel cultivars could be marketed at a relatively more advanced stage of development than traditional spray carnations, branded accordingly. Further trials are planned for 2013.

The evaluation of striking **new German cultivars of China aster**, the 'Krallen' and 'Gala' series, was started at the Centre in 2007 and, because of the interest shown, has continued to 2012. A large number of cultivars has been trialled and various agronomic trials carried out, including comparisons of plug- and block-raised plants and the effects of planting date and growth retardant treatments. Largely as a result the 'Krallen' series were grown by local producers in commercial quantities in 2009 and 2010; 'Karthauser' and 'Perser' were in great demand by the supermarkets. Despite this commercial potential, however, post-harvest quality subsequently became an issue because of petal-spotting and flower-tip browning, the cause of which has not yet been identified. Losses became so severe that 'Krallen' is unlikely to be grown again on any large scale until this disorder can be remedied. Petal-spotting was less severe, but still present, on other cultivars. The Centre needs to investigate how this issue should be taken forward and to continue to seek alternative "blue" varieties. Growth retardants other than daminozide (which has so far been ineffective in these trials) should be evaluated.

Other **new China aster cultivars of the 'Standby', 'Benary Princess', 'Matador', 'Meteor' and 'Ribbon' series** were evaluated in trials, largely as alternatives for 'Krallen'. None of these appeared to have a real prospect as alternative varieties, but this work will be continued in 2013 using earlier planting dates and additional new varieties. The 'Meteor' series appears to be susceptible to Tomato Spotted Wilt Virus. The 'Bonita' range generated interest from growers of the traditional 'Matsumoto' varieties, but did not attain its full potential in trials in 2012 owing to poor weather, and it appears growers may undertake their own trials in 2013.

'Breanthus', a new range of annual dianthus, was assessed in 2012. The demonstration received a positive market response from retailers and growers, with the tight, spherical head considered especially appealing. However, the crop was planted unavoidably late due

to wet weather, and the poor season probably had a negative effect on crop performance, so the results should be used cautiously and further trials are needed before these cultivars can be recommended (or otherwise) by the Centre. In 2013 it is planned to investigate staggered planting for continuity of supply, as well as differences between pinched and non-pinched plants and between flowers of the first and second flushes.

Lisianthus has achieved considerable popularity in the UK as a rather 'exotic' cut-flower. Although its longer growing season compared with many other flowers, and high heat and light requirements, restrict the number of rounds that could be accomodated in a year, the possibility of growing a short summer 'spot' crop in Spanish tunnels was suggested in discussions. In 2010 crops were grown in a tunnel fitted with side skirts and doors, and the results were impressive, with high-quality blooms, good stem strength and no pest and disease problems. Investigations were continued to examine a wide range of cultivars, soil sterilisation, planting density and growth in 'open' and 'closed' tunnels. Production in an open tunnel was much more risky, and was not successful during the last two years of trials. With this quality in a home-grown product, it was considered lisianthus could generate a good return if the supermarkets would pay a premium price for it. The Centre has demonstrated the potential of lisianthus as a UK crop for closed Spanish tunnels, and it now up to the industry to develop it further.

For economic success **ornamental brassicas** need to be grown on as low-cost a basis as practical, which is likely to involve direct-drilling (as increasingly practiced in the Netherlands). In trials a direct-drilled crop performed well, resulting in management at a local nursery deciding to direct-drill most of its ornamental brassicas in future. Cultivar trials conducted in co-operation with the same grower led to several lines being assessed as promising novelties or as alternatives to 'Crane' cultivars. New lines particularly identified as suitable for commercialisation included 'Moon Light', 'Snow Bright' and 'Dream Red', and these could well be further exploited by UK growers after more field-scale trials by individual producers.

Phlox cultivars were established in 2009 in plots in a tunnel, and produced blooms of far superior quality to an outdoor crop. The 'Magical' series showed outstanding resistance to powdery mildew. Although no further trials were carried out in 2012, the plots were grown-on and produced another crop much superior to that obtained outdoors, and was used to provide high-quality samples for demonstration to supermarket buyers. The trial showed that phlox is a good candidate for production in Spanish tunnels or cold glass and that the production of high-quality stems is possible, although there is still a potential issue with petal drop in the vase. As with so many other potential cut-flower lines, production needs to be

developed in conjunction with the market outlets, and as such the Centre feels it cannot take the phlox trials any further and it is up to the industry to decide whether to commercialise phlox.

After establishment, plots of three **sedum cultivars** produced impressive stem counts, with the stem length, weight and quality required for cut-flowers. The original planting was supplemented with further cultivars. Standard VL tests showed a long post-harvest life and the ability to crop flowers over a wide range of developmental stages. In 2012 the sedums generated probably more attention at the Centre than any of the other crops. Numerous samples were made available to the industry for information and promotion, and commercial plantings are now being made.

Column stocks for autumn-flowering were included in the Centre's programme in 2009, when the suggested advantage of using block-raised plants was tested. This showed there was no advantage due to using blocks over plugs, so ensuring growers did not waste resources with an unsuccessful technique. Stocks, however, are prone to failing or abnormal flower initiation when growing in summer temperatures. The 'Katz' series was bred for resilience to higher temperatures, so work was planned to investigate summer cropping. This raised the question of whether, irrespective of its advantages as a crop in a warm summer, the series might be suitable as a late tunnel crop. Unlike many stocks varieties, the 'Katz' series is selectable for double flowers "only with difficulty" and automated methods are not sufficiently sensitive, but in the right circumstances a profitable crop might still be possible if a reasonable percentage of double flowers can be obtained growing in a Spanish tunnel or under minimally heated or unheated glass. The overall percentage of plants producing double flowers varied from 32 to 57% in different lines; further tests are needed to determine if the performance of the different 'Katz' lines is consistent year-on-year. An extensive variety trial in 2012 showed the effects of growing in steamed or non-steamed soil depended on the variable being measured: there was a strong beneficial effect of steaming on stem weight, and a smaller positive effect on stem length. In terms of increased stem weight, more than half of the cultivars benefited from planting into steamed soil, with a smaller group showing little or no benefit. Trials also demonstrated that some varieties, such as the 'Figaro' series, performed very poorly on non-steamed soil (see also HDC project PO 005). The results of this trial, along with two associated grower variety trials, were viewed by about 95% of the UK column stock growers, and will help to determine variety choice for individual nurseries in 2013 and beyond. The grower opinions of the varieties viewed at the trials will also influence the direction of the breeding work in future years.

In 2010 sunflowers were included in the Centre's trials for the first time. Although sunflowers are already a well-established crop in the UK, their size means that harvesting and handling absorb significant resources. To facilitate handling, and perhaps mechanical harvesting, it was planned to investigate **new dwarf sunflower cultivars** as well as using plant growth regulators on standard cultivars. The variety trials gave the opportunity for growers to view a wide range of the recent sunflower introductions and make comparisons with their own trials. It is for growers themselves to determine the most appropriate variety for their situation, but 'Dafna' looked very promising from the 2011 trials, while VV 10-4 from the 2012 trial showed potential as a truly dwarf variety for both outdoor and protected production.

The future role of the Centre

The Centre's programme for 2010 to 2012 had three overarching aims.

1. To provide information about cut-flower crops and growing formats new to UK production, enabling UK growers to make informed choices about new marketing opportunities. As summarised above, information – negative or positive – has been discovered and made available to the cut-flower industry on over 30 types of cut-flowers.
2. To identify a small number of definite new opportunities for UK cut-flower growers. As a result of trials and demonstrations, new opportunities for UK growers have been presented in the shape of lisianthus, ornamental brassica, phlox, sedum, column stocks and dwarf sunflower, as well as with new cultivars or series of some 'older' crops, namely antirrhinum, Aster ericoides, spray carnation, China aster and 'Breanthus' (annual dianthus).
3. To enhance the perception of UK cut-flowers and flower growers. It is believed that this has been achieved to a substantial extent through the media of HDC publications and annual Open Days (the latter attracting a large number of growers from this small, disparate sector), and by both formal and informal contacts with seed houses, packers and multiple retailers, this including visits to the Centre and the distribution of many samples of cut-flowers for promotional purposes.

These aims were realised through a series of specific objectives.

1. Setting up field trials to demonstrate and evaluate novel cut-flower crops for growing in the open ground or under Spanish tunnels. A large number of demonstrations of 'novel' cut-flower crops have been undertaken, including both of unfamiliar species and of new cultivars and cultivar series of older types.
2. Carrying out cultivar trialling to identify the most appropriate cultivars. Several of the Centre's trials included substantial numbers of cultivars, and many of these emphasised the continued importance of careful varietal selection.
3. Identifying and solving agronomic issues evidenced in these crops. The bulk of the Centre's work has included problem-solving trials with practical outcomes, such as optimising plant spacings for efficient production, developing continuity or scheduling programmes based on manipulating planting dates, and the effects of pinching, module type, growing environment, soil sterilisation and growth regulators.
4. Testing the production of commercial-sized blocks of selected crops on commercial farms. This approach has been applied to ornamental brassicas and to new German cultivars of China asters.

5. Disseminating information from the trials to the industry. This has been achieved largely through results published in HDC News, samples distributed to the industry, initiating a series of NCFC/HDC factsheets, well attended Open Days and the development of a Centre web-site.

At the time of writing a proposal is being finalised to continue the work of the Centre over the period 2013 to 2017. Based on a development of the current concept the main changes will include:

- The information-gathering element will be formalised to include on-going reviews of (a) new cut-flower crops and cultivars available from breeders, seed houses, plant producers and other trials programmes worldwide, (b) the international literature (printed and web-based) on cut-flower crops, especially in respect of novel crops and improving cut-flower quality, and (c) the trends in cut-flower production in the UK and internationally.
- The experimental programme will include (a) demonstrations and assessments of novel cut-flower types, (b) evaluation of basic agronomic requirements for species and cultivars judged to have potential for producing high-quality cut-flowers in the UK, (c) the investigation of quality-enhancing factors (such as height control, control of nutritional disorders, pests or diseases and improvement of post-harvest quality), (d) the validation of novel crops through grower assessments on commercial sites and (e) the broadening of the scope of the project to include bulbous-types (probably lily and gladiolus initially).
- The Centre will reduce its focus on New Product Development (NPD) and will expand trials relating to problem solving of existing key crops which in 2013 will included herbicides in stocks and peony, herbicide contamination issues with “green waste” and Fusarium susceptibility of column stock varieties.
- The technology transfer element will be strengthened through (a) regular dissemination via the Centre’s website (as well as HDC News and Open Days), (b) reviewing the findings on two crops per year and presenting as fact-sheets, (c) dissemination of basic crop costings for cut-flowers with market potential, (d) encouraging the submission of concept notes for new R&D projects on cut-flower crops and (e) serving as an information hub for the UK cut-flower industry; (d) and (e) especially should assist the Centre to fulfil a ‘crop association role’ for cut-flowers.

Technology transfer and other outputs in 2012

- The MG met formally on 31st May, 3 August and 30 November 2012
- A successful Open Day was held on 12 September 2012 with over 65 attendees
- Many visitors were shown round the trials on an informal basis
- Reports on the work of the Centre appeared in HDC News issues for May and November 2012
- A Centre web-site was set at http://www.thecutflowercentre.co.uk/about-us/
- A fact-sheet on annual dianthus was issued to levy-payers in September 2012
- Connections made through the Centre resulted in the setting up of a new HDC project, PO 005, to define the factors responsible for the unreliability in the current production of column stock
- A project to test cut-flower production in hydroponics systems was discussed and continues to be developed
- A series of technical updates are being developed starting with Breanthus and Solomio spray carnations.
- A major part of the Centre’s extension work continued to be providing large numbers of flower samples to staff from major supermarkets and packers

Acknowledgments

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

Appendix 1: Pesticide applications

2010 pesticide applications

- For aphid, pymetrozine and lambda-cyhalothrin (as ‘Chess WG’ and ‘Hallmark with Zeon Technology’) on 23 June and 01 July, and thiacloprid and cypermethrin (as ‘Calypso’ and ‘Toppel 100 EC’) on 29 June and 19 July
- For thrips, spinosad (as ‘Conserve’) on 06 July
- For aphids and thrips, spirotetramat and lambda-cyhalothrin (as ‘Movento’ and ‘Hallmark with Zeon Technology’) on 23 July
- For mildew and caterpillar, sulphur and indoxacarb (as ‘Thiovit Jet’ and ‘Steward’) on 25 June and 21 September
- For mildew, mancozeb + metalaxyl-M and azoxystrobin (as ‘Fubol Gold WG’ and ‘Amistar’) on 28 September

2011 pesticide applications

- For thrips and powdery mildew, spinosad and bupirimate (as ‘Conserve’ and ‘Nimrod’) in ‘Pro-Tech’ tunnel bay 3 on 16 June
- For aphid, spirotetramat (as ‘Movento’) in ‘Pro-Tech’ tunnel bay 1 on 16 and 29 June and 28 July and in bay 2 on 28 July
- For mildew, mancozeb + metalaxyl-M (as ‘Fubol Gold WG’) in the ‘Haygrove’ tunnel on 29 June
- For mildew, sulphur (as ‘Thiovit Jet’) in ‘Pro-Tech’ tunnel bay 3 on 29 June
- For aphid and thrips, thiacloprid and spinosad (as ‘Calypso’ and ‘Conserve’) in all tunnels on 11 July
- For powdery mildew, mites and insects, bupirimate and abamectin (as ‘Nimrod’ and ‘Dynamec’) in ‘Pro-Tech’ tunnel bay 3 on 11 July
- For powdery mildew, kresoxim-methyl (as ‘Stroby WG’) in ‘Pro-Tech’ tunnel bay 3 on 28 July and 18 August

2012 pesticide applications

- For rust, ring-spot and aphids, propiconazole and spirotetramat (as ‘Bumper 250 EC’ and ‘Movento’) to phlox on 21 April
- For aphids, cypermethrin (as ‘Toppel 100EC’) to A. ericoides on 21 May
- For aphids, cypermethrin (as ‘Toppel 100EC’) to eryngium (indoor and outdoor) on 2 June

- For downy mildew, aphids and powdery mildew, mancozeb + metalaxyl-M, cypermethrin and azoxystrobin (as ‘Fubol Gold WG’, ‘Toppel 100EC’ and ‘Amistar’) to lisianthus and column stocks on 16 June
- For flea beetle on column stocks and caterpillars on phlox, lambda-cyhalothrin (as ‘Hallmark with Zeon Technology’) on 22 June 2012
- For downy mildew, mancozeb + metalaxyl-M (as ‘Fubol Gold WG’) to column stocks on 25 June
- For powdery mildew, azoxystrobin (as ‘Amistar’) to phlox on 25 June
- For rust and ring-spot, propiconazole (as ‘Bumper 250 EC’) to dianthus on 25 June
- For powdery mildew and downy mildew, azoxystrobin and mancozeb + metalaxyl-M (as ‘Amistar’ and ‘Fubol Gold WG’) to column stocks on 3 July
- For aphids, spirotetramat and indoxacarb (as ‘Movento’ and ‘Steward’) to all plants in all tunnels on 13 July
- For rust, tebuconazole (as ‘Folicur’) to dianthus and breanthus on 13 July
- For aphids, spirotetramat (as ‘Movento’) to all plants in all tunnels on 23 July
- For downy mildew, mancozeb + metalaxyl-M (‘Fubol Gold WG’) to column stocks on 7 August
- For rust, tebuconazole (as ‘Folicur’) to dianthus and breanthus on 7 August
- For thrips, spinoxad (as ‘Conserve’) to all plants in all tunnels on 13 August
- For rust and ring-spot, propiconazole (as ‘Bumper 250 EC’) to foliage plants on 13 August
- For aphids and powdery mildew, spirotetramat and azoxystrobin (as ‘Movento’ and ‘Amistar’) to all plants in all tunnels and outdoors on 15 August
- For thrips, spinoxad (as ‘Conserve’) to all plants in all tunnels and outdoors on 21 August
- For powdery mildew, krexoxim-methyl (as ‘Stroby WG’) to A. ericoides and phlox on 24 August and 25 September
- For powdery mildew, myclobutanil (as ‘Systhane’) to A. ericoides and phlox on 6 and 17 September
- For powdery mildew and thrips, azoxystrobin and spinoxad (as ‘Amistar’ and ‘Conserve’) to A. ericoides and phlox on 1 October
- For aphids, spirotetramat (as ‘Movento’) to aster ‘Bonito’ on 3 October

Appendix 2: VL results for 2012

Crop, cultivar, etc	*Week no. picked*	*Hydration solution*	*Longevity (days)*[1]	*VL (days)*[2]	*Condition at end of VL*
Aster ericoides					
2011 outdoor 'Double Fun Blue'	44	Prof 2	9	5	Good
2011 outdoor 'Double Fun Pink Dark'	44	Prof 2	9	5	Good
2011 outdoor 'Double Fun White'	44	Prof 2	9	5	Good
2011 outdoor (plot 1)	44	Prof 2	9	5	Foliage yellowing
2011 outdoor (plot 2)	44	Prof 2	9	5	Flowers dehydrating and browning
2011 outdoor (plot 3)	44	Prof 2	9	5	Foliage yellowing
2011 outdoor (plot 4)	44	Prof 2	9	5	Flowers dehydrating, foliage yellowing
2011 outdoor (plot 6)	44	Prof 2	9	5	Foliage yellowing
2011 outdoor (plot 9)	44	Prof 2	9	5	Flowers dehydrating, foliage yellowing
2012 outdoor 'Cape Town'	44	Prof 2	9	5	Good
2012 tunnel 'Cirina Dark'	44	Prof 2	9	5	Good
2012 outdoor 'Chicago'	44	Prof 2	9	5	Good
2012 outdoor 'Blue Tail'	44	Prof 2	9	5	Foliage yellowing
2012 outdoor 'Cassandra'	44	Prof 2	9	5	Good
2012 outdoor 'Cirina Dark'	44	Prof 2	9	5	Flowers dehydrating
2012 tunnel 'Blue Tail'	42	Prof 2	9	5	Good
2012 tunnel 'Cape Town'	42	Prof 2	9	5	Good
2012 tunnel 'Cassandra'	42	Prof 2	9	5	Good
2011 outdoor 'Chicago'	42	Prof 2	9	5	Good
2011 outdoor 'Cirina Dark'	42	Prof 2	9	5	Good
Breanthus					
'Earl'	34	CVBN	13	7	Flowers senescing
'Earl'	34	Prof 2	13	7	Flowers senescing, water cloudy
'Earl'	35	Prof 2	14	7	Flowers dying, water cloudy
'King'	34	CVBN	13	7	Flowers senescing
'King'	34	Prof 2	13	7	Flowers senescing, water cloudy
'Queen'	34	CVBN	13	7	Flowers senescing
'Queen'	34	Prof 2	13	7	Flowers senescing, water cloudy

'Queen'	35	Prof 2	14	7	Flowers dying, water cloudy
Celosia					
'Bombay Flora'	34	CVBN	8	2	Foliage yellowing, stems dead, rotting at neck
'Bombay Flora'	34	Prof 2	8	2	Foliage yellowing, stems dead, rotting at neck
Cotinus					
'Magical Green Mountain'	35	CVBN	14	7	Foliage yellowing. dehydrating
'Magical Green Mountain'	35	Prof 2	8	3	Foliage wilting
'Magical Green Mountain'	39	eZ Dose	10	6	Good
'Royal Purple'	35	CVBN	9	4	Foliage wilting
'Royal Purple'	35	Prof 2	6	1	Stem dehydrating
'Royal Purple'	39	eZ Dose	10	6	Foliage dehydrated
Spray carnation					
'Fen'	39	eZ Dose	10	6	Good
'Sem'	39	eZ Dose	10	6	Good
'Vin'	39	eZ Dose	10	6	Good
Eryngium					
Eryngium	34	CVBN	13	7	Foliage yellowing, heads browning, water cloudy
Eryngium	34	Prof 2	13	7	Foliage yellowing, heads browning
Hypericum					
'Magical Green Fall'	39	eZ Dose	10	6	Foliage senescing
'Magical Tropical Fall'	35	CVBN	12	7	Foliage wilting, buds yellowing
'Magical Tropical Fall'	35	Prof 2	14	7	Foliage wilting
'Magical Tropical Fall'	39	eZ Dose	10	6	Development of rust
'Magical White Fall'	35	CVBN	6	1	Foliage wilting
'Magical White Fall'	35	Prof 2	6	1	Foliage wilting
Lisianthus					
Lisianthus (deep-purple, edge white)	39	eZ Dose	10	6	Good
Lisianthus (light-purple, edge white)	39	eZ Dose	10	6	Foliage senescing
Lisianthus (lilac)	39	eZ Dose	10	6	Good
Lisianthus (pink)	39	eZ Dose	10	6	Good
Lisianthus (white)	39	eZ Dose	10	6	Good
Lisianthus (white/green)	39	eZ Dose	10	6	Good
Lisianthus 'Arena Yellow'	35	Prof 2	14	9	Stem wilting
Lisianthus 'Ceremony Blue Flash'	36	Prof 2	11	6	Stems wilting
Lisianthus 'Papillion Flash Pink'	36	Prof 2	11	6	Stems wilting
Lisianthus ''Piccolo 2 Rose Pink'	35	Prof 2	13	8	Stem wilting
Lisianthus 'Purple/white Piccolo'	36	Prof 2	11	6	Flowers dehydrated
Lisianthus 'Velvet Purple Summer'	35	Prof 2	14	7	Stem wilting

Lisianthus 'Velvet Purple Summer'	36	Prof 2	7	2	Stems wilting
Phlox					
'Icecap'	34	CVBN	13	7	Flowers senescing
'Icecap'	34	Prof 2	13	7	Flowers senescing, foliage browning
'Sugar Missy'	34	CVBN	13	7	Stems wilting, water cloudy
'Sugar Missy'	34	Prof 2	13	7	Stems wilting, water cloudy
Sedum					
'Brilliant'	34	CVBN	13	7	Good
'Brilliant'	34	Prof 2	13	7	Good
'Herbstfreude'	34	CVBN	13	7	Good
'Herbstfreude'	34	Prof 2	13	7	Good
'Magical Bon Bon'	34	CVBN	13	7	Heads fading
'Magical Bon Bon'	34	Prof 2	13	7	Good
'Magical Bon Bon' plot 2	34	CVBN	13	7	Good
'Magical Bon Bon' plot 3	34	Prof 2	13	7	Good
'Magical Twist'	34	CVBN	13	7	Foliage browning, dehydrating; water cloudy
'Magical Twist'	34	Prof 2	13	7	Lower foliage dehydrating
'Matrona'	34	CVBN	13	7	Good
'Matrona'	34	Prof 2	13	7	Good
'Mr Goodbud'	34	CVBN	13	7	Good
'Mr Goodbud'	34	Prof 2	13	7	Good
Symphoricarpos					
'Bright Fantasy'	39	eZ Dose	10	6	Berries dehydrated, discoloured
'Charm Fantasy'	39	eZ Dose	10	6	Good
Carnation, spray					
'Fen'	39	eZ Dose	10	6	Foliage wilting
'Sem'	39	eZ Dose	10	6	Foliage wilting
'Vin'	34	CVBN	13	7	Flowers senescing
'Vin'	34	Prof 2	13	7	Flowers senescing

[1] Including storage/transport/retail and consumer phases
[2] Consumer phase only (VL)

Appendix 3: Index to crops included in each year's trials

Ageratum (*Ageratum houstonianum*)	2007					
Amaranthus (*Amaranthus caudatus*)		2008			2011	2012
Antirrhinum (*Antirrhinum majus*)		2008	2009	2010	2011	2012
Aster ericoides	See aster, September-flowering					
Aster (*Aster pringlei*), 'Monte Cassino' type		2008				
Aster, September-flowering (*Aster ericoides*)	2007			2010	2011	2012
Brassica, ornamental (*Brassica oleracea*)		2008	2009	2010	2011	2012
Breanthus	See dianthus, annual					
Callistephus chinensis	See china aster					
Campanula (*Campanula spp*.)						2012
Carnation, spray (*Dianthus caryophyllus*)		2008				2012
Caryopteris (*Caryopteris* x *clandonensis*)		2008				
Celosia (*Celosia cristata*)						2012
Chasmanthium spp.	See grasses, ornamental					
China aster (*Callistephus chinensis*)	2007	2008	2009	2010	2011	2012
Clarkia grandiflora	See godetia					
Column stocks	See stocks, column					
Consolida ajacis	See larkspur					
Cynara (*Cynara cardunculatus*)	2007	2008				
Dahlia (*Dahlia hybrida*)			2009	2010		2012
Delphinium (*Delphinium elatum*)	2007	2008				2012
Delphinium consolida	See larkspur					
Dianthus caryophyllus	See dianthus, annual					
Dianthus, annual (*Dianthus barbatus*)	2007	2008	2009			
Dianthus, annual (*Dianthus* spp.)	2007	2008				2012
Echinops (*Echinops* spp.)	2007	2008				
Eryngium (*Eryngium* spp.)	2007	2008			2011	2012
Eustoma	See lisianthus					
Foliage, foliage plants	See hardy foliage					
'German' asters	See china aster					
Godetia (*Godetia grandiflora*)	2007	2008				
Grasses	See grasses, ornamental					
Grasses, ornamental (various species)	2007	2008				
Hardy foliage (various species)				2010	2011	2012
Heath aster	See aster, September-flowering					
Helianthus annuus	See sunflower					
'Karma' dahlia	See dahlia					
Larkspur (*Delphinium consolida*)	2007	2008				
Lathryus odoratus	See sweet pea					
Lisianthus (*Eustoma grandiflorum*)				2010	2011	2012
Love-lies-bleeding	See amaranthus					

Lychnis (*Lychnis chalcedonica*)		2008				
Matthiola incana	See stock, column					
Miscanthus spp.	See grasses, ornamental					
'Monte Cassino' aster	See aster (*Aster pringlei)*					
Ornamental brassica, ornamental cabbage	See brassicas, ornamental					
Ornamental grasses	See grasses, ornamental					
Panicum spp.	See grasses, ornamental					
Phlox (*Phlox paniculata*)	2007	2008	2009	2010	2011	2012
Pinks	See dianthus, annual					
Rudbeckia (*Rudbeckia hirta*)					2011	2012
Sedum (*Sedum spectabile*)		2008	2009	2010	2011	2012
Setaria italica	See grasses, ornamental					
Snapdragons ('Trumpet' cultivars)	See antirrhinum					
Solidago (*Solidago media*)		2008				
Spray carnation	See carnation, spray					
Stock, column (*Matthiola incana*)			2009		2011	2012
Sunflower (*Helianthus annuus*)				2010	2011	2012
Sweet pea (*Lathyrus odoratus*)					2011	2012
'Trumpet' antirrhinums	See antirrhinum					
Veronica (*Veronica* spp.)	2007					
Zinnia (*Zinnia elegans*)	2007	2008				