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Signed on behalf of Cut Flower Centre Ltd:

Signature:…… Date: ……..

Name: *Lyndon Mason, Director*

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

For accurate reporting, materials may be referred to by the name of the commercial product. No endorsement is intended of products mentioned, or criticism of those not mentioned.

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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Headline

Seven crops have been identified as having definite potential for further exploitation and commercialisation in the UK: ornamental brassica, 'German asters' (new German varieties of China aster), delphinium, annual dianthus, larkspur, phlox and sedum.

Background and expected deliverables

The past 10 to 20 years saw a marked increase in *per capita* purchases of cut-flowers in the UK, with consumption moving up from what was a very low level by European standards. There has been a spectacular and continuing increase in the imports of cut-flowers to the UK. Despite this, the UK's own production of cut-flowers is still very limited. The production of more cut-flowers in the UK would have the advantage of closeness to markets, delivering freshness without air-miles, a lack of know-how may be critical in holding back expansion and enterprise. In 2007 the Cut Flower Centre was established at Kirton to supply this practical knowledge.

The expected deliverables were:
- Demonstrations, trials and problem-solving experiments in cut-flower production;
- Evaluation of selected crops on a commercial scale;
- 'Best Practice' for the most promising varieties;
- Promotion of UK cut-flower production;
- Stimulation of further R&D and promotional projects.

Summary of the project and main conclusions

1. Seven crops were identified as having definite potential for further exploitation and commercialisation in the UK: ornamental brassica, 'German aster' (new German varieties of China aster), delphinium, annual dianthus, larkspur, phlox and sedum.
2. Three crops were thought to have some potential for further exploitation <u>if</u> better varieties become available: ageratum, amaranthus and aster (*Aster pringlei* Monte Casino type).
3. Thirteen crops were eliminated from trials as having little or no potential for exploitation <u>under present conditions</u>, either because:
    - the economics of the crop were negative (antirrhinum, spray carnation, godetia, ornamental grasses and pinks),
    - there were specific negative points (caryopteris and zinnia) or
    - there was no clear indication of commercial appeal and uptake (cynara, echinops, eryngium, lychnis, solidago and veronica).

1. <u>Crops recommended for further development in the UK</u>

1.1. <u>Brassica (ornamental)</u>

The popularity of ornamental brassica is a recent phenomenon that is currently met almost entirely by imports. Trials were set up to investigate a range of varieties and planting dates, to see the potential for production in the UK and highlight any likely problems. In 2008 twelve varieties were transplanted into tunnel or outside plots (week 26). In tunnels the plants became etiolated and the stems were unmarketable. Grown outside, the different varieties started to show the required

colour change between weeks 34 and 40, producing yields between 31 and 45 stems/m^2. However, stem lengths failed to reach specification.

Five 'Crane' varieties were drilled into outside plots (weeks 21, 26 and 30) and cropping started in week 29 for the first drilling and week 35 for the second. The third drilling was too late, the plants remained small and the leaves did not colour. Yields fell off in some varieties with the third planting. None of these produced sufficiently long stems.

The post-harvest quality of stems was assessed in vases following conditioning in CVBN. Their vase-life ranged from 7 to 17 days, with high leaf quality scores, though in many cases the vase-water became unpleasant.

Ornamental brassica are likely to remain in demand for some time, but to maintain economic production with the current price, and considering the requirement for providing herbicides and support netting, the crop needs to be direct-drilled and grown cheaply in the open. Despite the problems referred to, the trials also demonstrated the potential for the crop in the UK. Early planting (weeks 16 to 18) is important if short stems are to be avoided. There is a need to examine newer varieties with foliage that changes colour better and earlier, and to see if high-density drilling can avoid the need for support netting and the labour involved in moving netting up with the crop. For these reasons a larger trial is planned for 2009.

1.2. China aster ('German asters')

China asters are annuals with generally low yields, but some recent selections in Germany have robust and highly attractive blooms and seem to have potential for growing under protection in the UK. For convenience these are referred to here as 'German asters'. In 2007 commercial evaluations were planted at two nurseries. Although one trial was destroyed by the severe wet weather, the other generated significant interest amongst supermarkets to justify further work. In 2008 a further commercial evaluation was conducted under glass, and raised several further issues: there is a lot that we do not know about these plants!

The issues to be resolved include planting dates, planting density, height restriction (probably using Alar), achieving earlier and later cropping, seed provenance (varieties are not uniform, and appear to be coming from more than one source), control of (possibly seed-borne) mould, and quality in the vase. It is proposed that in 2009 a further evaluation should take place on a commercial nursery, and that specific issues should be addressed in trials at Kirton, including demonstrations that include a range of varieties from all suppliers, and post-harvest work to reduce the rapid leaf yellowing or blackening that occurs in the vase.

1.3. Delphinium

Although delphiniums are a widely grown outdoor crop, there are problems in achieving continuity and the high quality demanded by supermarkets, and trials were set up to explore these issues. In 2007 the effects of planting date on continuity were investigated in thirteen varieties, including representatives from three important series ('Scent', 'Takii Aurora' and 'Pan American Guardian'). They were transplanted to outside plots and tunnels in weeks 21, 23 and 27. Stem lengths and weights were longer and heavier in tunnel-raised plants. Flowers were produced over the period week 27 to week 36, and, despite using three planting dates and up to 15 varieties, there were breaks in continuity, particularly in weeks 29 and 33-34. For the delphinium crop to be economically viable, this lack of continuity needs to be

rectified. Further issues were that several varieties from the first tunnel planting developed mildew, while in the third planting some varieties produced poor, short stems.

In the crop's second year, for any given planting date or flowering flush, cropping dates were similar whether the plants had been grown in tunnels or outside. The plots started cropping between week 19 and 40, but even then cropping was not continuous, with gaps in weeks 25-29 and 35-38, so more work is needed. Stem lengths and weights were always greater in tunnel-grown plants, with the stems exceeding the 75cm-length for a premium product for all three planting dates and all three flushes. Many, but not all, of the batches of stems from outside plots also exceeded 75cm in length. Varieties of the 'Scent' series consistently produced stems of good length and weight, while some 'Takii Aurora' varieties were short, especially from the second and third plantings. Stem weights generally fell from later plantings and in later flushes. Mildew remained a problem, despite the fungicides applied.

In 2008 a second trial was planted, with varieties 'Aurora', 'Aurora Blue', 'Aurora Light Blue', 'Centurion Gentian', 'Guardian Blue' and 'Guardian Early Blue' planted in tunnels in weeks 15, 17, 19 and 21. The crop produced two flushes and an overall cropping period from week 26 to week 43, but despite using six varieties and four planting dates there were still distinct peaks and troughs in production, with gaps in weeks 32 to 33 and 38 and 42. 'Guardian Blue' and 'Guardian Early Blue' were particularly productive at the beginning of each flush. Spike length ranged from 46 to 75cm. Most stems from the first flush reached 75cm in length, while in the second flush this proportion fell to around 50%. 'Guardian Blue', 'Guardian Early Blue' and 'Aurora' all produced high total yields of stems in the 75+cm grade from the two earlier plantings (at least 45 stems/m^2) and this productivity fell off in later plantings. However, some varieties had low yields, particularly from the later plantings.

A selection of varieties from the 2008 trial was subjected to vase-life testing. Stems were conditioned in AVB or plain water, moved to water with a T-bag conditioner for a transport/retail period, and placed in vases with flower food. There was a marked effect of using conditioner, with treated stems showing a doubling of vase-life. Varietal differences in vase-life and flower quality were small, and poor leaf quality and poor water quality were the exception.

Besides the evaluation of a range of varieties, the main concern with delphinium cut-flowers is the need for a continuity programme. Although some gaps in production were still evident, the trials advanced the quest for continuity of supply stretching over a 16-week period. Continuity would be improved if it were practical to start planting earlier, but growing in Spanish tunnels means that planting cannot begin before week 15. A less vulnerable, low tunnel might be more suited for starting an earlier round, but would be uneconomic with delphiniums as they could be planted only in the middle of the tunnel. But since delphiniums are suitable for growing in cold glass, continuity could almost certainly have been extended by planting the first rounds under glass.

A review of the literature suggested several ways in which the flowering season might be extended. The simplest, and possibly the most effective, way to extend the season would be through combining first-year and over-wintered plantings with additional variety selection and pinching part of the crop (pinching delays flowering but increases quality). Since delphinium have a quantitative response to vernalisation in advancing flowering and improving spike length, cold treatments could be applied to seedlings, or possibly even to seed.

1.4. Dianthus (annual)

The main aim of the trials on annual dianthus was to provide sufficient data on yields and continuity to decide whether the crop is worth considering for UK production. In 2007 the effects of planting date and variety on continuity and vase-life were investigated in eleven varieties, including several from the 'Amazon' and 'Sweet' series. They were transplanted to tunnels and outside plots in weeks 22 and 26. Tunnel-raised stems were consistently heavier and longer than those raised outside. The results demonstrated a clear potential for this crop in the UK, with flowers picked from week 27 to week 36 (though with some gaps in weeks 28, 34 and 35).

In 2008, seven varieties from the 'Amazon' and 'Scent' series were transplanted to tunnels in weeks 17, 19 and 28, with a further planting outside in week 18. The effect of pinching or not pinching was also investigated. In the main varieties cropping started in weeks 26 to 30 for tunnel plantings in weeks 17 and 19, in weeks 35 to 41 for tunnel planting from week 28, and in week 29 to 32 for the outdoor planting in week 18. Thus, some small gaps in continuity remained. There was a marked effect of planting date on the proportion of stems above or below 60cm in length. For tunnel-grown plants planted week 17, about two-thirds were in the longer grade, while tunnel plants planted in week 19 had many more short stems. For the outside plants planted in week 18, three varieties produced predominantly long stems ('Amazon Neon Cherry', 'Duo' and 'Purple') and the others predominantly short ones. There were large differences between the varieties in productivity and stem length: grown in tunnels, 'Amazon Neon Duo' and 'Purple' and 'Amazon Rose Magic' produced good yields of long stems, and 'Amazon Neon Cherry' produced poorer yields of long stems, while 'Sweet Coral', 'Purple' and 'Scarlet' produced still good but smaller yields of long stems.

In this trial, pinching or not pinching did not affect the start of cropping and had little effect on the total yield of stems (150 to 200 stems/m^2). Non-pinched plants produced longer and heavier stems than pinched plants.

In 2007, selected varieties were subjected to vase-life testing. In vases with flower food vase-life varied from 7 to 14 days. Leaf quality was good throughout, but flower quality was poorer in two varieties. In 2008, a selection of varieties from early and late planting was taken through vase-life testing on plain water, following conditioning in plain water or RVB. Vase-life varied from 10 to 25 days, but this spread was due to one poorly performing variety and one long-lived one, and without them vase-life varied between 11 and 18 days only. Using RVB increased vase-life by about a day. Early plantings had a vase-life about 1 day longer than late plantings. Flower and leaf quality scores and water clarity scores were high, with a few exceptions. The varieties tested had long vase-lives and, usually, high quality scores. There clearly were varietal differences that need to be taken into account, for example the differences between the responses of 'Amazon' and 'Sweet' varieties. The data also suggested a strong effect related to planting date. The vase-life in this trial of 'Green Trick' appeared to be exceptional and should be checked.

The trials indicated that reasonable continuity could be obtained, that outdoor growing was not worthwhile, and that pinching had a detrimental effect on stem length and weight. To achieve likely specifications, stems needed to be over 60cm in length, and this might be difficult in some situations. Head size and bunch weight are important and varieties of the naturally smaller 'Sweet' series needed three times as many stems to achieve the bunch weight as the 'Amazon' varieties. There was potential for further development of the crop, provided it did not appear on the

market at the same season as sweet William. The crop was probably economic if 60 stems/m^2 could be cropped and realised 20p per stem.

1.5. Larkspur

The main aim of the trials on larkspur was to establish whether it could be improved sufficiently to make a worthwhile crop, through scheduling, variety selection, manipulating planting density, disease control or other means. At present larkspurs are perceived as having inconsistent quality and poor post-harvest quality, though it might be possible to produce a high-quality, graded stem under tunnels. In 2007, eight varieties were transplanted to outdoor plots (week 21) as a variety demonstration, but the very wet weather resulted in no meaningful results being obtained, except that 'Single Red', 'Single White' and 'Sydney Pink' stood out as being the more vigorous. In 2008, a factorial trial was set up with two varieties ('Sydney Blue' and 'Sydney Pink') planted under tunnels on three planting dates (weeks 17, 21 and 23) and three planting densities (64, 80 and 100 plants/m^2). Continuity of cropping was obtained from week 27 to beyond week 31, and over this period stem lengths and weights were acceptable. There were no consistent effects on stem length or weight of planting date or planting density. The start of cropping was unaffected by variety and planting density and was simply delayed by later planting. Stem length was shorter in 'Sydney Pink' than in 'Sydney Blue', as planting was later, and was reduced at planting densities of 80 and 100 plants/m^2 compared with 64 plants/m^2. Stem weight was similar in the varieties, was lower with later planting, and was reduced at planting densities of 80 and 100 plants/m^2. Flower yield was similar in each variety and greatest from the middle planting date and with increasing planting density.

Samples were subjected to vase-life testing after conditioning in water or AVB followed by RVB. There were few differences in post-harvest quality between the treatments, though there was a slight benefit to vase-life where the conditioner was used. Further data on the post-harvest quality of larkspur from different treatments is needed.

If consistent quality and an eight-day vase-life could be achieved, the crop would have great potential for use in bouquets. However, unlike delphinium, larkspur appears to be relatively unresponsive to post-harvest treatments and is severely affected by damp weather with mildew and loss of the lower florets. Further trials are needed to resolve these issues.

1.6. Phlox

The main aim of growing phlox was to assess the quality of the stems, including vase-life, for a selection of varieties. In 2007, varieties 'Icecap', 'Miss Marple', 'Miss Fiona' and 'Sugar Missy' were transplanted to tunnel and outside plots (week 25), which was probably too late. Some varieties were slow to flower in outside plots. For plants grown in tunnels there were large between-variety differences in stem weight in stems of similar length. Despite this disappointing performance the variety plots generated considerable interest amongst UK retailers that viewed it. The crop was grown on in 2008, with some further varieties added ('Magical Dream', 'Magical Fragrance' and 'Magical Surprise' planted in week 18). The original varieties started to crop in weeks 24 to 27 in tunnel and outside plots. Stem length and weight of tunnel-raised plants were consistently 10-20% greater than those from outside plots. The yield of stems was highly variable (44 to 101 stems/m^2), one variety producing similar yields whether in tunnels or outside and the others more productive outside. The three first-year crops flowered in significant numbers only in the protected plots,

where they were later, had poorer yields and stems were shorter and lighter than for the previous year's plantings.

In 2007 samples of phlox from the tunnels were subjected to vase-life testing. All varieties exceeded their expected 5-day vase-life by two or more days, one lasting for 9 days. Leaf quality remained excellent in all varieties, but flower quality was poorer and the vase-water was generally turbid. Further samples were tested in 2008 after conditioning in RVB or plain water. The effects of treatments were modest. Vase-life ranged from 5 to 9 days, flower quality was generally high and leaf quality and water clarity scores were consistently high. There was a one-day increase in vase-life when conditioner had been used.

Although phlox are traded widely, disadvantages are high cost of plant material, restricted colour range, limited availability and need for careful choice of varieties. These issues will be addressed by the Centre in 2009.

1.7. Sedum

The main aim of growing sedum in the trials was to determine how well it would perform as a commercial crop under typical Lincolnshire conditions. In 2007, due to problems in availability and delivery, eight varieties of sedum were transplanted to outside plots in week 28 or 39, too late to achieve any meaningful results in year 1, and their potential was assessed in 2008. Two *S. tephilium* varieties started to crop in week 30 and all others followed between weeks 32 and 35. Average stem length varied from 25 to 40cm, which may be insufficient, though stem weight was impressive (82 or 164g). *S. spectabile* 'Brilliant' planted in July gave twice the stem length and weight of the September planting.

Samples were subject to vase-life testing. Except for the two *S. tephilium* varieties there was a very long vase-life (23 to 34 days). In the *S. tephilium* varieties vase-life was 6 or 8 days. Flower quality scores were high except for the *S. tephilium* varieties. Leaf quality was acceptable for most varieties but poor in two cases. Water clarity was very high.

As a cut-flower sedum has a number of advantages: adequate length and high weight, making it ideal for use in bouquets, and it is attractive in the vase over a long period. All varieties tested here would easily achieve the 300g bunch specification. The disadvantages are that plants are expensive, it occupies a large amount of space but only crops for about a month each year, and it is available in pink only. Nevertheless, one supermarket has used sedums in bouquets and has trialled them as a bunch, but the grower needs to realise 70p/bunch to allow for the high plant costs and space needed. With some exceptions, sedums have a long vase-life and high flower and leaf quality. Growing sedums was considered a practical option up to the point of sale, but wider acceptance by the supermarkets is needed. Possibly it is a crop for a smaller, specialist grower. Further information is needed – the plants in this trial had all been grown outside in an un-amended soil, and the potential for cropping over a three-year cycle needs to be tested.

2. Crops with potential for commercialisation if better varieties become available

2.1. Ageratum

Ageratum has only recently been bred for cutting as well as for bedding, and little is known about its market potential, continuity and performance of ageratum in commercial cut-flower production. 'Blue Horizon', one of the first long-stemmed

varieties, was transplanted to tunnel and outside plots in week 21, 2007, as a demonstration. The plantings produced their first flowers in week 26 and stems grown outside were markedly taller than those from tunnels.

Ageratum has a small colour range and the flowers may be too delicate for other than short transport periods. But the demonstration generated sufficient interest from major retailers to justify including ageratum in later trials if some of the newer, cutting-raised varieties can be sourced.

2.2. Amaranthus

Five varieties were transplanted into tunnel and outside plots in week 22, 2008. The two dwarf varieties, 'Green Thumb' and 'Pygmy Torch', started to flower in week 27, whether grown under protection or outside. They produced stems about 50cm long in tunnels and up to 20% less outside. Three tall varieties cropped successfully only in outside plots, starting between week 29 and 35, with stems averaging 77 to 110cm in length.

Amaranthus generate very different reactions from different customers. Following the demonstration there were still questions about the commercial acceptability of the crop and its market potential, though some varieties have fashionably green flowers. A further variety demonstration would be justified as other suitable varieties become available.

2.3. Aster (*Aster pringlei*) (Monte Casino type)

New aster varieties have been attracting attention amongst growers, and a demonstration was included to assess their commercial potential. Three September-flowering varieties were planted in tunnel and outside plots in week 25, 2007 and assessed in 2008.

The relative performance of the three varieties was not consistent, so it was not possible to generalise. Those grown in the demonstration proved to be very vigorous, but it was clear much remains to be learned about them. Interest in the crop remains, but there was no immediate potential for further trials at present. Improved seed stocks might alter this perception.

3. Crops without potential for commercialisation under present conditions

3.1. Antirrhinum

Despite a large body of information on antirrhinum and wide appreciation of the flowers and the colour range available, in the UK this crop has been almost entirely imported. A large commercial evaluation was carried out on a commercial nursery in 2007. The grower reported "the flowers are attractive, but relatively delicate, and we thought a more durable product might be obtained by production in the UK, close to the markets. The main question for us, and the reason for the commercial evaluation, was to find out whether the flowers could be managed down the line… could we handle and pack within a budget?"

"Antirrhinums were planted in beds worked with a bed former, so the slightly raised beds allowed water to run off. They were transplanted through carrot film at a planting rate of 64/m^2. Support netting was provided - and this had to be shaded from the wind because the flowers bruise easily. The nets had to be lifted regularly. Although 2007 was extremely wet the antirrhinums did not suffer as some crops

would, though it was difficult getting enough good days to plant. Because of the weather it was not possible to apply the appropriate amounts of feed in the growing period. Overall the 'Potomac' series was the best and most even producer, though this may be different in a drier year. The most attractive variety was 'Apple Blossom'. 'Deep Orange', 'Early White', 'Ivory White', 'Plum Blossom', 'Royal' and 'Yellow' were other good varieties. The stems were no better grown in tunnels than outside. They grow too fast in the warm, and come harder outside – a better product altogether."

"But specifications demand a 40g stem, which is far too ambitious - realistically it should be nearer 30 or 35g. The specification was originally set up at a time of year when quality is naturally higher. The plants were cropped every 48 hours with a bloom count of five open florets and a column length of 15cm. A length of 60cm was required and only 74% made this specification, so they need to fetch 19 or 20p per stem. We will not be growing snaps again! Growing snaps in the UK would only be possible on a very restricted scale for a niche market – and a very well researched market at that."

Vase-life trials showed the potential for several varieties of antirrhinum to perform well in the vase under a range of flower treatments.

The extensive commercial evaluation undertaken in 2007 provided useful experience with the crop, demonstrated the value of outdoors growing, and identified a number of good varieties. However, in the evaluation only 74% of the plants reached the high specification demanded by a UK supermarket, and at the poor price that could be obtained the crop was uneconomic unless for a specialised market.

3.2. Carnation (spray)

UK growers believe the quality of UK-grown spray carnations is superior to that of imported produce. In 2007 a demonstration was set up with two varieties both autumn- and spring-planted. The main purpose was to determine market potential and performance of the crop and to benchmark spray carnations against pinks. Varieties 'Natila' and 'Scarlet Queen' were transplanted to tunnels in September 2007 (week 39) and April 2008 (week 15). The September plantings started cropping in week 30, three weeks earlier than the spring plantings. Planting in September also resulted in longer, heavier stems and a markedly greater yield of stems. Both varieties produced stems of about the same length and weight and at about the same time. In general stem length and head size were good, and there were plenty of breaks. Stems of each variety were tested in vases following conditioning in plain water, AVB followed by CVBN, or AVB followed by RVB. 'Scarlet Queen' showed a longer vase-life and higher flower quality score than 'Natila', and leaf quality and water clarity scores were similar. Vase-life was all increased when a conditioner had been used, and generally the best results were obtained with the combination of AVB+RVB.

The stems produced were of high quality and excellent for bouquet work, but thought it unlikely such a crop could be marketed at a premium price. Post-harvest quality was good, though there may be some varietal differences, and there was a good response to conditioners. However, with a supermarket price war and large quantities of good, cheap spray carnations being imported from Kenya, it was thought unlikely that UK production could be profitable.

3.3. Caryopteris

Little is known about the cultivation of caryopteris for cut-flowers, although they are prolific growers. In 2008 three varieties were planted in a tunnel (week 15). All varieties started flowering in week 37 and achieved broadly similar yields of stems (108 to 114 stems/m^2). 'Large Blue' produced longer, but lighter, stems than the other varieties. Mildew was a problem in these plots. Concerns were expressed about the unacceptable aroma sometimes associated with the crop, mainly at the point when stems were cut or re-cut. Although individual opinions varied and there appeared to be differences between varieties, sufficient concerns were raised to discourage further trialling. Samples were vase-life tested and there was little difference in vase-life, flower or leaf quality, water clarity or water uptake between them. Vase-life was acceptable at about 9 days.

Although good stem yields, lengths and weights were obtained from all varieties tested, caryopteris was judged to be a doubtful subject for exploitation because of its aroma. This aspect of the plant should be further discussed with plant breeders.

3.4. Cynara

Little is known of the commercial possibilities of cynara, so a small variety demonstration was planted in 2007. Two new lines were transplanted to outside and tunnel plots (week 22), which proved to be too late for flowering by a reasonable date. Because of their large size in tunnels, only the outside plots were kept for assessment in 2008. Cropping started in week 30 and the average stem length and weight were 80cm and 755g.

At the present time there is no clear market potential for cynara. If this situation changes, specifications will have to be addressed and the effects of pinching assessed, since, in a non-pinched plant, the central stems tend to be too large and the side shoots too small. A further issue is that the leaves die in the bucket within a few days of cropping, so an effective treatment would be needed to delay this.

3.5. Echinops

A single variety of echinops was included in the project in 2007 to assess its commercial potential. 'Veitch's Blue' was transplanted to tunnel and outside plots (week 18) and its flowering performance assessed in 2008. In the first year the crop was seriously affected by mildew and its appearance overall was poor; nevertheless, when both outside and protected plots started to produce flowers in late-June, and noteworthy interest was generated among the retailers who saw it. In 2008 stem yields were poor in the first flush (starting in week 25), though stem length and weight under protection were reasonable. The second flush started in week 41-42, and yields were just over 100 stems/m^2, but stem length and weight were poor compared with those from the earlier flush. Although echinops is well liked by many, no clear potential for developing its production in the UK was seen at this time.

3.6. Eryngium

A small variety demonstration of eryngium was included in the project. In 2007 seven varieties were transplanted to outside and tunnel plots (week 17 or 24). In the first growing season variety 'Belladonna' was the most attractive variety and produced the largest number of flowers, but other varieties showed a number of problems such as variable height, shyness to flower, poor growth in outside plots, and tip-burn. In 2008 there were wide differences between varieties in the start of cropping (from week 21-22 to week 29). For each variety, generally the dates of starting cropping

were similar, whether grown in tunnels or outside. Overall, stems were longer and heavier from tunnel plantings than from outside plots, but there were large differences in response between varieties. All varieties produced 40-55 stems/m^2 in the first flush when grown in tunnels, and when grown outside only one variety produced such a yield. In the second flush only two tunnel-grown varieties produced over 20 stems/m^2. No clear potential for commercialising eryngium was seen at this time.

3.7. Godetia

For godetia the main requirement was to assess marketable yield, stem length and vase-life, and a selection of varieties was set up in two demonstrations. In 2007 four varieties of the 'Grace' series were transplanted to outside plots and tunnels (weeks 21 and 25). One variety produced inferior quality blooms, and poor yield from the second planting, but the trial demonstrated the potential of godetia for production in the UK and generated interest amongst some retailers.

In 2008 four varieties were transplanted to tunnels in weeks 17 and 26. From both plantings, stem length was notably greater in one variety than in the others, though differences in stem weights were less. Godetia produced a high number of stems (210 to 273/m^2 from the first planting, and 116 to 227/m^2 from the second). Stems were tested in vases following conditioning in RVB or plain water. The vase-life attributes showed there was no notable difference in vase-life, flower or leaf quality or water clarity between the four varieties. There was a small but beneficial effect of adding a conditioner, a 1-day increase in vase-life.

The demonstrations highlighted a number of difficulties in exploiting godetia as a large-scale cut-flower. The stems need to be cut as soon as there is the slightest show of colour, which accentuates the low stem weight of the product. When a conditioner was used the vase-life was adequate, but not outstanding, at about 7 days. Godetia is probably more suitable for growing as a florist's speciality, though some packers did feel that it could have supermarket potential.

3.8. Grasses (ornamental)

Ornamental grasses find many applications in bouquet work, so there is an interest in determining whether they might be a commercial possibility for growers in the UK. A straightforward demonstration plot was set up. Four grasses, varieties of *Panicum* and *Setaria*, were transplanted to outdoor plots in 2007 (weeks 22 or 25), and two further grasses – *Chasmanthium* and *Miscanthus* – in 2008 (week 18). In 2007 the four grasses started flowering 5 to 6 weeks after transplanting. *Setaria italica* produced taller and much heavier stems (85cm, 29g) than the *Panicum* varieties (60-70cm, 10-11g). In the next growing season *S. italica* started to flower in week 28, 2-4 weeks before the *Panicum* grasses, and produced stems of similar length but heavier than in the previous year. *P. virginatum* 'Fontane' produced stems of similar weight to the previous year, but the other *Panicum* varieties were markedly shorter (about 45cm, compared with 70cm) than before. In 2008 the first-year *Miscanthus* started cropping relatively late (week 35), but produced very long (124cm) and heavy (31g) stems. *Chasmanthium latifolium* started to produce a few flowers in 2008, but nothing of marketable quality could be cropped.

Samples were taken through a vase-life test, following conditioning in RVB or plain water. Using conditioner had no effect on vase-life. There was a much longer vase-life for *Miscanthus* than the other varieties, and the leaf quality score of *Panicum* 'Fontaine Virgatum' was superior to the other varieties.

Ornamental grasses are probably better grown in a hot, moist environment, for example under polythene. Additionally, it would not be possible to compete with the large production areas of ornamental grasses that are grown in Costa Rica.

3.9. Lychnis

A single variety of lychnis was included in the project to assess its potential as a cut-flower. In 2008 lychnis 'Jenny' was transplanted to outside plots (week 3). Cropping started in week 19, and average stem length was 61cm and weight 8g. The first flush looked very encouraging, but disappointingly the plants failed to produce another good quality flush, just flowers with weak stems. The very light stems were not suitable as a cut-flower, although stem length and the general look of the flower were all adequate. It may be interesting to see the performance of these plants grown-on in 2009.

3.10. Pinks

The main aim of the pinks trials, which included both spring- and autumn-plantings, was to introduce an 'old traditional' crop to a new generation of consumers, and to identify the best yielding varieties for meeting supermarket specifications. In 2007 varieties 'Bright Eyes', 'Lily the Pink', 'Monica Wyatt' and 'Rose Monica' were transplanted (week 18) to outdoor and tunnel plots. All plantings started to produce flowers in the second week of July, and there was continuous cropping between July and November. In general the tunnel-raised plants produced more stems per plant and heavier stems than those grown outdoors. Protection was needed to produce stems of sufficient length and quality. There were marked differences in productivity between varieties.

In 2008 (week 15) the tunnel where the above varieties were growing was damaged by wind and the plants were moved to an adjacent tunnel alongside new plants of 'Dancing Queen', 'Devon Cream', 'Gran's Favourite' and 'Letitia Wyatt'. All varieties commenced cropping in week 23. Mean stem length varied from 33 to 50cm, and stem weights from 7 to 18g. Varieties with the best combinations of stem length and weight included 'Devon Cream', 'Monica Wyatt' and 'Rose Monica', but, of these, 'Monica Wyatt' and 'Rose Monica' produced low yields of flowers (less than 300/m^2) compared with some others. 'Dancing Queen', 'Devon Cream', 'Gran's Favourite' and 'Laetitia Wyatt' produced well over 300 stems/m^2.

In 2007, 'Bright Eyes', 'Dancing Queen', 'Devon Cream' and 'Gran's Favourite' were transplanted (week 42) to tunnel and outside plots. These autumn plantings outside produced double the yield, and autumn plantings under protection treble the yield, of the spring-planted, tunnel-grown crop.

A vase-life experiment was set up over four cropping dates to study the effects of conditioner and storage temperature using the eight pinks varieties flowering in 2008. The conditioner treatments were 1 or 2 ml/L AVB or plain water, and stems were stored at 5 or 20°C. All varieties gave a very acceptable vase-life. Overall, the average for the eight varieties varied from 11.8 days ('Devon Cream') to 15.5 days ('Dancing Queen'). Flower quality was high in 'Bright Eyes', 'Dancing Queen', 'Letitia Wyatt', 'Monica Wyatt' and 'Rose Monica', and lower in 'Devon Cream', 'Gran's Favourite' and 'Lily the Pink'. Overall, using 1ml/L AVB increased vase-life by about 1 day, and using 2ml/L increased it by about 3 days. There was little effect on post-harvest measures of storing stems at either 5 or 20°C. Leaf quality scores and water clarity scores were high in all cases. One variety, 'Gran's Favourite', was

especially responsive to AVB. Pinks have a good vase-life which is boosted by use of a conditioner.

The trials enabled a younger generation of retail buyers to look at pinks again. As a direct result of the 2007 trial, one major UK retailer decided to use the product in 2008. Despite this encouraging outcome, producing supermarket-quality pinks is a difficult task with current prices and no room for sub-standard stems. Unless there is an outlet for bouquet work, pinks are required in consistently high volumes which are difficult to achieve with the peaks and troughs in production. A further issue is that one supermarket requires fragrant varieties, which have poorer yields. Adding to these marketing difficulties, it is more difficult to purchase high-quality planting material than it was 20 years ago.

3.11. Solidago

Solidago media was included in the trials as a demonstration of a new line in 2007. It was transplanted to tunnel and outside plots in week 17. In 2008, earlier, taller and heavier stems were obtained from the tunnel-grown plots than from the outside ones. Cropping started in week 32 (tunnel) or 33 (outside). Stem length and weight averaged 124cm and 274g for tunnel-grown plants, and 106cm and 222g for outside plots. Solidago is often used as a filler with flowers such as freesia, requiring small stems weighing 15g, whereas those produced in the trial were heavy and suitable only as a straight line.

3.12. Veronica

Some growers have wondered about the potential of veronica as a UK crop, and so in 2007 a small demonstration was included in the project. Four varieties were transplanted to tunnels and outside plots (week 25). In the tunnel 'Blue Spark' was the first variety to flower (week 30) and 'Pink Spark' the latest (week 33), while in outside plots all four varieties began flowering in week 32. Lodging was a problem in some plants. All varieties produced considerably longer and heavier stems when tunnel-grown (overall, 55% longer and 78% heavier grown under protection).

For a number of reasons, mainly the low price of the imported stems and the small production window, it was concluded that veronica was probably not a crop likely to be economic in the UK. Consequently, no further trials were planned.

3.13. Zinnia

It is widely accepted that zinnia is a very attractive flower with a spectacular colour range, but its vase-life and neck-strength are key issues that would affect any future development of the crop. The trials aimed to assess post-harvest quality, and especially neck strength, across a range of varieties. In 2007 ten varieties were grown to test vase-life and stem strength. They were direct-drilled outside in week 21, direct-drilled in tunnels in week 24, and grown as plugs and transplanted to outside plots and tunnels in week 27. Marketable stems were obtained from many of the plots, and at cropping a simple assessment of neck strength was made. This identified 'Zowee Yellow Flame' as having the greatest stem strength of those grown.

In 2008 varieties 'Zowee Yellow Flame', 'Meteor', 'Purple Prince' and 'Uproar' were planted in tunnels (week 28). Flower cropping started in week 30. Depending on variety, between 104 and 152 stems/m^2 were picked, the most productive variety being 'Zowee Yellow Flame'. While stem lengths were similar to those in 2007, stem weight was disappointing at only about 20g in 'Meteor' and 'Purple Prince' and 13g

in 'Uproar' and 'Zowee Yellow Flame'. At cropping samples stems each were again assessed for neck strength as in 2007. This confirmed that 'Zowee Yellow Flame' possessed markedly greater neck strength than the other varieties tested.

From the 2007 trials samples of six selected varieties were subjected to vase-life testing. Stems were harvested at three stages of maturity and conditioned after cutting by standing in either CVBN or RVB Clear prior to vase-life testing. Vase-life ranged from 5 to 9 days. Cropping at Stage 1 (flower open) resulted in the longest vase-life (8 days) and highest flower quality score, while cropping at Stages 2 (one cluster of stamens visible) or 3 (two clusters of stamens visible) gave a vase-life of 6 and lower quality scores. A conditioning treatment in CVBN produced a longer vase-life (7 days) than using RVB Clear.

Samples of the four varieties grown in 2008 were cropped at Stage 2-3 and subjected to vase-life testing. Stems were conditioned in CVBN or plain water, followed by transfer to water with a 'T-bag' for 1 day at 5°C followed by 4 days at 20°C, after which they were placed in vases containing plain water. In 'Purple Prince' and 'Uproar' using CVBN increased vase-life. Despite its many attractive qualities, it was considered that the weakness of the zinnia stem posed severe problems to its wider exploitation as a cut-flower at this time.

Financial benefits

The project identified seven crops as having definite potential for further exploitation and commercialisation in the UK: ornamental brassica, 'German asters' (new German varieties of China aster), delphinium, annual dianthus, larkspur, phlox and sedum. A further year's development work is needed on most of these crops. It is estimated that two or three new products would help to maintain a significant number of larger or medium-sized businesses.

Action points for growers

Growers interested in investigating new options for their cut-flower production could consider these findings and begin to look at the economics and market opportunities. For larger growers, ornamental brassica, 'German asters', delphinium, annual dianthus, larkspur, phlox and sedum are suggested, but some of these (phlox, sedum) might also suit more specialist growers.

Growers who would like to know about other novel cut-flowers should contact the project leader or the HDC with suggestions for the Centre's programme in 2009 and 2010.

Preface

These quotations were taken from at an open meeting held on 21 September 2006 at Kirton to discuss setting up a cut Flower Centre.

"There is huge potential to substitute imported product by locally produced flowers once we have the know-how available to be able to grow them" - local grower

"Your competitor is not your neighbour, it is coming from over the water. We must work together to ensure that we can offer quality, quantity and continuity if we want to compete with imports" - local grower

"New product development is the lifeblood of our industry and we must be in a position to offer innovative new products to our customers" - local grower

"Supermarkets expect you the growers and us the pack-house to come to them with innovative new products. We obviously need the confidence to be able to grow these products before we are able to offer them to our customers. The provision of the Cut Flower Centre will give us this confidence" - local pack-house

"We need to look at perennial flower crops – there must be huge potential for import substitution amongst perennials" - local grower

"If the Cut Flower Centre had trialled these crops first, it would give us growers the confidence that we need to have a go with them" - local grower

"Because trials are expensive to undertake, we must not reinvent the wheel and should ensure that the cultural information required is not already available in Holland. However there is still a need to ensure that the information is applicable for the production of appropriate UK specifications (especially for supermarkets) by appropriate trialling" - local grower

"While most of the work will be aimed at developing new products for the supermarkets, the information will still be useful for growers who supply the wholesale market" - local grower

"There are a huge number of products that we can look at and it will be very easy to develop a top ten of flowers worth looking at trialling. There is no doubt that our supermarket customers will take UK product in preference to imported product providing they are at least on par for quality, price and continuity" - local pack-house

"It is a disgrace that we do not already have a Centre of Excellence already established in this country. The industry desperately needs such a facility" - local grower

"The strength of the Management Committee will ensure that this project is enthusiastically driven in the right direction which will ultimately be of great benefit to the industry as a whole" - local pack-house

Science Section

Introduction

Despite consumer trends that have led to a huge increase in the sales of cut-flowers in the UK over the past 10 to 20 years, few of these flowers are grown in the UK, the great bulk of them being imported. Why have UK growers not responded more positively to this consumer trend? After all, they are close to their markets and the climate is suitable for growing many of the traditional summer flowers that are popular as cut-flowers today.

One contributory factor is a lack of know-how – not surprising, perhaps, given that the number of potential species runs into hundreds and that the seed houses are producing huge numbers of new cultivars and other introductions. **But innovation is the key to a successful UK cut-flower industry: we need to identify those products that can be grown well and efficiently under UK conditions and which appeal to both mass and niche markets. Some multiple retailers are committed to buying fresh UK produce if the price, availability and quality are right. Two or three new products would maintain `a significant number of larger or medium-sized businesses.**

The project aim was the establishment of a cut-flower trials centre for the UK in South Lincolnshire, where a high proportion of these crops are grown and where UK fresh produce logistics are concentrated. The need for such a Centre was identified by cut-flower growers themselves, and the project has been industry-led (see Preface). Growers and other businesses associated with the local cut-flower industry drew up the application and established a company (Cut Flower Centre Ltd) as the legal vehicle for running the Centre. The trials were carried out under contract by The Kirton Research Centre (KRC), Warwick HRI. The overall direction of the project has been steered and overseen by a Management Group (MG) of local growers, marketing companies, supermarkets and consultants.

The aims of the Centre were:

- Demonstrations, trials and problem-solving experiments in cut-flower production;
- Evaluation of selected crops on a commercial scale;
- 'Best Practice' for the most promising varieties;
- Promotion of UK cut-flower production;
- Stimulation of further R&D and promotional projects.

These are specific aims - but there is also a 'bigger picture': to grow the concept of a dynamic UK cut-flower industry that is confident, world-class, and not dependent on what is left to grow after imports have satisfied the bulk of the market. Establishing a cut-flowers trials centre at Kirton will help put UK cut-flower producers and packers 'on the map'.

This Report presents the full results of two years of flower trials carried out in the field and under Spanish tunnels.

Materials and methods

Trials and demonstrations at Kirton

Crop husbandry protocols were agreed between KRC staff and the Centre's MG, and aimed to achieve good commercial practice adapted as necessary to suit small trial plots. The species and varieties trialled at Kirton in 2007 and 2008 are listed in Table 1, along with the dates of transplanting or direct-drilling, whether grown outside or in tunnels, plot size, planting density, cropping stage, and any special treatments. Planting dates, spacing between plants, and whether plants were pinched or supported by netting were appropriate to the species being trialled. Transplanted crops were either obtained as 'plugs' or were raised from seed in cellular trays at KRC using standard procedures. Several types of cellular tray were used, from 96- to 308-celled trays, as appropriate for the species.

The soil at KRC is a medium silt typical of south Lincolnshire. Prior to trialling, the usual ploughing, agricultural soil analysis, fertilizing according to needs, and cultivation were carried out. 1.2m-wide beds were marked out, three beds per tunnel, along 5.5m-wide, 54m-long Spanish tunnels fitted with gutters and 'smart ends' (Haygrove Ltd, Hereford, HR8 2JL, UK). In 2008 the areas were worked with a bed former so as to produce a slightly raised bed that assisted run-off of water. Beds of equivalent size and arrangement were made outside in the adjacent field. Demonstration and trial plots were typically about 4m-long, with 1m-long unplanted guard areas between plots.

All transplanting was done through black carrot polythene film, either standard 2.0m-wide film (for 2-year-down and some 1-year-down plantings) or biodegradable 1.2m-wide film (for 1-year-down plantings in replicated blocks). Biodegradable mulch was included in order to determine its suitability in cut-flower production. It performed adequately, but was very delicate, difficult to work without causing damage.

A liquid feed (1000L of water with magnesium sulphate (50.6kg), mono-potassium phosphate (77.0kg), dissolved iron (10.0L) and nitric acid (40.6L)) was diluted at 1:200 and applied to all plots regularly and as deemed necessary.

A herbicide, Treflan, was applied to the soil before ornamental brassica were planted or before they had emerged in the case of drilled plots. Weeds in direct-drilled, non-mulched plots were removed by hand as needed. Insecticides, fungicides and slug pellets were applied as needed, across all plots in 2007 (Table 2) and to specific crops in 2008 (Table 3). All pesticides were applied according to recommendations.

In 2007 the larkspur and ornamental brassica trials were replicated, each with three randomised blocks. Other crops were regarded as demonstrations and were not replicated.

Evaluations at commercial nurseries

In 2007 a large evaluation of antirrhinum was grown on a commercial nursery in south Lincolnshire. Many varieties were grown, including some new numbered varieties, and including the following:

- 'Potomac' Series: 'Dark Orange', 'Pink', 'Ivory White', 'Pink', 'Rose', 'Early Pink', 'Plum', 'Royal', 'Apple Blossom', 'Early White', 'Yellow', 'Cherry Rose' and 'Crimson Red'

- 'Opus' Series: 'Plum Blossom', 'Lavender', 'Red', 'Rose', 'Pink', 'White' and 'Apple Blossom'
- 'Axiom' Series: 'Yellow Improved', 'Bronze', 'Pink', 'Paper White', 'Dark Orange', 'Dark Rose' and 'Deep Rose'.

Over a 4000m^2 site, antirrhinums were planted in outside beds worked with a bed former so that the slightly raised beds allowed water to run off. They were transplanted through carrot film at a planting rate of 64 plants/m^2. Support netting and shading from wind were provided. To control pests and diseases the crop was sprayed with Amistar and Fubol Gold (twice) for downy mildew, with Plenum for aphids, with Ambush for caterpillars, and with Rovral for *Botrytis*.

In 2007 commercial-scale evaluations of 'German asters', recent selections from China aster, were planted in outdoor beds at two commercial nurseries in south Lincolnshire. Both evaluations were severely affected by waterlogging in the year's excessively wet weather. The larger of the two evaluations was ploughed in, but the smaller evaluation, on the second nursery, grew well enough to attract significant interest amongst supermarkets. In 2008 a further large-scale evaluation of German asters was planted under glass at the first nursery; several issues arose during the course of the evaluation, and these are discussed under 'Results and discussion'.

Cropping records and commercial assessments

Stems were picked from each crop at the appropriate stage of flower development (see information supplied by pack-houses and others in Table 1). Records made included the number of stems cropped, cropping dates and the length and weight of stems. In the tables of results, the start of cropping refers to the date the first marketable stems were available. Dates are generally expressed as ISO week numbers. Where appropriate, stems were graded by length according to market requirements (Table 1). For determining mean lengths and weights, 10 or 20 cropped stems were taken at random and measured individually. For zinnia, where stem strength is an issue, this was assessed at harvest on 10 stems of each variety: each stem was waved in a standard fashion and scored on a one to four scale (1, stem easily broken; 2, stem bends but does not break; 3, stem remains rigid with normal shaking; 4, stem remains rigid with vigorous shaking). Flowers from many trials were subjected to vase-life testing (see below).

The crops and results for the project, along with plans for further work, were assessed at regular meetings by the industry members of the MG and others. For the purposes of this Final Report the key MG meetings were those on 21 October and 28 November 2008, when the work in 2007 and 2008 was reviewed and plans made for the trials programme for 2009, assuming funding and facilities would be in place for the extension of the Centre's work. These assessments are mentioned throughout this report.

Vase-life trials

General methods

Freshly harvested stems of marketable quality were cropped from Kirton trials and commercial evaluations and used for vase-life testing. Any conditioning, storage or other treatments carried out between cropping and placing in vases is specified below. Prior to placing in vases, stems were re-cut with sharp secateurs (re-cutting stems was done in air, not while held under water) and the lower leaves and any damaged leaves that might foul the vase-water were removed. All tests were

carried out in clean, 1.2L vases containing 1.0L water (or water with flower food) and, usually, five stems.

Several post-harvest, conditioning and flower food products were used in the course of this project: the post-harvest conditioning products Chrysal AVB, RVB, RVB Clear and CVBN, the transport conditioner Chrysal Clear New Professional 2 (as 'T-bags'), and the standard flower food Chrysal Clear Universal Cut Flower Food (as powder sachets) (Chrysal UK, Leeds, WF3 2DW, UK). These product names are abbreviated to AVB, RVB, RVB Clear, CVBN, T-bags and flower food in the text. Post-harvest conditioning was for 24 hours or overnight, unless stated otherwise.

(Continued on page 23)

Table 1. Cut-flower species and varieties trialled in 2007 and 2008.

Species and purpose of trial	*Varieties, series, (producer/supplier)*	*Transplanting or drilling dates*	*Site, density and spacing*	*Picking stages and specs*
1. Ageratum (*Ageratum houstonianum*) Demonstration	Blue Horizon	Transplanted week 21 2007	Tunnel and outside 32 plants/m^2	Not specified
2. Amaranthus (*Amaranthus* spp.) Variety demonstration	Candelabra Green Cascade Green Thumb Pygmy Torch Velvet Curtains[a] (Sahin)	Transplanted week 22 2008	Tunnel and outside 9 plants/m^2 30cm x 30cm [a]50cm x 50cm	Not specified
3. Antirrhinum (*Antirrhinum majus*) Commercial evaluation	See text – commercial evaluation			
4. Aster (*Aster pringlei*) Monte Casino type Demonstration	Caitlyn Moerlyn Cirina Dark Monte Euro Moercasino	Transplanted week 25 2007	Tunnel and outside	Stage 2, 33-50% of florets open, length 55+ or 60+cm.
5. Brassica (ornamental) (*Brassica oleracea*) Trial 1: Variety and drilling date	Crane Pink Crane White Red Crane Rose Crane	Direct-drilled week 28 2007 week 31 2007 week 35 2007	Outside In 5 rows, 5cm apart in outer rows, 7cm apart in inner rows	Significant colour change, length 65+cm.
Brassica (ornamental) (*Brassica oleracea*) Trial 2: Variety, transplanting and drilling date	Alesa Anchutka Cheneve Crane Bicolor Crane Pink Crane Red Crane Rose Crane White Galina Ludmila Tatjana Varvara Roze & Tulpvorm	Direct-drilled week 21 2008 Direct-drilled and transplanted[b] week 26 2008 Direct-drilled week 30 2008	Outside Outside and tunnel Outside In 5 rows, 5cm apart in outer rows, 7cm apart in inner rows [b] 64plants/m^2 12cm x 12cm	As above

6. Carnation (spray) (*Dianthus caryophyllus*) Demonstration	Natila Scarlet Queen (Hilverda)	Transplanted week 39 2007 week 15 2008	Tunnel 16 plants/m^2 25cm x 25cm	4 buds coloured, length 60+cm.
7. Caryopteris (*Caryopteris x clandonensis*) Demonstration	Deep Pink Large Blue Large White (Liss Forest Nursery)	Transplanted week 15 2008 pl 11/04/08 tunnels	Tunnel 6 plants/m^2 30cm x 50cm (staggered)	50% florets open.
8. China aster (*Callistephus chinensis*) 'German asters' Commercial evaluations	See text – commercial evaluations			
9. Cynara (*Cynara cardunculus*) Demonstration	3222 3223 (Combifleur)	Transplanted week 22 2007	Tunnel and outside 24 plants/m^2 30cm x 50cm	Not specified
10. Delphinium *(Delphinium* Elatum Group*)* Trial 1: Planting date, variety and continuity	<u>Scent</u> White Pink Rose Sky Blue Centurion Blue <u>Takii Aurora</u> Light Blue Light Purple Blue Lavender Deep Purple <u>Pan American Guardian[c]</u> Lavender Blue White Belladonna Blue Shadow[c] Blue Donna Imperial[d] [c]planting 1 only [d]planting 2 only	Transplanted week 21 2007 week 23 2007 week 27 2007	Tunnel and outside 36 plants/m^2	1/3rd of flower column open, 2/3rds in bud, column 30+cm. Length grades 55, 75, 108cm.

Delphinium *(Delphinium* Elatum Group) Trial 2: Planting date, variety and continuity	Centurion Gentian[e] Guardian Blue Guardian Early Blue[f] Guardian White[g] Aurora[e,h] Aurora Blue[i] Aurora Light Blue[j] Sky Blue / White Beej[i] [f] weeks 15, 17 and 19 only [g]week 17 only [h]week 15 and 21 only [i]week 19 only [j]week 21 only (Ball) [e](Combifleur)	Transplanted week 15 2008 week 17 2008 week 19 2008 week 21 2008	Tunnel 36 plants/m^2 20cm x 20cm	As above
Delphinium *(Delphinium* Elatum Group) Demonstration of tissue-cultured plants	DO8006 DO8007 L DE 1-1 L DE 2-1 L DE 3-1 L DE 4-1 L DE 5-1 L DE 6-1 (Ball)	Transplanted week 21 2008	Tunnel 36 plants/m^2 20cm x 20cm	As above
11. Dianthus (annual) (*Dianthus barbatus*) Trial 1: Planting date, variety, continuity and vase-life trial	<u>Amazon</u> Neon Cherry Neon Purple Rose Magic Bodestolz[k] <u>Sweet</u> Coral Purple Red Scarlet White 3850[l] 4244[m] (Pan American/ Ball Holland) [k](Quedlinburg)	Transplanted week 22 2007 [l]week 24 2007 [m]week 25 2007 week 26 2007	Tunnel and outside 36 plants/m^2	Stage 2, 3-5 florets open, stem 60+cm.

Dianthus (annual) (*Dianthus barbatus*) Trial 2: Planting date, variety, continuity, pinching and vase-life trial	<u>Amazon</u> Neon Cherry[n] Neon Duo[n] Neon Purple[n] Rose Magic[n] Bodestolz Green Trick[o] <u>Sweet</u> Coral[n] Purple[n] Red Scarlet[n] White [n]pinched or not pinched as part of trial; other varieties included for observations only (Ball) [o](Hilverda)	Transplanted week 17 2008 week 19 2008 week 28 2008 week 18 2008	Tunnel Tunnel Tunnel Outside 36 plants/m^2 20cm x 20cm	As above
12. Echinops (*Echinops ritro)* Demonstration	Veitch's Blue	Transplanted week 18 2007	Tunnel and outside	Stage 2, stem 60+cm.
13. Eryngium (*Eryngium planum*) Variety demonstration	Belladonna Blue Bell Ellabella Farid Marbella (Astée Flowers) Purple Sheen[p] 3221[p] (Combifleur/Sohin)	Transplanted week 17 2007 [p]week 24 2007 Purple Sheen replaced week 15 2008	Tunnel and outside 9 plants/m^2 40cm x 40cm	Pronounced, well developed cone showing true blue colour and green stems, stem 60+cm.
14. Godetia (*Clarkia amoena,* syn. *Godetia grandiflora*) Demonstration 1	<u>Grace</u> Rose with Pink Salmon Red Shell Pink (Sacata)	Transplanted week 21 2007 week 25 2007	Tunnel and outside 32 plants/m^2	Not specified
Godetia (*Clarkia amoena,* syn. *Godetia grandiflora*) Demonstration 2	Mixed Colours (Sahin) Miss Nagasaki (Miyoshi) Satin Mix Grace Mix (Sacata)	Transplanted week 17 2008 week 26 2008	Tunnel 32 plants/m^2 25cm x 12.5cm	As above
15. Grasses (ornamental) (*Panicum, Setaria, Chasmanthium* and *Miscanthus* spp.) Demonstration	*Panicum elegans* Frosted Explosion *P. virgatum* *P. virgatum* Fontane[r] *Setaria italica*[q] *Chasmanthium latifolium*[s] *Miscanthus sinensis* Malepartus[s,t] (Kolster)	Transplanted week 22 2007 [q]week 24 2007 [r]week 25 2007 [s]week 18 2008	Outside 9 plants/m^2 30cm x 30cm [t]4 plants/m^2 50cm x 50cm	Stems 55+ or 60+ cm.

16. Larkspur (*Consolida ajacis*) Variety demonstration	Early Bird Giant Imperial Braveheart Single Blue Single Deep Blue Single Red Single White (Sahin) Sublime Lilac (Tezier) Sydney Pink (Kieft)	Transplanted week 21 2007	Outside 64 plants/m^2	Stage 1 or 2, spike length 15 or 20+cm, stem 62 or 65+cm.
Larkspur (*Consolida ajacis*) Trial 1: Variety and planting date	Kingsize Scarlet (Sahin) Sublime Deep Blue (Tezier) Sydney Lilac Sydney Rose Sydney White Blue Picote Light Blue Sydney Purple Sydney White (Kieft/Combifleur)	Transplanted week 21 2007 week 25 2007	Outside 64 plants/m^2	As above
Larkspur (*Consolida ajacis*) Trial 2: Planting date and planting density	Sydney Blue Sydney Pink (Kieft/Combifleur)	Transplanted week 17 2008 week 21 2008 week 23 2008	Outside 64, 81 or 100 plants/m^2 12.5cm x 12.5cm, 11cm x 11cm or 10cm x 10cm	As above
17. Phlox (*Phlox paniculata*) Variety demonstration	Icecap Miss Marple Miss Fiona Sugar Missy (Bartels) Magical Dream[u] Magical Fragrance[u] Magical Surprise[u] (Kolsters)	Transplanted week 25 2007 [u]week 18 2008	Tunnel and outside 16 plants/m^2 25cm x 25cm	Self-supporting stem, spike length 8+cm, stem 52+cm.
18. Pink (*Dianthus* sp.) Variety demonstration 1	Bright Eyes Lily the Pink Monica Wyatt Rose Monica (Whetman)	Transplanted week 18 2007	Tunnel and outside 16 plants/m^2	Calyx just broken and showing colour, stem 40+cm.
Pink (*Dianthus* sp.) Variety demonstration 2	Bright Eyes[v] Lily the Pink Monica Wyatt Rose Monica Dancing Queen[v] Devon Cream[v] Gran's Favourite[v] Letitia Wyatt [v]week 42 only (Whetman)	Transplanted week 42 2007 Transplanted week 23 2008	Tunnel and outside Tunnel 16 plants/m^2 25cm x 25cm	As above

19. Sedum (*Sedum* spp.) Variety demonstration	*S.* Herbstfreude[w] *S. hybrida* Autumn Joy *S.* Matrona[w] *S. spectabile* Brilliant[x] *S.* Superior Pink *S.* Superior White *S. telephilium* Carl *S. telephilium* Munstead Dark Red (Combifleur, Kolsters)	Transplanted week 28 2007 [w]week 39 2007 [x]both dates	Outside 6 plants/m^2	50% florets showing colour, stem 50+cm, 300g bunch.
20. Solidago (*Solidago media*) Demonstration	*Solidago media* (Astée Flowers)	Transplanted week 17 2007	Tunnel and outside	Stage 2, stem 53+cm and 15+g.
21. Veronica (*Veronica* sp.) Demonstration	Blue Spark Lavender Spark Pink Spark White Spark (Astée Flowers)	Transplanted week 25 2007	Tunnel and outside	Not specified
22. Zinnia (*Zinnia elegans*) Trial 1: Varieties and stem strength	Canary Bird Cerise Queen Luminosa Meteor Orange King Purple Prince (Sahin) Yellow Flame (Goldsmith) Sun Cherry[y] Sun Red[y] Sunshine Mix[y] (Takii) [y]only in tunnel and week 27	Direct drilled week 21 2007 Direct drilled week 24 2007 Transplanted week 27 2007	Outside Tunnel Tunnel and outside 32 plants/m^2 25cm x 12.5cm (staggered)	Stage 2, stem 60+cm.
Zinnia (*Zinnia elegans*) Trial 2: Assessment of stronger-stemmed varieties	Meteor Purple Prince (Sahin) Uproar Zowee Yellow Flame (Goldsmith)	Transplanted week 26 2008	Tunnel 32 plants/m^2 25cm x 12.5cm (staggered)	As above

Table 2. Pesticides applied to all trial plots in 2007.

Date	*Products applied*
09 July 2007	Callipso, Hallmark
12 July 2007	Stroby
12 July 2007	Plover
27 July 2007	Plover, Stroby
06 August 2007	Nimrod
10 August 2007	Aphox
13 August 2007	Solfa
14 August 2007	Bravo 500
17 August 2007	Majestik
20 August 2007	Plover
31 August 2007	Aphox
12 September 2007	Systane
13 September 2007	Majestik
25 September 2007	Solfa
28 September 2007	Aphox, Hallmark
02 October 2007	Systane
04 October 2007	Majestik
11 October 2007	Solfa
12 October 2007	Aphox, Hallmark
18 October 2007	Systane
19 October 2007	Majestik
06 November 2007	Solfa
07 November 2007	Aphox
11 December 2007	Slug pellets

Table 3. Pesticides applied to trial plots in 2008.

Date	*Products applied*	*Crops treated*
21 April 2008	Aphox	All
01 May 2008	Jet 5, Thiovit	Aster, delphinium, solidago
01 May 2008	Slug pellets	All
04 May 2008	Aphox	All
13 May 2008	Delsene	Pinks
13 May 2008	Systhane	Delphinium
21 May 2008	Systhane	Delphinium
22 May 2008	Plover	Dianthus, pinks
23 May 2008	Aphox	All
27 May 2008	Jet 5, Thiovit	Aster, delphinium
04 June 2008	Bravo	Dianthus, pinks
05 June 2008	Stroby	Aster, delphinium, larkspur, phlox, solidago
09 June 2008	Aphox	All
13 June 2008	Jet 5, Thiovit	Delphinium
16 June 2008	Plover	Dianthus, pinks
17 June 2008	Dynamec	Pinks, solidago
20 June 2008	Systhane	Aster, delphinium, larkspur, phlox, solidago
23 June 2008	Dynamec	Pinks, solidago
24 June 2008	Systhane	Larkspur
27 June 2008	Thiovit	Aster, delphinium, larkspur, solidago
30 June 2008	Bravo	Dianthus, pinks
01 July 2008	Systhane	Aster, delphinium, larkspur, solidago

03 July 2008	Starion flo	Pinks, solidago
04 July 2008	Thiovit	Aster, delphinium, larkspur, solidago
08 July 2008	Stroby	Aster, delphinium, larkspur, solidago
10 July 2008	Thiovit	Aster, delphinium, larkspur, solidago
15 July 2008	Systhane	Delphinium, larkspur, solidago
18 July 2008	Thiovit	Aster, delphinium, larkspur, solidago
22 July 2008	Stroby	Aster, delphinium, larkspur, solidago
22 July 2008	Aphox	Zinnia
23 July 2008	Plover	Dianthus, pinks
25 July 2008	Thiovit	Aster, delphinium, larkspur, solidago
29 July 2008	Systhane	Aster, delphinium, larkspur, solidago
30 July 2008	Bravo	Dianthus, pinks, zinnia
01 August 2008	Thiovit	Aster, delphinium, larkspur, solidago
01 August 2008	Aphox	Brassica
05 August 2008	Systhane	Aster, delphinium, larkspur, solidago
05 August 2008	Decis	Brassica
06 August 2008	Aphox, Hallmark	All
06 August 2008	Delesene	Zinnia
08 August 2008	Thiovit	Delphinium, phlox, solidago
12 August 2008	Systhane	Delphinium, phlox, solidago
13 August 2008	Bravo	Pinks, zinnia
16 August 2008	Stroby	Delphinium, phlox, solidago
19 August 2008	Thiovit	Delphinium, phlox, solidago
22 August 2008	Stroby	Delphinium, phlox, solidago
26 August 2008	Fortress	Delphinium, phlox, solidago
27 August 2008	Systhane	Delphinium, phlox, solidago
28 August 2008	Aphox, Hallmark	All
29 August 2008	Thiovit	Delphinium, phlox, solidago
02 September 2008	Stroby	Delphinium, phlox, solidago
05 September 2008	Thiovit	Delphinium, phlox, solidago
08 September 2008	Potassium bicarbonate	Delphinium, phlox, solidago
09 September 2008	Systhane	Delphinium, phlox, solidago
11 September 2008	Dynamec	Caryopteris, pinks
12 September 2008	Thiovit	Delphinium, phlox, solidago
16 September 2008	Systhane	Delphinium, phlox, solidago
19 September 2008	Thiovit	Delphinium, phlox, solidago
23 September 2008	Stroby	Delphinium, phlox, solidago
25 September 2008	Aphox, Hallmark	All
26 September 2008	Thiovit	Delphinium, phlox, solidago
30 September 2008	Systhane	Delphinium, phlox, solidago
03 October 2008	Thiovit	Delphinium, phlox, solidago
07 October 2008	Stroby	Delphinium, phlox, solidago
10 October 2008	Thiovit	Delphinium, phlox, solidago
16 October 2008	Systhane	Delphinium, phlox, solidago

(continued from page 16)

Once the stems were in vases they were placed on the bench of a vase-life room (20°C, *ca.* 60% relative humidity, and tubular florescent lamps producing 1000 lux at flower height on for 12 hours per day). Stems were usually examined daily, recording the date when each stem reached the end-point of its vase-life. In zinnia this was taken as when 50% of the ray-florets had wilted, and, in the other species, when more than 50% of the florets on a stem had started to wilt or drop petals.

Each stem was scored for flower and leaf quality and each vase for water clarity, on a scale of 1 to 5, a score of 5 always representing the highest quality (Table 4). The main assessments were carried out on specified vase-days (days after flowers went into vases), generally related to the guaranteed vase-life (see 'Results'). Observations were then continued until each stem had reached its end-point. If a stem reached its end-point before the main assessment date it was left in the vase until that time; thereafter stems were discarded individually as they reached their end-point. The volume of liquid remaining at the end of vase-life was noted so that water uptake could be measured.

Table 4. Quality scores used in vase-life testing.

Score	*Flower or leaf quality*
1	Very poor quality, consumers would discard
2	Poor quality, most consumers would discard
3	Reasonable quality, most consumers would not yet discard
4	Good quality, consumers would not discard
5	Very good quality
Score	*Water clarity*
1	Poor clarity
2	
3	Moderate
4	
5	Good

Annual dianthus and phlox vase-life trials, 2007

Ten stems of each variety from the trials at Kirton were placed in a vase of water containing flower food.

Antirrhinum vase-life trials, 2007

Three vase-life tests were set up, all using eight varieties. Flowers were cropped by the nursery carrying out the commercial evaluation, treated with conditioner, and transported vertically in buckets of water to Kirton for testing on 20 August 2007.

1. Variety trial: the vase-life of the eight varieties was compared. After harvest all stems were placed in buckets containing CVBN at the growers. For each variety five or six stems were placed in a vase containing flower food.
2. Post-harvest treatment trial: bunches of the eight varieties were placed in buckets to receive one of seven treatments at the grower's holding:
   (1) AVB then dry
   (2) AVB then RVB Clear
   (3) AVB then CVBN
   (4) RVB Clear throughout
   (5) CVBN throughout
   (6) plain water
   (7) plain water
   On receipt at KRC the buckets were placed in the vase-life room for 4 days (retail store phase), the stem bases of treatment (1) first being re-cut, stems from treatments (1) to (6) being placed in water with a T-bag, and stems from treatment (7) being placed in plain water. All stems were then transferred to vases as described under Trial 1, except that for treatment (7) the vases contained plain water. For each of the seven treatments four 'replicate' vases were set up, replicate 1 containing three stems each of varieties 1 and 2, replicate 2 containing three stems each of varieties 3 and 4, and so on.

3. Flower food trial: at the grower's bunches of the eight varieties were placed in buckets containing either CVBN (treatments 1-3) or plain water (treatment 4). On receipt at KRC the buckets were placed in the vase-life room for 4 days (retail store phase), the stems from treatments (1) to (3) being placed in water with a T-bag and stems from treatment (4) in plain water. Stems were then transferred to vases containing:
   (1) Chrysal Clear Universal Cut Flower Food (as powder)
   (2) Chrysal Clear Lilium and Alstroemeria Food (as powder)
   (3) Chrysal Clear Bulb Flower Food (as powder)
   (4) Plain water.
   For each of the four treatments four 'replicate' vases were set up as described for Trial 2.

Zinnia vase-life trials, 2007

The trial provided stems cropped at three cropping stages (1, flower open; 2, one cluster of stamens visible; 3, two clusters of stamen visible). There was a post-harvest treatment in CVBN or RVB Clear for 24 hours at 2-5°C in the dark. Following this, all stems were transferred to water containing one T-bag for a simulated transport period of 24 hours under the same conditions as post-harvest, followed by a 96-hour period in the same conditions as the vase-life test itself (retail store phase). Six varieties were tested, placing three stems of each of two varieties in a vase with flower food.

Vase-life trials, 2008

After cropping from trials stems were placed in buckets for conditioning treatments, the details of which are given in Table 5. Afterwards they were transferred to vases, usually of plain water, in the vase-life test room. Stems were assessed after the number of days in vases given in Table 5.

Table 5. Details of post-harvest treatments in vase-life tests in 2008.

Crop	Post-harvest treatment(s)	Transport phase treatment	Vase treatment	Assessment day (in vase)
Brassica (ornamental)	CVBN 1 tablet/L	Nil	Plain water	10
Carnations (spray)	1. AVB 2ml/L then CVBN 1 tablet/3L 2. AVB 2ml/L then RVB 2ml/L 3. Plain water	Nil	Plain water	10
Caryopteris	Plain water	Nil	Plain water	10
Delphinium	1. AVB 2ml/L 6h 2. Plain water	T-bag 1 day at 5°C then 4 days at 20°C	Flower Food	5
Dianthus (annual)	1. RVB 2ml/L 2. Plain water	Nil	Plain water	10
Godetia	1. RVB 2ml/L 2. Plain water	Nil	Plain water	6
Grasses (ornamental)	1. RVB 2ml/L 2. Plain water	Nil	Plain water	10
Larkspur	1. AVB 2ml/L then RVB 2ml/L	Nil	Plain water	5

	2. Plain water			
Phlox	1. RVB 2ml/L 4h 2. Plain water	Nil	Plain water	5
Pinks	1. AVB 1ml/L 20°C 2. AVB 2ml/L 20°C 3. AVB 1ml/L 5°C 4. AVB 2ml/L 5°C 5. Plain water	Nil	Plain water	10
Sedum	Plain water	Nil	Plain water	10
Zinnia	1. CVBN 1 tablet/3L 2. Plain water	T-bag 1 day at 5°C then 4 days at 20°C	Plain water	5

Results and discussion

Tables and figures are to be found at the end of each crop section.

1. AGERATUM

Ageratum is an attractive flower, only relatively recently bred for cutting as well as for bedding, 'Blue Horizon' being one of the first long-stemmed varieties. Little is known about the market potential, continuity and performance of ageratum in commercial cut-flower production and, to gain some basic experience with the crop, 'Blue Horizon' was grown in 2007 as a demonstration.

Ageratum demonstration

'Blue Horizon' was transplanted to tunnel and outside plots in week 21, 2007. The plantings produced their first flowers in week 26. When cropped in week 33 (mid-August) the stems grown outside were markedly taller (mean, 42cm) than those from tunnels (31cm), though stem weights were similar (17 and 19g respectively).

Discussion

Ageratum has a relatively small colour range, and the flowers may be too delicate for other than short transport periods. Nevertheless, the demonstration generated sufficient interest from major retailers to justify including ageratum in later trials, though only if newer, cutting-raised varieties can be sourced. At this time the opinions of the MG about taking ageratum forward varies, but it remains a possibility for future trials if new varieties from the USA could be included.

2. AMARANTHUS

Amaranthus are considered very attractive by some customers and too 'odd' by others. There was a specific request from the industry to include an amaranthus variety demonstration in 2008.

Amaranthus demonstration

Five varieties were transplanted into tunnel and outside plots in week 22, 2008 (Table 2.1). The two dwarf varieties, 'Green Thumb' and 'Pygmy Torch', started to flower in week 27, irrespective of whether grown under protection or outside. They produced stems about 50cm long and weighing 60-70g in tunnels, and up to about 20% less outside. The three tall varieties cropped successfully only in outside plots, starting between weeks 29 and 35. Stems averaged 77-110cm long and 189-311g in weight.

Discussion

The MG thought there were still doubts about the commercial acceptability of amaranthus, and specially considering its small window of production. Despite its advantage of including fashionably green flowers, a further variety demonstration would only be justified if other suitable varieties become available.

Table 2.1. Summary of flowering data for amaranthus varieties, 2008.

Variety	*Start of cropping (week)*		*Stem length (cm)*		*Stem weight (g)*	
	Tunnel	*Outside*	*Tunnel*	*Outside*	*Tunnel*	*Outside*
Candelabra	-*	35	-	77	-	249
Green Cascade	-	30	-	110	-	311
Green Thumb	27	27	51	40	70	69
Pygmy Torch	27	27	49	38	58	49
Velvet Curtains	-	29	-	81	-	189

* -, did not flower

See photographs on next page

Amaranthus variety demonstration (11 September 2008)

'Candelabra'

'Green Cascade'

'Green Thumb'

'Pygmy Torch'

'Velvet Curtains'

3. ANTIRRHINUM

Despite the large body of information that exists on antirrhinum, the wide appreciation of the flowers and the huge colour range available, in the UK this crop has been almost entirely imported. A large commercial evaluation was therefore carried out on a commercial nursery in 2007.

Antirrhinum commercial evaluation

Sue Lamb writes: *"Until we undertook this trial we had not grown antirrhinums before at Lamb's Flowers. Previously, snaps had been sourced from Holland. The flowers are attractive, but relatively delicate, and we thought a more durable product might be obtained by production in the UK, close to the markets. Another attraction was that, using outside beds, tunnels and cold glass, flowers could be cropped for 46 weeks of the year. The main question for us, and the reason for the commercial evaluation, was to find out whether the flowers could be managed down the line… could we handle and pack within a budget? No one can afford to make unrealistic promises to supermarkets!*

The soil structure here is a bodied loam which received a base dressing of 60 units N, 100 units each of potash and phosphate, over a 4000m^2 site. Antirrhinums were planted in beds worked with a bed former, so the slightly raised beds allowed water to run off. They were transplanted through carrot film at a planting rate of 64/m^2. Support netting was provided - and this had to be shaded from the wind because the flowers bruise easily. The nets had to be lifted regularly, keeping at foliage level to avoid damage to the flowers. To control pests and diseases the crop was sprayed with Amistar and Fubol Gold (twice) for downy mildew, with Plenum for aphids, with Ambush for caterpillars and with Roval for botrytis.

Although 2007 was extremely wet the antirrhinum did not suffer as some crops would, though it was difficult getting enough good days to plant. Because of the weather it was not possible to apply the appropriate amounts of feed in the growing period. In 2007, certainly, using a raised bed system helped - the crop does not like to sit in water, which leads to plant stress and short stems. In a normal year antirrhinums would require irrigating!

Overall the 'Potomac' series was the best and most even producer, though this may be different in a normal (drier) year. The most attractive variety was 'Apple Blossom'. 'Deep Orange', 'Early White', 'Ivory White', 'Plum Blossom', 'Royal' and 'Yellow' were other good varieties. But we found it impossible to keep the aphid out of 'Cherry Rose'. The stems were no better grown in tunnels than outside. They grow too fast in the warm, and come harder outside – a better product altogether.

Antirrhinum is basically a 10-week crop, and like most summer crops it closes up in the middle a bit depending on temperature. The costs, per 1000 plants, were about £10 to plant, £10 to crop and £20 to put down the line. Specifications demand a 40g stem, which is far too ambitious - realistically it should be nearer 30 or 35g. The problem is that the spec was originally set up at a time of year when quality is naturally higher. The plants were cropped every 48 hours with a bloom count of five open florets and a column length of 15cm. A length of 60cm was required and only 74% made this specification, so they need to fetch 19 or 20p per stem. This is different to other crops planted at 64/m^2, where 90 to 95% of the plants can be expected to reach the specification.

We will not be growing snaps again! The marketplace is different for the Dutch. They manage to grow snaps because they grow outdoors, large-scale, with lower costs and although the Dutch experience low prices of 17p - 18p, with their auction system they also have the pleasure of experiencing prices in excess of 30p. Compare our market with a flat 20p per stem. Growing snaps in the UK would only be possible on a very restricted scale for a niche market – and a very well researched market at that."

Vase-life trials

In 2007 three vase-life trials were carried out with antirrhinums. For the varieties and treatments used, see Tables 3.1 – 3.3.

Vase-life trial 1 – variety trial All varieties exceeded their guaranteed 5-day vase-life, with vase-lives between 6.2 ('Opus Red') and 10.0 days ('Apple Blossom') (Table 3.1). Leaf quality scores were high for all varieties by vase-day 5, but flower quality scores were variable, from 2.8 ('Opus Red' again) to 4.6 ('Apple Blossom' again). Water clarity was good, except in one variety ('Yellow'). The low water uptake of 'Opus Red' may account for this variety's short vase-life and poor flower quality, although in 'Dark Orange' the high water uptake was not matched by an exceptional vase-life.

Vase-life trial 2 - post-harvest, in-store and consumer treatments In this trial antirrhinums exceeded their guaranteed vase-life in all treatments, with vase-lives between 6.9 and 8.4 days (Table 3.2). There were no leaf quality or water clarity issues, and flower quality and water uptake were similar in all treatments, including the control in which water was used throughout.

Vase-life trial 3 – vase treatments Antirrhinums exceeded their guaranteed vase-life in all treatments, with a vase-life of 6.6 for the water control and between 7.5 and 8.2 for the three flower food treatments (Table 3.3). There were no water clarity issues. The water control had lower leaf and flower quality scores and lower water uptake than stems from any of the flower food treatments. The reason for the discrepancy in the performance of the controls in trials 2 and 3 is, at this point, unexplained.

These vase-life trials showed the potential for several varieties of antirrhinum to perform well in the vase under a range of flower treatments.

Discussion

The extensive commercial evaluation undertaken in 2007 provided useful experience with the crop, demonstrated the value of outdoors growing, and identified a number of good varieties. However, in the evaluation only 74% of the plants reached the high specification demanded by a UK supermarket, and at the poor price that could be obtained, 20p/stem, the crop was considered uneconomic unless for a specialised market. The MG considered that these difficulties have arisen because the specification was originally set at an unrealistic level.

Table 3.1. The vase-life and quality of antirrhinum varieties assessed on vase-day 5 (Trial 1, 2007). Stems were placed in CVBN at the growers and tested in vases with flower food.

*Variety**	*Leaf quality score (1-5)*	*Flower quality score (1-5)*	*Vase -life (days)*	*Water clarity score (1-5)*	*Water uptake (ml/vase)*
BP Dark Orange	5.0	3.3	8.5	5.0	790
BP Apple Blossom	4.6	4.6	10.0	5.0	530
C Opus Red	4.7	2.8	6.2	4.0	270
BP Cherry Rose	4.5	3.5	8.2	5.0	485
C White	5.0	3.4	8.8	5.0	480
CP Early Pink	5.0	4.2	8.4	4.0	420
C Axiom Bronze	4.8	3.0	7.0	4.0	405

BP Yellow	4.8	4.0	8.0	3.0	470

* B = Ball, P = Potomac and C = Combifleur.

Table 3.2. The vase-life and quality of mixed antirrhinum varieties assessed on vase-day 5 following post-harvest, in-store and vase treatments (Trial 2, 2007).

Treatment			*Leaf quality score (1-5)*	*Flower quality score (1-5)*	*Vase -life (days)*	*Water clarity score (1-5)*	*Water uptake* (ml/stem)*
Post-harvest	*Store*	*Vase*					
AVB-dry	T-bag	Flower food	4.7	3.6	6.9	4.8	17
AVB-RVB Clear	T-bag	Flower food	4.4	3.5	7.4	4.8	19
AVB-CVBn	T-bag	Flower food	4.8	3.4	7.3	5.0	19
RVB Clear	T-bag	Flower food	4.8	3.3	7.6	4.8	20
CVBn	T-bag	Flower food	4.7	3.7	7.3	5.0	20
Water	T-bag	Flower food	4.8	3.4	7.0	5.0	18
Water	Water	Plain water	4.8	3.6	8.4	5.0	22

* Note that in this table water uptake is in ml/stem not ml/vase.

Table 3.3. The vase-life and quality of mixed antirrhinum varieties assessed on vase-day 5 following various treatments (Trial 3, 2007).

Treatment			*Leaf quality score (1-5)*	*Flower quality score (1-5)*	*Vase -life (days)*	*Water clarity score (1-5)*	*Water uptake* (ml/stem)*
Post-harvest	*Store*	*Flower food*					
CVBN	T-bag	Universal food	4.9	3.7	7.5	5.0	30
CVBN	T-bag	Lily and alstro	4.4	3.4	8.0	5.0	29
CVBN	T-bag	Bulb food	4.8	3.4	8.2	5.0	38
Water	Water	Plain water	4.2	3.1	6.6	5.0	12

* Note that in this table water uptake is in ml/stem not ml/vase.

4. ASTER (*ASTER PRINGLEI*) (MONTE CASINO TYPE)

New Monte Casino-type aster varieties have been attracting attention amongst growers, and a demonstration was included to assess their commercial potential.

Aster demonstration

Three September-flowering varieties – 'Caitlyn Moerlyn', 'Cirina Dark' and 'Monte Euro Moercasino' - were planted in tunnel and outside plots in week 25, 2007 and assessed in 2008 (Table 4.1).

The relative performance of the three varieties was not consistent, so it was not possible to generalise.

- Cropping started in week 38 in tunnels for all varieties, and slightly earlier (weeks 35 – 38) outside.
- Under glass, 'Cirina Dark' produced the heaviest yields (156/m^2), with good stem lengths (132cm) and weights (195g). Outside, yields were lower (96/m^2), with a similar stem length but much greater stem weight (263g).
- 'Monte Euro Moercasino' produced similar yields (about 125/m^2), stem length (around 112cm) and stem weight (123 or 152g) whether grown in tunnels or outside, with cropping starting 3 weeks' earlier outside.
- 'Caitlyn Moerlyn' produced higher yields and longer and heavier stems in tunnels (120/m^2, 119cm and 276g) than outside, and cropping was 3 weeks earlier outside.

Discussion

The asters grown in the demonstration proved to be very vigorous, but the three varieties performed very differently. It was clear that much remains to be learned about them. Although interest remains, the MG considered there was no immediate call for further trials at present. Improved seed stocks might alter this perception.

4.1. Performance of three September-flowering aster varieties, 2008.

Variety	*Start of cropping (week no.)*		*Stem yield (no. per m^2)*		*Stem length (cm)*		*Stem weight (g)*	
	Tunnel	*Outside*	*Tunnel*	*Outside*	*Tunnel*	*Outside*	*Tunnel*	*Outside*
Caitlyn Moerlyn	38	35	120	64	119	100	276	188
Cirina Dark	38	38	156	96	132	134	195	263
Monte Euro Moercasino	38	35	126	123	119	108	152	123

5. BRASSICA (ORNAMENTAL)

The popularity of ornamental brassica is a recent phenomenon, currently met in the UK almost entirely by imports. Trials were set up to investigate a range of varieties and planting dates, to point up the potential for production in the UK and highlight likely problems.

Ornamental brassica variety and planting date trials

In 2007 four 'Crane' varieties were direct-drilled into outside plots in weeks 28, 31 and 35, but problems with delivery and the unusually wet weather meant that few meaningful results were obtained. As there was continued interest in the crop, a more extensive trial was planned for 2008.

In 2008 twelve varieties were transplanted into tunnel or outside plots in week 26. In addition the five 'Crane' varieties were drilled into outside plots only in weeks 21, 26 and 30 (Tables 5.1 and 5.2).

- Outside drilled crops ('Crane' varieties only):
    - Following reaching a marketable colour, cropping started in week 29 for the first drilling and about week 35 for the second. The third drilling was too late, and these plants remained small and failed to colour or to colour sufficiently to justify cropping.
    - Yields generally remained around 35 stems/m^2, though they fell off in some varieties from the third planting.
    - None of these crops produced sufficiently long stems (65cm or more). Lengths were about 50-60, 40-55 and 20-30cm long for the first, second and third drilling, respectively.
    - Heavy stems from first drilling (269 – 426g), falling markedly with later drilling (32 – 102g in third drilling).
- Outside transplants (all varieties):
    - The various varieties started to show colour change in weeks 34 to 40.
    - Yields were 31 – 45 stems/m^2.
    - Stem lengths averaged from 38 to 63cm in the different varieties, failing to reach the specification. Stem weights varied considerably between varieties.
- Tunnel transplants (all varieties):
    - The plants in tunnels were etiolated, growing to be very tall (80-110cm) and weak and therefore unmarketable. Most varieties started to show colour development about week 40, while some failed to colour.

Vase-life trial

The post-harvest quality of stems of each variety from the 2008 trial was assessed in vases of plain water, following conditioning in CVBN. This showed wide differences between the varieties (Figure 5.1).

- Vase-life ranged from 6.6 days ('Tatjana') to 17.4 days ('Crane Pink'), with several varieties lasting for over 2 weeks.
- 'Anchutka', 'Crane Pink' and 'Crane Pink' had high leaf quality scores (4 or more) and high water clarity scores (5), while 'Tatjana' and 'Varvara' had very low scores (about 1).
- Although water uptake varied between 438 and 720ml/vase in the different varieties, it did not correlate with other quality aspects – for example, both 'Tatjana' and 'Varvara' had high water uptake but very poor water quality.
- In most cases the vase-water became unpleasant.

Discussion

Although sometimes considered a fashion item, the MG thought that ornamental brassica are likely to remain in demand for some time. To maintain economic production with the current price of 18 to 19p/stem, and considering the necessary provision of herbicides and of the labour involved in providing and raising support netting, the crop needs to be direct-drilled and grown cheaply in the open.

The MG considered that the potential for the crop in the UK had been clearly demonstrated, but early planting (weeks 16 to 18) is important if short stems are to be avoided, and there is a need to examine 'Red Crane' and newer varieties with foliage that changes colour better and earlier and to find out more about the factors inducing colour change. A larger-scale trial was therefore planned for 2009, and this should incorporate the validation of an early-drilling schedule and improvements in husbandry (e.g. crop sprays and netting). Some Dutch growers drill ornamental brassica very densely and thereby avoid the costs of support netting, and this might also be investigated.

Supermarkets are using ornamental brassica in bouquets, a market that needs to be further developed. Vase-life testing confirmed the longevity of ornamental brassica, though there were major differences between varieties and further selection is needed for this characteristic. The degree of water fouling was also variable but is generally obnoxious, and a vase treatment is needed to deal with the problem; this continues to be investigated by Chrysal.

See photographs on next page

Ornamental brassica vase-life test (18 September 2008)


'Crane Red'


'Varvara'


'Crane Pink'


'Crane Rose'


'Crane Bicolor'


'Cheneve'


'Tatjana'


'Anchutka'

Table 5.1. Start of cropping and stem yield of ornamental brassica varieties transplanted or drilled in tunnel or outside plots in the week numbers shown, 2008.

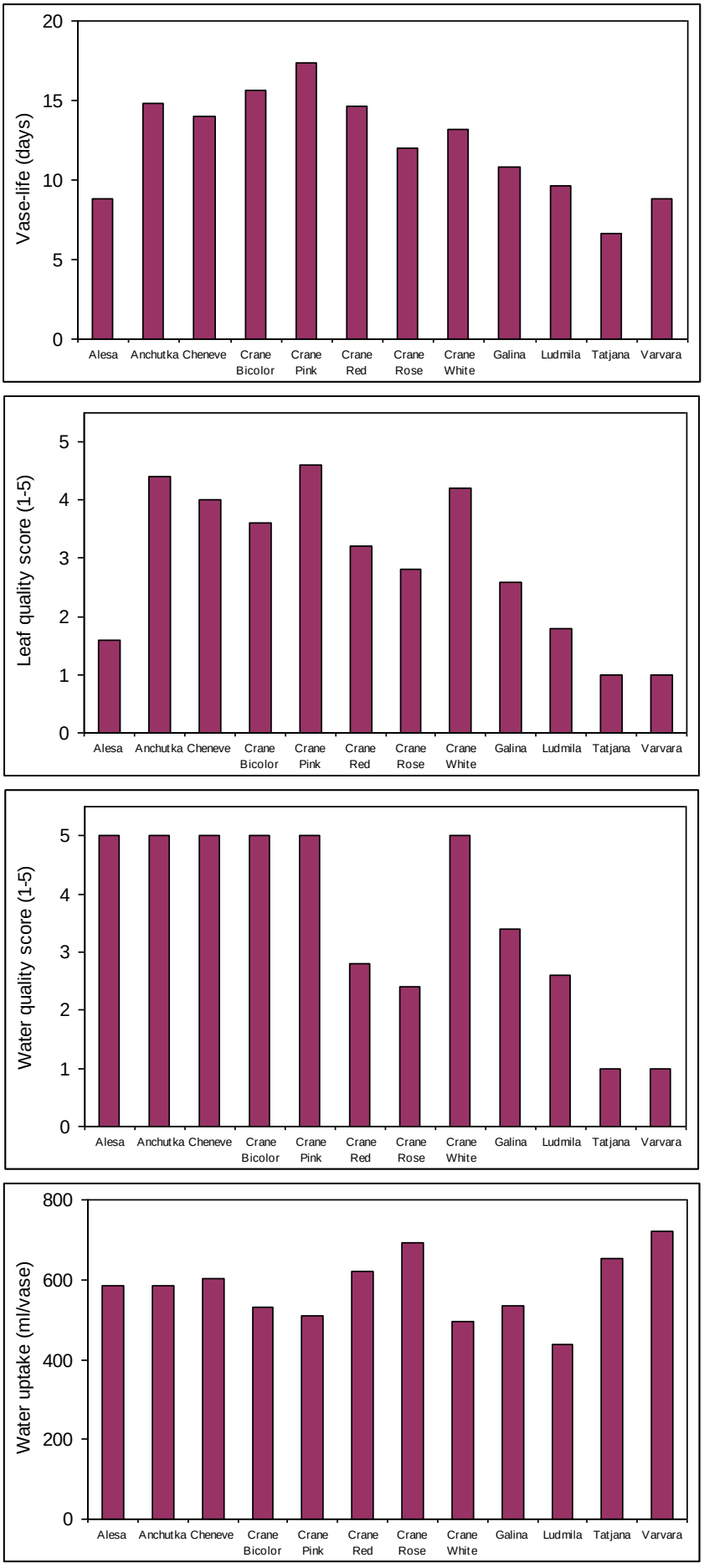
Variety	*Start of cropping (week no.)*					*Yield (stems/m²)*				
	Tunnel	*Outside*				*Tunnel*	*Outside*			
	Transplant	*Transplant*	*Drilled*			*Transplant*	*Transplant*	*Drilled*		
	week 26	*week 26*	*week 21*	*week 26*	*week 30*	*week 26*	*week 26*	*week 21*	*week 26*	*week 30*
Alesa	na	40	nt*	nt	nt	nm	44	nt	nt	nt
Anchutka	40	36	nt	nt	nt	nm	39	nt	nt	nt
Cheneve	40	36	nt	nt	nt	nm	39	nt	nt	nt
Crane Bicolor	40	34	29	34	na	nm	45	34	36	36
Crane Pink	40	34	29	35	na	nm	44	35	35	38
Crane Red	40	36	29	35	na	nm	40	34	39	28
Crane Rose	40	34	29	35	na	nm	43	34	38	29
Crane White	40	38	29	38	na	nm	42	34	36	31
Galina	na	40	nt	nt	nt	nm	31	nt	nt	nt
Ludmila	na	40	nt	nt	nt	nm	33	nt	nt	nt
Tatjana	40	35	nt	nt	nt	nm	43	nt	nt	nt
Varvara Roze and Tulpvorm	40	35	nt	nt	nt	nm	38	nt	nt	nt

* nt, treatment combination not tested; na, not applicable, either no colour change (tunnel) or too small to assess (outside); nm, not marketable.

Table 5.2. Stem length and weight of ornamental brassica varieties transplanted or drilled in tunnel or outside plots in the week numbers shown, 2008.

Variety	*Stem length (cm)*					*Stem weight (g)*				
	Tunnel	*Outside*				*Tunnel*	*Outside*			
	Transplant	*Transplant*	*Drilled*			*Transplant*	*Transplant*	*Drilled*		
	week 26	*week 26*	*week 21*	*week 26*	*week 30*	*week 26*	*week 26*	*week 21*	*week 26*	*week 30*
Alesa	100	56	-	-	-	288	224	-	-	-
Anchutka	94	46	-	-	-	411	114	-	-	-
Cheneve	90	48	-	-	-	367	137	-	-	-
Crane Bicolor	83	47	61	55	31	624	165	426	281	73
Crane Pink	82	40	59	47	31	616	135	289	288	102
Crane Red	82	38	51	40	23	379	119	333	219	32
Crane Rose	85	40	59	41	22	367	210	269	148	46
Crane White	99	48	60	48	32	330	210	281	204	95
Galina	98	56	-	-	-	345	162	-	-	-
Ludmila	108	63	-	-	-	518	235	-	-	-
Tatjana	107	56	-	-	-	396	222	-	-	-
Varvara Roze & Tulpvorm	108	62	-	-	-	628	175	-	-	-

Figure 5.1. Vase-life attributes of 12 ornamental brassica varieties (conditioned in CVBN, plain water in the vase), 2008. From top to bottom: vase-life, leaf quality, water clarity and water uptake.



6. CARNATION (SPRAY)

UK growers believe the quality of UK-grown spray carnations is superior to that of imported produce, and wished to initiate discussions on the quality and value of the home-produced flowers and imported ones. A simple demonstration with two varieties was set up using autumn- and spring-planting, the main purpose of which was to determine market potential and performance of the crop and to benchmark spray carnations against pinks.

Spray carnation demonstration

Varieties 'Natila' and 'Scarlet Queen' were transplanted to tunnels in September (week 39) 2007 and April (week 15) 2008 (Table 6.1).

- September plantings started cropping in week 30, three weeks earlier than the spring plantings.
- Planting in September also resulted in longer, heavier stems and a markedly greater yield of stems.
- 'Natila' was the slightly better yielder, though both varieties produced stems of about the same length and weight and at about the same time.
- In general stem length and head size were judged very good, and there were plenty of breaks.

Vase-life testing

In 2008 stems of each variety were tested in vases of plain water following conditioning in plain water or in AVB followed by CVBN or RVB (Figure 6.1).

- 'Scarlet Queen' showed a longer vase-life and higher flower quality score than 'Natila'.
- Leaf quality and water clarity scores were similar in each variety.
- Vase-life, flower and water quality scores and water uptake were all increased when a conditioner was used. The best results were obtained when the combination of AVB and RVB was used.

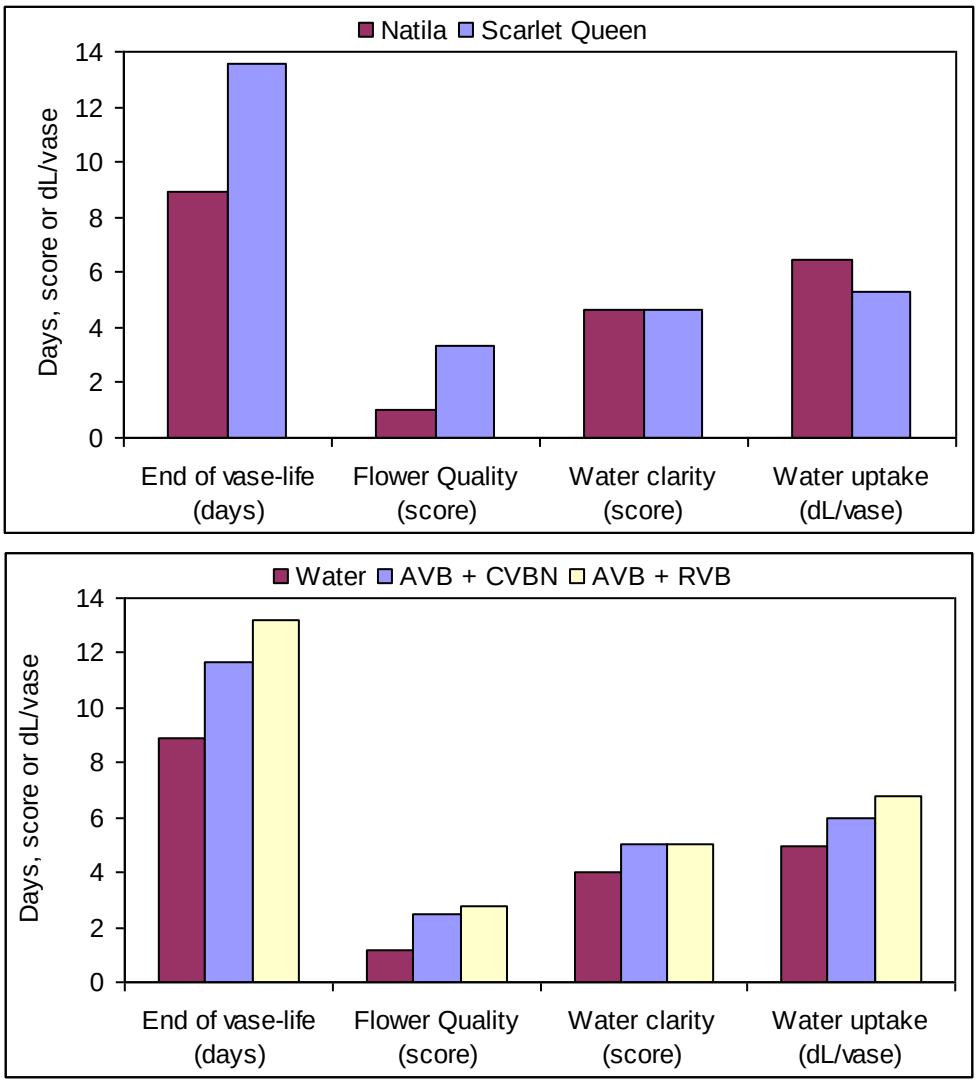
Discussion

The MG considered the stems produced in the trials were of very high quality and excellent for bouquet work, but thought it unlikely such a crop could be marketed at a premium price. Post-harvest quality was good, though there may be some varietal differences, and there was a good response to flower conditioner. However, with a brutal supermarket price war and large quantities of good, cheap spray carnations being imported from Kenya, it was thought unlikely that UK production could be profitable.

Table 6.1. The performance of autumn- and spring-planted spray carnations in tunnels, 2008.

Variety	*When planted*	*Start of cropping (week no.)*	*Stem length (cm)*	*Stem weight (g)*	*Stem yield*	
					(no./m2)	*(no./plant)*
Natila	spring 2008	33	55	40	70	4
Scarlet Queen	spring 2008	33	57	47	63	4
Natila	autumn 2007	30	66	54	107	7
Scarlet Queen	autumn 2007	30	65	52	86	5

Figure 6.1. Vase-life attributes of spray carnation varieties 'Natila' and 'Scarlet Queen' (plain water in the vase following conditioning in plain water, AVB+RVB or AVB+CVBN), 2008. The values are marginal means for (top) the two varieties, and (bottom) the three conditioner treatments.



7. CARYOPTERIS

Little is known about the cultivation of caryopteris for cut-flowers, although they are believed to be prolific growers. Three varieties were included as a demonstration to judge the acceptability of the crop.

Caryopteris demonstration

Three varieties, 'Deep Pink', 'Large White' and 'Large Blue', were planted in a tunnel in week 15, 2008 (Table 7.1).

- All varieties started flowering in week 37 and achieved broadly similar yields of stems (108 to 114 per m^2).
- 'Large Blue' produced longer, but lighter, stems than the other varieties.
- Mildew was a problem in these plots.

Concerns were evident about the unacceptable aroma sometimes associated with the crop, and an *ad hoc* group of eight people was asked to rate stems of each variety as having a very or slightly pleasant odour, no odour, or a slightly or very unpleasant odour, scored from 1 to 5 respectively (Table 7.1). Although individual opinions varied and there appeared to be differences between varieties, sufficient concerns were raised to discourage further trialling. The odour appeared to be noticeable mainly at the point when stems were cut or re-cut.

Vase-life

Sample stems of each variety were tested in plain water (Figure 7.1). There was little difference in vase-life, flower or leaf quality, water clarity or water uptake between them. Vase-life was adequate at about 9 days.

Discussion

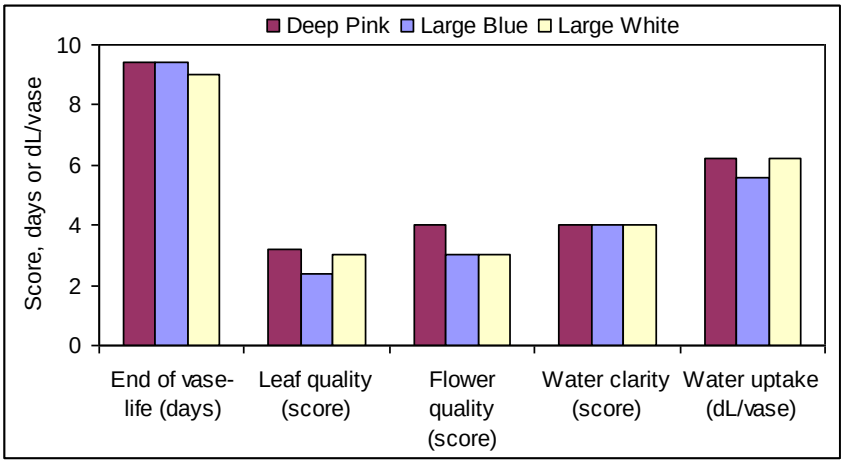
Although good stem yields, lengths and weights were obtained from all varieties tested, caryopteris was judged to be a doubtful subject for exploitation because of its aroma. This aspect of the plant should be further discussed with plant breeders.

Table 7.1. The performance and aroma assessment of three tunnel-grown caryopteris varieties, 2008.

Variety	*Start of cropping*	*Stem yield*	*Stem length*	*Stem weight*	*Aroma score 1-5*

	(week no.)	*(no. per m²)*	*(cm)*	*(g)*	*(5 being worst)*
Deep Pink	37	114	65	78	2.6
Large Blue	37	108	81	69	3.1
Large White	37	129	64	80	2.8

Figure 7.1. Vase-life attributes of three caryopteris varieties, 2008.



8. China Aster ('German Asters')

China asters (*Callistephus chinensis)* are annuals producing generally low yields, but some recent selections produced in Germany are believed to have great potential for growing under protection in the UK because they have attracted attention with their robust and attractively coloured blooms of a wide colour range. For convenience these are referred to in the report as 'German asters'.

'German aster' commercial evaluations

In 2007 commercial evaluations of 'German aster' varieties were planted at two nurseries. The main trial site was severely affected by heavy rain, and there was no alternative but to plough it in. A smaller trial on the second nursery, also adversely affected by the wet weather, nevertheless resulted in significant interest amongst supermarkets. The varieties that showed most promise were 'Gal', 'Steestern', 'Igle' and 'Krallen'.

In 2008 a further, large commercial evaluation was planted out under glass at the first commercial nursery, with a number of varieties and sequential plantings. Although experience had been gained with the crop in the previous year, in 2008 several other difficulties became evident. Although a proportion of the stems was marketed, it was considered inappropriate to collect a great deal of data from this evaluation. The early crop produced plants that were too tall, the mid-season crop was reasonable, and the late crop was planted too close together and lost the robustness typical of these varieties. The crop was also affected by moulds and the seed supplies appeared to be very variable.

Discussion – 'German asters'

Despite the problems due to weather in 2007, the market potential of 'German aster' varieties was recognised by both retailers and growers. In 2008, a further commercial evaluation highlighted a number of problems needing resolution, and these were confirmed by some other growers who were trying the same varieties. Because of the quality of the flowers, the MG considered that further trials were justified so that the crop could be exploited. Issues to be resolved include planting dates, planting density, height restriction (probably using Alar), achieving earlier and later cropping, seed provenance (varieties appear to be coming from more than one source and are not uniform), control of (possibly seed-borne) mould, and quality in the vase (to reduce rapid leaf yellowing or blackening). The MG proposed that in 2009 a further evaluation should take place on a commercial nursery, and that specific issues should be addressed in trials at KRC, including demonstrations that include a range of varieties from all suppliers.

Examples of 'Igel', 'Krallen' and 'Prinova' types of 'German asters'.

9. CYNARA

Little is known of the commercial possibilities of cynara and a small variety demonstration was included in the project.

Cynara demonstration

Two new, coded varieties, 3222 and 3223, were transplanted to outside and tunnel plots in week 22, 2007. This proved to be too late a planting date, and, although the plants became vary large, flowering in the first year was very late. Because of their large size in tunnels, only the outside plots were kept for assessment in 2008, when flowering dates and stem lengths were more reasonable. Cropping started in week 30 and the average stem length and weight were 80cm and 755g. Variety 3222 was the more vigorous of the two.

Discussion – cynara

At the present time there is no clear market potential for cynara. If this situation changes, specifications will have to be addressed and the effects of pinching assessed, since, in a non-pinched plant, the central stems tend to be too large and the side shoots too small. A further issue is that the leaves die in the bucket within a few days of cropping, so an effective conditioner or flower food would be needed to prevent or delay this.

10. DELPHINIUM

Although delphiniums are a widely grown outdoor crop, there are problems in achieving continuity and the high quality demanded by supermarkets. Trials were set up to explore these issues. A small demonstration of tissue-cultured plants of new smaller-flowered lines (more like the Belladonna type) was also planted in 2008. The aim of the latter was to provide more consistent stems over a longer period with higher returns per m^2.

Delphinium trial 1

Starting in 2007, the effects of planting date on continuity were investigated in thirteen delphinium varieties including representatives from three important series ('Scent', 'Takii Aurora' and 'Pan American Guardian') as well as 'Belladonna Blue Shadow' and a new line, 'Blue Donna Imperial'. Transplanting into outside plots and tunnels were made on three dates in 2007, week 21, 23 and 27.

- Several varieties from the first planting in tunnels developed moderate to severe mildew symptoms, the most affected varieties being 'Scent Centurion Blue' and 'Takii Aurora Light Blue' and 'Light Purple'.
- 'Takii Aurora' lines, especially 'Light Blue', from the third planting produced short, poor quality stems.
- Mean stem lengths and weights, recorded only for the first (and most successful) planting, showed that tunnel-raised stems were longer and heavier (overall means 104cm and 108g) than those from outside plots (overall means 65cm and 49g) (Table 10.1).
- Flowers were produced over the period from week 27 to week 36. Despite using three planting dates and up to 15 varieties, there were still breaks in continuity, particularly in weeks 29 and 33-34 (Figure 10.1). For the delphinium crop to be economically viable, this lack of continuity needs to be rectified.

Further assessments were made in 2008, the second growing season (Table 10.2).

- The start of cropping and stem length and weight are summarised across all varieties in Figure 10.2.
  - For any given planting date or flowering flush, cropping dates were similar whether grown in tunnels or outside.
  - Stem lengths and weights were always greater in tunnel-grown plants.
  - In tunnel-grown crops stem lengths exceeded 75cm, within a 'premium range', for all three planting dates and all three flushes. Many, but not all, of the batches of stems from outside plots also exceeded 75cm in length. Stem weights were lower after the first flush.
- Stem lengths and weights are shown for individual varieties for tunnel plantings in Figures 10.3 and 10.4.
  - Varieties of the 'Scent' series consistently produced stems of good length and weight.
  - Some of the 'Takii Aurora' varieties were short, especially from the second and third plantings.
  - Weights generally fell from later plantings and in later flushes.
- In 2008, mildew remained a problem, despite a full fungicide programme, and this issue will need to be addressed.

Considering all planting dates, varieties, tunnel- and outside-grown plants and three flushes, the various plots started flowering between week 19 and week 40. Assuming that each plot was in cropping for about three weeks at each flush, the pattern of cropping over the season is shown in Figure 10.5. Even using this number of combinations, cropping was not continuous, with notable gaps in cropping in weeks

25-29 and 35-38. Further work is needed to address the problems over continuity and poor quality.

Delphinium trial 2

Continuing the theme of the earlier trial, a second trial of delphiniums was planted in 2008. Varieties 'Aurora', 'Aurora Blue', 'Aurora Light Blue', 'Centurion Gentian', 'Guardian Blue' and 'Guardian Early Blue' were planted in plots in tunnels in weeks 15, 17, 19 and 21 (it was not practical to include full plots of all varieties at all plantings).

- The crop produced two flushes and an overall cropping period from week 26 to week 43. To illustrate the continuity of supply over this period, the overall yield of stems is shown in Figure 10.6. (In Figure 10.6 the extra high yield in week 27 was due to marketing problems the previous week; more properly, these stems should have been shared between weeks 26 and 27.) Despite using up to six varieties and four planting dates, however, there were still distinct peaks of production, with gaps in weeks 32 to 33, 38 and 42.

- There was some debate about the grading to be applied to stem length, and for this analysis stems less than 55cm in length were considered unmarketable; any exceeding 75cm in length were considered a premium product. To show the relative productivity and seasonality of these varieties, the yields of stems in the premium grade are given in Figure 10.7. In order to relate production to a 'unit area' and adjust for differences in the areas of plots for different plantings, yields were adjusted to a stems per 100m^2 basis. 'Guardian Blue' and 'Guardian Early Blue' were particularly productive at the beginning of each flush, 'Guardian Blue' having a subsidiary production spurt in the middle of each flush. Spike length is an important factor for delphinium, and on sample batches from the main six varieties it ranged from 46 to 75cm, with an average of 62cm. With the exception of 'Guardian Early Blue' planted at week 19, most or all stems from the first flush reached the premium grade (75cm long or more). In the second flush this proportion fell to around 50% (Table 10.3).

- 'Guardian Blue', 'Guardian Early Blue' and 'Aurora' all produced high total yields of stems in the 75+cm grade from the two earlier plantings, at least 45 stems/m^2, divided between the two flushes. This productivity fell off by the later plantings (Figure 10.8). Most varieties and plantings gave a high proportion of the yield in the 75+cm grade in the first flush, but this was reduced in the second flush (Figure 10.9). The yield of stems in the first growing season are summarised in Table 10.3. Some varieties (particularly 'Guardian Blue') produced very low yields, particularly from the later plantings.

Demonstration – tissue-cultured plants

Eight lines were transplanted to small plots in a tunnel in week 21, 2008 (Table 10.4).

- The 'DO' lines started cropping earlier and had greater stem lengths and weights than the 'DE' lines.
- DO lines started to flower in week 28 (flush 1) and 37-38 (flush 2) and DE lines in weeks 30-31 and 41, respectively.
- Stem lengths averaged 86 and 122cm for the two flushes of DO lines, while in the DE lines the average was 63cm in flush 1 and in flush 2 stems never exceeded 32cm.
- Stem weights averaged 99 and 71g in the first and second flush for DO lines, but averaged only 38g for DE lines in flush 1 (DE lines failed to produce acceptable stems in flush 2).

The performance of these lines was considered poor, and it will be interesting to see if there are any improvements as the plants grow-on in 2009.

Vase-life testing

A selection of varieties, nine in all, from the 2008 trials was taken through vase-life testing. The stems were conditioned in AVB or plain water post-harvest, moved to water with a T-bag for a transport/retail phase, and placed in vases with flower food (Figure 10.10).

- There was a major effect of using a post-harvest conditioner, with treated stems showing a doubling of vase-life, flower quality score and water uptake, compared with plants on plain water.
- Varietal differences in vase-life and flower quality were fairly small.
- Leaf quality was poor in 'Aurora Light Blue'.
- Water clarity was poor in 'Aurora'.
- There were major differences in water uptake between the varieties – between about 1000ml and 2500ml per vase – but these differences were not obviously correlated with other aspects of quality.

Discussion - delphinium

Besides the evaluation of a range of varieties, the main concern with the delphinium cut-flower crop is the need to establish a continuity programme through sequential planting. Although some gaps in production were still evident in the two trials carried out, the general view of the MG was that the trials had advanced the quest for continuity of supply stretching over a 16-week period, and that continuity would have been even better had it been practical to start planting the second trial earlier. But growing the crop in Spanish tunnels meant that planting could not begin before week 15. Although using a less vulnerable low tunnel might be more suited for starting early crops, this would have been uneconomic with delphiniums as it would not be possible to plant to the edges of the tunnel. Since delphiniums are a suitable crop for cold glass, continuity could almost certainly have been extended by planting the first rounds under glass.

A review of the scientific literature on flowering in delphinium was conducted by Dr Allen Langton and is included as Appendix 2 to this report. This suggested several ways in which the flowering season might be extended. The simplest, and possibly the most effective, way to extend the season would be through combining first-year and second-year (over-wintered) plantings with additional variety selection and with part of the crop being pinched (pinching delays flowering but increases quality). Since delphinium have a quantitative (but not obligate) response to vernalisation (cold treatment) in advancing flowering and improving quality (spike length), cold treatments could be applied to seedlings, or, possibly more cost-effectively, to seed. Using supplementary lighting (with SON/T lamps) and various means of heating would also be expected to advance flowering date, but would be likely to be prohibitively expensive under the current economic situation.

Vase-life was generally satisfactory, and delphinium responded very well to conditioning in AVB. But some varieties perform poorly for some attributes, and will need to be identified and excluded.

Quality remains an important aspect of delphinium sales into supermarkets, and a more substantial product is needed. Initially the stems were graded to <55cm, 55-75cm and 75+cm, but a single threshold at 75cm would be better, and in the results section the emphasis was therefore on these longer stems. A premium quality stem might attract a price of £0.50, while it was suggested that supermarkets might be prepared to pay a further £1.00 per bunch if this helped continuity through

integrating supplies of glass- and tunnel-grown crops. Anything below 75cm is likely to have a limited market potential.

The new lines of smaller-flowered delphinium from tissue culture added very little to the programme in their first year, but they should not be totally dismissed until it is seen how they perform in the second year. They may be better suited to glasshouse production.

Table 10.1. Summary of flowering data for delphinium varieties grown in 2007.

Variety	*Planting no. and date*	*Start of cropping*		*Stem length (cm)*		*Stem weight (g)*		*Notes*
		Tunnel	*Outside*	*Tunnel*	*Outside*	*Tunnel*	*Outside*	
Scent White	1 (25/05)	02/08	25/07	112	61	123	40	-
Scent Pink	1	01/07	09/07	110	71	120	53	-
Scent Rose	1	25/07	02/08	113	68	99	49	-
Scent Sky Blue	1	02/08	02/08	112	76	98	47	-
Scent Centurion Blue	1	02/08	02/08	117	71	115	33	Serious mildew in tunnel
Takii Aurora Light Blue	1	29/06	09/07	99	59	84	59	Serious mildew in tunnel
Takii Aurora Light Purple	1	29/06	25/07	93	64	72	54	Serious mildew in tunnel
Takii Aurora Blue	1	09/07	25/07	102	67	70	44	-
Takii Aurora Lavender	1	01/07	09/07	108	65	107	56	-
Takii Aurora Deep Purple	1	22/06	29/06	99	60	105	47	Mildew in tunnel
Pan Am Guardian Lavender	1	01/07	01/07	103	62	121	52	Mildew in tunnel
Pan Am Guardian Blue	1	22/06	04/07	86	61	142	58	-
Pan Am Guardian White	1	01/07	05/07	96	64	153	44	-
Scent White	2 (04/06)	02/08	02/08	-	-	-	-	-
Scent Pink	2	09/07	25/07	-	-	-	-	-
Scent Rose	2	25/07	25/07	-	-	-	-	-
Scent Sky Blue	2	15/08	02/08	-	-	-	-	-
Scent Centurion Blue	2	15/08	02/08	-	-	-	-	-
Takii Aurora Light Purple	2	25/07	25/07	-	-	-	-	-
Belladonna Blue Shadow	2	02/08	02/08	-	-	-	-	-
Blue Donna Imperial	2	02/08	02/08	-	-	-	-	-
Scent White	3 (03/07)	31/08	06/09	-	-	-	-	-
Scent Pink	3	31/08	06/09	-	-	-	-	-
Scent Rose	3	28/08	06/09	-	-	-	-	-
Scent Sky Blue	3	31/08	06/09	-	-	-	-	-
Scent Centurion Blue	3	28/08	06/09	-	-	-	-	-
Takii Aurora Light Blue	3	07/08	09/08	-	-	-	-	Poor quality, short in tunnel, very short outside
Takii Aurora Light Purple	3	07/08	09/08	-	-	-	-	-
Takii Aurora Blue	3	07/08	09/08	-	-	-	-	Poor quality, short in tunnel
Takii Aurora Lavender	3	02/08	09/08	-	-	-	-	Poor quality, short in tunnel

Takii Aurora Deep Purple	3	02/08	09/08	-	-	-	-	Poor quality, short in tunnel

* -, inadequate or no cropping recorded

Table 10.2. Start of cropping and stem length and weight in 2008 for delphinium varieties planted on three dates in 2007.

	anting number*, series and variety**	First flush						Second flush						Third flush					
		Crop (week no.)		Stem length (cm)		Stem weight (g)		Start of cropping		Stem length (cm)		Stem weight (g)		Start of cropping		Stem length (cm)		Stem weight (g)	
		Tunnel	Outside	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside	Tunnel	Outside
1	S Centurion Blue	22	21	146	113	87	89	30	30	133	86	103	53	39	40	133	73	53	45
	S Pink	21	22	138	118	152	125	32	32	135		158							
	S Rose	22	22	151	97	221	84	32	30	124	65	134	39						
	S Sky Blue	22	22	151	128	268	223	31	32	127	87	147	64	39		102		83	
	S White	23	22	166	137	419	261	30	32	99		75							
	TA Blue	19	21	97	83	144	99	28	30	144	74	107	53	39	40	108		80	
	TA Deep Purple	21	21	111	99	188	123	28	30	127	78	111	53	39	40	105	73	56	46
	TA Lavender	21	21	121	95	117	110	30	30	123	64	57	47	39	40	114	59	57	28
	TA Light Blue	21	21	125	79	143	197	30	30	133	72	115	41						
	TA Light Purple	21	21	106	87	171	116	30	30	129	67	81	56	39		97		75	
	PAG Blue	22	21	108	82	202	81	30	30	104	69	82	48	39	40	103	62	54	51
	PAG Lavender	19	21	108	93	104	62	28	30	132	84	88	70	39	40	126	77	45	60
	PAG White	21	21	110	92	157	122	28	30	108	72	87	62	39	40	120	74	38	49
2	Bel. Blue Shadow	22	22	126	98	151	92	30	30	111	76	49	57	39	40	94	70	30	29
	Blue Donna Imp.	22	23	124	101	232	146		30	87	62	32	29						
	S Centurion Blue	21	22	175	140	128	157	31	32	142	122	115	118	40		129		48	
	S Pink	22	22	154	131	214	206	31	32	134		95		39	40	105	79	55	73
	S Rose	22	22	140	130	275	230	30	31	109	76	84	71	39	40	100	70	70	50
	S Sky Blue	21	22	158	125	433	209	30	30	115	76	86	62	40		116		79	
	S White	21	23	160	115	329	187	30	32	123		92		39		93		46	
	TA Blue	21	21	108	78	110	96	30	30	139	72	145	63	39	40	119	60	81	43
	TA Deep Purple	19	21	124	91	205	142	28	30	112	76	136	68	39	40	88	64	55	40
	TA Lavender	19	21	104	98	179	224	30	30	117	86	86	127	39	40	105	78	44	40
	TA Light Blue	21	21	80		100		31	30		93		49						
	TA Light Purple	21	21	87	82	148	109	28	30	85	80	87	75	39		78		54	
3	S Centurion Blue	21	22	172	109	307	169	31	30	121	92	143	61	32	31	98	79	69	47
	S Pink	21	23	153	100	215	122	33	32	149	102	93	83						

S Rose	22	23	142	106	210	184	33	32	133	84	94	52						
S Sky Blue	21	22	149	93	219	106	33	32	124	81	79	60						
S White	21	23	105	97	187	210	32	32	133	80	88	73						
TA Blue	22	21	102	70	132	44	30	30	141	74	132	53	32		115		83	
TA Deep Purple	21	21	83	80	98	90	28	30	107	75	70	59	31	31	95	75	36	50
TA Lavender	21	21	104	82	185	70	28	30	122	82	137	68	31	31	109	69	75	42
TA Light Blue	22	21	120	60	269	60	28	30	118		115		32		105		76	
TA Light Purple	22	21	75	67	146	101	28	30	99		54		32	31	109	59	62	41

* Planting dates 1, 2 and 3 are 25 May, 4 June and 3 July.
** Abbreviations for series and variety names are S, Scent; TA, Takii Aurora; PAG, Pan Am Guardian; Bel Blue Shadow, Belladonna Blue Shadow; and Blue Donna Imp, Blue Donna Imperial.

Table 10.3. Number of stems in grades cropped for delphinium varieties planted at four dates, 2008.

Planting week	*Culitivar*	*Stems cropped in grades (no. per m²) and percentage in 75+cm grade*								
		1st Flush			*2nd flush*			*Both flushes*		
		<75 cm	*75+ cm*	*% in 75+*	*<75 cm*	*75+ cm*	*% in 75+*	*<75 cm*	*75+ cm*	*% in 75+*
15	Centurion Gentian	1.4	16.9	92	11.1	12.7	53	12.5	29.7	70
15	Guardian Blue	1.0	21.3	96	10.4	23.9	70	11.4	45.1	80
15	Guardian Early Blue	0.9	23.6	96	18.9	21.3	53	19.8	44.9	69
17	Aurora	3.4	18.9	85	26.7	29.2	52	30.1	48.1	62
17	Centurion Gentian	0.7	8.4	92	12.8	11.2	47	13.5	19.6	59
17	Guardian Blue	0.6	22.7	97	16.5	27.6	63	17.1	50.3	75
17	Guardian Early Blue	0.5	22.5	98	40.5	22.6	36	41.0	45.1	52
19	Aurora Blue	1.8	21.3	92	23.5	10.0	30	25.3	31.3	55
19	Aurora Light Blue	4.2	21.4	84	10.3	14.9	59	14.5	36.3	71
19	Centurion Gentian	0.0	14.3	100	7.4	15.0	67	7.4	29.3	80
19	Guardian Blue	4.0	19.4	83	39.0	26.1	40	43.0	45.5	51
19	Guardian Early Blue	18.5	1.4	7	19.4	15.8	45	38.0	17.2	31
21	Aurora	0.0	17.5	100	5.2	16.6	76	5.2	34.1	87
21	Centurion Gentian	0.0	15.7	100	4.0	9.9	71	4.0	25.6	86
21	Guardian Blue	0.0	2.7	100	6.3	6.1	49	6.3	8.8	58

Table 10.4. Flowering assessments for eight tissue-cultured delphinium lines, 2008.

Line reference	*Start of cropping (week no.)*		*Stem length (cm)*		*Stem weight (g)*	
	Flush 1	*Flush 2*	*Flush 1*	*Flush 2*	*Flush 1*	*Flush 2*
DO8006	-*	38	75	120	95	59
DO8007	28	37	97	123	103	82
L DE 1-1	30	41	71	32	54	-
L DE 2-1	30	41	71	17	36	-
L DE 3-1	31	41	66	25	56	-
K DE 4-1	30	41	59	16	35	-
L DE 5-1	31	-	62	-	21	-
K DE 6-1	31	41	49	17	24	-

* -, inadequate numbers or quality to assess

Figure 10.1. First flowering dates for delphinium cultivars and three transplanting dates in 2007. The planting date and variety codes follow the same order as Table 10.1 (1A = Planting 1 of 'Scent White', etc.).

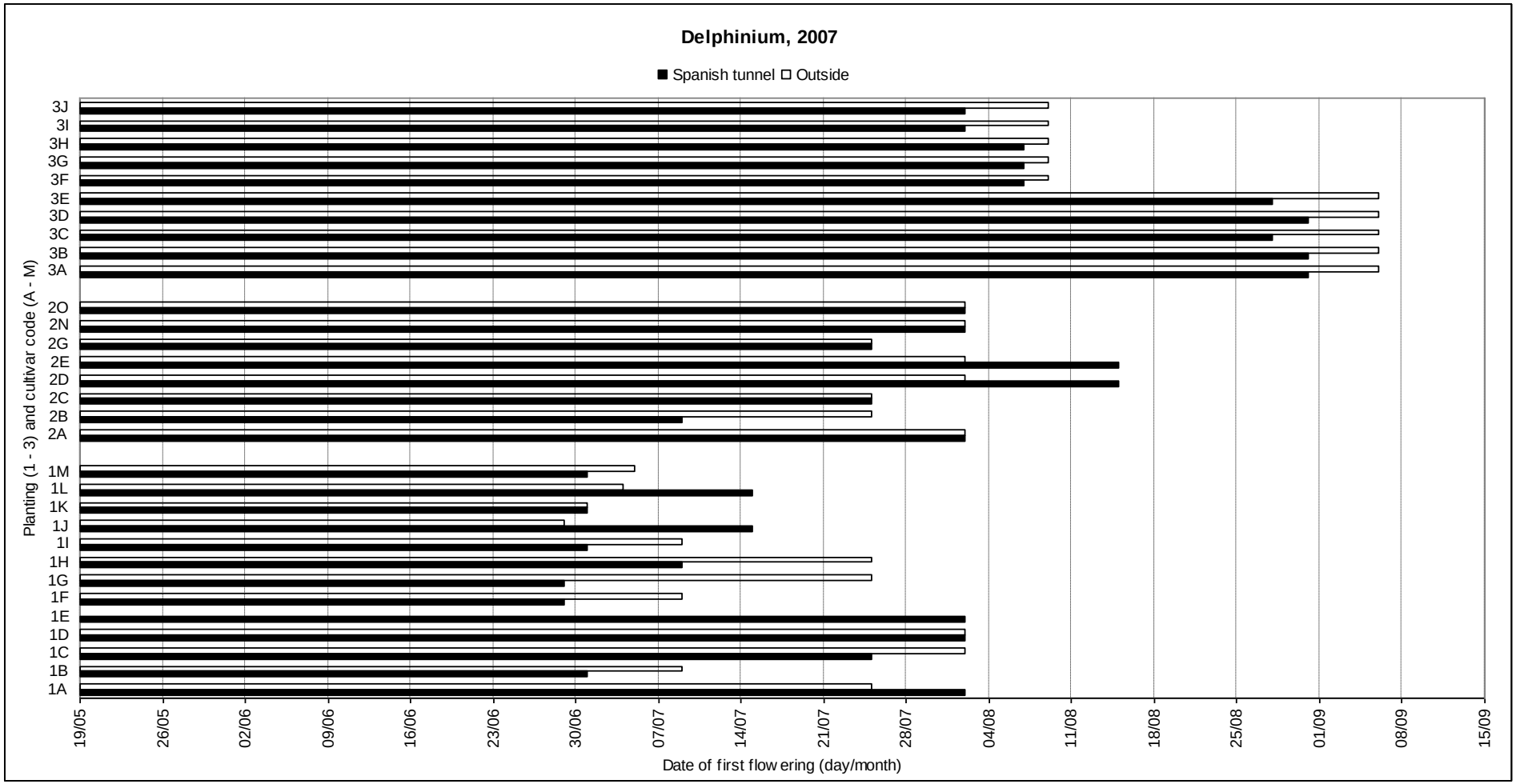


Figure 10.2. Start of cropping (top), stem length (middle) and stem weight (bottom) in 2008 for delphiniums from three plantings in 2007 weeks 21, 23 and 27 (indicated by date 1, 2 and 3) in tunnels and outside. The values are means across all varieties tested, recorded in three flushes.

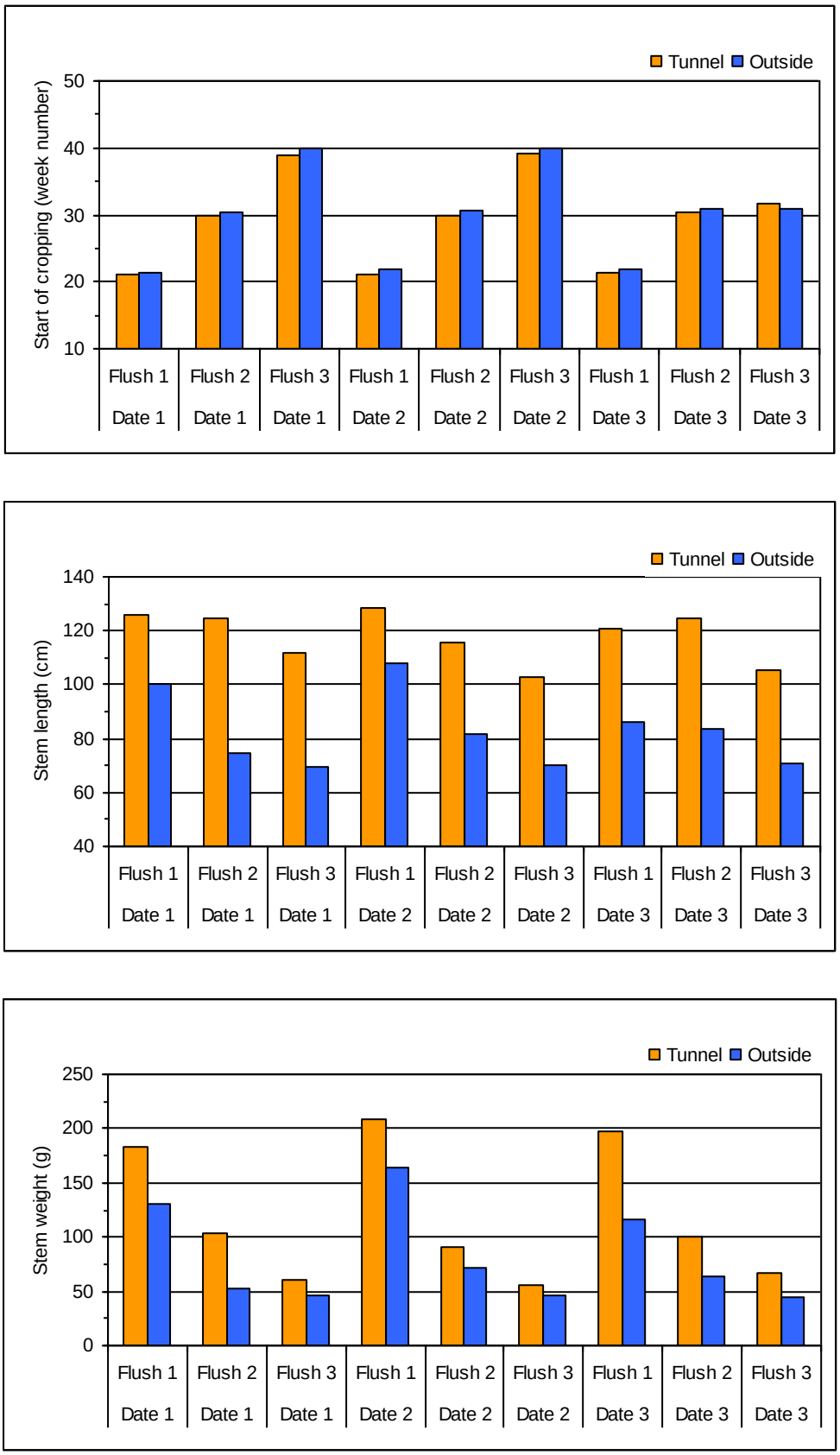


Figure 10.3. Stem length in the second year, 2008, for delphiniums from plantings 1 (top), 2 (middle) and 3 (bottom) of 2007 in tunnels. The values are means for each variety, recorded over three flushes.

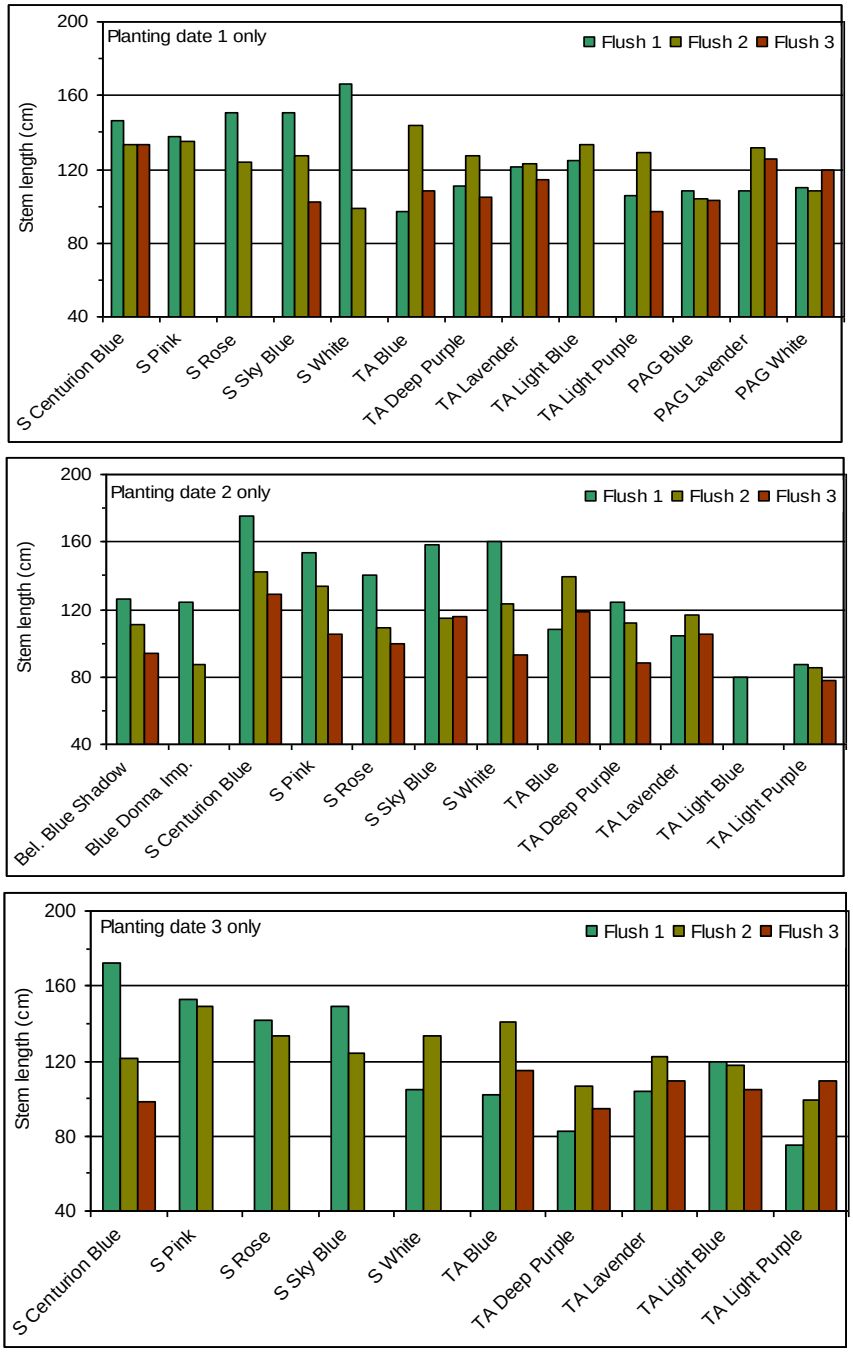


Figure 10.4. Stem weight in the second year, 2008, for delphiniums from plantings 1 (top), 2 (middle) and 3 (bottom) of 2007 in tunnels. The values are means for each variety recorded over three flushes.

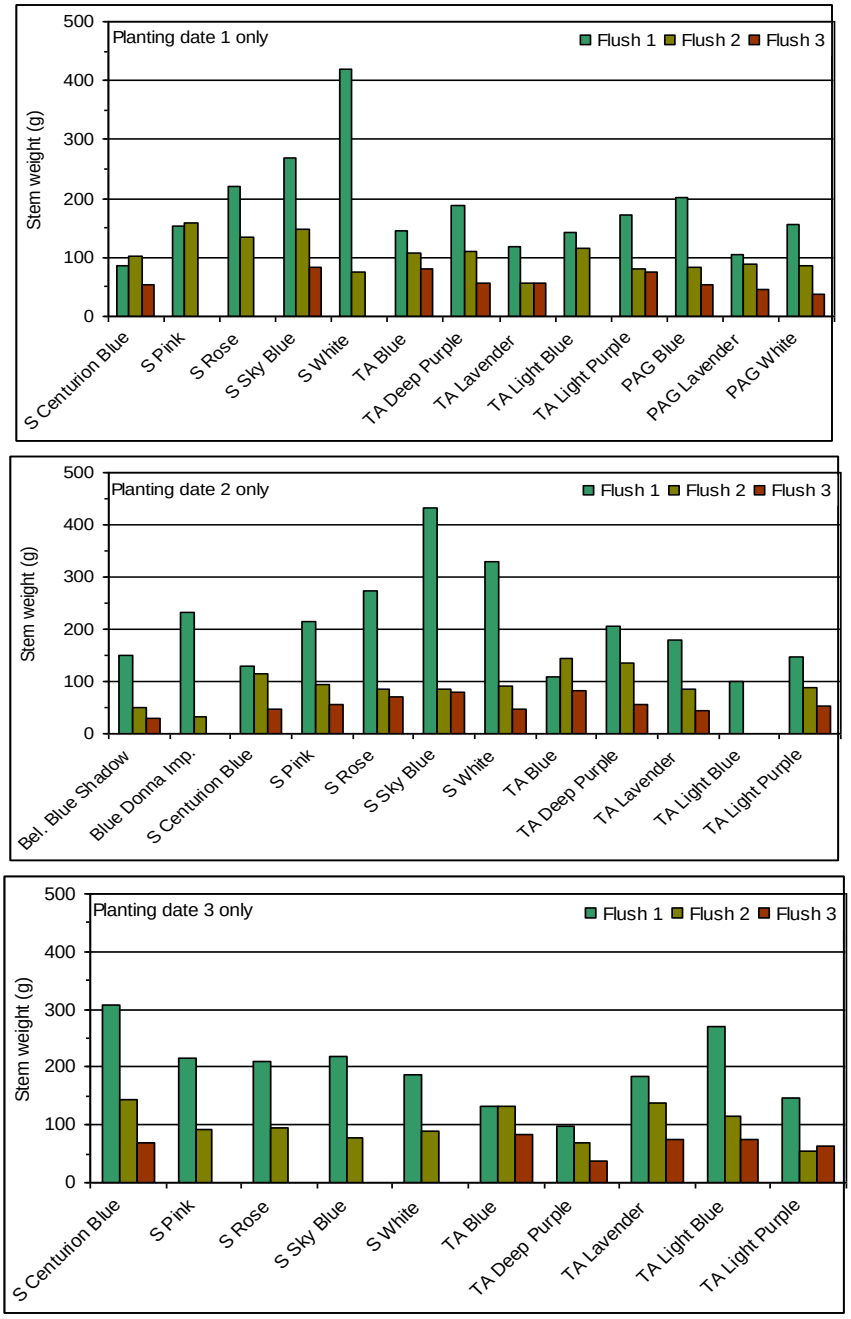


Figure 10.5. Delphinium Trial 2 (2008): weekly production of stems expressed as the number of plots in cropping in each week.

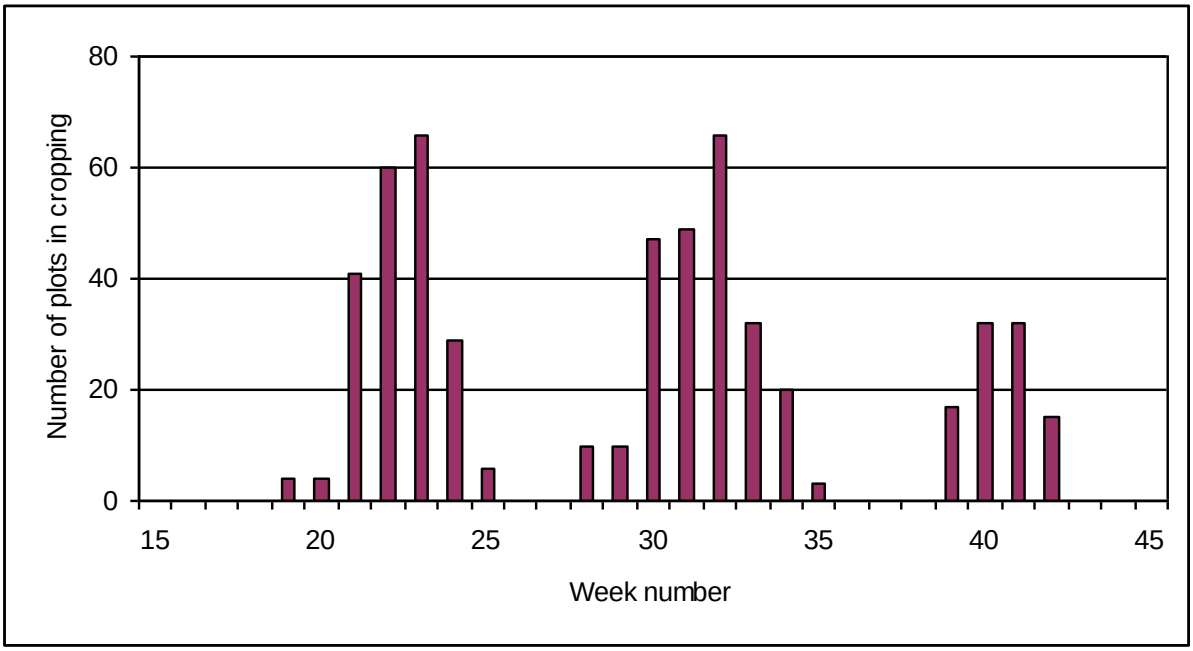


Figure 10.6. Delphiniums, weekly production of stems bulked across all varieties in Trial 2 (2008). Note that marketing problems in week 26 led to stems being held over for week 27. The figures are actual totals from the trial area, graded to 55-75cm and 75+ cm and excluding stems <55cm.

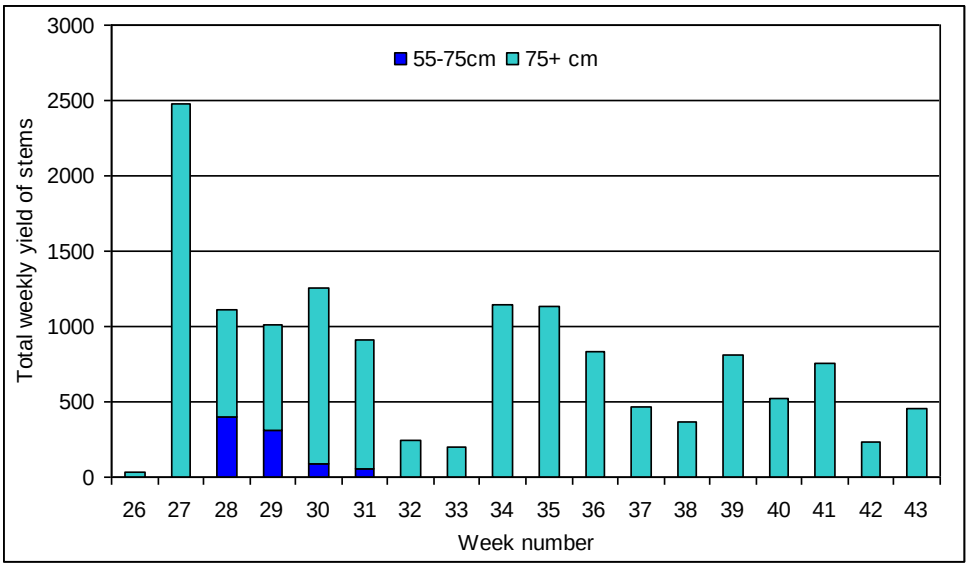


Figure 10.7. Delphinium, weekly production of stems of six varieties in Trial 2, 2008. Only stems of length 75cm and longer are recorded. In order to relate production to a 'unit area' and adjust for differences in the areas of plots used for different plantings, yields have been adjusted to a stems per 100m² basis.

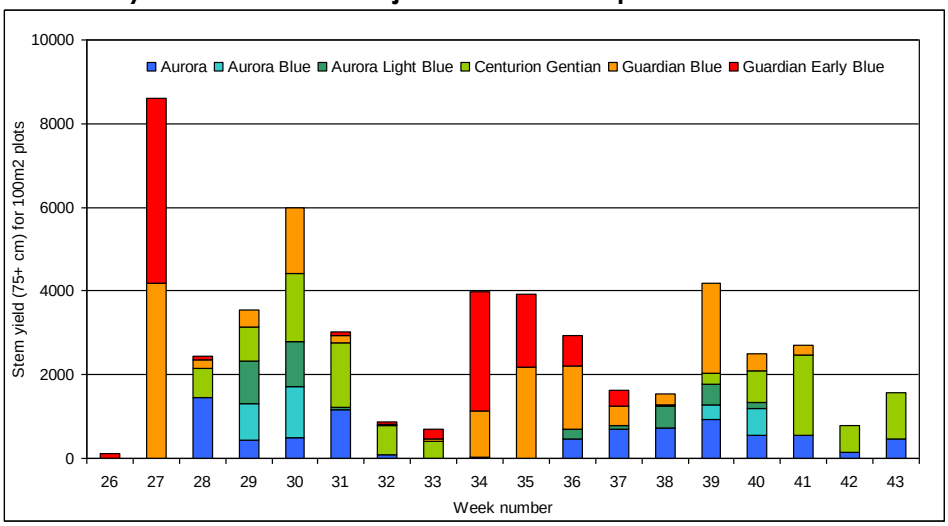


Figure 10.8. Delphinium in Trial 2, 2008, distribution of 75+ cm stems to the first and second flushes for varieties and planting dates. For variety abbreviations, see text.

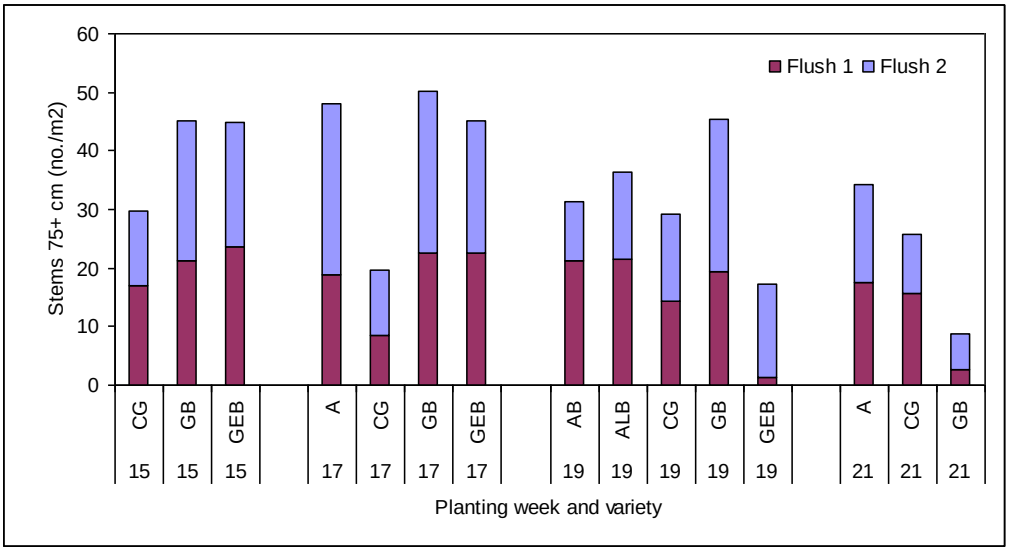


Figure 10.9. Delphinium in Trial 2, 2008, percentage of stems in the 75+ cm grade in the first and second flushes for varieties and planting dates. For variety abbreviations, see text.

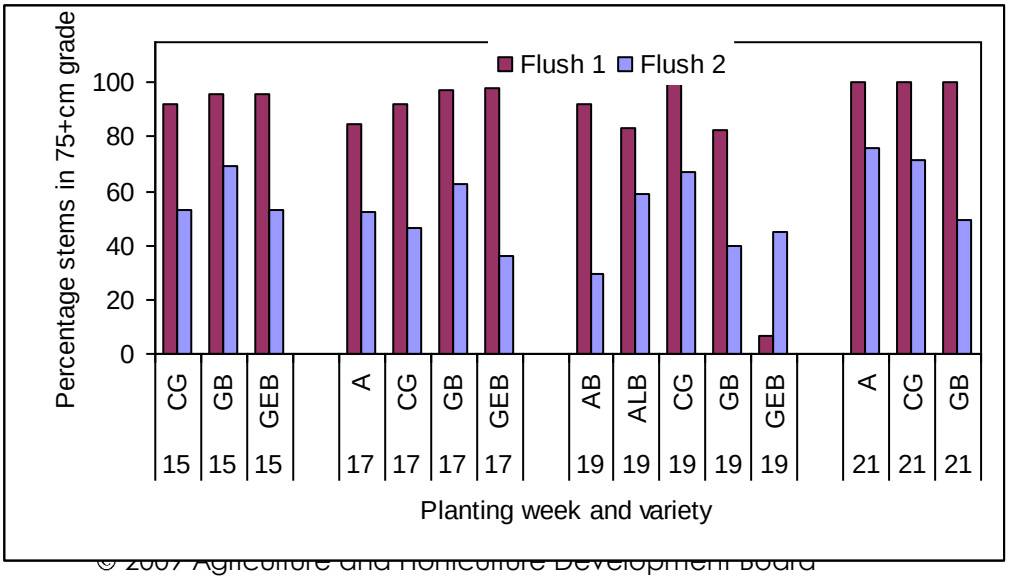
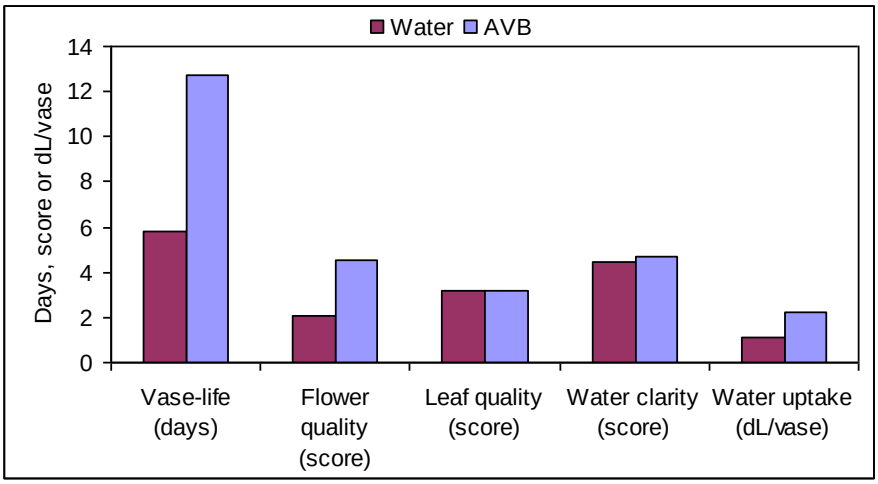
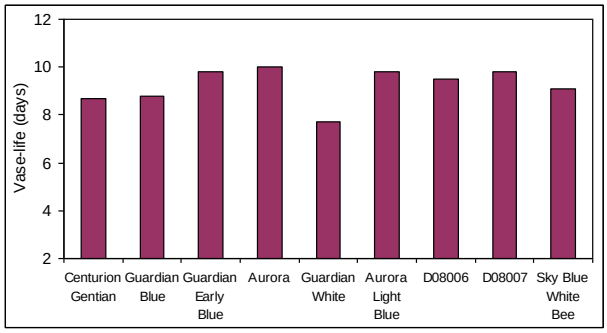
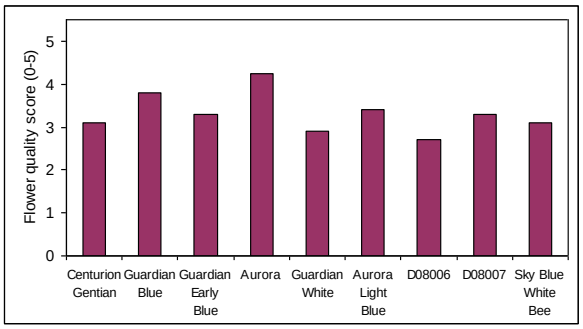
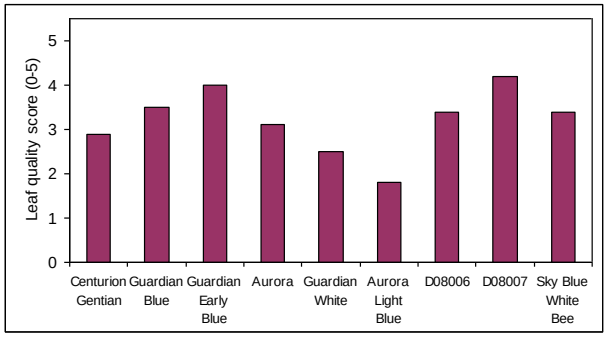


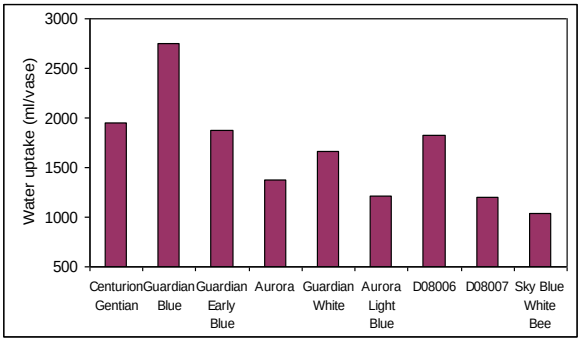
Figure 10.10. Vase-life attributes in 2008 trial of nine delphinium varieties following conditioning in plain water or AVB. The values are marginal means for (top) conditioner treatments and (bottom four graphs) the varieties.











11. Dianthus (annual)

The main aim of the trials on annual dianthus was to provide sufficient data on yields and continuity to decide whether the crop is worth considering for UK production.

Annual dianthus trial 1

In 2007 the effects of planting date and variety on continuity and vase-life were investigated in eleven varieties, including several from the 'Amazon' and 'Sweet' series, 'Bodestolz' and two numbered lines. The plants were transplanted to tunnels and outside plots in weeks 22 (two varieties arrived late and were planted two or three weeks later) and 26, 2007.

- Tunnel-raised stems were consistently heavier and longer than those raised outside (Table 11.1).
- The results demonstrated the clear potential of this crop for UK production, with flowers being picked from week 27 to week 36 - though with some gaps (weeks 28, 34 and 35) (Figure 11.1).
- Further investigations are required into scheduling and the economics of production.

Annual dianthus trial 2

To address the theme of continuity, in 2008 seven varieties from the 'Amazon' and 'Scent' series were transplanted to tunnels in weeks 17, 19 and 28, with a further planting outside in week 18. The effects of pinching or not pinching were also investigated. Four additional varieties, including a new introduction, 'Green Trick', were included in some plantings for observations. Data are summarised in Tables 11.2 and 11.3.

In the main seven varieties, cropping started in weeks 26 to 30 for tunnel plantings made in weeks 17 and 19, in weeks 35 to 41 in tunnel planting from week 28, and in week 29 ('Amazon' series) or 32 ('Scent' series) for the outdoor planting in week 18. This indicated that some small gaps in continuity remained.

Regarding the effect of pinching, data for the most complete sub-set – the seven varieties planted in tunnels in weeks 17 and 19 and outside in week 18 - are summarised in Figure 11.2. The findings were not completely consistent across varieties, but in general:

- Pinching or not pinching did not affect the start of cropping.
- There was little effect of pinching or not pinching on the total yield of stems, which was around 150 to 200 stems/m^2.
- Non-pinched plants produced longer and markedly heavier stems than pinched plants.

The data also showed a marked effect of planting date on the proportion of stems above or below 60cm in length:

- For tunnel-grown plants planted week 17, about two-thirds were in the longer grade, while tunnel-grown plants planted in week 19 had many more short stems.
- For the outside-grown plants, planted in week 18, three varieties produced predominantly long stems ('Amazon Neon Cherry', 'Duo' and 'Purple') and the others predominantly short stems ('Sweet Coral', 'Purple' and 'Scarlet').

As the above results show, there were large differences between the varieties in productivity and stem length, so the effects on individual varieties are shown in Figure 11.3.

- Grown in tunnels, 'Amazon Neon Duo' and 'Purple' and 'Amazon Rose Magic' produced good yields of long stems, whether pinched or not. 'Amazon Neon Cherry' produced poorer yields of long stems.
- 'Sweet Coral', 'Purple' and 'Scarlet' produced still good but smaller yields of long stems, with some loss of stems when pinched, especially in 'Sweet Purple'.
- Though some apparent effects of pinching could be seen, not all varieties or crops responded in the same way or at all. Figure 11.4 confirms the generally detrimental effect of pinching on stem length and, particularly, weight, for most of the varieties tested.

Some other varieties – 'Bodestoltz', 'Sweet Red', 'Sweet White' and 'Green Trick' – were grown for observations and vase-life testing. Data are appended to Tables 11.2 and 11.3, where it can be seen that their performance was broadly comparable to other varieties of the 'Sweet' series. 'Green Trick' showed market potential and could be investigated further, as it showed such an exceptional vase-life.

Vase-life testing

Vase-life testing 2007 Samples of eight selected varieties were cropped from trials at Kirton and subjected to vase-life testing in vases with flower food (Table 11.4).

- Mean vase-life varied from 7 days (for 'Sweet Red') to 14 days (for 'Amazon Rose Magic'), and these differences were clearly reflected in the extent of water uptake in the different varieties.
- Leaf quality was good throughout, but flower quality was poorer than most in 'Sweet Scarlet' and lower in 'Sweet Red'.
- There were no serious water clarity issues.

Vase-life testing 2008 A selection of varieties from the early planting (week 17 or 19) and late planting (week 28) of trial 2 was taken through vase-life testing on plain water after conditioning in either plain water or RVB. The treatment means are in Table 11.5 and some marginal means in Table 11.6. Compared with the responses of some other species tested in this project, the effects of treatments on the post-harvest qualities of annual dianthus were relatively small.

- Vase-life:
  - Treatment means for vase-life varied from 10 to 25 days, but this very wide range was due to one poorly performing variety ('Bodestoltz') and one long-lived one ('Green Trick'). If these 'outliers' were removed, vase-life varied between 11 and 18 days.
  - Overall, using RVB increased vase-life by about a day, from an average of 14.4 days using plain water to 15.4 days (see tables of marginal means).
  - Overall, early plantings (week 17 or 19) had a vase-life about 1 day longer than the late plantings (see Table 11.6).
- Flower quality score:
  - Apart from two varieties ('Bodestoltz' and one planting of 'Sweet Coral') which had low flower quality scores of <3, scores were high in all other cases.
  - There was virtually no difference between the flower quality of early and late plantings.
- Leaf quality score:
  - Leaf quality scores were high except for some varieties from the later planting where the score was 3 or less ('Bodestoltz', 'Sweet Scarlet', 'Amazon Neon Cherry' and 'Amazon Neon Purple').
  - Overall, leaf quality was greater in stems from the early planting (score of 4.8) than from the late planting (3.9). This effect was largely due to differences between the plantings of 'Amazon' varieties (5.0 and 3.5, respectively).
- Water clarity scores were high in all except one instance.

- Water uptake:
  - Water uptake was highly variable. Overall, water uptake was greater in stems from the early planting (mean of 1430ml/vase) than from the late planting (822ml). This effect was largely due to differences between the plantings of 'Amazon' varieties (1430ml and 950ml, respectively), and so followed the effects of treatments on leaf quality scores. The corresponding water uptakes for 'Sweet' varieties were 801ml and 785ml, respectively.

Discussion – annual dianthus

The trials had indicated that reasonable continuity could be obtained, that outdoor growing was not worthwhile, and that pinching had a detrimental effect on stem length and, especially, weight. To achieve likely specifications, stems needed to be over 60cm in length, and this might be difficult in some situations – for example in Trial 2 there was a dramatic fall in the number of longer stems cropped following tunnel-planting in week 19 as opposed to week 17. Head size and bunch weight are important considerations, so varieties of the 'Sweet' series, which were naturally smaller, needed three times as many stems to achieve a bunch weight like those of the 'Amazon' varieties.

The annual dianthus varieties tested had long vase-lives and, usually, high quality scores. There was a modest response to conditioner. There are clear varietal differences that need to be taken into account, for example the differences between the responses of 'Amazon' and 'Sweet' varieties. The data also suggest a strong effect related to planting date. The vase-life of the new variety 'Green Trick' was exceptional and this should be investigated further.

The MG agreed that there was potential for further consideration of this crop, provided it did not appear on the market at the same season as sweet Williams (by comparison with which annual dianthus might seem relatively poor): annual dianthus is only worth cropping from August onwards.

The crop was considered probably economic if 60 stems/m^2 could be cropped and realise 20p per stem. There is demand for dianthus for bouquets, fetching perhaps 22p per stem, though it was doubted whether there was a significant demand for bunches.

Table 11.1. Summary of flowering data for annual dianthus varieties in 2007.

Variety	*Planting no. and date*	*Start of cropping*		*Stem length (cm)*		*Stem weight (g)*	
		Tunnel	*Outside*	*Tunnel*	*Outside*	*Tunnel*	*Outside*
Amazon Neon Cherry	1 (30/05)	09/07	25/07	43	35	32	23
Amazon Neon Purple	1 (30/05)	15/08	20/08	52	48	54	56
Amazon Rose Magic	1 (30/05)	07/08	20/08	49	45	44	53
Bodestolz	1 (30/05)	25/07	09/08	50	28	24	16
Sweet Coral	1 (30/05)	02/08	02/08	56	35	28	21
Sweet Purple	1 (30/05)	02/08	02/08	53	35	29	19
Sweet Red	1 (30/05)	25/07	02/08	53	42	27	25
Sweet Scarlet	1 (30/05)	02/08	02/08	56	42	28	22
Sweet White	1 (30/05)	25/07	25/07	52	38	28	25
3850	2 (13/06)	26/07	25/07	52	35	17	24
4244	2 (19/06)	25/07	25/07	49	34	20	17
Amazon Neon Cherry	2 (25/06)	28/08	02/08	-*	-	-	-
Amazon Rose Magic	2 (25/06)	31/08	25/07	-	-	-	-
Sweet Coral	2 (25/06)	15/08	06/09	-	-	-	-
Sweet Purple	2 (25/06)	28/08	06/09	-	-	-	-
Sweet Red	2 (25/06)	28/08	06/09	-	-	-	-
Sweet Scarlet	2 (25/06)	31/08	25/07	-	-	-	-
Sweet White	2 (25/06)	28/08	06/09	-	-	-	-

* -, inadequate or no cropping recorded

Table 11.2. Summary of flowering data for tunnel- and outside-grown annual dianthus varieties in 2008.

*Variety**	*Pinched ?*	*Tunnel - week 17*			*Tunnel - week 19*			*Tunnel - week 28*			*Outside - week 18*		
		Start of cropping (week no.)	*Stem length (cm)*	*Stem weigh t (g)*	*Start of cropping (week no.)*	*Stem length (cm)*	*Stem weigh t (g)*	*Start of cropping (week no.)*	*Stem length (cm)*	*Stem weigh t (g)*	*Start of cropping (week no.)*	*Stem length (cm)*	*Stem weigh t (g)*
AN Cherry	yes	27	64	30	30	65	46	-**	-	-	32	46	36
AN Cherry	no	27	75	67	30	65	44	36	60	31	32	42	63
AN Duo	yes	28	64	33	30	63	39	-	-	-	32	43	32
AN Duo	no	28	71	78	30	68	73	-	-	-	32	48	61
AN Purple	yes	30	71	50	30	57	37	-	-	-	32	44	41
AN Purple	no	30	75	88	30	64	59	41	74	61	32	50	66
AR Magic	yes	28	66	36	29	61	35	-	-	-	-	-	-
AR Magic	no	28	76	81	28	74	105	40	69	42	-	-	-
S Coral	yes	26	72	35	27	53	23	-	-	-	29	34	8
S Coral	no	26	72	71	26	57	32	35	61	28	29	41	29
S Purple	yes	26	58	23	26	51	30	-	-	-	29	32	10
S Purple	no	26	65	56	26	58	50	36	57	23	29	39	25
S Scarlet	yes	26	65	25	27	61	32	-	-	-	29	38	14
S Scarlet	no	26	72	51	27	75	54	37	61	25	29	40	22
Green Trick	yes	-	-	-	29	47	23	-	-	-	-	-	-
Green Trick	no	-	-	-	29	49	55	-	-	-	-	-	-
Bodestollt z	no	-	-	-	-	-	-	35	51	30	-	-	-
S Red	no	-	-	-	-	-	-	37	56	32	-	-	-
S White	no	-	-	-	-	-	-	37	64	33	-	-	-

* AN indicates Amazon Neon series; AR, Amazon Rose series; and S, Scent series

** -, indicates not tested

Table 11.3. Summary of yield for annual dianthus varieties in 2008.

Variety	Pinched?	Stems cropped in grades (no./plot)								Stems cropped in grades (no./m²)							
		Tunnel Week 17		Tunnel Week 19		Tunnel Week 28		Outside 28 April		Tunnel Week 17		Tunnel Week 19		Tunnel Week 28		Outside 28 April	
		<60cm	60cm+	<60cm	60cm+	<60cm	60cm+	<60cm	60cm+	<60cm	60cm+	<60cm	60cm+	<60cm	60cm+	<60cm	60cm+
AN Cherry	yes	347	69	156	54				197	193	38	87	30				109
	no	221	58	250	36	58	173		216	123	32	139	20	32	96		120
AN Duo	yes	50	310	190	45				123	28	172	106	25				68
	no	75	342	264	22				143	42	190	147	12				79
AN Purple	yes	49	270	230	40				106	27	150	128	22				59
	no	47	270	273	22	60	170		112	26	150	152	12	33	94		62
AR Magic	yes	49	290	224	64					27	161	124	36				
	no	57	319	250	26	50	207			32	177	139	14	28	115		
S Coral	yes	65	242	242	93			146		36	134	134	52			81	
	no	98	181	389	70	30	257	133		54	101	216	39	17	143	74	
S Purple	yes	129	277	330	83			177		72	154	183	46			98	
	no	85	140	403	110	50	218	130		47	78	224	61	28	121	72	
S Scarlet	yes	207	248	363	85			136		115	138	202	47			76	
	no	101	256	453	86	60	209	118		56	142	252	48	33	116	66	
Boldestoltz	no					30	206							17	114		
S Red	no					55	220							31	122		
S White	no					65	202							36	112		

Table 11.4. The vase-life and quality of tunnel-grown annual dianthus from planting 1, 2007, on vase-day 5.

Variety	*Leaf quality score (1-5)*	*Flower quality score (1-5)*	*Vase-life (days)*	*Water clarity score (1-5)*	*Water uptake (ml/vase)*
Amazon Neon Cherry	4.8	4.0	11.1	4	1200
Amazon Neon Purple	5.0	4.7	12.1	3	1130
Amazon Rose Magic	4.9	4.6	14.3	5	1430
Sweet Coral	4.4	4.3	10.9	3	1170
Sweet Purple	4.7	4.5	10.4	5	970
Sweet Red	4.2	2.6	6.9	5	720
Sweet Scarlet	4.1	3.3	11.2	5	930
Sweet White	4.8	4.3	10.4	5	900

Table 11.5. Vase-life attributes of annual dianthus varieties planted at two dates (early and late) and conditioned on plain water or RVB (2008). The values in this table are treatment means.

Planting date	*Cultivar*	*Conditioner treatment*	*Vase-life (days)*	*Flower quality score (1-5)*	*Leaf quality score (1-5)*	*Water clarity score (1-5)*	*Water uptake (ml/vase)*
Early	Amazon Neon Cherry	Water	10.8	3.6	4.6	5.0	880
		RVB	12.4	4.0	5.0	5.0	1090
	Amazon Neon Duo	Water	16.6	4.8	5.0	5.0	1320
		RVB	15.2	5.0	5.0	5.0	1610
	Amazon Neon Purple	Water	13.6	4.8	5.0	5.0	1390
		RVB	15.4	5.0	5.0	5.0	1590
	Amazon Rose Magic	Water	17.4	3.8	5.0	5.0	1700
		RVB	17.4	4.0	5.0	5.0	1860
	Sweet Coral	Water	12.0	2.6	4.6	5.0	730
		RVB	13.0	3.8	4.5	5.0	565
	Sweet Purple	Water	11.4	4.0	4.6	5.0	820
		RVB	11.3	4.0	4.7	5.0	575
	Sweet Scarlet	Water	15.4	4.4	5.0	5.0	1120
		RVB	16.2	4.0	5.0	5.0	1000
	Green Trick	Water	23.6	5.0	4.4	5.0	1100
		RVB	24.8	4.4	4.4	5.0	1050
Late	Bodestoltz	Water	9.8	3.2	3.0	4.0	640
		RVB	9.6	2.8	4.0	4.0	610
	Sweet Coral	Water	14.0	5.0	5.0	4.0	830
		RVB	16.6	5.0	5.0	4.0	770
	Sweet Purple	Water	15.2	5.0	3.6	5.0	890
		RVB	15.8	5.0	4.4	5.0	700
	Sweet Scarlet	Water	11.8	3.0	2.4	3.0	580
		RVB	13.6	5.0	4.2	4.0	560
	Sweet White	Water	14.2	4.0	4.0	5.0	850
		RVB	17.8	5.0	4.4	5.0	850
	Sweet Red	Water	15.0	4.8	3.8	5.0	1000
		RVB	17.2	5.0	4.8	5.0	820
	Amazon Neon Cherry	Water	12.6	5.0	3.2	4.0	530
		RVB	13.8	5.0	3.4	5.0	770
	Amazon Rose Magic	Water	15.0	5.0	4.6	4.0	910
		RVB	18.8	5.0	4.4	5.0	700

	Amazon Neon Purple	Water RVB	15.8 15.4	5.0 5.0	2.4 2.8	5.0 5.0	1360 1430

Table 11.6. Vase-life attributes of annual dianthus varieties planted at two dates (early and late) and conditioned on plain water or RVB (2008). The values in this table are marginal means (see text).

Marginal means	*Vase-life (days)*	*Flower quality score (1-5)*	*Leaf quality score (1-5)*	*Water clarity score (1-5)*	*Water uptake (ml/vase)*
Conditioner treatment					
Water	14.4	4.3	4.1	4.6	979
RVB	15.5	4.5	4.5	4.8	974
Planting date					
Early	15.4	4.2	4.8	5.0	1150
Late	14.6	4.6	3.9	4.5	822
Variety and planting date					
Amazon Neon Cherry - early	11.6	3.8	4.8	5.0	986
Amazon Neon Duo - early	15.9	4.9	5.0	5.0	1465
Amazon Neon Purple - early	14.5	4.9	5.0	5.0	1490
Amazon Rose Magic - early	17.4	3.9	5.0	5.0	1780
Sweet Coral - early	12.5	3.2	4.6	5.0	648
Sweet Purple - early	11.4	4.0	4.6	5.0	698
Sweet Scarlet - early	15.8	4.2	5.0	5.0	1060
Green Trick - early	24.2	4.7	4.4	5.0	1075
Bodestoltz - late	9.7	3.0	3.5	4.0	625
Sweet Coral - late	15.3	5.0	5.0	4.0	800
Sweet Purple - late	15.5	5.0	4.0	5.0	795
Sweet Scarlet - late	12.7	4.0	3.3	3.5	570
Sweet White - late	16.0	4.5	4.2	5.0	850
Sweet Red - late	16.1	4.9	4.3	5.0	910
Amazon Neon Cherry - late	13.2	5.0	3.3	4.5	650
Amazon Rose Magic - late	16.9	5.0	4.5	4.5	805
Amazon Neon Purple - late	15.6	5.0	2.6	5.0	1395
Series and planting date					
Amazon - early	14.9	4.4	5.0	5.0	1430
Amazon - late	15.2	5.0	3.5	4.7	950
Sweet - early	13.2	3.8	4.7	5.0	802
Sweet - late	15.1	4.7	4.2	4.5	785

Figure 11.1. Mean first flower dates for annual dianthus varieties and two transplanting dates (2007). The planting date and variety codes follow the same order Table 11.1 (1A = Planting 1 of 'Amazon Neon Cherry', etc.).

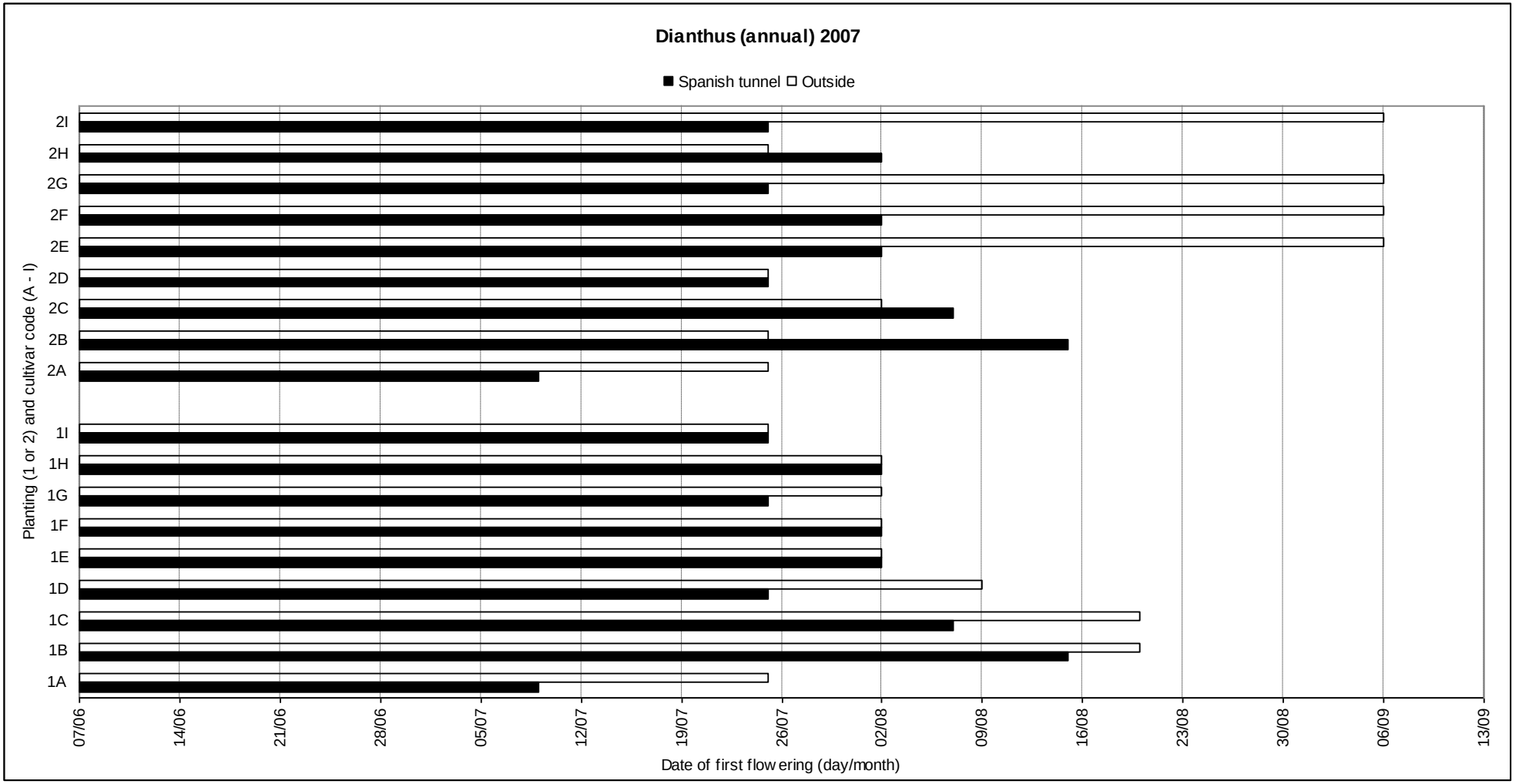


Figure 11.2. From top to bottom: date of start of cropping, stem yield, stem length and stem weight for pinched and non-pinched annual dianthus in trial 2, 2008. The data are averages for seven varieties planted at three dates (see text).

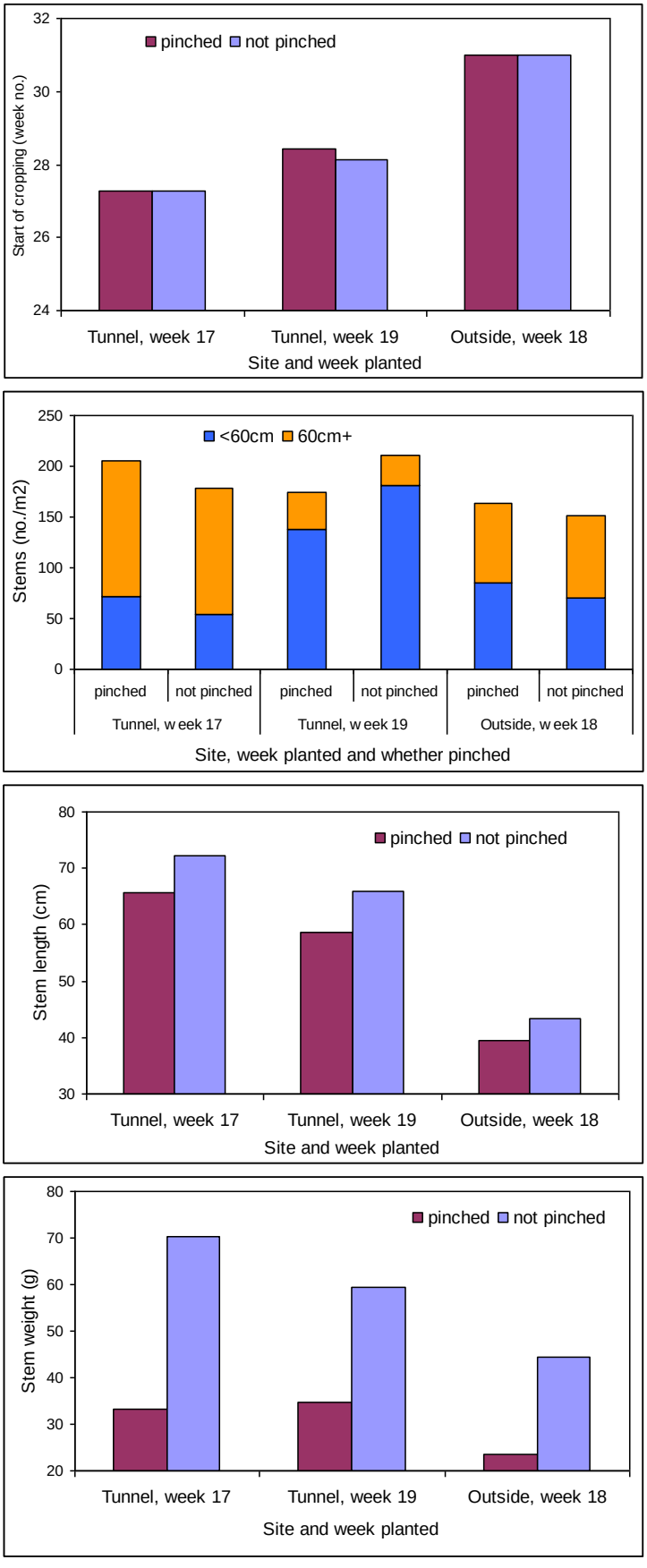


Figure 11.3. The effect of pinching or not pinching on stem yield of annual dianthus varieties in trial 2, 2008.Top and middle: Planted in tunnel in week 17 or 19, yields in <60 and 60+ cm grades. Bottom: planted outside in week 18, stem grades indicated by colour of bars.

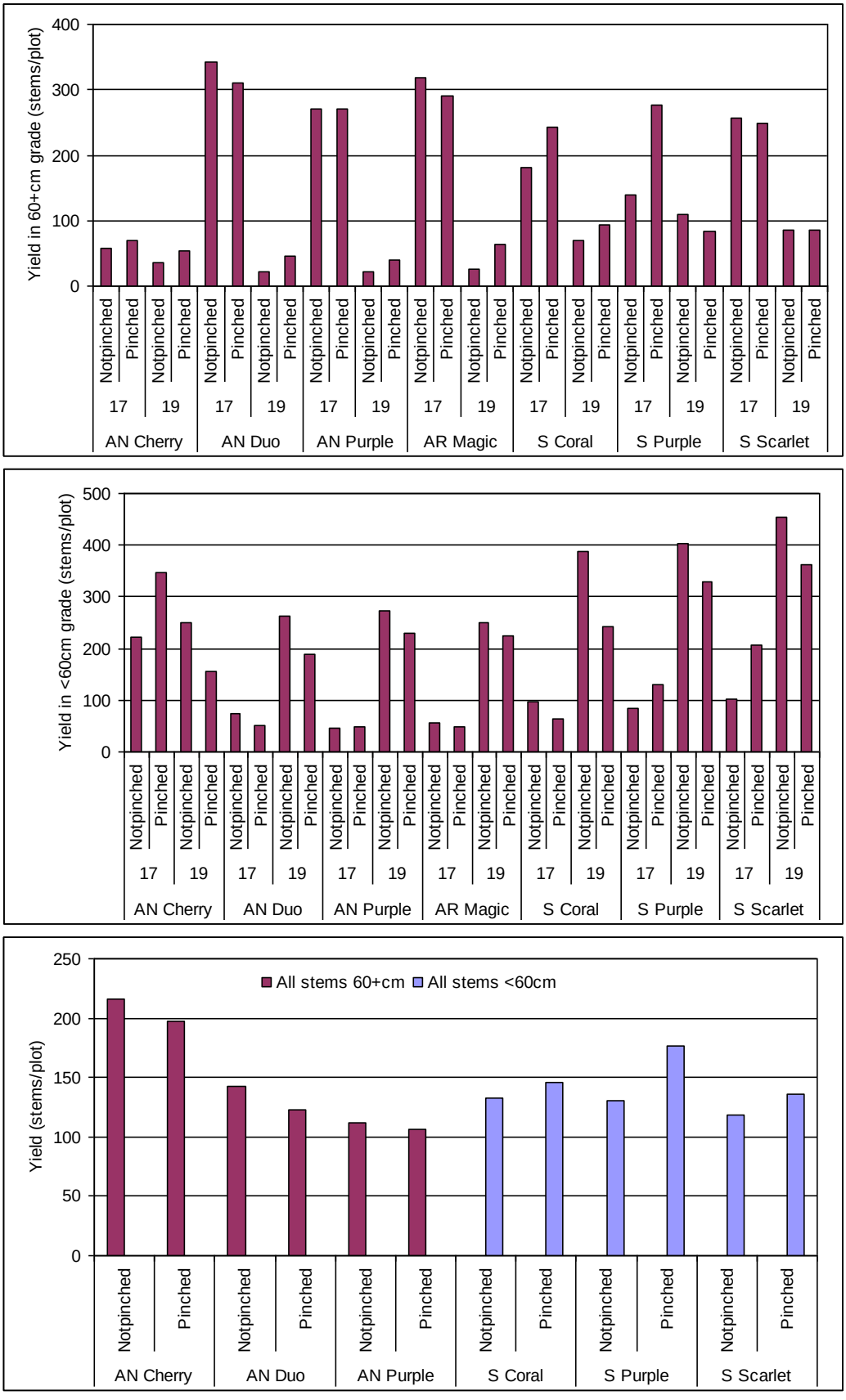
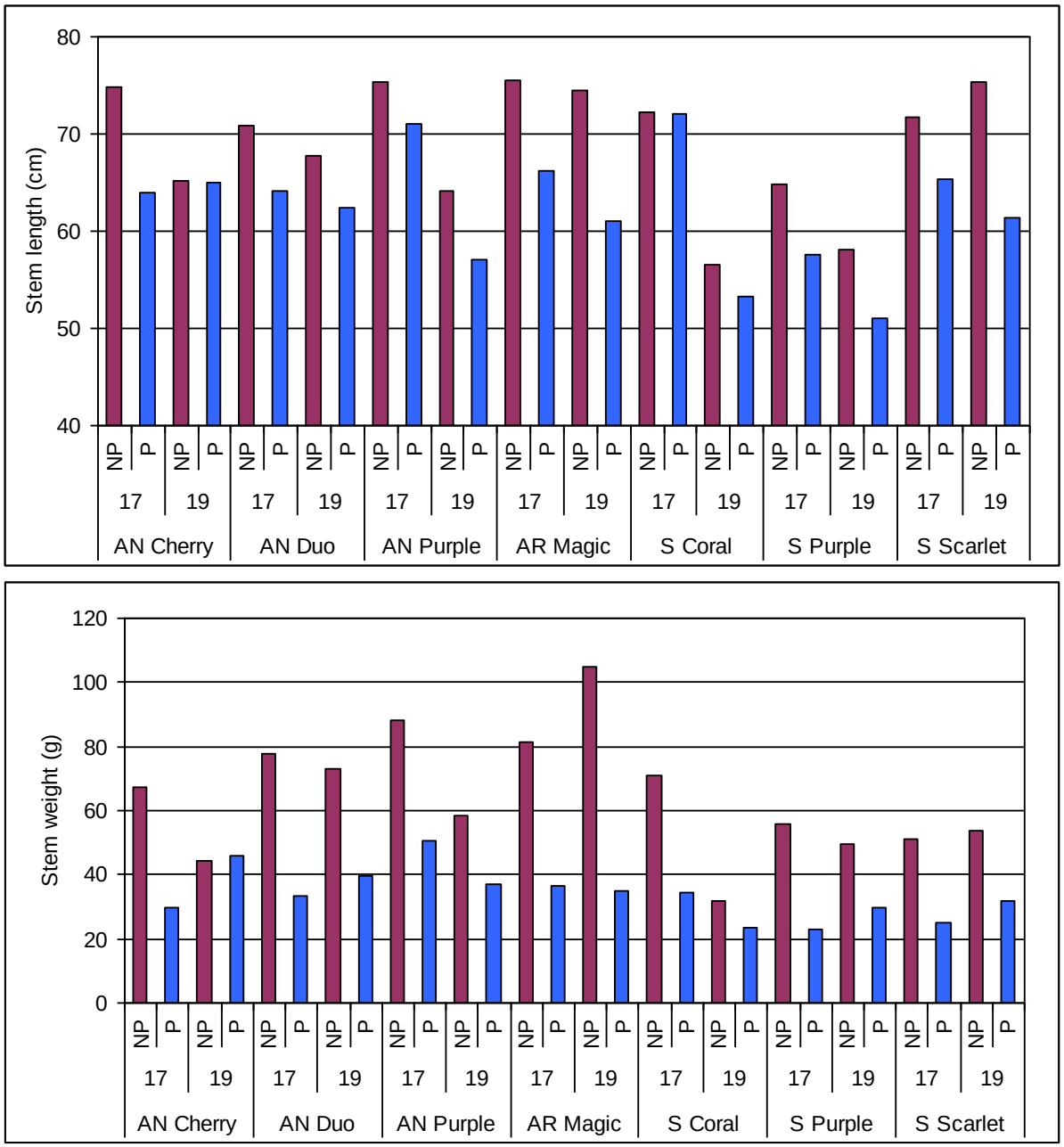


Figure 11.4. The effect of pinching or not pinching on (top) stem length and (bottom) stem weight of annual dianthus varieties planted in tunnels in week 17 or 19; trial 2, 2008.



12. ECHINOPS

A single variety of echinops was included in the project to assess its commercial potential.

Echinops demonstration

'Veitch's Blue' was transplanted to tunnel and outside plots in week 18, 2007 and its flowering performance assessed in 2008. In the first year the crop was seriously affected by mildew and its appearance overall was poor; nevertheless, when both outside and protected plots started to produce flowers in late-June, noteworthy interest was generated among the retailers who saw it.

Its performance in 2008 is summarised in Table 12.1. Stem yields were poor in the first flush, starting in week 25, though stem length and weight, under protection, were reasonable. The second flush started in week 41-42: yields were just over 100 stems/m^2, but stem length and weight were poor compared with those from the earlier flush.

Discussion - echinops

Although echinops is well liked by many, the MG saw no clear potential for developing its production in the UK at this time.

Table 12.1. The performance of echinops 'Veitch's Blue' in tunnel and outside plots, 2008.

Variety	*Flush*	*Stem yield (per m^2)*		*Start of cropping (week no)*		*Stem length (cm)*		*Stem weight (g)*	
		Tunnel	*Outside*	*Tunnel*	*Outside*	*Tunnel*	*Outside*	*Tunnel*	*Outside*
Vetch's Blue	First	-	-	25	25	110	95	117	52
	Second	102	106	41	42	68	56	49	32

13. ERYNGIUM

A small variety demonstration of eryngium was included in the project.

Eryngium demonstration

Seven varieties (including one un-named new line) were transplanted to outside and tunnel plots in weeks 17 or 24, 2007, depending on delivery date. In the first growing season variety 'Belladonna' was the most attractive variety and produced the largest number of flowers. Other varieties showed a number of problems:

- 'Blue Bell' was variable in height and the plants were shy to flower.
- 'Ellabella', 'Marbella' and 3221 were slow to flower, while 'Farid' was very poor when grown outside.
- 'Purple Sheen' had tip-burn on the flower heads, no plants were cropped, and this variety was replaced with fresh transplants in 2008.

Crop performance in 2008 is summarised in Table 13.1.

- There were wide differences between varieties in the start of cropping, from week 21-22 ('Belladonna') to week 29 (3221); 'Purple Sheen' did not begin cropping until week 32, but this was from a new planting.
- For each variety, generally the dates of starting cropping were similar, whether grown in tunnels or outside.
- Overall, stems were longer and heavier from tunnel plantings than from outside plots (100cm against 84cm, and 150g against 108g), but there were large differences in response in stem length and weight between varieties and the stems of 'Ellabella' and 'Purple Sheen' were notably heavier from tunnel crops.

Eryngium stem yield is shown in Table 13.2.

- All varieties, including the first-year 'Purple Sheen', produced 40-55 stems/m^2 in the first flush when grown in tunnels.
- When grown outside, only 'Marbella' produced such a yield (53 stems/m^2).
- In the second flush, only tunnel-grown 'Belladonna' and 'Blue Bell' produced over 20 stems/m^2, with poor or no yields in other cases.

Discussion - eryngium

As in the case of echinops, the MG saw no clear potential for commercialising eryngium at this time.

Table 13.1. Summary of flowering data for Eryngium varieties, 2008.

Variety	*Start of cropping (week no.)*		*Stem length (cm)*		*Stem weight (g)*	
	Tunnel	*Outside*	*Tunnel*	*Outside*	*Tunnel*	*Outside*
Belladonna	22	21	105	91	106	91
Blue Bell	27	26	123	103	131	105
Ellabella	24	24	114	88	204	79
Farid	22	24	62	50	62	60
Marbella	29	21	105	98	123	117
Purple Sheen	32	32	89	59	335	183
3221	29	29	99	88	87	124

* Purple Sheen plants replaced in 2008

Table 13.2. Stem yield for Eryngium varieties, 2008.

Variety	*Stems cropped (no. per plot)*						*Stems cropped (no. per m²)*					
	Tunnel			*Outside*			*Tunnel*			*Outside*		
	First flush	*Second flush*	*Both*	*First flush*	*Second flush*	*Both*	*First flush*	*Second flush*	*Both*	*First flush*	*Second flush*	*Both*
Belladonna	102	53	155	44	9	53	43	22	65	18	4	22
Blue Bell	133	59	192	43	5	48	55	25	80	18	2	20
Ellabella	116	12	128	42	7	49	48	5	53	18	3	20
Farid	110	9	119	19	3	22	46	4	50	8	1	9
Marbella	111	29	140	127	3	130	46	12	58	53	1	54
Purple Sheen	143	0	143	0	0	0	40	0	40	0	0	0
3221	118	6	124	50	15	65	49	3	52	21	6	27

* Purple Sheen plants replaced in 2008

14. GODETIA

For godetia the main requirement was to assess marketable yield, stem length and vase-life, and a selection of varieties was set up in two demonstrations.

Godetia demonstration 1

Four varieties of the 'Grace' series were transplanted to outside plots and tunnels in weeks 21 and 25, 2007, and the data are summarised in Table 14.1. 'Grace Rose with Pink' produced inferior quality blooms, and from the second planting its flowers were poor. However, the trial demonstrated the potential of godetia for production in the UK, and generated interest amongst some retailers, so a second demonstration was set up in 2008.

Godetia demonstration 2

In the second trial four varieties were grown, each transplanted in weeks 17 and 26, 2008, to tunnels (Table 14.2):

- From both plantings, stem length was notably greater in 'Mixed Colours' than in the other varieties, though differences in stem weights were less.
- Godetia produced a high number of stems/m^2, between 210 and 273, from the first planting, and between 116 and 227 from the second, 'Mixed Colours' again being the most vigorous variety trialled.

Vase-life

Sample stems of each variety from demonstration 2 were tested in vases of plain water following conditioning in plain water or water with added RVB (Figure 14.1).

- The vase-life attributes showed there was no notable difference in vase-life, flower or leaf quality, water clarity or water uptake between the four varieties.
- The marginal means for conditioner treatments showed there was a 1-day increase in vase-life when conditioner was used.

Discussion - godetia

The demonstrations highlighted a number of difficulties in exploiting godetia as a large-scale cut-flower. The stems need to be cut as soon as there is the slightest show of colour, which accentuates the low stem weight of the product. When a conditioner was used the vase-life was adequate, but not outstanding, at about 7 days. Godetia is probably more suitable for growing as a florist's speciality, though some packers did feel that it could have supermarket potential.

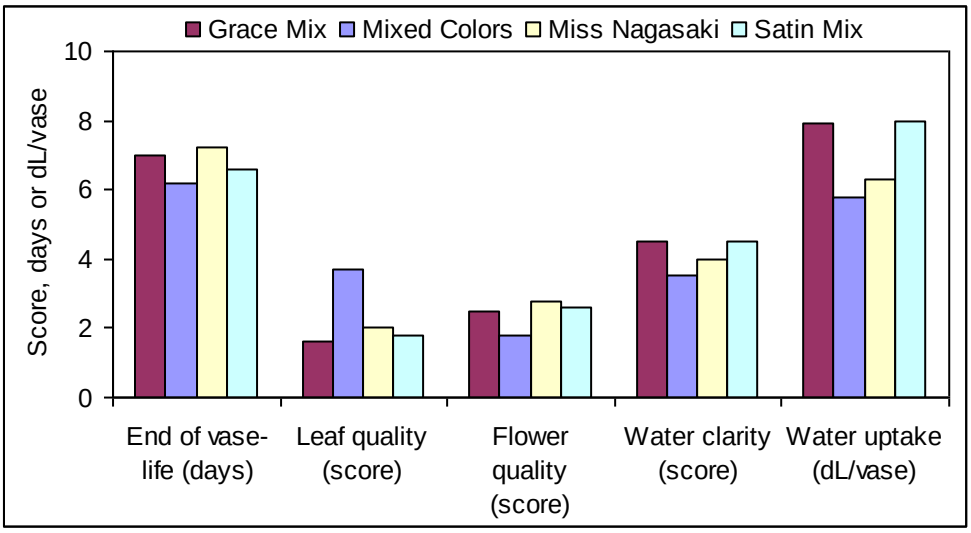
Table 14.1. Summary of flowering data for godetia varieties, first planting only, 2007.

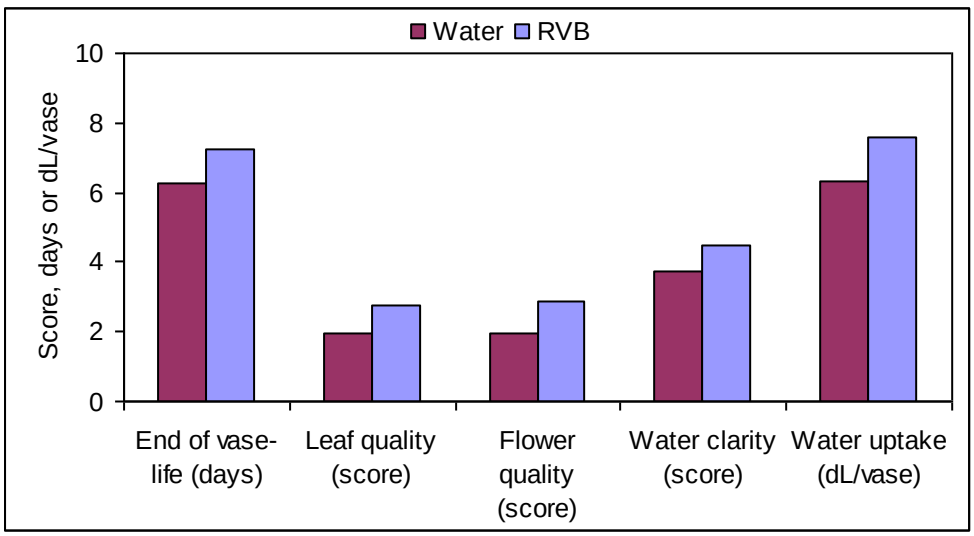
Variety	*Start of cropping*		*Stem length (cm)*		*Stem weight (g)*	
	Tunnel	*Outside*	*Tunnel*	*Outside*	*Tunnel*	*Outside*
Rose with Pink	25/07	25/07	38	29	29	22
Salmon	25/07	25/07	42	32	30	23
Shell Pink	02/08	02/08	41	34	30	32
Red	02/08	02/08	41	34	39	36

Table 14.2. Summary of flowering data for godetia varieties grown in tunnels, 2008.

Variety	Planting	Start of cropping (week)	Stem length (cm)	Stem weight (g)	Stem yield	
					No./plot	No./m^2
Grace Mix	1	27	56	44	777	216
Miss Nagasaki	1	27	59	46	755	210
Mixed Colours	1	23	84	40	983	273
Satin Mix	1	25	58	34	873	243
Grace Mix	2	34	53	39	565	157
Miss Nagasaki	2	35	53	57	784	218
Mixed Colours	2	35	95	52	816	227
Satin Mix	2	32	43	37	416	116

Figure 14.1. Vase-life attributes of four godetia varieties following conditioning in plain water or RVB in 2008. The values are marginal means for (top) the four varieties and (bottom) the two conditioner treatments.





15. GRASSES (ORNAMENTAL)

Ornamental grasses find many applications in bouquet work, so there is an interest in determining whether they might be a commercial possibility for growers in the UK. A straightforward demonstration plot was set up.

Ornamental grasses demonstration

Four ornamental grasses, *Panicum* and *Setaria* varieties, were transplanted to outdoor plots between weeks 22 and 25 in 2007. Two further grasses – *Chasmanthium* and *Miscanthus* - were planted in week 18 of 2008 to augment the demonstration.

- In 2007 (Table 15.1) all four grasses started flowering 5 to 6 weeks after transplanting. *Setaria italica* produced taller and much heavier stems (85cm, 29g) than the *Panicum* varieties (60-70cm, 10-11g).
- In the next growing season (Table 15.2) *S. italica* started to flower in week 28, 2-4 weeks before the *Panicum* grasses, and produced stems of similar length but heavier (18g average) than in the previous year. *P. virginatum* 'Fontane' produced stems of similar weight to the previous year, but the other *Panicum* varieties were markedly shorter (about 45cm, compared with 70cm) than before.
- In 2008 the first-year *Miscanthus* started cropping relatively late, in week 35, but produced very long (124cm) and heavy (31g) stems.
- In 2008 *Chasmanthium latifolium* started to produce a few flower, but nothing of marketable quality could be cropped this year.

Vase-life testing

In 2008 stems of the six grasses were taken through a vase-life test on plain water, following conditioning in plain water or water with RVB (marginal means in Figure 15.1).

- The marginal means for conditioner treatments showed that using RVB had no effect on vase-life.
- The marginal means for variety showed the much longer vase-life of *Miscanthus* than the other varieties, and the superior leaf quality score of *Panicum virgatum* 'Fontaine'.
- Leaf quality scored 5.0 in all cases.

Discussion – ornamental grasses

The MG considered that ornamental grasses are better grown in a hot, moist environment, for example under polythene. Additionally, it would not be possible to compete with the large production areas of ornamental grasses that are grown in Costa Rica.

Table 15.1. Summary of flowering data for ornamental grasses in outdoor plots, 2007.

Variety	*Start of cropping (week no.)*	*Stem length (cm)*	*Stem weight (g)*
Panicum elegans 'Frosted Explosion'	27	70	11

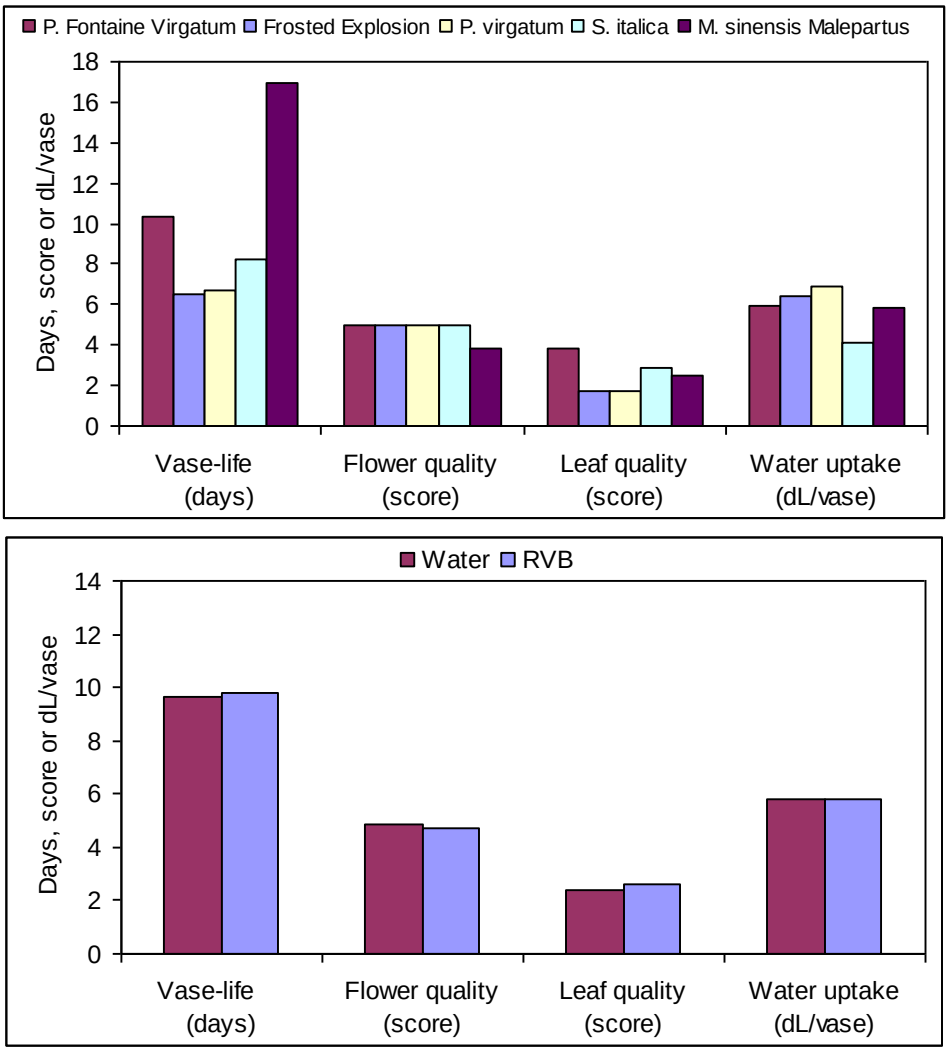
P. virgatum	28	70	10
P. virgatum 'Fontane'	31	60	10
Setaria italica	31	85	29

Table 15.2. Summary of flowering data for ornamental grasses in outdoor plots, 2008.

Variety	*Planting year*	*Start of cropping (week no.)*	*Stem length (cm)*	*Stem weight (g)*
Panicum elegans 'Frosted Explosion'	2007	30	46	10
P. viragatum	2007	30	45	11
P. virigatum 'Fontane'	2007	32	62	11
Setaria italica	2007	28	70	18
Chasmanthium latifolium	2008	-*	-	-
Miscanthus sinensis 'Malepartus'	2008	35	124	31

* -, did not flower

Figure 15.1. Vase-life attributes of five ornamental grasses following conditioning in plain water or water with RVB in 2008. The values are marginal means for (top) the five varieties, and (bottom) the two conditioner treatments.



16. LARKSPUR

The main aim of the trials on larkspur was to establish whether it could be improved sufficiently to make a worthwhile crop, either through scheduling, variety selection, manipulating planting density, disease control or other means. Presently, larkspurs are perceived as having inconsistent quality and poor post-harvest qualities - a 'poor man's delphinium'. Is it possible to produce a high-quality, graded stem under Spanish tunnels?

Larkspur trial and demonstration in 2007

In 2007 eight varieties were raised from seed and transplanted to outdoor plots in week 21 as a variety demonstration. The plants were so severely affected by the excessively wet weather that no meaningful results could be obtained from them - though, as some indication of vigour, varieties 'Single Red', 'Single White' and 'Sydney Pink' stood out as coping better with these conditions than the others. In addition, nine varieties were transplanted into outside plots in weeks 21 and 25 as a planting date trial; this too was invalidated by the adverse weather. Further trials under protection were therefore planned for 2008.

Larkspur planting date and planting density trial, 2008

In 2008 a factorial trial was set up with two varieties ('Sydney Blue' and 'Sydney Pink') planted outside on three planting dates (weeks 17, 21 and 23) and three planting densities (64, 80 and 100 plants/m^2) (Table 16.1). Using the three planting dates, continuity of cropping was obtained from week 27 to beyond week 31, and over this period stem lengths and weights were broadly acceptable. There were, however, no consistent trends of length or weight with planting date or planting density – for example, longer but weaker stems might have been expected with increasing planting density, countering any benefits of a greater yield of stems.

To understand the results better the 'marginal means' are shown in Figure 16.1. This shows the overall means for the two varieties over all planting dates and densities, the overall means for each planting date over both varieties and planting densities, etc., so indicates which factor or factors – variety, planting date or planting density – are critical in achieving various outcomes. The main findings were:

- The start of cropping was unaffected by variety and planting density, it was simply delayed by later planting.
- Stem length was less in 'Sydney Pink' than in 'Sydney Blue', was shorter as planting was later, and was reduced at planting densities of 80 and 100 plants/m^2 compared with 64 plants/m^2.
- Stem weight was similar in the two varieties, was lower with later planting, and (like length) was reduced at planting densities of 80 and 100 plants/m^2.
- Flower yield was similar in each variety and greatest from the middle planting date (and, of course, was greater with increasing planting density).

Vase-life testing

In 2008 samples from the first date were subjected to vase-life testing in plain water after conditioning initially in plain water or in AVB followed by RVB (Figure 16.2).

- The stems used in this test seem to have been a poor sample, as the vase-life varied between 4.4 and 5.6 days only, and the flower quality score never exceeded 1.6 (out of 5) for any treatment combination.
- Water uptake was generally greater in 'Sydney Blue' than in 'Sydney Pink'.
- Water clarity and leaf quality scores were high in all cases.

- There were no obvious differences in post-harvest quality parameters due to planting density.
- There was a small benefit to vase-life where RVB/AVB was used as conditioner, but this was too small to regard as significant with such generally short-lived and poor flowers.

Further data in the post-harvest quality of larkspurs under different treatments is needed.

Discussion - larkspur

Opinions within the MG were divided about the potential for larkspur. One view is that, if consistent quality and an eight-day vase-life could be achieved, the crop would have great potential for use in bouquets. However, larkspur appears to be relatively unresponsive to post-harvest treatments; in the 2008 trial vase-life was only about 5 days, despite the promising quality of the stems in the field. Unlike delphinium, larkspur is severely affected by damp weather, with mildew and loss of the lower florets. On balance the MG was of the opinion that another year's trials were needed to resolve these issues.

Table 16.1. Summary of flowering data for two varieties of larkspur planted at three dates at three densities, 2008.

Variety	*Planting date (week no.)*	*Planting density (plants/m²)*	*Start of cropping (week no.)*	*Stem length (cm)*	*Stem weight (g)*	*Yield (stem/ m²)*
Sydney Blue	17	64	27	121	83	50
		80	27	108	58	64
		100	27	111	49	78
	21	64	28	107	62	60
		80	28	110	51	75
		100	28	101	45	87
	23	64	31	100	50	47
		80	31	88	48	57
		100	31	102	62	90
Sydney Pink	17	64	27	111	68	53
		80	27	99	41	68
		100	27	106	52	69
	21	64	28	99	60	66
		80	28	101	64	79
		100	28	94	50	86
	23	64	31	84	54	63
		80	31	77	44	90
		100	31	81	54	60

Figure 16.1. (From top to bottom) date of start of cropping, yield of stems, stem length and stem weight for larkspur in planting date and planting density trial in 2008. The values are the marginal means expressed across varieties (left), across planting dates (middle) and across planting density (right) (see text).

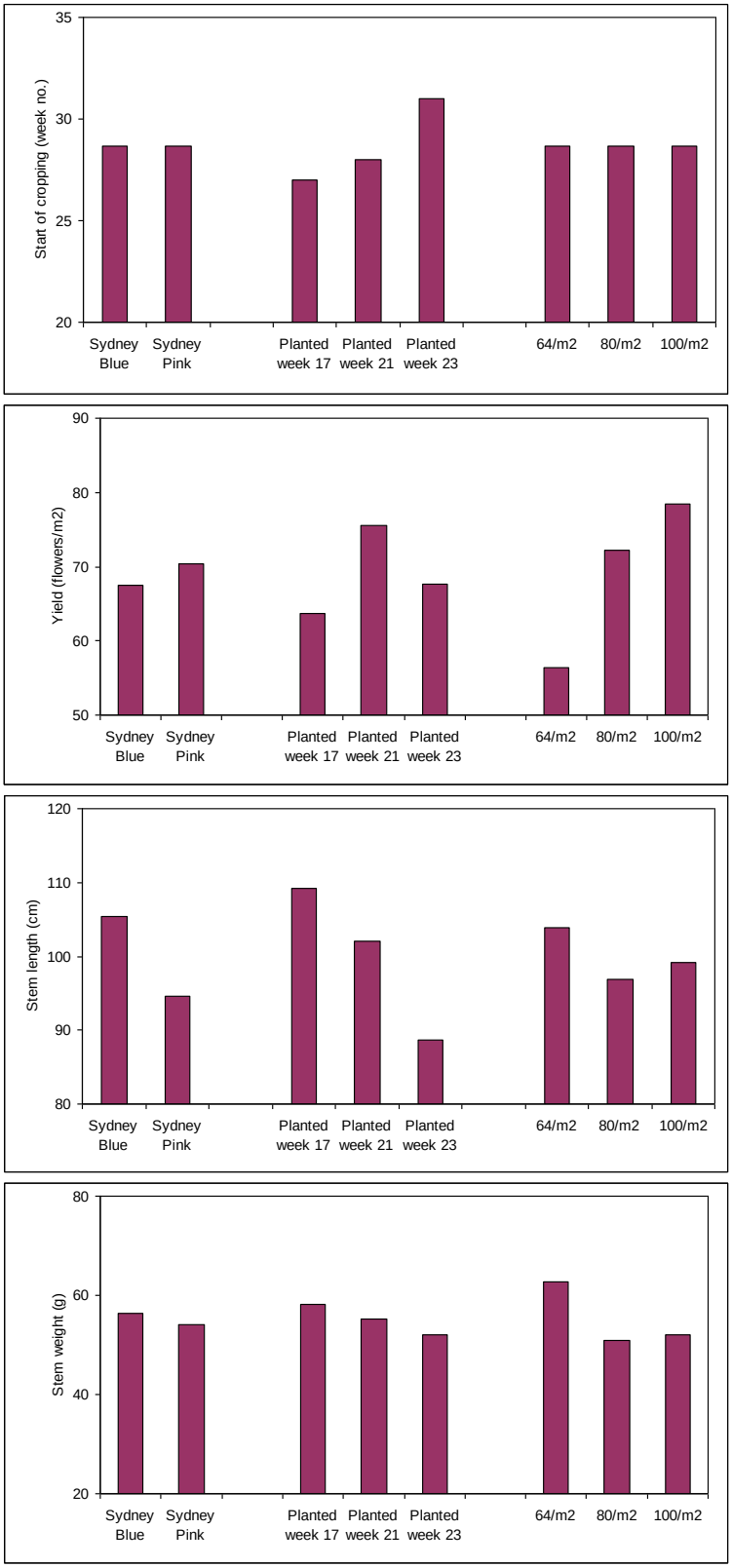
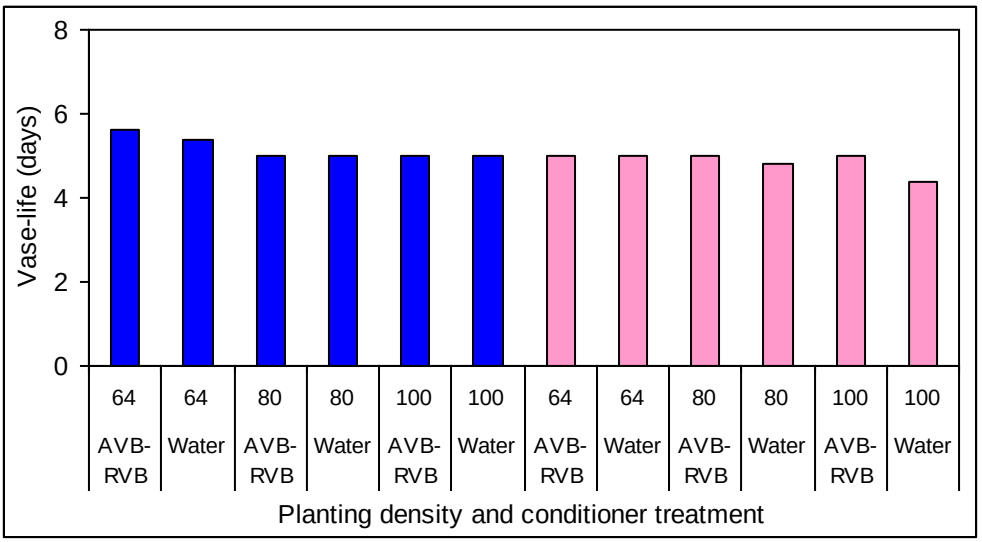
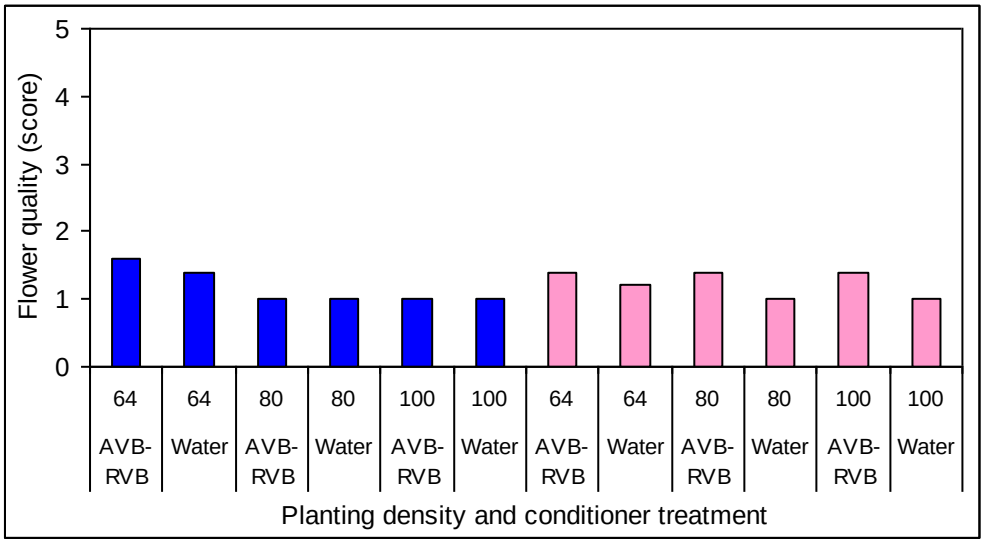
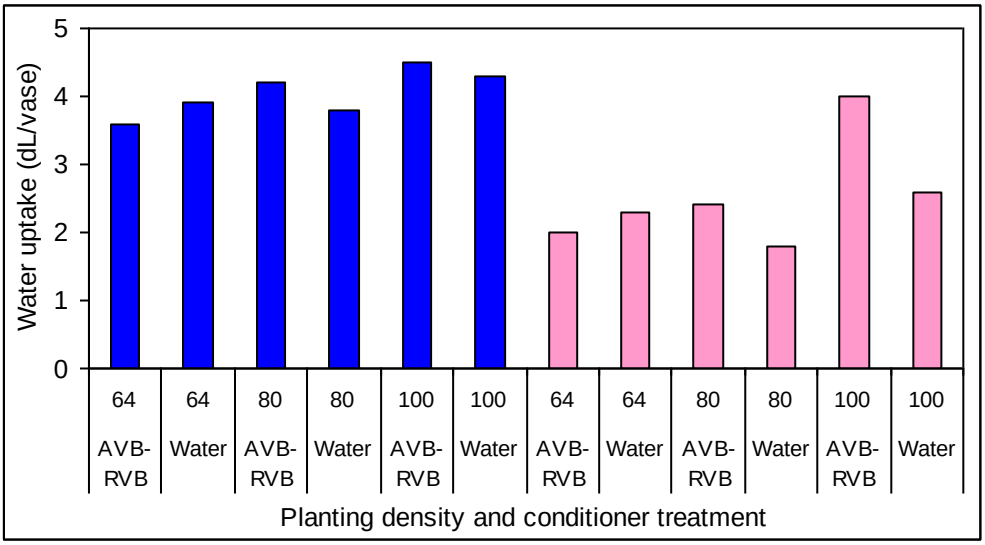


Figure 16.2. Vase-life attributes of larkspur 'Sydney Blue' (on left of figure) and 'Sydney Pink' (on right) grown at three planting densities (64, 80 and 100plants/m²) and conditioned in AVB followed by RVB or in plain water, 2008. Top: vase-life; middle, flower quality, and bottom, water uptake.







17. LYCHNIS

A single variety of lychnis was included in the project to assess its potential as a cut-flower.

Lychnis demonstration

Plants of *Lychnis flos-cuculi* 'Jenny' were transplanted to outside plots week 3, 2008. Cropping started in week no. 19, and average stem length was 61cm and weight 8g.

Discussion - lychnis

The first flush looked very encouraging, but disappointingly the plants failed to produce another good quality flush, just flowers with weak stems. The very light stems were not suitable as a cut-flower, although stem length and the general look of the flower (double flowered 'ragged robin') were all adequate. It may be interesting to see the performance of these plants in 2009.

18. PHLOX

The main aim of growing phlox was to assess the quality of the stems, including vase-life, for a selection of varieties.

Phlox variety trial

Following the late delivery of plants in 2007, varieties 'Icecap', 'Miss Marple', 'Miss Fiona' and 'Sugar Missy' were transplanted to tunnel and outside plots in week 25. This proved too late to produce many meaningful results, with 'Icecap' and 'Miss Marple' failing to flower in the outside plots within a practical time-span (Table 18.1). For plants grown in tunnels, there were large between-variety differences in stem weight in stems of similar length (between 46 and 58cm): 'Miss Marple' produced the heaviest stems (56g) and 'Miss Fiona' the lightest (34g).

Despite this disappointing performance, largely a result of late planting, the variety plots generated considerable interest amongst the UK retailers that viewed it. Therefore the crop was grown on in 2008, with some new varieties being added: 'Magical Dream', 'Magical Fragrance' and 'Magical Surprise' were planted in week 18 of 2008 (Table 18.2 and Figure 18.1).

- The four original varieties started to crop in week numbers 24 to 27 in tunnel and outside plots.
- The stem length and weight of tunnel-raised plants were consistently 10-20% greater than those from outside plots, 'Sugar Missy' having markedly longer and heavier stems than the other varieties.
- The yield of stems/m^2 was highly variable – from 44 to 101. 'Miss Fiona' produced similar yields whether in tunnels or outside (58-64/m^2), while the other varieties were more productive outside, remarkably so in the case of 'Sugar Missy' (44 and 101 stems/m^2), respectively.
- The three first-year crops flowered in significant numbers only in the protected plots, where they were later, had poorer yields and stems were shorter and lighter than for the year-old plantings.

Vase-life testing - 2007

In 2007 samples of phlox from the tunnels were tested in vases with flower food (Table 18.3).

- All four varieties exceeded their expected 5-day vase-life by 2 or more days.
- 'Sugar Missy' had the longest vase-life, nearly 9 days, and showed significantly greater water uptake than the other varieties.
- By vase-day 5 leaf quality remained excellent in all varieties, but flower quality was poorer (with a low score of 3.3 for 'Ice Cap') and the vase-water was generally turbid.

Vase-life testing - 2008

Further samples of all varieties were vase-life tested in 2008. In this test the stems were conditioned in RVB or plain water and were then placed in vases with plain water. The effects of treatments were modest and the marginal means for varieties and conditioner treatments are given in Figure 18.2.

- For the varieties:
    - Vase-life ranged from 4.8 days ('Miss Marple') to 9.4 days ('Sugar Missy').
    - Flower quality was greater in 'Ice Cap', 'Miss Fiona' and 'Sugar Missy' than for the other varieties.
    - Leaf quality score was consistently high (4 or more).

  - The water clarity score was 4.5 or higher except in one instance.
  - Water uptake was lower for 'Magical Dream' than for the other varieties.
- For conditioner treatments there was a one-day increase in vase-life overall when RVB conditioner had been used.

The vase-life of phlox varieties can be quite variable, so careful choice will be needed. Using a conditioner gave a modest improvement in post-harvest quality and may be needed to ensure an adequate vase-life.

Discussion - phlox

Although phlox are traded widely, opinions in the MG differed as to whether it was really had potential as a straight line. Presently a bunch (of five or seven stems) was realising £1.99, but it was considered this needed to be £2.99, partly to allow for the high cost of plant material due to PVR. Other disadvantages were the restricted colour range, the limited availability (in September) and the need for careful choice of varieties. The vase-life was probably adequate, though not exceptional. Nevertheless, the MG formed the opinion that these issues should be addressed by the Centre in a further trial in 2009.

Table 18.1. Summary of flowering data for phlox varieties in 2007.

Variety	*Start of cropping (week no.)*		*Tunnel-raised crops*	
	Tunnel	*Outside*	*Stem length (cm)*	*Stem weight (g)*
Icecap	38	-*	53.0	40.5
Miss Marple	36	-	55.0	56.0
Miss Fiona	31	36	46.4	34.0
Sugar Missy	36	36	58.5	37.5

* -, not assessed, flowers poor

Table 18.2. Summary of flowering data for phlox varieties, 2008.

Variety	*Start of cropping (week no.)*		*Stem yield (no./m²)*		*Stem length (cm)*		*Stem weight (g)*	
	Tunnel	*Outside*	*Tunnel*	*Outside*	*Tunnel*	*Outside*	*Tunnel*	*Outside*
Ice Cap	25	26	61	75	112	83	84	63
Miss Fiona	24	26	64	58	99	83	88	64
Miss Marple	26	26	49	85	93	80	88	53
Sugar Missy	27	26	44	101	124	102	147	87
Magical Dream*	32	-**	-	-	62	-	67	-
Magical Fragrance*	32	-	-	-	57	-	61	-
Magical Surprise*	32	-	33	-	54	-	88	-

* Planted 2008, other varieties planted 2007

** -, inadequate or no cropping recorded

Table 18.3. The post-harvest attributes of phlox bouquets assessed on vase-day 5 (2007).

Variety	*Leaf quality score (1-5)*	*Flower quality score (1-5)*	*Vase-life (days)*	*Water clarity score (1-5)*	*Water uptake (ml/vase)*
Ice Cap	4.8	3.3	7.5	3	920
Miss Fiona	4.7	3.7	7.5	2	950
Miss Marple	4.5	4.1	7.2	4	920

Sugar Missy	4.6	4.0	8.8	3	1170

Figure 18.1. (From top to bottom) date of start of cropping and stem yield, length and weight for phlox variety trial in tunnels or outside in 2008.

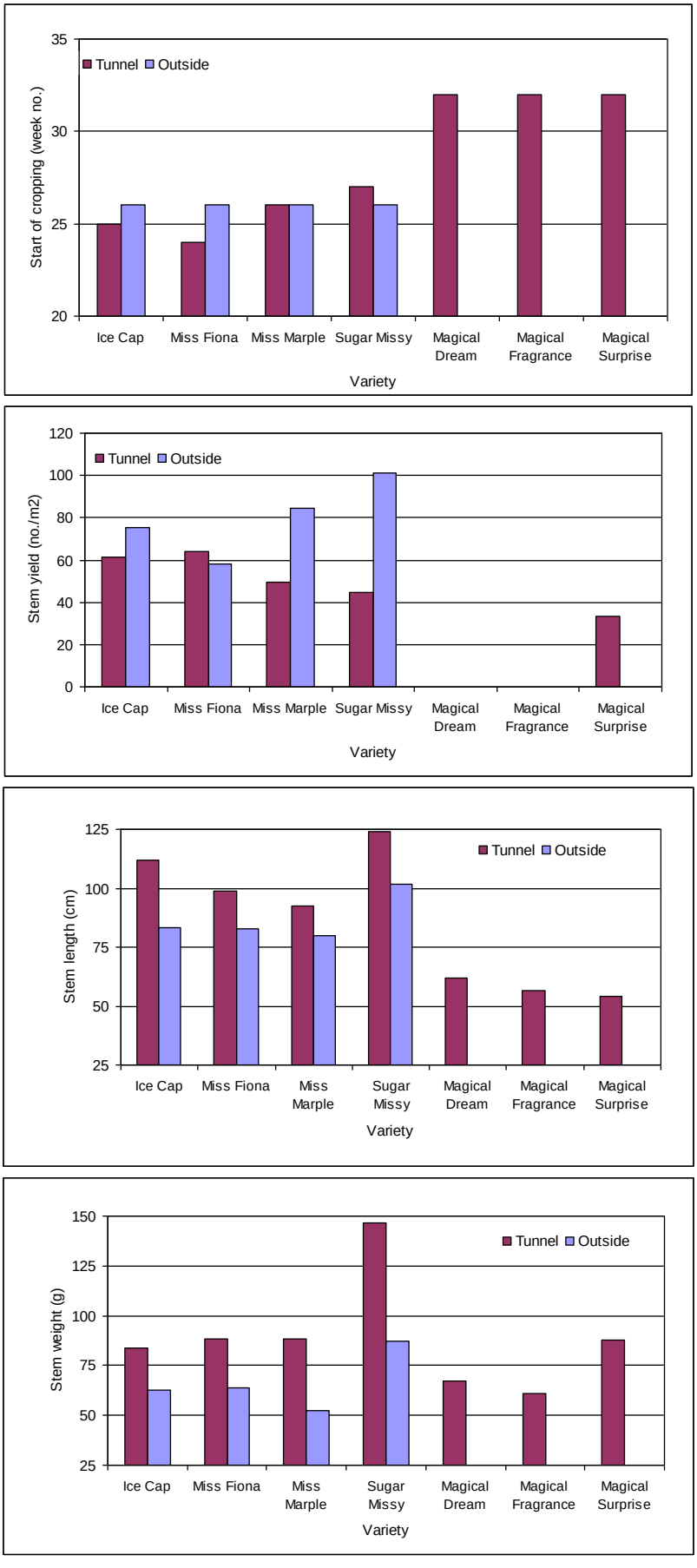
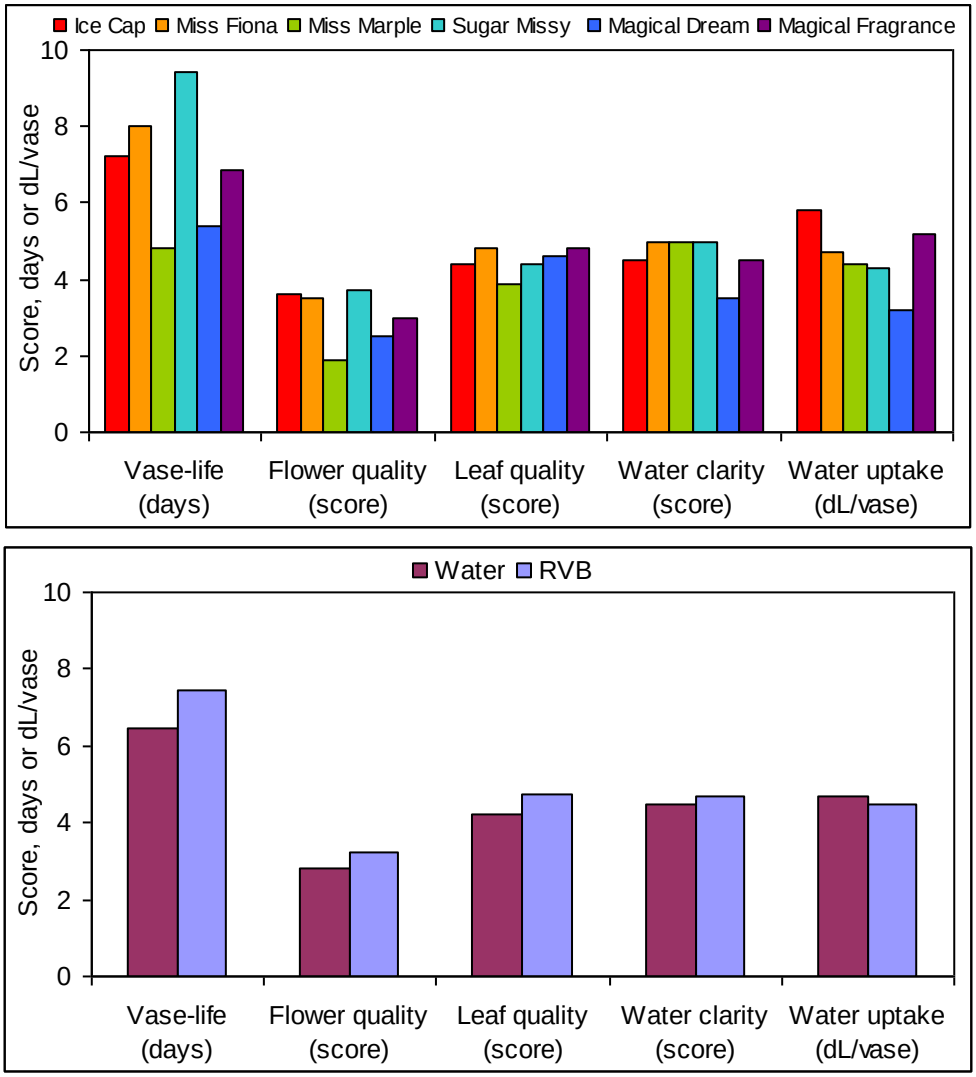


Figure 18.2. Vase-life attributes of six phlox varieties following conditioning in RVB or plain water, 2008. The values are marginal means for (top) the varieties and (bottom) the two conditioner treatments.



19. PINKS

The main aim of the pinks trials, which included both spring- and autumn-plantings, was to introduce an 'old traditional' crop to a new generation of consumers, and to identify the best yielding varieties for meeting supermarket specifications.

Pinks spring-planted demonstration 1

Varieties 'Bright Eyes', 'Lily the Pink', 'Monica Wyatt' and 'Rose Monica' were transplanted in week 18 of 2007 to outdoor and tunnel plots. All plantings started to produce flowers in the second week of July, and there was continuous cropping between July and November (Figure 19.1).

Stem numbers and weights are summarised in Table 19.1.

- In general tunnel-raised plants produced more stems per plant and heavier stems than those grown outdoors.
- Protection was needed to produce stems of sufficient length and quality.
- There were marked differences in productivity between varieties: for example, flower production of 'Lily the Pink' grown under protection was relatively low.

Pinks spring-planted demonstration 2

In week 15, 2008 the tunnel where the above four varieties were growing was damaged by wind and the plants were moved to an adjacent tunnel, alongside new plants of four further varieties, 'Dancing Queen', 'Devon Cream', 'Gran's Favourite' and 'Letitia Wyatt'. Cropping dates and stem lengths and weights for 2008 are shown in Table 19.2.

- All varieties commenced cropping in week 23.
- Mean stem length varied from 33 to 50cm, and stem weights from 7 to 18g.
- Varieties with the best combinations of stem length and weight included 'Devon Cream', 'Monica Wyatt' and 'Rose Monica', but, of these, 'Monica Wyatt' and 'Rose Monica' produced low yields of flowers – less than 300/m^2 - compared with some other varieties.
- 'Dancing Queen', 'Devon Cream', 'Gran's Favourite' and 'Laetitia Wyatt' produced well over 300 stems/m^2 (see Figure 19.2).

Pinks autumn-planted demonstration

Plants of 'Bright Eyes', 'Dancing Queen', 'Devon Cream' and 'Gran's Favourite' were planted in week 42 of 2007 in tunnel and outside plots. Figure 19.2 shows their stem yields (along with the yields for the spring-planted pinks). In round terms, autumn plantings outside produced double the yield, and autumn plantings under protection treble the yield, of the spring-planted, tunnel-grown crop.

Vase-life

An experiment to study the effects of conditioner and storage temperature was set up using eight pinks varieties flowering in 2008. For practical reasons the experiment was set up over four dates:

a) 8 July, conditioner treatment 1ml/L AVB or plain water, stems stored at 5°C
b) 11 July, conditioner treatment 2ml/L AVB or plain water, stems stored at 5°C
c) 24 July, conditioner treatment 1ml/L AVB or plain water, stems stored at 20°C
d) 24 July, conditioner treatment 2ml/L AVB or plain water, stems stored at 20°C

Marginal means for the treatment factors – test number, variety, conditioning treatment and storage temperature – are set out in Table 19.3. The main findings are listed here.

- All varieties gave a very acceptable vase-life. Overall, the average for the eight varieties varied from 11.8 days ('Devon Cream') to 15.5 days ('Dancing Queen').
- Flower quality was high (score of about 4) in 'Bright Eyes', 'Dancing Queen', 'Letitia Wyatt', 'Monica Wyatt' and 'Rose Monica', and lower (<3) in 'Devon Cream', 'Gran's Favourite' and 'Lily the Pink'.
- There were no obvious correlations between the amount of water uptake and other quality criteria in the different varieties.
- Overall, using 1ml/L AVB increased vase-life by about 1 day, and using 2ml/L increased it by about 3 days. Using AVB also increased the flower quality score.
- There was little effect on post-harvest measures of storing stems at either 5 or 20°C.
- Overall, the results of the four test occasions were reasonably consistent, with average vase-life varying from 11.8 to 14.1 days and flower quality score from 3.1 to 3.8.
- Leaf quality scores and water clarity scores were high in all cases.

The full results of the four tests on vase-life and flower quality are shown in Figures 19.3 and 19.4. Using AVB conditioner did not increase vase-life on every occasion or with every variety, but overall the benefits of using it were clear. One variety – 'Gran's Favourite' – appeared to be especially responsive to AVB. Pinks have a good vase-life which is further boosted by use of a conditioner.

Discussion - pinks

While pinks may be considered an old fashioned product, these trials enabled a younger generation of retail buyers to look at them again. As a direct result of the 2007 trial, one major UK retailer decided to use the product in 2008. Despite this encouraging outcome, the MG agreed that producing supermarket-quality pinks is a difficult task with current prices and no room for sub-standard stems ('seconds'). Unless there is an outlet for bouquet work, pinks are required in consistently high volumes (say, 40,000 bunches/week), which is difficult to achieve with the peaks and troughs in production. A further issue is that one supermarket requires fragrant varieties, which have poorer yields.

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Table 19.1. Stems per plant and stem weights of spring-planted pinks, 2007.

Location and variety	*No. stems per plant*	*20-stem weight (g)*		*Mean stem weight (g)*
		Picked week 32	*Picked week 34*	
Tunnel-grown				
Bright Eyes	4.2	500	325	20.6
Lily the Pink	2.9	605	375	24.5
Monica Wyatt	4.4	445	425	21.8
Rose Monica	3.7	505	410	22.9
Outside-grown				
Bright Eyes	2.7	315	220	13.4
Lily the Pink	2.6	445	320	19.1

Monica Wyatt	3.4	460	330	19.8
Rose Monica	3.4	380	335	17.9

Table 19.2. Flowering performance of eight spring-planted pinks varieties, 2008.

Variety	*Start of cropping (week no.)*	*Stem length (cm)*	*Stem weight (g)*
Bright Eyes	23	43	16
Dancing Queen	23	33	9
Devon Cream	23	47	18
Gran's Favourite	23	37	7
Letitia Wyatt	23	42	13
Lily the Pink	23	40	15
Monica Wyatt	23	50	14
Rose Monica	23	47	17

Table 19.3. Vase-life attributes of pinks varieties tested in 2008 on four occasions with three conditioner treatments (water or 1 or 2ml/L AVB) and storage at 5 or 20°C. The values in this table are marginal means (see text).

Marginal means	*Vase-life (days)*	*Flower quality score (1-5)*	*Water uptake (ml/vase)*
Test number			
Test a	11.8	3.6	316
Test b	14.1	3.8	397
Test c	12.8	3.1	434
Test d	14.0	3.4	363
Conditioner treatment			
Water	12.2	3.0	356
AVB (1ml/L)	13.4	4.0	403
AVB (2ml/L)	15.0	4.0	395
Variety			
Bright Eyes	12.5	3.9	424
Dancing Queen	15.5	4.2	312
Devon Cream	11.8	2.4	336
Gran's Favourite	12.1	2.9	252
Letitia Wyatt	14.6	3.8	375
Lily The Pink	12.1	2.5	375
Monica Wyatt	13.7	4.4	454
Rose Monica	13.4	3.8	490
Storage treatment			
5°C	13.0	3.7	356
20°C	13.4	3.3	398

Figure 19.1. The pattern of flower cropping for spring-planted pinks grown in tunnels or outdoor plots, 2007.

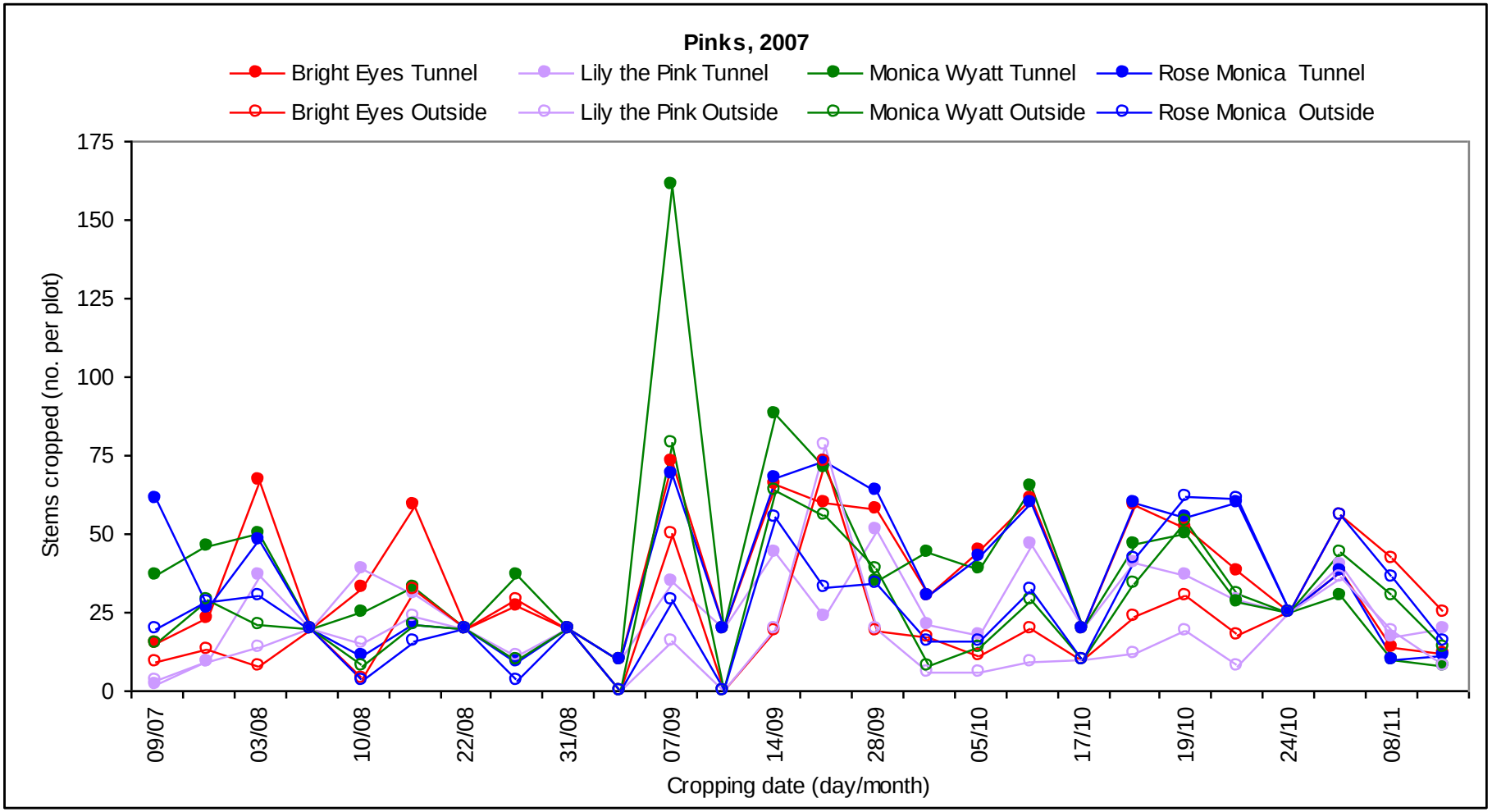
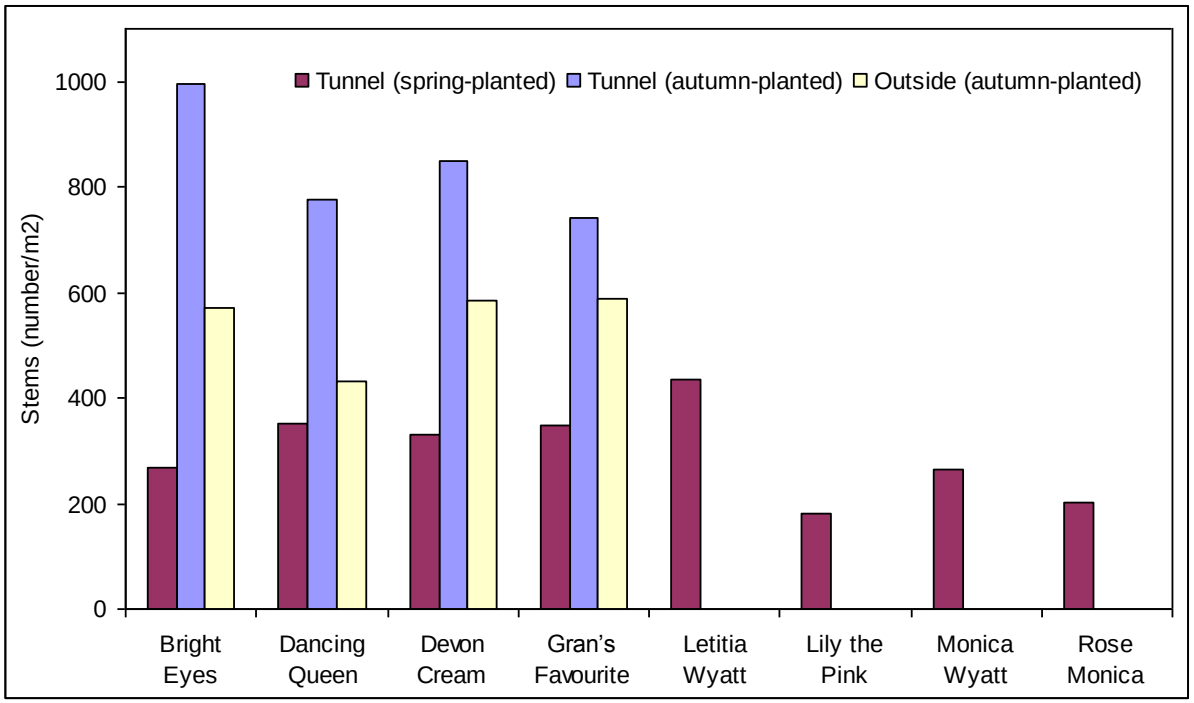


Figure 19.2. Flower yield in 2008 of pinks varieties planted autumn 2007 (tunnel or outside) or spring 2008 (tunnel only). Yields expressed as stem/m² (top) and stems/plant (bottom).



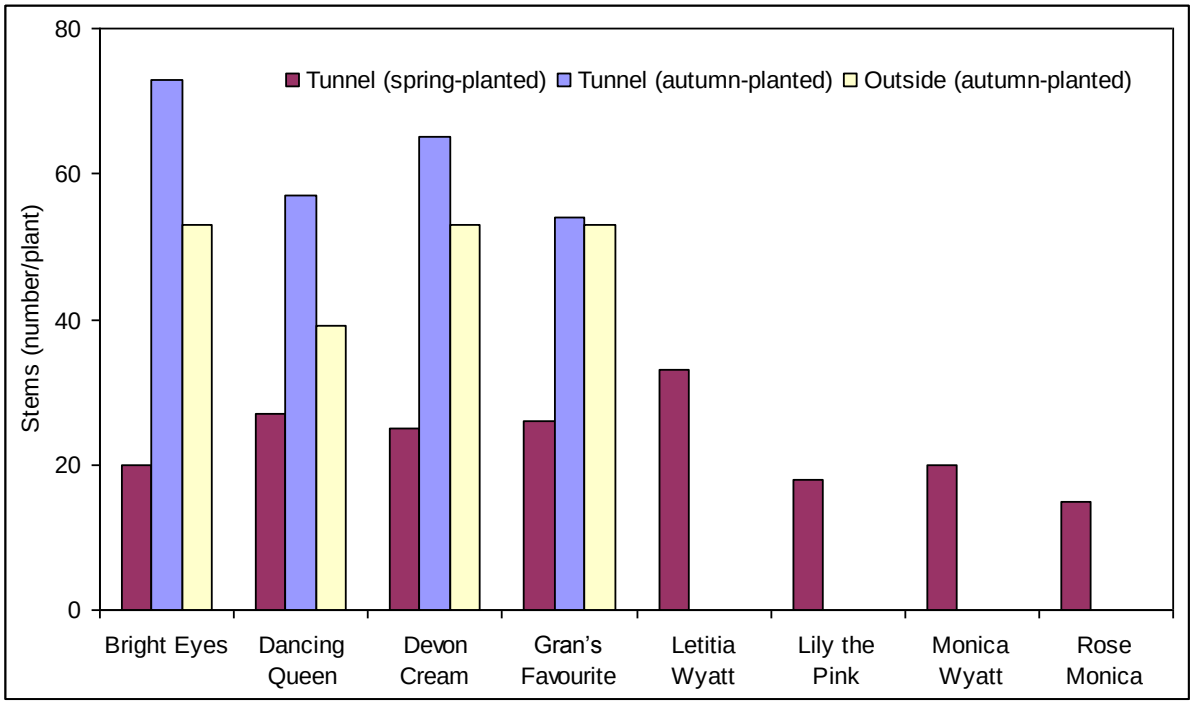
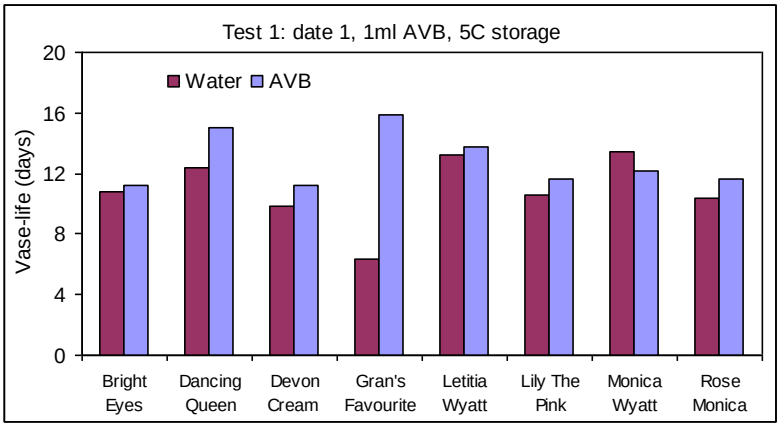
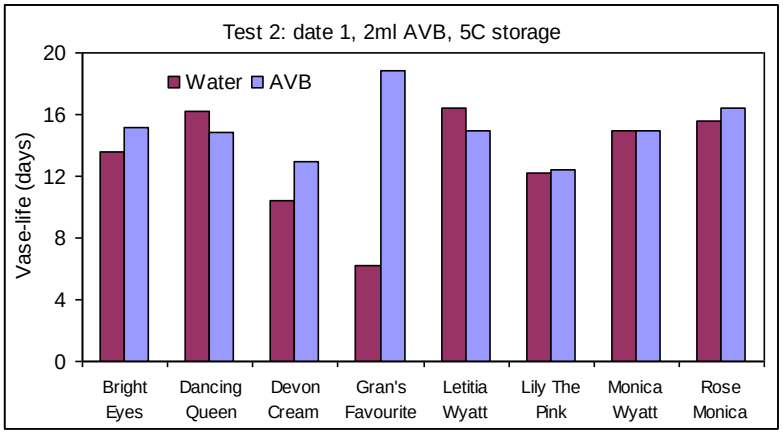
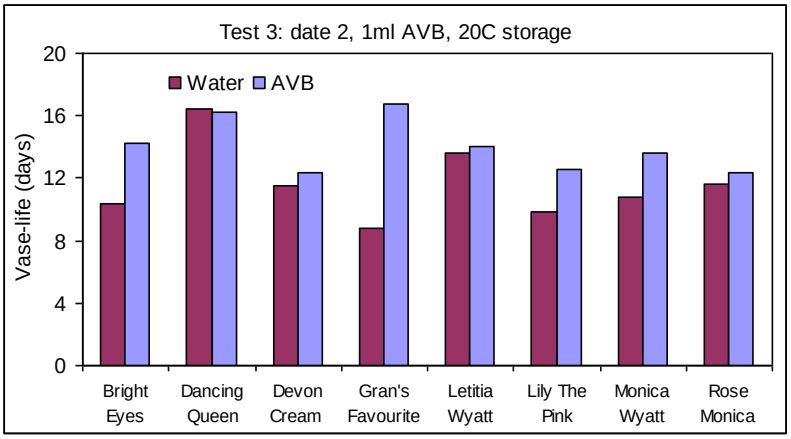


Figure 19.3. Vase-life of eight pinks varieties tested on four occasions with three conditioner treatments (water or 1 or 2ml/L AVB) and storage at 5 or 20°C. The experiment was carried out in 2008 in four sub-sets (labeled Test 1, etc., on each figure).







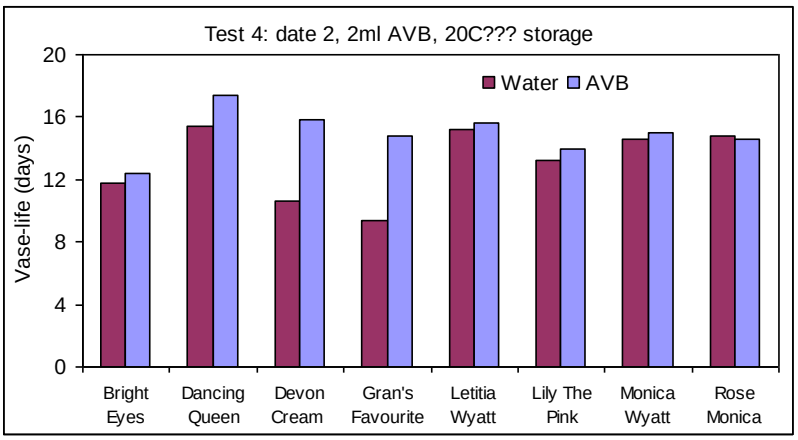
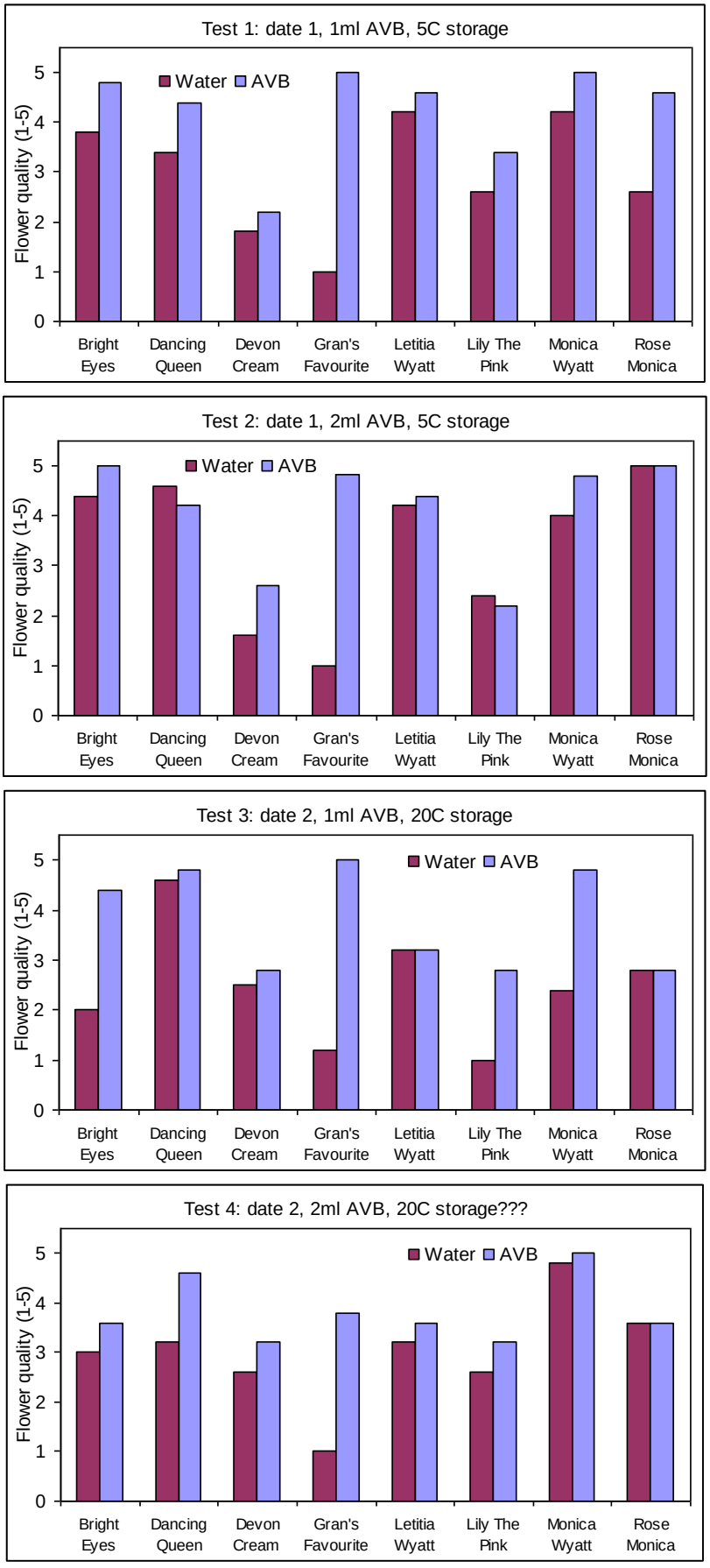


Figure 19.4. Flower quality scores of eight pinks varieties tested on four occasions in 2008 with three conditioner treatments (water or 1 or 2ml/L AVB) and storage at 5 or 20°C. The experiment was carried out in four sub-sets (Test 1, etc.).



20. SEDUM

The main aim of growing sedum in the trials was to determine how well it would perform as a commercial crop under typical Lincolnshire conditions.

Sedum trial

Due to problems in availability and delivery, in 2007 eight varieties of sedum were not transplanted to outside plots until week 28 or 39, probably too late to achieve any meaningful results in year 1. Their potential was assessed in 2008 (Figure 20.1, Table 20.1).

- The two *S. tephilium* varieties started to crop in week 30 and all others followed between weeks 32 and 35.
- The average stem length varied from 25 to 40cm, which may be insufficient, though stem weight was impressive, between 82 and 164g.
- Where two planting dates were available – for *S. spectabile* 'Brilliant' – stem length and weight for the July planting were about double those of the September planting.

Vase-life testing

In 2008 samples of each sedum planting were subject to vase-life testing in plain water (Figure 20.2).

- For all sedums, except the *S. tephilium* varieties, there was a very long vase-life, between 23 and 34 days. In the *S. tephilium* varieties vase-life was 6 or 8 days.
- Flower quality scores were very high except for the *S. tephilium* varieties where it was low.
- Leaf quality was varied. It was acceptable for most varieties but was <3 for 'Matrona' and one batch of *S. spectabile* 'Brilliant'.
- Water uptake was higher (>750ml/vase) for the two *S. tephilium* varieties than for the other sedums.
- Water clarity was very high in all cases.

Discussion

As a cut-flower sedum has a number of advantages: adequate length and high weight, making it ideal for use in bouquets, and it is attractive in the vase over a long period. It also has potential as a bunch, and all the varieties tested here would easily achieve the 300g specification. The disadvantages are that plants are expensive (partly due to PVR), it occupies a large amount of space but only crops for about a month each year, and it is available in pink only. Nevertheless, one supermarket has used sedums in bouquets and has trialled them as a bunch, but the grower needs to realise 70p/bunch (rather than the present 50p/bunch) to allow for the high plant costs and space needed. With some exceptions, sedums have a long vase-life and high flower and leaf quality even in plain water.

The MG concluded that the variety trial had proved that growing sedums was a practical option up to the point of sale: wider acceptance by the supermarkets is the issue here. Possibly it is a crop for a smaller, specialist grower. Nevertheless, the MG concluded that some further information was needed – the plants in this trial had all been grown outside in an un-amended soil that had a relatively high pH, whereas it was thought that the crop prefers an acid soil. The potential for cropping over a three-year cycle also needs to be tested.

See photographs on next page

Sedum variety demonstration (11 September 2008)

S. hybrida 'Autumn Joy'

S. spectabile 'Brilliant'

S. 'Superior Pink'

S. 'Superior White'

S. tephilium 'Carl'

S. tephilium 'Munstead Dark Red'

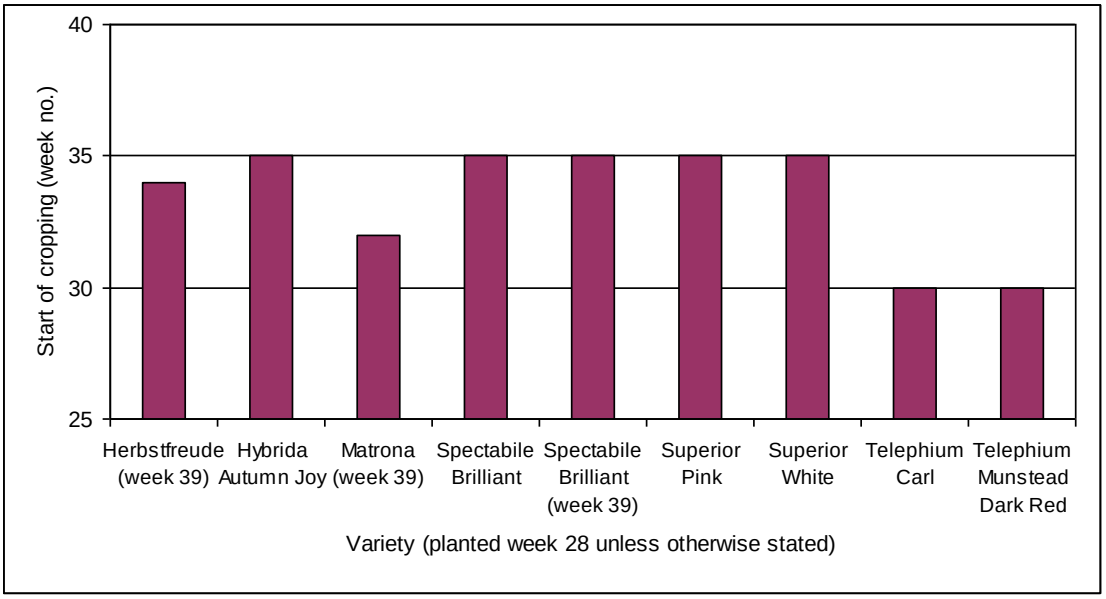
S. 'Herbstfreude'

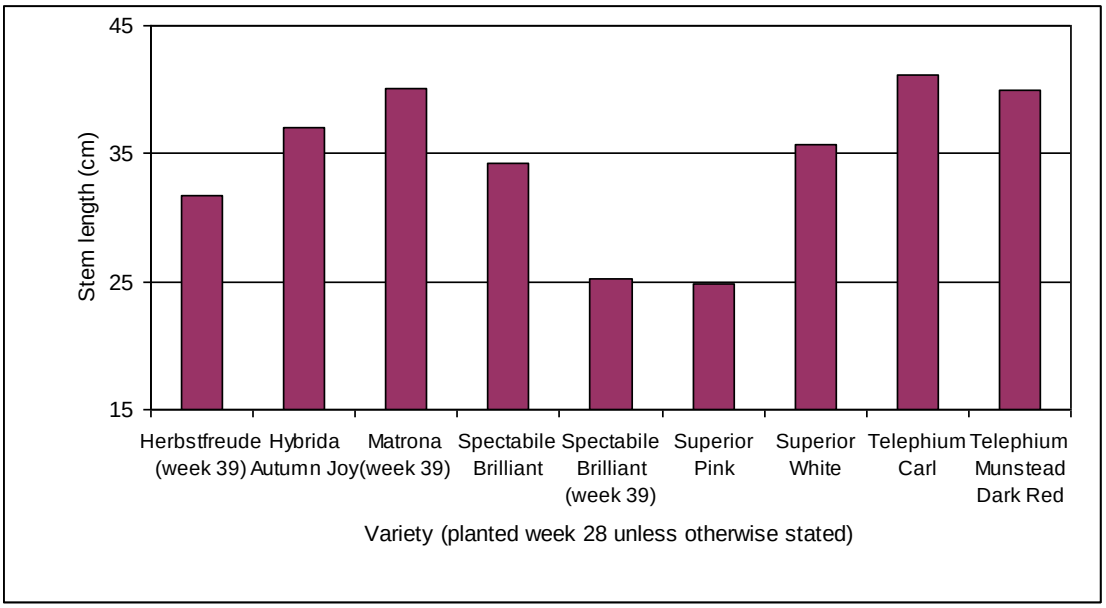
S. 'Matrona'

Table 20.1. Summary of flowering data for sedum varieties, 2008.

Variety	*Planting date*	*Start of cropping (week no.)*	*Stem length (cm)*	*Stem weight (g)*
S. hybrida 'Autumn Joy'	1	35	37	128
S. spectabile 'Brilliant'	1	35	34	136
'Superior Pink'	1	35	25	82
'Superior White'	1	35	36	153
S. telephium 'Carl'	1	30	41	164
S. telephium 'Munstead Dark Red'	1	30	40	128
'Herbstfreude'	2	34	32	85
'Matrona'	2	32	40	103
S. spectabile 'Brilliant'	2	35	25	83

Figure 20.1. Date of start of cropping (top), stem length (middle) and stem weight (bottom) in sedum variety trial in 2008.





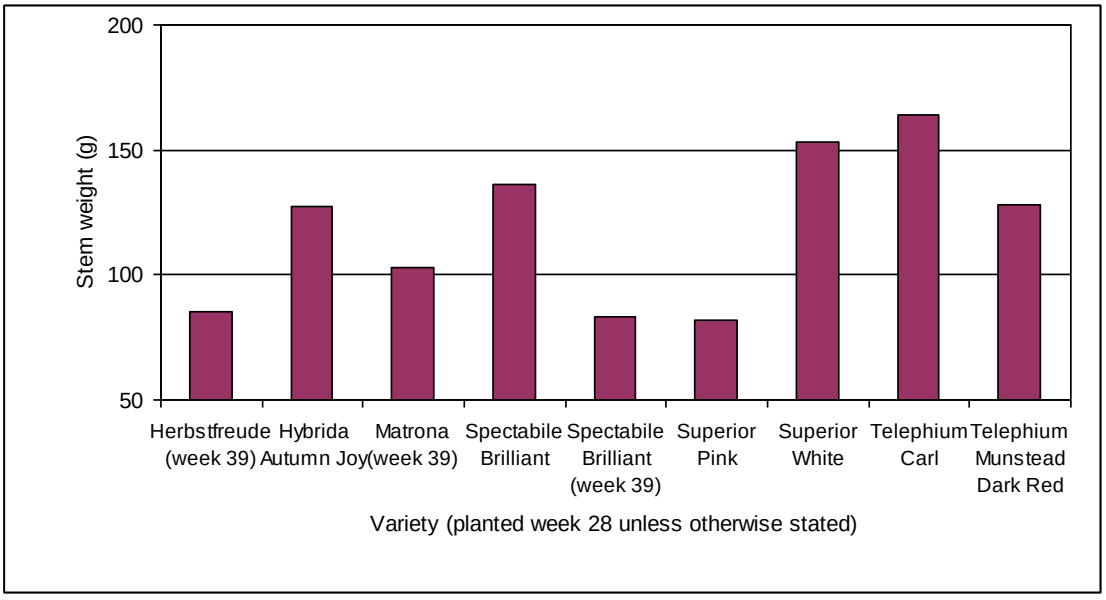
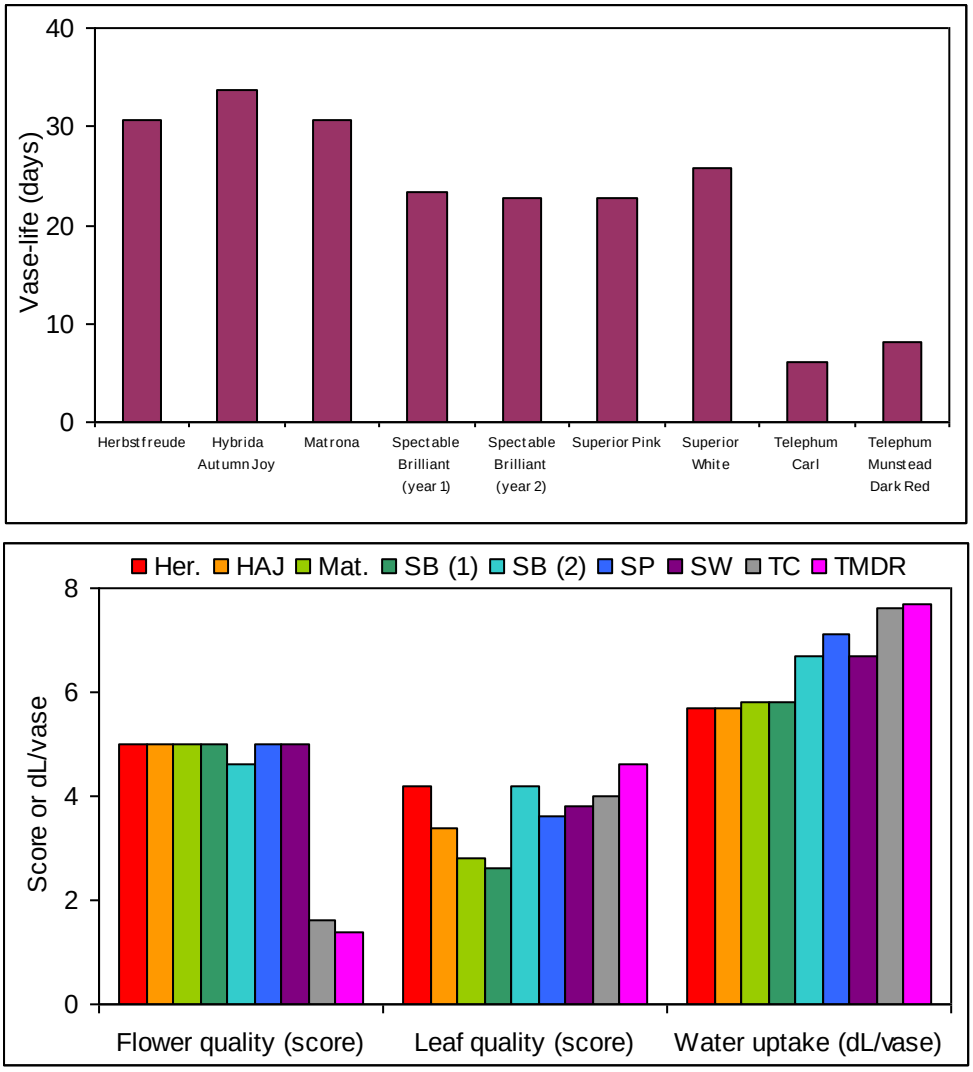


Figure 20.2. Vase-life attributes of nine sedum crops in plain water, 2008. Top: vase-life; bottom: flower and leaf quality scores and water uptake (variety names abbreviated, see top figure).



21. SOLIDAGO

Solidago media was included at the suggestion of one of the in-kind suppliers as a demonstration of a new line.

Solidago demonstration

Solidago media was transplanted to tunnel and outside plots in week 17, 2007. In 2008, earlier, taller and heavier stems were obtained from the tunnel-grown plots than from the outside ones. Cropping started in week 32 (tunnel) or 33 (outside). Stem length and weight averaged 124cm and 274g for tunnel-grown plants, and 106cm and 222g for outside plots.

Discussion - solidago

Solidago is often used as a filler with flowers such as freesia, requiring small stems weighing 15g, supplied very cheaply from imports. The solidago tested here was far too large for this, and would only be suitable for bunch work, for which there is unlikely to be demand.

22. VERONICA

Some growers have wondered about the potential of veronica as a UK crop, and so a small demonstration was included in the project.

Veronica demonstration

Four varieties of veronica were transplanted to tunnels and outside plots in week 25, 2007. Table 22.1 summarises the results.

In the tunnel 'Blue Spark' was the first variety to flower (25 July) and 'Pink Spark' the latest (15 August), while in outside plots all four varieties began flowering in early August. Lodging was noted as a problem in some plants. All varieties produced considerably longer and heavier when tunnel-grown; overall, stems were 55% longer and 78% heavier when grown under protection.

Discussion - veronica

For a number of reasons, mainly the low price of the imported stems and the small production window, it was concluded that veronica was probably not a crop likely to be economic in the UK. Consequently, no further trials were planned.

Table 22.1. Summary of flowering data for veronica in 2007.

Variety	*Start of cropping (week no.)*		*Stem length (cm)*		*Stem weight (g)*	
	Tunnel	*Outside*	*Tunnel*	*Outside*	*Tunnel*	*Outside*
Blue Spark	30	32	58.4	39.9	22.0	16.5
Lavender Spark	31	32	55.0	26.5	37.4	16.3
Pink Spark	33	31	72.7	48.0	42.3	18.5
White Spark	31	32	66.3	49.1	24.0	19.0

23. ZINNIA

It is widely accepted that zinnia is a very attractive flower with a spectacular colour range, but its vase-life and neck-strength are key issues that would affect any future development of the crop. The trials aimed to assess post-harvest quality, and especially neck strength, across a range of varieties.

Zinnia trial 1

In 2007 ten varieties were grown to test vase-life and stem strength. They were direct-drilled outside in week 21, direct-drilled in tunnels in week 24, and grown as plugs and transplanted to outside plots and tunnels in week 27.

Marketable stems were obtained from many of the plots, and the cropping results and assessments of stem strength at cropping are shown in Table 23.1. At cropping a simple assessment of neck strength was made, using a scale from 1 (easily broken) to 4 (stem rigid). This identified 'Zowee Yellow Flame' as having the greatest stem strength of those grown.

Zinnia trial 2

In 2008, varieties 'Zowee Yellow Flame', 'Meteor', 'Purple Prince' and 'Uproar' were planted in tunnels in week 28 (Table 23.2).

- Flower cropping started in week 30.
- Depending on variety, between 104 and 152 stems/m^2 were picked, the most productive variety being 'Zowee Yellow Flame'.
- While stem lengths were similar to those in 2007, stem weight was disappointing – only about 20g in 'Meteor' and 'Purple Prince' and 13g in 'Uproar' and 'Zowee Yellow Flame'.

At cropping samples of ten stems each were individually assessed for neck strength as in 2007. It was obvious that the stems were much stronger than those which had been tested previously. The assessment showed that 'Zowee Yellow Flame' possessed markedly greater neck strength than the other varieties tested (Table 23.2).

Vase-life trial 2007

From the 2007 trials samples of six selected varieties were subjected to vase-life testing. Stems were harvested at three stages of maturity (see Materials and methods) and conditioned after cutting by standing in either CVBN or RVB Clear prior to vase-life testing in plain water (Table 23.3).

- Using marginal means for the six varieties, the vase-life ranged from 5.2 ('Sun Cherry') to 8.9 days ('Canary Bird'). 'Sun Cherry' also had the lowest flower quality score, while the score for 'Canary Bird' was among the highest.
- Considering cropping stage, cropping at Stage 1 (flower open) resulted in the longest vase-life (7.8 days) and highest flower quality score, while cropping at Stages 2 (one cluster of stamens visible) or 3 (two clusters of stamens visible) gave a vase-life of 6.1 or 6.2 and lower quality scores.
- Conditioning in CVBN produced a longer vase-life (7.1 days) and a higher quality score than treating in RVB Clear (6.5 days).

Vase-life trial 2008

Samples of the four varieties grown in 2008 were cropped at Stage 2-3 and subjected to vase-life testing. Stems were conditioned in CVBN or plain water, followed by transfer to water containing a T-bag for 1 day at 5°C followed by 4 days at 20°C, after which they were placed in vases containing plain water (Figure 23.1).

- Using CVBN increased vase-life in 'Purple Prince' and, in 'Uproar', where stems in the control were of very poor quality (vase-life <3 days), CVBN markedly increased vase-life
- In 'Meteor' and 'Zowee Yellow Flame' there were no benefits of conditioning in CVBN.

Discussion - zinnia

In the 2007 vase-life tests the neck of the stem was weaker than in the 2008 samples, through the reason for this is not clear. It might be related to growing conditions or cropping stage, the latter having been shown to have a distinct effect on vase-life and flower quality in the 2007 test (cropping at a later stage of development improved post-harvest quality). Stem strength also seems to be a varietal factor, and the utilisation of zinnia as cut-flowers probably awaits a breeding solution.

Recent research in the USA (E.Y. Possiel and J.M. Dole, personal communication) showed that cut-flowers of zinnia do not respond positively to being re-cut, but if they are re-cut they benefit from a period of dry storage afterwards. As in the present project, re-cutting was done in air, as re-cutting under water has led to contamination in some species (this has not been tested with zinnia). It may be useful to maintain a check on future developments in this research.

Despite its many attractive qualities, it was considered by the MG that the weakness of the zinnia stem posed severe problems to its wider exploitation as a cut-flower.

Table 23.1 is on the next page

Table 23.2. Summary of flowering data (including stem strength) for four zinnia varieties, 2008.

Variety	*Start of cropping (week no.)*	*Stem length (cm)*	*Stem weight (g)*	*Stem yield (no./m²)*	*Stem strength score (1-4)*
Meteor	30	42	22	136	3.2
Purple Prince	31	38	20	104	3.1
Uproar	31	26	13	128	2.9
Zowee Yellow Flame	30	24	13	152	3.8

Table 23.1. Summary of flowering data for zinnia varieties in 2007. Stem strength scores for direct-drilled tunnel crop only.

Variety	*Planting no. and date*	*Start of cropping*		*Stem length (cm)*		*Stem weight (g)*		*Stem strength score (1-4)*	*Notes*
		Tunnel	*Outside*	*Tunnel*	*Outside*	*Tunnel*	*Outside*		
Canary Bird	1 (25/05)	-	25/07	-	28	-	12	-	-
Cerise Queen	1	-	07/08	-	25	-	14	-	Plant vigour poor outside
Luminosa	1	-	02/08	-	27	-	17	-	-
Meteor	1	-	02/08	-	25	-	14	-	-
Orange King	1	-	02/08	-	31	-	16	-	-
Purple Prince	1	-	02/08	-	28	-	16	-	-
Yellow Flame	1	-	25/07	-	19	-	10	-	-
Sun Cherry	1	-	25/07	-	24	-	18	-	-
Sun Red	1	-	02/08	-	22	-	19	-	-
Sunshine Mix	1	-	25/07	-	24	-	13	-	-
Canary Bird	2 (13/06)	07/08	-	44	-	24	-	2.1	-
Cerise Queen	2	15/08	-	41	-	20	-	2.0	-
Luminosa	2	07/08	-	38	-	19	-	2.1	-
Meteor	2	07/08	-	37	-	24	-	2.3	-
Orange King	2	07/08	-	40	-	24	-	2.3	-
Purple Prince	2	07/08	-	36	-	18	-	2.4	-
Yellow Flame	2	02/08	-	28	-	28	-	2.7	-
Sun Cherry	2	02/08	-	35	-	25	-	1.8	-
Sun Red	2	07/08	-	34	-	31	-	2.2	-
Sunshine Mix	2	02/08	-	36	-	29	-	1.9	-
Canary Bird	3 (03/07)	07/08	20/08	42	28	26	16	-	Pale plants outside
Cerise Queen	3	15/08	20/08	42	30	36	14	-	-
Luminosa	3	07/08	20/08	43	23	30	13	-	-
Meteor	3	15/08	20/08	43	30	33	15	-	-
Orange King	3	15/08	20/08	48	33	33	20	-	-
Purple Prince	3	15/08	20/08	42	29	28	17	-	-
Yellow Flame	3	07/08	20/08	35	16	31	9	-	-
Sun Cherry	3	07/08	n.a.	40	n.a.	33	n.a.	-	-

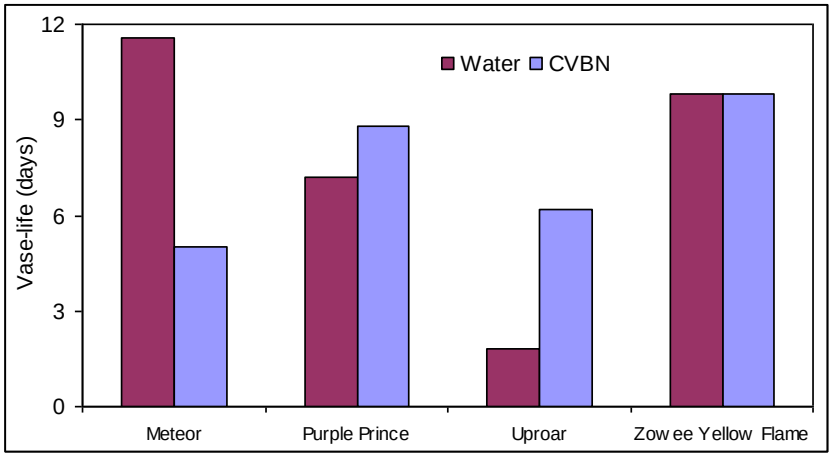
Sun Red	3	15/08	n.a.	38	n.a.	31	n.a.	-	-
Sunshine Mix	3	15/08	n.a.	38	n.a.	29	n.a.	-	-

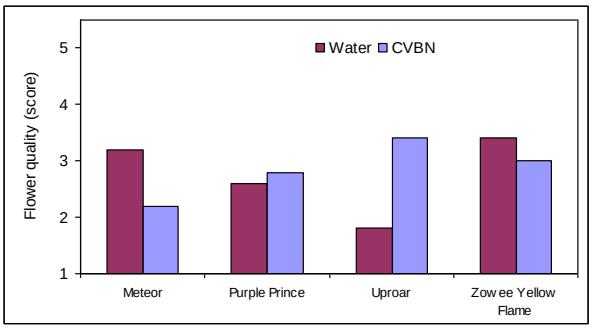
Table 23.3. Vase-life and flower quality score (on vase-day 5) of zinnia varieties following cropping at three stages and two conditioning treatments, 2007. Figures are treatment means, except for those in bold type which are marginal means for the indicated factors. For marginal means for varieties, see last section of table.

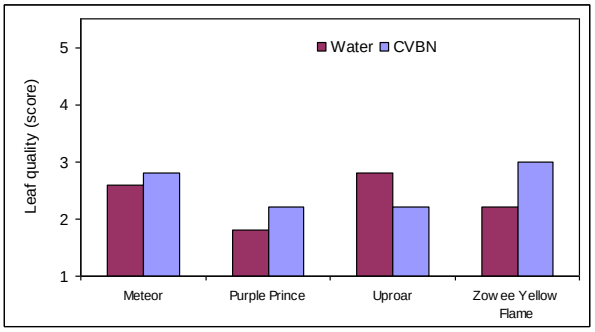
Conditioner treatment	*Variety*	*Flower quality score (1-5) after cutting at stages 1 - 3*				*Vase-life (days) after cutting at stages 1 - 3*			
		1	*2*	*3*	***Mean of all stages***	*1*	*2*	*3*	***Mean of all stages***
CVBN	Meteor	4.0	3.3	4.0	**3.8**	7.7	5.7	7.5	**7.0**
	Canary Bird	5.0	3.3	3.0	**3.8**	14.5	7.7	7.0	**9.7**
	Yellow Flame	3.0	2.7	2.0	**2.6**	5.5	7.7	6.0	**6.4**
	Sun Cherry	3.0	1.0	2.7	**2.2**	7.7	4.0	4.7	**5.5**
	Purple Prince	3.7	3.0	n.a.	**3.4**	9.0	5.7	n.a.	**7.4**
	Orange King	3.3	2.3	4.5	**3.4**	7.7	5.3	8.5	**6.6**
	Mean of all in CVBN	**3.7**	**2.6**	**3.2**	**3.2**	**8.7**	**6.0**	**6.7**	**7.1**
RVB Clear	Meteor	3.3	2.7	3.3	**3.1**	7.7	5.7	6.3	**7.9**
	Canary Bird	2.3	4.0	2.7	**3.0**	7.7	10.3	5.7	**7.9**
	Yellow Flame	2.5	1.7	2.0	**2.2**	6.0	5.7	5.0	**5.6**
	Sun Cherry	2.0	3.3	1.7	**2.3**	4.3	6.0	4.3	**4.9**
	Purple Prince	3.0	2.3	n.a.	**2.7**	6.3	5.7	n.a.	**6.0**
	Orange King	3.5	1.0	3.0	**2.5**	9.0	3.7	7.0	**6.6**
	Mean of all in RVB	**2.8**	**2.5**	**2.5**	**2.6**	**6.8**	**6.2**	**5.7**	**6.5**
	Mean of all above	**3.3**	**2.6**	**2.9**	**2.9**	**7.8**	**6.1**	**6.2**	**6.7**

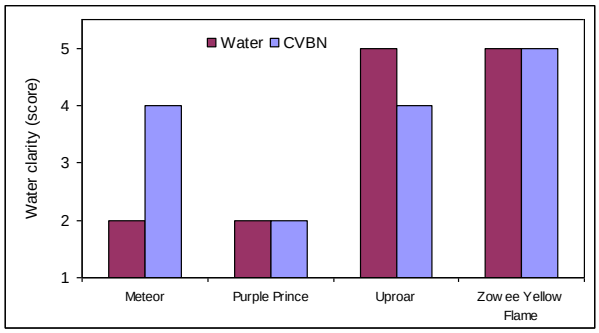
-	**Meteor**	**3.5**	**7.5**
	Canary Bird	**3.4**	**8.9**
	Yellow Flame	**2.4**	**6.0**
	Sun Cherry	**2.3**	**5.2**
	Purple Prince	**3.1**	**6.7**
	Orange King	**3.0**	**6.6**

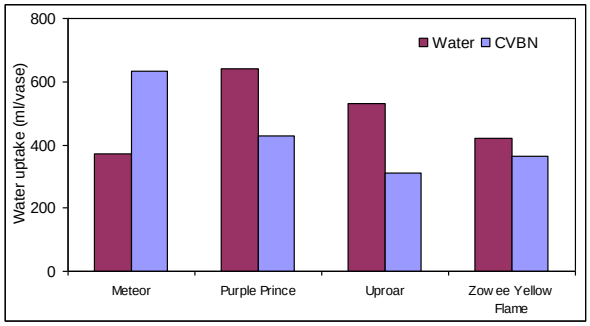
Figure 23.1. Vase-life attributes of four zinnia varieties conditioned in CVBN or plain water, 2008. Top: vase-life; bottom: flower and leaf quality scores, water clarity score and water uptake.











General discussion

The vision of the Cut Flower Centre is to identify a (probably quite small) number of definite new opportunities for cut-flower production for the UK. As will be seen from reading this report, this objective is being realised. Some 23 flower types have been trialled or demonstrated in the first two years of the Centre, and of these considerable sifting-out has been achieved. The trials included some 150 varieties in areas of 2400m^2 of Spanish tunnels and 800m^2 of outside plots. In addition, antirrhinum and 'German asters' have been evaluated on a larger scale at commercial nurseries.

- **Seven crops were regarded as having definite potential for further evaluation or commercial trialling: 'German asters' (new varieties of China aster), ornamental brassica, delphinium, annual dianthus, larkspur, phlox and sedum.** UK growers are currently very well placed to take advantage of the desire of the UK multiples to reduce their carbon footprint by selling more UK-grown produce, including flowers.
- Three crops were thought to have some potential – but only if better varieties become available: ageratum, amaranthus and aster (*Aster pringlei* Monte Casino type).
- Thirteen crops were eliminated as having little or no potential for exploitation under present conditions, either because (a) the economics of the crop were negative (five crops), (b) there were specific negative points (two crops), or (c) there were simply no indications of commercial appeal and uptake (six crops).

These conclusions are summarised in Table 6. Estimates of various economic factors for each cut-flower are tabulated in Appendix 1.

Table 6. Cut-flower crops identified as having minimal, possible or definite potential for commercial production and exploitation in the UK.

Minimal potential with current varieties, economics and technology	*Possible potential if better varieties become available*	*Definite potential for further evaluation and (or) commercial-scale trialling*
Antirrhinum (a) Carnations (spray) (a) Caryopteris (b) Cynara (c) Echinops (c) Eryngium (c) Godetia (a) Grasses (ornamental) (a) Lychnis (c) Pinks (a) Solidago (c) Veronica (c) Zinnia (b)	Ageratum Amaranthus Aster (*A. pringlei* Monte Casino type)	Brassica (ornamental) China aster ('German asters') Delphinium Dianthus (annual) Larkspur Phlox Sedum

From its inception an on-going role been envisaged for the Centre, and as of the date of this report (December 2008) proposals are well under way to secure funding for the Centre to continue its work at Kirton in 2009 and 2010. The chief issues and work being planned for the 2009 season is listed below.

1. Ornamental brassica

Ornamental brassica are likely to remain in demand for some time, and to maintain economic production with current prices and the costs of herbicides and support netting, the crop must be direct-drilled and grown cheaply in the open. A larger-scale trial is planned and will incorporate the validation of an early-drilling schedule (to avoid short stems) and improvements in the use of crop sprays and netting. There is also a need to:

- Test if high-density drilling can avoid the need for support netting and the labour involved in moving it up.
- Test 'Red Crane' and newer varieties with better, earlier (late-August or September) colour changes;
- Find out more about the factors inducing colour change (successful Dutch growers seem to be able to achieve it);
- Investigate vase-life or other post-harvest treatments to overcome the water fouling associated with brassica.

2. 'German asters'

These striking new varieties have attracted considerable interest, but there is a lot that is not known about them. Issues to be resolved include planting dates, planting density, height restriction (probably using Alar), achieving earlier and later cropping, seed provenance (varieties are not uniform, and appear to be coming from more than one source), control of (possibly seed-borne) mould, and quality in the vase. The MG proposed that in 2009 a further evaluation should take place on a commercial nursery, and that specific issues should be addressed in trials at KRC, including demonstrations that include a range of varieties from all suppliers, and post-harvest work to reduce the rapid leaf yellowing or blackening that occurs in the vase.

3. Delphinium

There is a need to develop continuity programmes through sequential planting incorporating an early round grown under cold glass. This should be carried out through an in-depth study of one variety that would also provide data for crop modelling. Previous plantings should be followed to see the potential for third-year production. Some varieties have poor vase-life and do not respond to flower conditioners, and these will need to be identified and screened out. Throughout such trials it is important to maintain focussed on obtaining a premium-quality product.

4. Annual dianthus

Trials in Spanish tunnels with the 'Amazon' series should address the improvement of head size and bunch weight in plants cropped from August onwards. There is a need to resolve whether to use high planting rates to increase stems per square meter in a crop where seed is very expensive. Plants should not be pinched. 'Green Trick' should be tested further.

5. Larkspur

Larkspur is needed both as a standard and as a filler and can fetch good prices, but the industry needs a cheap, drilled crop with a better vase-life. Belladonna types should be further investigated.

6. Phlox

For tunnel-grown phlox there is a need to address quality issues and achieving two flushes. Other challenges to be addressed are the restricted colour range, the limited availability (in September) and the unexceptional vase-life. Previous plantings should be followed to see the potential for third-year production.

7. Sedum

Sedum, grown outside, should be tested over a three-year production cycle. Soil amendment to increase acidity should be investigated. Herbicide recommendations are needed.

8. Demonstrations of a wide range of novel flower crops

To maintain its impetus the Industry – and the Centre - need a flow of new material: both must do more than just complete trials with existing crops. Though relatively little new material is currently being tested in Holland (mainly concentrating on cut-flower varieties of celosia, which are higher-temperature crops), but this should not be used as an excuse to do nothing new. Trials with *Pericalis* (cut-flower cineraria) have already been proposed, this is a new crop with a good colour range and vase-life. Another possibility is kangeroo's paw Arigiozanthos manglesii), since there are now varieties for northern Europe. A literature review was suggested, to see what new crops were being developed, for it is likely that many novel crops will be related to crops already grown successfully and they would be likely to have similar husbandry requirements. If improved varieties appear on the market, ageratum, amaranthus and aster (*A. pringlei* Monte Casino type) could be included in demonstration plots.

Technology transfer

Articles relating to the Centre have been included in *HDC News*, *Horticulture Week*, *The Garden* (the journal of the RHS), *The Times* and *Country Homes and Interiors*. The Centre's work was also featured on Radio 4's *Farming Today* programme, and filming was undertaken for a *Gardener's World* cut-flower special. Press releases have been issued both locally and nationally in conjunction with the Government News Network (GNN). A stand was mounted at a LEADER+ publicity day.

There were well attended Open Days at Kirton on 5 September 2007and 2 July 2008. The 2008 Open Day was one of the HDC's best attended events.

The following comments were made by members of the MG and other growers during 2008:
"We have seen immediate results from the trials which have been put into commercial practice… four product lines on supermarket shelves as a result of 2007/8 trials, i.e. German asters, pinks, delphinium and panicum grass."

"These products are being grown on at least six holdings in 2008. … estimated that the value of these products was about £1million this year…"

"The Centre acts as vital forum for the industry to view and discuss new products. It also acts as a forum for discussions about future research activities and enables research objectives to be set."

"Plant suppliers have also received enquires from pack-houses and growers about new products that they have seen in the Centre's trials."

"At a time of global economic uncertainly, rising energy prices, the threat of global warming, etc., the UK cut-flower industry needs near-market research more than ever, and initiatives such as the Centre will have a vital role to play in sustaining UK businesses."

"The success of the project revolves around the fact that the research is close to market and industry orientated."

"We have been offered exclusive access to a new cut-flower crop, which would be trialled in 2009. We have been offered this because of the reputation that the Centre has acquired."

"Not only has the Centre produced some very meaningful results over the past 18 months, but I (and many other people) feel that it has acted as a vital forum for what is a very disparate industry, to come together to both view and discuss new products."

"These products have huge potential and I would suggest that the German asters will become a 'core' line in the future. I believe they are already one of the top- ten selling lines for ….. The continuity work undertaken on delphinium will I believe open up a huge market for what has always been a very difficult 'stop-start' type of product."

"Production under Spanish tunnels will be very important but I also feel that with the rise in fuel prices, the results of the Centre's activities will be of great interest to glasshouse producers (especially small family businesses) who are looking for low energy alternatives to their current cropping."

"Where in any other sector of horticulture do you have a multidisciplinary group of industry representatives meeting around one table and representing the supermarkets, pack-houses, growers, seed-houses, propagators and scientists? The momentum that has been generated over the past two years must not be allowed to dissipate, but this is exactly what will happen if funding cannot be secured for 2009 and beyond."

Acknowledgments

Thanks are due to many people and the Project Leader apologises to anyone who may have been missed.

Special thanks go to all members of the MG and to Kirton staff for the time they have dedicated to the project: Sue Lamb (Lambs Flowers), Simon Crawford (Flowers by Design), Phil Collison (J Collison & Son), Andy Coaten (FastTrack Flowers), Mike Mann (Winchester Growers), Louise Motala (Waitrose), Susanna Janes (Tesco), David Fryer (Tesco), Roy Willingham (formerly HDC Panel Chairman), Nina Chantry (HDC), Dr Lindrea Latham (HDC), Rodney Asher (Kirton), Chris Hill (Kirton), Pippa Hughes (formerly Kirton), Dr Brian Smith (HRI Wellesbourne), Leanne Cozens (formerly Kirton), Sarah Robinson (formerly Kirton), Charlie Woods (Kirton), Tom Newton (Kirton) and Gordon Hanks (HDC Project Co-ordinator).

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Appendix 1

Estimates of economic factors for the 23 cut-flowers in the report.

Crop	*Market potential (0-10)*	*UK penetration (0-10)*	*Vase-life and quality (0-10)*	*Continuity of cropping (0-10)*	*Market price (p/stem)*	*Stem yield (stem/m²)*
1. Ageratum	2	1		0		
2. Amaranthus	**3**	**1**		0		
3. Antirrhinum	5	1	9	8	20	45
4. Aster (*Aster pringlei* Monte Casino type)	2	1		0		110
5. Brassica (ornamental)	**7**	**0**	**6**	**9**	**22**	35
6. Carnation (spray)	**3**	**8**	**10**	**9**	**20**	80
7. Caryopteris	2	**0**	5	0		115
8. China aster ('German asters')	7	**1**		8		
9. Cynara	**2**	**1**		0		
10. Delphinium	**10**	**2**	**9**	**10**	**30**	45
11. Dianthus (annual)	**9**	**1**	**10**	**8**	**22**	150
12. Echinops	2	**1**		0		100
13. Eryngium	**5**	**2**	**8**	0	**30**	45
14. Godetia	**5**	**1**	**7**	**0**	**20**	200
15. Grasses (ornamental)	**5**	**2**	**10**	**8**	**8**	
16. Larkspur	**7**	**0**	**7**	8	**20**	70
17. Lychnis	2	**0**		0		
18. Phlox	**7**	**3**	**7**	4	**25**	65
19. Pinks	**7**	**1**	**10**	**7**		300
20. Sedum	**7**	**0**	**10**	**0**	**20**	
21. Solidago	2	**1**	9	0		
22. Veronica	2	**1**	7	0		
23. Zinnia	**7**	**0**	**1**	0	**20**	130

Appendix 2

Extending the Flowering Season of Delphinium: a Review for the Cut Flower Trials Centre at Kirton

Dr F. Allen Langton, Associate Fellow of Warwick HRI

1. Summary and Conclusions

Most delphinium cultivars grown commercially for cut flowers are of the Elatum Group, originating from *D. elatum*. However, Belladonna Group cultivars are also grown. Cultivars are seed and vegetatively raised and flower true to type.

Flowering always follows stem extension (bolting) but it is unclear whether bolting is an essential prequel to flowering or whether bolting is triggered by flower induction. Seedlings do not have an absolute requirement for cold (vernalisation) in order to bolt and flower. However, flower yield and quality appear to be enhanced by cold treatment. Delayed bolting gives rosetted plants and this seems to be a particular problem in autumn- and winter-sown plants in Japan. Rosetted plants can be induced to bolt by exposure to a chilling treatment and subsequent return to higher temperature. Rosetting appears to be caused by the interaction of short days (SD) and low temperatures, and long-day (LD) treatments have been shown to hasten spring flowering. The optimum night temperature for delphinium growth is around 10-16°C. High temperatures (>21°C) promote premature bolting and flowering and reduce yield and quality.

The literature review suggests several possibilities for extending the flowering season of delphinium:

- *Successional planting*
  Japanese work has shown that successional planting has the potential to extend the harvest period of delphiniums. However, high temperatures in summer can seriously reduce flower quality. A key element in extending the harvesting period is the combined use of first- and second-year plants, since over-wintered plants tend to flower earlier than the first of the seedling-raised plants.
- *Cold treatments*
  Cold treatments applied to seedlings can advance flowering and enhance quality. However, the effectiveness (and cost-effectiveness) of such treatments need to be assessed for spring flowering under UK conditions. It is speculated that the application of cold treatment to seed could be more cost-effective.
- *Long-day (LD) lighting*
  LD lighting from planting can be expected to advance spring and summer flowering by 1-3 weeks. Both night-break lighting and day extension lighting can be used for the purpose. However, much larger advances in flowering date can be expected from the use of supplementary lighting (SON/T lamps).
- *Cultivar selection*
  Cultivars vary greatly in speed of flowering, and considerable season extension ought to be obtained simply by growing a suitable mix of contrasting cultivars - certainly more than is likely to be obtained by applying LD treatments to any single cultivar!
- *Pinching treatments*
  US greenhouse experiments have shown that pinching will delay the initial flowering of Elatum and Belladonna cultivars by several weeks, but will also increase stem length and give higher early yields. It is possible that growing a mix

of unpinched and pinched plants could extend the UK cropping season. Pinching might also be useful as a means of concentrating yield into periods of peak demand. However, these possibilities require testing under UK conditions.

- *Heating*
- Basal heating (20-25°C) has been shown to greatly advance the spring flowering of greenhouse delphiniums in Italy. Similarly the flowering of field crops in Germany has been markedly brought forward by covering plants with a heated plastic structure at the end of February. Heating (of normally unheated crops) can be expected to advance flowering and extend the production season, but its cost-effectiveness will depend on a premium being paid for early flowers.
- *Use of PGRs*
  Despite having positive influences on flower quality, gibberellin and daminizide (Alar) appear unlikely to have any value for the manipulation of delphinium flowering.

2. Delphiniums in commerce

Some three hundred or more distinct species of *Delphinium* are known, but the great majority of cultivars grown commercially as cut flowers are of the Elatum Group, originating from *D. elatum* (Legro, 1961; Wilkins, 1985; Bassett and Bassett, 2006). Elatum cultivars have upright, hollow stems with broad-lobed leaves below a prominent terminal flower spike (raceme). They are tetraploid (2n = 4x = 32) and have larger flowers than the ancestral, diploid species. The flower colour range is also wider, ranging from whites and pinks, through purples to blues of all intensities. Flowers can be singles, semi-doubles or doubles.

Cut-flower, Elatum cultivars are seed and vegetatively raised and true-breeding, and the first of these were the 'Pacific Hybrids' introduced by Vetterle and Reinelt in California in the 1930s (Bassett and Bassett, 2006). The original introductions were followed over the next 40 years or so by such well known series as 'Blue Bird', 'Black Knight', 'Astolat', 'King Arthur', 'Galahad' and 'Summer Skies' (Armitage, 1993; Bassett and Bassett, 2006). More recent F_1 Elatum selections include Pan American's 'Guardian' series and Sahin's 'Centurion' series. According to Simon Crawford (personal communication), 'Centurion' was developed using English-bred clonal varieties, and can be expected to flower in the UK around two weeks later than 'Guardian' which was bred from open-pollinated lines such as 'Clear Springs' in Santa Paula, California, at a much more southerly latitude. Plants of these two series comprise the main plots in the 2008 Kirton delphinium trials.

Elatum cultivars are frequently reported to differ in their response to a given environmental treatment (e.g. Dalla Guda *et al*., 2000). However, differences tend to be of a quantitative nature (speed of flowering, degree of rosetting etc) and responses determined using one cultivar can generally be assumed to be applicable, in principle if not in detail, to others.

Belladonna Group cultivars constitute a second set of commercially-grown delphiniums. A characteristic of these is extensive branching, resulting in plants having both a terminal stem and several strong, lateral shoots, each with a terminal flower spike (Bassett and Bassett, 2006). According to Armitage (1993), flowering on the lateral stems occurs only slightly later than on the main stem, and the plants in general flower over a longer period than Elatum types. Leaves of Belladonna cultivars tend to be extensively dissected with narrow lobes (Bassett and Bassett, 2006). The origins of Belladonna delphiniums are obscure but may have involved a cross between a tetraploid Elatum hybrid and a diploid species such as *D. grandiflorum* (Legro, 1961; Bassett and Bassett, 2006).

A Belladonna cultivar that has been particularly widely grown in commerce is the German-bred 'Völkerfrieden' ('International Peace'). This was early recognized in Danish work as being particularly suited to cool-growing and early flowering (end of April) under protection (Geertsen and Bredmose, 1985). Armitage (1993) notes that this cultivar flushes up to three times each year and may be planted as close as 6 inches apart in the greenhouse (four flushes per year claimed by Hamrick, 2003). However, these notes presumably relate to cropping in the USA rather than N.W. Europe. Other Belladonna cultivars listed by Armitage (1963) include 'Princess Caroline', 'Clivenden Beauty', 'Casa Blanca', 'Beverly Hills', 'Bellamosa' and 'Belladonna' itself.

In general, the flowering responses of Elatum and Belladonna cultivars appear to be similar, as in the pinching studies of Garner *et al*., 1997 (see Section 4.5). However, differences are sometimes shown, as in field trials using perforated plastic sheet covers reported by Penningsfeld *et al*., 1980a, b (see Section 4.6).

Other less important delphiniums from the standpoint of cut-flower growing include those of the Grandiflorum Group, based on the large-flowered *D. grandiflorum*, and individual species such as the scarlet-red flowered *D. cardinale*, the orange-red flowered *D. nudicaule* and the yellow flowered *D. semibarbatum* (also called *D. zalil*) (Armitage, 1993). Crosses between Elatum cultivars and colchicine-doubled *D. cardinale* x *D. nudicaule* hybrids by Legro (Legro, 1961) ultimately gave rise to the 'University hybrids'. These combined Elatum foliage characteristics with red, orange or crimson flowers, and derivative cultivars are still grown in Holland for the cut-flower market (Bassett and Bassett, 2006).

The annual larkspur has in the past been classified as *D. ajacis*, and this name is still to be found in seed-house literature. However, taxonomists now consider larkspur to belong to a quite separate genus, *Consolida*. Modern cultivars are derived from species crosses and their characteristics are described by Bassett and Bassett, 2006.

3. Bolting and flowering

The first leaves of delphinium seedlings are typically arranged as a rosette with little or no internodal separation. However, stem extension (bolting) soon occurs and the plants go on to flower. Apical dissection studies using Elatum 'Blue Springs' showed that flower bud differentiation is invariably associated with bolting, and that flower primordia are not seen on rosetted plants (Katsutani and Ikeda, 1997). However, it is unclear as to whether bolting is an essential prequel to flower induction or whether bolting is triggered by flower induction.

3.1 Vernalisation requirement

In his 1985 review, Wilkins states that both annual and perennial species of delphinium require a vernalisation treatment (cold treatment) for shoot elongation and flower initiation and development. However, this conclusion appears to have been largely based on work using the annual larkspur (e.g. David and Séchet, 1947).

Successional sowing experiments in Japan appear to indicate that Elatum cultivars are able to flower rapidly without a chilling treatment (e.g. Katsutani and Ikeda, 1997). This view is confirmed by Armitage (1993) who states that plants benefit from, but do not have an absolute requirement for cold temperatures. Thus, plants will flower in their first year from seed without exposure to cold, but flower yield and

quality are enhanced by a chilling treatment. The potential value of a cold treatment for spring forcing is discussed further in Section 4.2.

It is common practice in N. W. Europe to crop delphiniums for a second year after over-wintering the first-year crowns. This over-wintering practice can be expected to satisfy any possible vernalisation requirements, assuming that it occurs in the field or in unheated structures. This view stems from work in Japan (Katsutani *et al*., 2002b) which has shown that 30 days at 5°C is sufficient for the elongation and bolting of basal lateral buds of Elatum cultivars cut back in December.

3.2 Rosetting

The transition from seedling rosette to bolting plant can, on some occasions, be very delayed. When this occurs, the number of leaves in the rosette continues to increase and such plants are said to exhibit 'rosetting'. If they ever do bolt and flower, they tend to develop malformed flower spikes (Katsutani and Ikeda, 1997). Rosetting appears to be a particular problem in Japan (although isolated examples have been seen at Kirton) and it appears to be especially associated with autumn- and winter-sown plants (Ogasawara *et al*., 1996).

Rosetted plants can be induced to bolt by the application of chilling treatments and subsequent return to higher temperatures (Ogasawara *et al*., 1996). This response to chilling is quantitative, since treatment for 28 days at 9°C advanced bolting in rosetted plants by three weeks compared to other plants given only an 18-day treatment (both returned to higher temperature on the same date). Katsutani *et al*. (2002b) similarly found that exposure to temperatures below 7°C for 30 days induced bolting of rosetted seedlings.

3.3 Effect of photoperiod

It has been concluded that rosetting in Elatum cultivars in Japan is a consequence of short days (SD), and that this effect is accentuated by temperatures below 15°C or by low irradiance (shading) (Kikuchi *et al*., 2000; Katsutani *et al*., 2002a). In the experiments of Katsutani *et al*. (2002a), only 20% of 'Blue Springs' seedlings had bolted after 80 days in a phytotron in the natural SD of winter (10-12 hours) at 22°C. However, 100% had bolted when long days (LD) were given using day-extension lighting (5 hours). Kikuchi *et al*. (2000) found an interaction between daylength and temperature. Thus, all of their plants of Elatum 'Clear Springs mix' bolted in a 16-hour photoperiod at 24°C day / 19°C night, but only 50% bolted in this photoperiod at 17°C day / 12°C night. In contrast, all plants bolted in both temperature regimes when the photoperiod was 20 or 24 hours (lighting treatments not given). The optimal treatment appeared to be a 20-hour photoperiod at 17°C day / 12°C night, since plant quality (florets per spike) was much improved at the lower temperature.

Researchers in the USA have also reported that LD treatments hasten spring flowering (Wilkins, 1985; Armitage, 1983; Garner *et al*., 1997). However, it is not clear whether this is associated with earlier bolting or earlier flower initiation / development after bolting. The topic of photoperiod (long-day lighting) is addressed further in Section 4.3.

3.4 High temperature effects

According to Armitage (1993), night temperatures of 10-16°C are optimal for delphinium plant growth, and temperatures above 21°C reduce flower size and yield. This reduction in quality may be a consequence of the finding in Japanese

work that high temperatures promote early bolting and flowering, and give plants with relatively few leaves and poor quality spikes with few florets (Ogasawara *et al*., 1996; Katsutani and Ikeda, 1997). In the Katsutani and Ikeda (1997) study, delphinium 'Blue Springs' grown at continuous 25°C bolted after producing an average of only 5.5 macroscopically visible leaves, and ultimately produced flowering plants averaging 15.3 leaves to the first floret and only 15.8 florets per spike. In contrast, plants grown at continuous 20°C bolted after producing an average of 8.1 macroscopically visible leaves, and produced flowering plants averaging 18.8 leaves to the first floret and 29.3 florets per spike, almost double the number given at the higher temperature.

4. Extending the flowering season

4.1 Successional planting

Chono *et al*. (1986) showed that cut flowers of both Elatum and Belladonna delphiniums ('Blue Bird' and 'Belladonna' respectively) could be produced over an extended summer / autumn period in the field in Japan by successional sowing. Plants tended to reach the open flower stage sooner as the sowing date became later (Table 1), and this was probably an effect of increasing air temperature. Nevertheless, cut flower quality (see flower spike length, Table 1) appears to have been good and rather similar for the February-, March- and May-plantings. In contrast, plants sown in June were of much poorer quality, particularly 'Blue Bird', and this was probably due to the effects of very high summer temperatures on bolting and flower initiation. The authors also showed that the May-sown plants of both cultivars flowered in their second year around one month earlier than any of the first-year plants, and they suggested that cut-flower production ought to be possible in Japan over an extended period by utilizing one- and two-year old plants sown in and earlier than May.

Table 1. Speed of flowering and flower quality for successional sowings of two delphinium cultivars in Japan (Chono *et al*., 1986)

	Days to anthesis (and date)		Flower spike length (cm)	
Sowing date	**'Blue Bird'**	**'Belladonna'**	**'Blue Bird'**	**'Belladonna'**
25 February	161 days (3 August)	152 days (25 July)	72.5	16.8
31 March	145 days (22 August)	134 days (11 August)	58.7	23.6
2 May	146 days (24 September	126 days (4 September)	73.2	21.1
5 June	129 days (11 October)	125 days (7 October)	6.3	12.2

Katsutani et al. (1997) also showed by successional planting that flower initiation can occur at any time of year. However, high temperatures in the summer (in Japan) gave premature bolting and very poor flower quality (Section 3.4) and this limited the effective harvesting season. A potential solution to this problem was subsequently suggested by Kawana *et al*. (2001) who showed that cut delphiniums could be produced in November by keeping May-sown seedlings at 15°C before planting in late August. Flowering crops could even be obtained in December by maintaining low temperatures for longer. A similar approach has been suggested in the US by Armitage (1993), with seedlings (or cuttings) transplanted in August flowering in a cool greenhouse by January.

It is clear that there is potential for extending the harvest period of delphinium by successional planting, and the Kirton trials this year (2008) should indicate the extent of this potential under UK conditions and with modern varieties. A key element in extending the harvesting period will almost certainly be the combined use of both one- and two-year old plants.

4.2 Cold treatments

As noted in Section 3.1, delphinium seedlings do not have an absolute requirement for a cold treatment in order to flower, but cold can enhance flower yield and quality (Armitage, 1993). This appears to be the basis of the common US practice of over-wintering plugs of autumn-sown delphiniums for spring cropping. Hamrick (2003) claims that cold treatment gives more prolific and uniform flowering and notes that, because of this, some delphinium propagators in the USA offer cold-treated plugs ready for potting on and forcing for the spring market. The artificial chilling of delphiniums is not normal commercial practice in N. W. Europe, but it is possible that a cold treatment could be beneficial. As a suitable treatment, Hamrick (2003) recommends the holding of plants for 5-6 weeks at 2-4°C with natural or low-irradiance lighting (presumably, to retain plant greenness). How cost-effective such a treatment would be remains to be seen, and it might well be possible (and more cost effective) to apply chilling to delphinium seeds rather than plugs. This possibility is suggested by David and Séchet's 1947 work which showed that the holding of seeds at 2°C for 6 weeks (without light) fully satisfied the vernalisation requirement of annual larkspur.

4.3 Long-day (LD) lighting

The use of LD lighting has the potential to advance spring flowering (Section 3.3) and Armitage (1993) has outlined a growing protocol in the US where August-sown plants growing in a cool greenhouse in LD (>12 hours) flower first in January and then once or twice more so long as cool temperatures are maintained. Garner *et al*. (1997) showed that unpinched plants of Elatum 'Barbara Blue' and 'Barbara Pink' flowered 21 and 18 days earlier respectively in LD (night-break lighting for 4 hours per night at 5 $\mu mol.m^{-2}.s^{-1}$) than in SD (black-out covers applied for 15 hours per day). The LD plants were also taller and gave greater yields (stems/plant) but the yield increases proved non-significant at P=0.05. The photoperiod data in this study appear clear on inspection, but it should be noted that the way in which the photoperiod treatments were applied meant that the SD plants received a lower daily light integral than the LD plants.

More recently, Dalla Guda *et al*. (2000) in Italy tested the effects on seven 'Pacific Court' (Elatum) hybrids of LD lighting applied from planting in October until the end of April. Plants were grown in an unheated greenhouse either with a) no control of daylength (control treatment), b) in LD given by extending the daylength to 16 hours using low-intensity, incandescent lamps (1.1 $\mu mol.m^{-2}.s^{-1}$) (LD treatment), or c) in LD (16 hours) given by incandescent lamps supplemented with high intensity SON/T lamps (1.1 $\mu mol.m^{-2}.s^{-1}$ plus 20 $\mu mol.m^{-2}.s^{-1}$) (LD/HI treatment). As shown in Table 2, LD lighting advanced time to anthesis (averaged over all cultivars) by around 17 days, confirming the promotional effect of LD noted by Garner *et al*. (1997). However, a much greater promotional effect (around 50 days) was given by the LD/HI treatment, showing the highly beneficial effects of supplementary lighting. In none of the treatments did all of the plants reach anthesis by the end of the trial in June and this was thought by the authors to be due to high temperatures experienced in

late spring. However, flowering percentage was highest in the LD/HI treatment (data not given), probably because LD/HI plants were furthest advanced when the high temperatures were experienced. In contrast to earlier work, LD did not increase stem length, flower spike length or numbers of flowers per spike. Numbers of flowers per spike were actually reduced by supplementary lighting, but it is not recorded whether this reduced the commercial value.

Table 2. Speed of flowering and flower quality characters in three photoperiod treatments (data averaged over 7 cultivars) (Dalla Guda *et al.*, 2000)

Lighting treatment[1]	Days to anthesis*	Stem length (cm)*	Flower spike length (cm)*	Flowers per flower spike*
a) Control	200.3 c	139.4 a	68.1 a	91.4 b
b) LD	183.7 b	132.9 a	66.0 a	86.4 a,b
c) LD/HI	150.2 a	126.1 a	59.2 a	66.1 a

[1] See text for treatment details; * For each factor, means followed by different letters are significantly different at $P = 0.05$.

A LD treatment (in combination with basal heating) has also been shown by Pascale *et al*. (2001) to give earlier flowering in a greenhouse crop of Elatum delphiniums in Italy. In this case, LD were given using cyclical night-break lighting (2 minutes on / 6 minutes off for 5 hours), and the average flowering advance (over basal heating without LD) was 8 days. This appears rather modest compared to the 77 days advance given by basal heating (Section 4.6). However, the effects of LD were not tested in the absence of basal heating!

4.4 Cultivar selection

A factor of particular interest in the Dalla Guda *et al*. (2000) study was that of cultivar, with very large differences being shown between these in speed of flowering. Averaged over lighting treatments, 'Black Knight' and 'Galahad' flowered around 18 days ahead of 'Blue Bird', 'Guinevere' and 'King Arthur', and around 45 days ahead of 'Astolat' and 'Summer Skies'. It is clear that considerable season extension can be expected simply by growing a suitable mix of contrasting cultivars - certainly more than is likely to be obtained by applying LD treatments to any single cultivar!

4.5 Pinching treatments

Garner *et al*. (1997) used 'Barbara Blue' and 'Barbara Pink', two Elatum cultivars, and Völkerfrieden, a Belladonna cultivar, to test the effects of decapitation (pinching) on subsequent yield and flower characteristics. The Elatum plants were planted in a heated greenhouse in the US in early December, half in SD and half in LD (see Section 4.3), and half of the plants in each of the photoperiod treatments were subsequently 'soft' pinched. This removed the apical tip and all stem and leaf tissue associated with leaves $\leq$ 4 cm in diameter, leaving 2-3 nodes with associated leaf tissue. The two cultivars responded essentially similarly, and Table 3 shows data from just one of these, 'Barbara Blue'. The Völkerfrieden plants were also planted in December (different year) in a heated greenhouse, but all were in natural SD. In early January, one third were 'soft' pinched (see above) and one third were 'hard' pinched. 'Hard' pinching removed the apical tip and all stem and leaf tissue associated with leaves $\leq$ 10 cm in diameter, leaving one node and 1-2 leaves above the crown of the plant. Results of the two pinching treatments were also essentially similar, and Table 3 shows data averaged over the two.

As can be seen in Table 3, pinching significantly delayed initial harvest. The delay averaged around 22 days overall, but rose to 29 days in the 'Barbara Blue' LD treatment. In compensation, however, the growth of multiple shoots given by pinching caused early yields to be higher. In 'Völkerfrieden', pinching more than doubled the initial stems/plant yield after 30 days. This yield advantage was not maintained, however, because the unpinched plants were able to produce a second flush of flowering shoots, and both pinched and unpinched plants averaged 3.0 stems/plant at final harvest after 90 days. In 'Barbara Blue', the final yield of pinched plants was around three times that of unpinched plants when cropping was in LD. However, much slower flowering in SD resulted in fewer flowering stems of pinched plants reaching a harvestable stage before excessively high greenhouse temperatures caused the experiment to end in early June. In general, harvested stem length was increased by pinching (by an average of 24% for treatments in Table 3) and 'hard' pinching gave even longer stems than 'soft' pinching in 'Völkerfrieden'. The only pinching treatment not to give longer stems was 'Barbara Pink' growing in SD.

Table 3. Effects of pinching on an Elatum cultivar ('Barbara Blue') grown in short days (SD) and in long days (LD), and on a Belladonna cultivar (Völkerfrieden) (Garner *et al.*, 1997)

Cultivar	Time to Harvest (days)		Stem length (cm)		Yield (stems/plant) ♣♣	
	Unpinched	Pinched♣	Unpinched	Pinched♣	Unpinched	Pinched♣
'Barbara Blue' (SD)	155	173*	101	133*	1.42	1.08^{ns}
'Barbara Blue' (LD)	134	163*	122	137*	1.67	5.75*
'Völkerfrieden'	127	147*	100	129*	1.0	2.7*

* Indicates that the character comparison between non-pinched and pinched within a cultivar or cultivar/daylength treatment is significantly different at $P = 0.05$; ^{ns} signifies non-significance.

♣ Pinched data for 'Barbara Blue' are for 'soft' pinched plants; pinched data for Völkerfrieden are averaged over 'soft' and 'hard' pinch treatments (see text for details).

♣♣ Yield data for 'Barbara Blue' are at the end of the experiment in early June; yield data for 'Völkerfrieden' are after 30 days.

Overall, Garner *et al*. (1997) concluded that by pinching some plants and leaving others, high quality stems could be harvested over an extended period. In addition, pinching could be used to concentrate yields for peak marketing periods. However, it remains to be seen whether these findings have applicability to the UK since the data in Table 3 were obtained in heated greenhouses at a more southerly location, and with December planting!

4.6 Heating

As noted in Section 3.4, night temperatures of 10-16°C are reported to be optimal for delphinium plant growth (Armitage, 1993). It is not surprising, therefore, that heating treatments have been shown to be effective in advancing the cropping of delphiniums. Pascale *et al*. (2001), for example, used basal heating (20-25°C) in Italy to bring forward the flowering of a (presumably otherwise unheated) greenhouse crop of Elatum hybrids (transplanted in November) by 77 days. The advance was increased to 85 days when LD were also given (see Section 4.3) and this was due, at

least in part, to earlier flower induction, since flowering stems with basal heating tended to have fewer leaves. The combined treatment of basal heating and LD also reduced stem and raceme length by around 25%.

A rather different manner of crop heating was reported by Plomacher (1979, 1980). He described trials being carried out in Germany at the time, where the field flowering of delphiniums was brought forward by 30-45 days (to early April) by covering plants with a heated plastic structure at the end of February. The covers gave a minimum day temperature of 12°C and a minimum night temperature of 6°C, and Plomacher believed that the treatment had advantages over greenhouse production where temperatures are often too high. However, Plomacher also noted that cultivars differed in their suitability for field forcing, and advised against the growing of Pacific Hybid cultivars.

Around the same time, Penningsfield *et al*. (1980a, b) reported other trials in Germany where field crops of delphinium were mulched by being covered with perforated plastic sheeting. This should have raised soil temperatures, but effects on flowering were not reported. Covering crops did, however, increase the yield and reduce the quality of 'Völkerfrieden' (a Belladonna cultivar), and increase the quality without increasing yield in 'Lanzentrager' (identified as *D cultorum*, but probably an Elatum cultivar).

It is clear that heating (but not necessarily crop mulching in the field) has the potential to advance delphinium flowering in the UK. However, trials would be needed before embarking on this approach to determine the commercial significance of any reductions in flower quality. Ultimately, the cost-effectiveness of heating treatments will, presumably, depend on whether a sufficient premium is paid for early flowers.

4.7 Use of PGRs

Early reports (quoted in Wilkins, 1985) indicate that the application of exogenous gibberellin (GA) accelerates flowering in annual larkspur. GA_3 applied at 100-400 ppm, four weeks after planting and again one month later, has also been reported to hasten flowering and to increase the stem length of Belladonna delphiniums (Shedeed *et al*., 1986). There were no adverse effects of GA_3 on yield (stems per plant) in this study, but there was some reduction in flower quality (florets per spike). In apparent contrast, Ogasawara *et al*. (2001) found that GA_3 had no promotional effect on the speed of flowering of Elatum 'Blue Bird', but that it did increase leaf expansion and, possibly as a consequence, gave increased flower quality (florets per spike). The basis for the differences in GA effect reported in these publications is not known, but may relate to delphinium type, GA application method or interactions between GA and environment.

Daminozide (alar) applied to Belladonna delphiniums (250-2,000 ppm, four weeks after planting and again one month later) delayed flowering and decreased plant height (Shedeed *et al*., 1986). However, it did increase both yield (stems/plant) and flower quality (florets/spike).

Despite positive influences on flower quality, it seems unlikely that growth regulants have much value for the manipulation of flowering time in cut-flower delphinium.

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