Project title:	The National Cut flower Trials Centre Programme for 2018-2022
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Project leader:	Lyndon Mason (Director, The Cut Flower Centre Ltd)
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The results and conclusions in this report are based on 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.

AUTHENTICATION

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

Lyndon Mason

Project Manager and Director

Cur Flower Centre Ltd

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GROWER SUMMARY

Headlines

- New varieties of *Astrantia major* have shown potential to be developed as a new UK cut flower crop, which is currently in demand by the market.
- Varieties of both Gomphrena and Lepidium have shown potential for production as seed-raised fillers which can be once-over harvested.
- Removing the central flower bud from Lysimachia and Veronica produced a taller, heavier and more floriferous premium end product.
- New Japanese-bred varieties of column stocks (Matthiola) have shown potential to extend the current production period, if seedling selection issues can be addressed.
- There are large differences in the varietal susceptibility of column stocks (*Matthiola incana)* to infection by *Fusarium oxysporum* even within specific series e.g. 'Centum' and 'Mathilda'.
- Phytotoxicity trials have indicated that Frupica SC (mepanipyrim) is a safe product to use on a wide range of cut flowers, when used at the rate stated in the EAMU.

Background

The National Cut Flower Trials Centre (CFC) was proposed by industry representatives and subsequently funded by the HDC (now AHDB Horticulture)[1], starting in 2007. Its short-term aim was to provide new product development information by investigating novel or alternative cut flowers for production outdoors or in polythene tunnels to stimulate UK production.

2018 was the first year of a new funded project and after taking guidance from industry, a new five year programme of work (2018 to 2022) was agreed to broaden the remit of the CFC, addressing a wider range of issues beyond new product development (NPD). Topics addressed in the first two years included: trials examining Fusarium control in column stocks

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

production, in conjunction with Warwick University; evaluation of new herbicide products for field-grown crops and reactive trials addressing current, important industry issues. During 2018, the CFC was able to quickly investigate a widespread occurrence of downy mildew in column stocks, commission sensitivity testing by Fera and recommend a revised spray programme to improve disease control on some nurseries. In 2019, the CFC also contributed to the setting up of an industry-led tulip promotional campaign - #loveBritishtulips. This campaign will launch in early 2020.

Summary

New product development

Asclepias (varieties of *Asclepias curassavica* and others)

Relatively unknown in the UK, when tunnel grown the most promising variety in trial during 2018 was *Asclepias curassavica* 'Apollo Orange', which produced prolific and attractive, orange-red inflorescences on long stems over a period of about four weeks. *Asclepias incarnata* 'Carmine Rose' and 'White' produced aborted or desiccated blooms. *Asclepias tuberosa* produced very attractive blooms but the stem length was too short at around 30cm. All of the 2018 plantings overwintered successfully into 2019 except 'Apollo Orange' which necessitated a fresh planting. The overwintered varieties performed very differently in 2019, with the *A. incarnata* 'Carmine Rose' and 'White' producing a marketable flush of good quality, long (in excess of 80 cm) flower stems in week 27 with a vase life (VL) of between nine and ten days. *A. tuberosa* produced very attractive blooms with a stem length of around 45 to 50cm (also in week 27) which would have made them potentially marketable. The new 2019, week 23, planting of *A. tuberosa* 'Apollo Orange' produced a flush of long attractive flower stems in week 36 but these only achieved a VL of one day owing to the foliage immediately wilting.

From the last two years trials, Asclepias does seem to have potential as a UK-grown cut flower, but because of the VL, stem length and bud abortion issues experienced at certain times throughout the trial, it is not likely to be reliable enough to be used as a supermarket

product without further work.

Astrantia (varieties of *Astrantia major*)

Astrantia was planted at the CFC for the first time in 2018 to trial a new range of varieties including ‘Sparkling Stars Pink’ and ‘Sparkling Stars Red’. These were overwintered into 2019 and produced a flush of good quality marketable stems from week 24 to week 35. Stem length was consistently in excess of 65cm with a VL of between ten and 12 days. Overall the plants were trouble-free, with two spotted spider mite being the only P&D issue evident in 2019. Astrantia is a product generating a lot of interest amongst the industry and is in demand by both the packers and end consumers. Growers would need to investigate the economics of production, but Astrantia does seem to have the potential to be developed as both a protected and outdoor new UK produced cut flower crop.

Didiscus (varieties of *Didiscus caeruleus*)

Plants were sown into modules in week 15 and transplanted in week 23, with the first marketable stems being produced in week 32, continuing through to week 34. Didiscus was included in the 2019 trials because it belongs to the Umbelliferae family, the same family as Ammi, Anethum and Daucus, all of which have proven successful in previous CFC trials. While the trial did generate a marketable crop, it was not easy to propagate or harvest, resulting in both uneven growth and untidy flower stems, making Didiscus more of a florist product, as it would be difficult to cost effectively grade the flower stems to a consistent level required by supermarkets (very similar to the issues experienced with Cosmos in previous CFC trials).

Echinacea (varieties of *Echinacea purpurea* and others)

A large variety trial of Echinacea is currently underway at RHS Wisley (2016 to 2020) and when viewed by the Project Manager in 2018 it was evident that a number of the varieties had potential as cut flowers. In order to assess this potential, a number of varieties were planted in late 2018 which then flowered in 2019. Most of the varieties overwintered successfully except for ‘Green Jewel’ which suffered 50% loses. Overall the trial generated

marketable flowers from week 28 onwards, but the stage of harvest was difficult to determine and requires further work. The crop will therefore be overwintered for one further year of trialling, focusing on determining the ideal harvesting stage of the flowers and subsequent VL performance.

Eryngium (varieties of *Eryngium alpinum, planum* and *yuccifolium)*

A range of different Eryngium varieties were planted in 2019 and these will be overwintered to assess their true potential as cut flowers the following year (2020). Eryngium is widely used in mixed bouquets sold in the UK, but most (if not all) of the stems are imported, indicating that there is potential for import substitution. Product from the trial will be used to provide samples for UK packers as well as to assess VL performance.

Gomphrena (varieties of *Gomphrena haageana*)

Gomphrena has been investigated by the CFC in previous years, and of the species trialled, *G. haageana*, was the only one that produced stems that were long enough to be suitable for use as a 'filler' in mixed bouquets. The product was not taken up by the industry, but recent interest in UK produced 'fillers' resulted in a request to revisit Gomphrena trials. A single planting was therefore made in week 23 which flowered from week 34 onwards. Overall the trial generated a crop that was very prolific, with a good stem length and acceptable VL, receiving positive feedback from the industry. However, the speed and cost of harvesting is a potential issue, but the crop could lend itself to multiple sowing dates with the possibility of once-over harvesting. This will be investigated in 2020.

***Lepidium* 'Green Dragon'**

While relatively unknown to UK growers, Lepidium is currently imported from The Netherlands indicating that there is a market for home produced product. Two plantings were made of 'Green Dragon', a recently released new variety. All plug formats used in the trial, including the small plugs supplied directly by the breeder, established well and grew away vigorously. The time from planting to cropping was 7 to 8 weeks and the flower stem length was consistently between 60 and 70cm. The 2019 trial has demonstrated that Lepidium is

relatively easy to produce, but because of the dense and tangled nature of the mature crop it needs to be once-over harvested and then graded on a packing line. Currently the main interest in this crop is from florist outlets, but it does have the potential for use as a filler in supermarket mixed bouquets.

Lysimachia (varieties of *Lysimachia fortunei*)

During 2018, two varieties of Lysimachia, 'Jumbo' and 'Mambo' were planted in week 21 at a density of 25/m^2. The crop was cut down in week 41 of 2018 and overwintered into 2019. The crop died back completely over the winter and new shoots began to appear in week 14, with the first flower stems being ready to harvest in week 26, most achieving or exceeding 60cm in length. The trial continued to flower for a further seven weeks and this was extended to week 35 by the removal of the centre bud from a few late flower stems. The centre bud can be removed at a very advanced stage of development and this allows the side shoots to develop. The resulting final flower stem was in excess of 80cm and produced a very bulky product with up to ten buds per stem. Such a large stem is unlikely to be suitable for supermarkets, but could possibly achieve a premium price as a florist product. VL tests undertaken on the standard stems (which had not been disbudded) demonstrated a VL of ten to 11 days. The varieties used in this trial are no longer commercially available, but alternative varieties still available include 'Abraham', 'Elisabeth' and 'Helene'. Specialist growers could consider the production of small areas of Lysimachia (including disbudded product) for floral display work.

Scabious (varieties of *Scabiosa atropurpurea*)

Scabious are well-known as a vigorous garden plants with prolific, attractive flowers in a wide range of colours with the perennial forms already grown as outdoor commercial cut flower crops. In recent years, new ranges of *S. atropurpurea* have been introduced to the market, with the 'Scoop series' generating the most interest from the industry over three years of CFC trials. New and improved varieties continue to be introduced, and the 2019 trials concentrated on a new range called 'Focal Scoop', which claim to have the advantage of longer stems and

larger flowers. Some of the best performing varieties from the previous year's trials were also included in 2019. Other propagators of Scabious were invited to provide their varieties for trial, but declined to be involved.

Trials in previous years have indicated that an early planting date produces a more prolific crop because it allows the plant to establish a sturdy frame and good root structure before being put under stress during warmer weather conditions. In order to maximise their potential, plugs were potted into 9cm pots in week 11, pinched four weeks later and the well branched plants transferred to the tunnel in week 20. Not all of the 'Focal series' were available for early planting and some were not delivered until week 23. The plants from 9cm pots established well and produced a very heavy flush throughout the very warm weather in July. At the end of July (week 31) a decision was made to cut down half of each bed to around six inches from the ground in order to rejuvenate the crop and see if the flowering period could be extended. The half of the bed that was not cut down continued to flower until the crop was removed in week 41. The half that was cut down started to flower again in week 36 and produced stronger and more vigorous stems than the plants which weren't cut back. Some commercial glasshouse crops grown in 2019 continued to flower from July to December, giving a six month harvesting period. The week 23 planting of 'Focal Scoop' produced weaker, shorter stems with smaller flowers than the earlier planted crop.

No further trials on Scabious are planned, unless the ongoing breeding work develops new varieties that have attributes that justify planting additional demonstration plots. A technical note summarising the CFC trials to date will be produced during 2020.

Veronica (varieties of *Veronica longifolia*)

In 2018, a new series of Veronica was trialled (the 'Skyler' series), available as blue, white and pink flowered varieties. The trial showed that when tunnel grown, a combination of different planting and pinching dates could achieve a three month flowering period. It is likely that this period could be extended further if the crop was grown in a glasshouse.

The 2018 planting was overwintered to assess the second year performance, along with

disbudding trials aimed at producing a heavier and more floriferous stem. In order to facilitate more air movement around the plant and hence reduce disease pressure, the density was reduced from 25/m^2 to 12/m^2 by removing every other plant.

The first flush of flowers was ready to harvest from week 24 and produced good quality long and strong flowers stems in excess of 80cm. However, a number of the flowers showed a level of distortion, resembling fasciation, which would have resulted in over 50% of the crop being unmarketable. The cause of this abnormal growth was not clear, but the problem was evident on a wide range of garden grown Veronica during 2019. The second flush of flower was produced from week 35 onwards and showed no signs of the fasciation that was evident in the first flush. Following a suggestion of a packer member of the Management Group, a number of stems had the centre bud removed and this resulted in the production of a longer, stronger flower stem with between four and six blooms per stem. This produced a better quality product compared to the non-disbudded product, making them more suitable for use in mixed bouquets. The technique will be investigated further after the crop is overwintered for a final year into 2020. The initial tests produced on the disbudded stems demonstrated a VL of between 11 and 12 days.

Other trials

Column stock (Matthiola) – Fusarium susceptibility variety trial

Fusarium oxysporum is an important pathogen associated with column stocks production, and growers regularly observe differences in susceptibility to this pathogen within the current commercial range of varieties. An attempt was made to quantify these differences in an extensive replicated trial undertaken on a grower's business in 2012, but since then there have been significant changes to the range of varieties that are grown. In order to examine these new varieties, along with a desire to determine the Fusarium susceptibility of the new range of Japanese-bred varieties, a large replicated trial was planted in the Haygrove tunnel at the CFC that had been inoculated with Fusarium two years earlier. The 2019 trial clearly demonstrated that there are large differences in the susceptibility of column stock varieties to

Fusarium oxysporum. Some of the older varieties are already known to be very susceptible (e.g. 'Centum Red', 'Debora' and 'Fedora Deep Rose') and this was confirmed in the 2019 trial. The 'Mathilda series' and the new Japanese-bred varieties, which were not included in the 2012 trial, expressed large differences in susceptibility between flower colours. Examples of this would be 'Iron Marine' that produced only two marketable flower stems/m^2, whereas 'Iron Cherry Blossom' produced 46 marketable flower stems/m^2. Such differences were also evident in the 'Mathilda series with 'Mathilda Pink' only producing two marketable stems/m^2, whereas 'Mathilda Yellow' produced 45 marketable flower stems/m^2.

The results from this trial can be used by growers to enable them to choose less susceptible varieties to plant in situations where the crop will be under more disease pressure, or in the case of later plantings, were the crop will experience higher temperature and stress levels during the production period.

Column stocks (Matthiola) - Fusarium T34 trial

A recent AHDB funded trial investigating Fusarium on lettuce has indicated that T34 Biocontrol (*Trichoderma asperellum* – strain T34, a biopesticide for the control of Fusarium) applied to the peat blocks at seeding gave a degree of control of the disease. In order to assess the potential of T34 to control Fusarium in column stocks, the CFC replicated this technique by direct seeding stocks into peat blocks. T34 was applied once to the blocks at seeding, immediately after planting into the Fusarium infected soil in the Haygrove tunnel and then again 10 days later at rate of 1g/10L of water per m^2.

The results of the 2019 trial were not conclusive, but were positive enough to justify additional trials in 2020. These trials will investigate the effect of a commercial propagator drenching the plugs with T34 at the seeding stage.

Column stocks (Matthiola) – late planted variety trial

There has been interest in the Japanese-bred varieties of column stocks for some time but there has been very little commercial uptake owing to the inability of not being able to automate the selection of double flowered seedlings, as is the case with the current widely

grown commercial varieties. The hand selection process required, and the higher than normal percentage of singles which pass through it, make these an expensive bloom to produce and there has to therefore be a commercial advantage in their production. The main potential advantage could be the ability to extend the season of the column stocks crop into the summer months, because it has previously been reported, and clearly demonstrated in the 2018 trial, that the Japanese-bred varieties are less prone to flower initiation problems during periods of higher temperatures.

In 2019, four plantings in weeks 18, 20, 22 and 24 demonstrated that the Japanese-bred varieties could produce reliably long flower stems, with all varieties exceeding 55cm and many in excess of 60cm. However, discussions with growers have highlighted that unless a reliable market outlet can be found for the single flowered stems, allowing the crop to be grown unselected, the cost of hand selection would currently mean that the production of Japanese-bred varieties would not be economically viable. It should be noted that a major Dutch plant propagator is currently investigating the possibility of automating the selection of these varieties, and the CFC will undertake appropriate additional trials if this proves to be a successful technique.

Lily - alternatives to peat-based growing media

Lily bulbs are generally grown in crates of growing medium in order to avoid any soil-borne pathogens. For many years peat was used as the standard growing medium, either alone or mixed with other materials; more recently businesses producing significant quantities of this crop have developed their own bespoke peat-based media (referred to as ‘grower’s peat-based medium’). Due to environmental concerns over the possible loss of lowland peat bog habitats, there has been a continued search – going back at least to the 1980s - for alternative materials to use as growing media, or at least to use as diluents in peat-based media. In recent years there has been renewed interest from growers and their customers to adopt more responsibly sourced peat-alternatives in the production of cut flower lilies, and this has been an objective of CFC trials which have been co-funded by Bulrush Horticulture Ltd. With

the increasing availability of green-waste and anaerobic digestate these materials have been of particular interest; other more familiar alternative materials were wood-derived or based on coir. The use of peat-free and peat-reduced mixes was further investigated during 2019 in the production of lily ‘Dynamite’ (Oriental group), along with a grower’s peat-based medium and a 100% peat medium for comparison.

The peat-reduced mix produced stems with an average length of 82cm and weight of 131g, the peat-free mix produced stems with an average length of 81cm and weight of 128g, the grower’s peat-based mix produced stems with an average length of 80cm and weight of 130g and the 100% peat mix produced stems with average length of 82cm and weight of 143g. There was no statistically significant difference between any of the treatments.

Phytotoxicity testing of recently approved pesticides

Through a process of trials and where appropriate, applications for EAMU’s, the AHDB Sceptre and SceptrePlus projects have provided a range of additional pesticide options to growers. However, these products are used at grower’s own risk, with limited knowledge of potential phytotoxicity issues. In order to try and address this, the CFC has developed a new trial to investigate the potential phytotoxicity of pesticides recently approved through the AHDB Sceptre/SceptePlus projects that are applicable for cut flower use. In 2019, an EAMU (1107/19) was obtained for the fungicide Frupica SC (mepanipyrim) for the control of powdery mildew on ornamentals. A number of cut flower crops are susceptible to powdery mildew including Delphinium, Phlox, Solidago and Veronica. Varieties from these were planted in two blocks with one block receiving a spray programme comprising of Amistar (azoxystrobin), Frupica SC (mepanipyrim), Nimrod (buprimate) and Takumi SC (cyflufenamid) and the other block receiving the same programme without Frupica SC. Frupica SC was applied at 90ml/100L of water at a volume rate of 1,000L/ha.

The powdery mildew spray programme was maintained up until harvest and no phytotoxicity was observed at any stage of production on any of the plants. This would indicate that Frupica SC is a safe product to use on cut flowers when used at the rate stated on the EAMU, but

owing to the wide range of species grown and the various growing conditions provided, growers should always test Frupica SC on a small number of plants before applying it on a wider scale.

Financial benefits

This is the second year of a new five year project and as such any financial benefits reported will not take into account the potential £2.5 million of new product trialled and facilitated by previous CFC trials.

The main financial benefit to the industry in 2019 has been from the 2018 work on downy mildew on column stocks. While reported last year, the adoption of the control measures and spray programme amendments from the 2018 trials resulted in no known major outbreaks of downy mildew on column stocks during the 2019 production year.

While the new products trialled in 2018 and 2019 have yet to be produced on a large scale for supply to the supermarkets, some species such as Scabious and Veronica have been planted by small to medium sized nurseries. An estimate of the total area of these new products in 2019 is 1 ha, and if Scabious is used as an example, with a yield of around 30 stems/m^2 at a return of 25p per stem this is an additional farm gate value of £75,000.

Action points

- Production of Astrantia, Didiscus, Lepidum, Scabious and Veronica could be suitable novel, niche ventures for UK cut flower growers.
- As an alternative to production of box-grown lilies in a peat-based medium, trials over the past five years have shown that production in peat + anaerobic digestate gives cut flower lilies of equal quality while reducing peat use, but care should be exercised when using anaerobic digestate until a standard specification is available. Peat + wood fibre or peat + cocopeat mixtures are also effective. Lily growers should follow the developments regarding the use of peat-free and peat-reduced growing media and amend growing media blends used accordingly.

- Column stock growers should continue to be vigilant to the ongoing threat of the new strain of downy mildew identified in 2018, and implement the recommendations contained in AHDB/CFC Information Sheet 11 '*Maintaining successful control of downy mildew in protected crops of cut flower column stocks'*.
- Column stock growers should use the results of the 2019 Fusarium varietal susceptibility trial to help with the selection of suitable varieties for production in high Fusarium risk situations, such as a second crop in soil with a known history of the disease.
- Growers should consider incorporating Frupica SC (mepanipyrim) into cut flower powdery mildew spray programmes, following any guidance in the EAMU and on the product label.

SCIENCE SECTION

Introduction

The past decade has seen a rise in imports of cut flowers into the UK at a time when home production has been declining. The crops produced by UK growers have also changed significantly over the past decade with protected chrysanthemum production (both AYR and natural season) declining to an insignificant area and also a decline in indoor lily bloom production. By contrast, production of protected tulips and column stocks have increased and are now the most important crops for UK protected flower growers. The production of outdoor flowers has also changed significantly with a major reduction in the natural season chrysanthemums and gladioli area but significant increases in sunflowers, peony and hardy foliage (including berries). Dried flower production has also decreased significantly and now mainly comprises Larkspur (and a few other species) for the confetti industry. The number of grower holdings has also decreased, with the majority of the production area now being managed by a small number of larger scale producers who have made significant investment in new capital facilities including packhouses, glasshouse and grading/packing equipment.

The desire of supermarkets to offer more UK produced flowers to their customers could offer further potential for import substitution with UK grown product having the advantage of freshness and market proximity, minimising air miles. The availability of Spanish and similar tunnels (to protect delicate crops from weather, extend the production season and augment growing outside or under cold glass) and the enduring popularity of ‘cottage-garden’ flowers (that grow well under UK conditions) are also aspects that can be further exploited. Brexit may also open up new opportunities for home grown produce, but could also cause issues with the supply of seasonal labour and costs of importing of young plant material.

The National Cut Flower Trials Centre (CFC) was proposed by industry representatives and subsequently funded by the HDC (now AHDB Horticulture), starting in 2007. Its short-term aim was to provide information on new product development - novel or alternative cut flowers for production in tunnels or outdoors to stimulate UK production.

Despite a wide range of potential products being identified and uptake by small to medium sized businesses, it has proven difficult to commercialise some of these new products on a large scale due to a number of issues, not least being able to provide them at a unit cost that is acceptable to UK supermarkets. Owing to this fact, after taking guidance from the industry, a new five year trials programme was developed (2018 to 2022) with a broader remit seeking to address technical issues such as identifying new pest, disease and weed control measures (in the form of Fusarium control in 2018 and 2019 and ongoing herbicide evaluations) and investigating current technical issues of concern to industry (such as the outbreak of downy mildew in column stocks during 2018, where the CFC commissioned sensitivity testing undertaken by Fera and generated revised spray programmes and an information sheet in early 2019 and provided samples for additional sensitivity testing in 2019). In 2019 the CFC has also contributed to an industry led tulip promotional campaign - #loveBritishtulips. New product development is still an important element of the overall CFC project, but is now balanced by other relevant programmes of work.

Materials and methods

By arrangement with David Robinson (Managing Director, Rookery Farm Packing Ltd), the trials programme is hosted at Rookery Farm, Holbeach St John, Spalding, Lincolnshire. The National Cut Flower Trials Centre (t/a Cut Flower Centre Ltd; CFC) is directed by project leader Lyndon Mason and overseen by a management group comprising representatives of growers, packers, retailers and AHDB Horticulture. Practical arrangements are agreed between David Robinson and the project leader to achieve a good standard of commercial husbandry adapted as necessary to suit small trial plots that might require individual pesticide, irrigation, fertiliser and other treatment applications to be made. Crop protection advice is provided by a BASIS and FACTS registered consultant.

The experimental programme is agreed with the CFC management group (MG) and amended annually, taking into account technical issues that need to be addressed as well as possible new product development subjects. Information from the reviews of new cut flower crops and

overseas cut flower trials, undertaken as part of the previous CFC project, are also used to identify suitable plant species.

Generic protocols are presented in this section, specific actions are documented within the results section.

Facilities and site preparation

The CFC facility at Rookery Farm comprises a single-span 'Haygrove' tunnel (7.9m wide × 38.1m in length; Haygrove Ltd, Redbank, Ledbury, Herefordshire), a triple-span 'Pro-Tech' tunnel (overall 22.7m wide × 38.0m in length; Pro-Tech Marketing Ltd, Ironbridge, Telford, Shropshire) and a 600m^2 adjacent area of outdoor beds provided with anti-rabbit fencing. Since it is an exposed site, wind-breaks of 2.5m-high polypropylene netting are provided at each end of the tunnel area. The tunnels are covered with a standard polythene film (in late March or early April) and, as is usual, in order to protect the structure of the tunnels, the polythene covers are removed for the winter period at the beginning of October. The Soil Survey of England and Wales' *Soils of England and Wales* describes the soil at the CFC as a deep alluvium drained by ditches and pumps, which is typical of the area.

The soil within the multi-span tunnels was steam-sterilised in mid-April 2018 with no further sterilisation taking place in 2019. Before planting, soil samples were taken across the site to undertake a standard glasshouse soil analysis. As fertiliser recommendations don't exist for all cut flower crops, the aim was to bring base nutrient levels up to those required for Chrysanthemum, i.e. indices of two for nitrogen, four for phosphorus, three for potassium and four for magnesium. Before planting in 2018 the 'Haygrove' tunnel received 15g/m^2 ammonium nitrate (as 'Nitram') and 40g/m^2 sulphate of potash; 'Pro-Tech' bay 1, 30g/m^2 ammonium nitrate and 40g/m^2 sulphate of potash and 'Pro-Tech' bay 3, 30g/m^2 ammonium nitrate and 40g/m^2 sulphate of potash.

Plant material and planting

Plants were obtained as plug-plants ('plugs'), seeds, or rooted cuttings as appropriate. Seeds

were germinated in module/plug trays and then transplanted. Most plants were transplanted into labelled plots along 1m-wide beds at the specified density. Individual plot lengths were dependent on the trial and plant availability, and wherever practical unplanted areas were left between plots and at the ends of the beds as ‘guard plots’. Crops were watered with a hand-lance immediately after planting and then as and when required to ensure good establishment.

Crop husbandry

Once established, plants were irrigated as required via lay-flat irrigation lines, a hand-lance was also used to provide supplemental irrigation. Once in full growth, plants received a liquid feed at every watering. The liquid fertiliser used was ‘Universal® Green’ (23:6:10:2.7 N:P:K:MgO with trace elements).

Beds were provided with one or more layers of support netting as required by the crop, the net was raised in line with crop growth. Sometimes plants were stopped (pinched) or other treatments applied.

Pesticide applications

The pesticides applied in 2019 are listed below, with ‘+’ indicating a tank-mix.

For powdery mildew control, Nimrod (bupirimate) to Veronica in week 14.

For powdery mildew control, Signum (pyraclostrobin and boscalid) to Veronica in week 16.

For powdery mildew control, Nimrod (bupirimate) to Veronica in week 17.

For downy mildew control, Fubol Gold WG (mancozeb and metalaxyl) to column stocks crops in week 19.

For powdery mildew control, Nimrod + potassium bicarbonate (bupirimate + potassium bicarbonate) to Veronica in week 19.

For downy mildew and aphid control, Fenomenal and Mainman (fenamidone and fosetyl-aluminium + flonicamid) to all Scabious plantings in week 20.

For powdery mildew and aphid control, Signum and Chess WG (pyraclostrobin and boscalid and pymetrozine) to Phlox and Veronica in week 20.

For downy mildew and diamond back moth control Percos + HortiPhyte + DiPel DF (ametactradin and dimethomorph + HortiPhyte + *Bacillus thuringiensis kurstaki* ABTS-35) on all column stocks crops in week 21.

For downy mildew control, Fubol Gold WG + HortiPhyte (mancozeb and metalaxyl + HortiPhyte) to column stocks crops in week 22.

For diamond back moth and flea beetle control, Hallmark WZT + DiPel DF (lambda-cyhalothrin + *Bacillus thuringiensis kurstaki* ABTS-35) on all column stocks plantings in week 22.

For powdery mildew control, Signum (pyraclostrobin and boscalid) to Phlox and Veronica in week 22.

For downy mildew control, Fenomenal (fenamidone and fosetyl-aluminium) to all column stocks plantings in week 22.

For downy mildew control, Fubol Gold WG + HortiPhyte (mancozeb and metalaxyl + HortiPhyte) to column stocks crops in week 23.

For aphid control, Calypso + Mainman (thiacloprid + flonicamid) to all plantings in week 25.

For downy mildew control Percos + HortiPhyte (ametactradin and dimethomorph + HortiPhyte) to all column stocks and Scabious plantings in week 25.

For diamond back moth and flea beetle control, Decis + DiPel DF (deltamethrin + *Bacillus thuringiensis kurstaki* ABTS-35) to all column stocks and Lepidium plantings in week 25.

For powdery mildew control, Takumi + potassium bicarbonate (cyflufenamid + potassium bicarbonate) to all crops in week 25.

For downy mildew control, Fubol Gold WG + HortiPhyte (mancozeb and metalaxyl + HortiPhyte) to column stocks crops in week 26.

For powdery mildew control, Amistar + potassium bicarbonate (azoxystrobin + potassium bicarbonate) to Phlox, Veronica and both beds of the phytotoxicity trial in week 26.

For downy mildew control, Paraat + HortiPhyte (dimethomorph + HortiPhyte) to column stocks crops and Scabious in week 27.

For powdery mildew control, Takumi SC + potassium bicarbonate (cylufenamid + potassium bicarbonate) to Phlox, Veronica and both beds of the phytotoxicity trial in week 27.

For two spotted spider mite and thrips control, Dynamec + Majestik (abamectin + maltodextrin) to Asclepias and Scabious in week 27.

For powdery mildew control, Frupica (mepanipyrim) to Phlox, Veronica and one bed of the phytotoxicity trial in week 27.

For two spotted spider mite and thrips control, Dynamec + Majestik (abamectin + maltodextrin) to Asclepias and Scabious in week 27.

For powdery mildew control, Amistar + potassium bicarbonate (azoxystrobin + potassium bicarbonate) to Phlox, Veronica and both beds of the phytotoxicity trial in week 28.

For powdery mildew control, Frupica (mepanipyrim) to lilies, Phlox, Veronica and one bed of the phytotoxicity trial in week 29.

For downy mildew control, Paraat + HortiPhyte (dimethomorph + HortiPhyte) to column stocks crops and Scabious in week 29.

For two spotted spider mite and thrips control, Dynamec + Majestik (abamectin + maltodextrin) to Asclepias and Scabious in week 29.

For downy mildew control, Fenomenal (fenamidone and fosetyl-aluminium) to all column stock plantings in week 30.

For downy mildew control, Paraat + HortiPhyte (dimethomorph + HortiPhyte) to column stocks crops and Scabious in week 31.

For diamond back moth and flea beetle control, Decis + DiPel DF (deltamethrin + *Bacillus thuringiensis kurstaki* ABTS-35) to all column stock and Lepidium plantings in week 31.

For powdery mildew control, Takumi SC + potassium bicarbonate (cylufenamid + potassium bicarbonate) to Phlox, Veronica and both beds of the phytotoxicity trial in week 31.

For aphid control, Gazelle SG + Mainman (acetamiprid + flonicamid) to all plantings in week 32.

For Botrytis control, Scala (pyrimethanil) to all lilies in week 32.

For downy mildew control, Revus + HortiPhyte (mandipropamid + HortiPhyte) to column stocks crops and Scabious in week 32.

For two spotted spider mite and thrips control, Dynamec + Majestik (abamectin + maltodextrin) to Asclepias and Scabious in week 32.

For powdery mildew control, Nimrod (buprimate) to Phlox, Veronica and both beds of the phytotoxicity trial in week 32.

For Botrytis control, Frupica (mepanipyrim) to all lilies in week 33.

For downy mildew control, Paraat + HortiPhyte (dimethomorph + HortiPhyte) to column stocks crops and Scabious in week 33.

For powdery mildew control, Frupica (mepanipyrim) to lilies, Phlox, Veronica and one bed of the phytotoxicity trial in week 33.

For powdery mildew control, Takumi SC + potassium bicarbonate (cylufenamid + potassium bicarbonate) to Phlox, Veronica and both beds of the phytotoxicity trial in week 34.

For powdery mildew control, Nimrod (buprimate) to Phlox, Veronica and both beds of the phytotoxicity trial in week 35.

For Botrytis control, Scala (pyrimethanil) to all lilies in week 35.

For Botrytis control, Frupica (mepanipyrim) to all lilies in week 37.

For Botrytis control, Scala (pyrimethanil) to all lilies in week 39.

Crop assessments

Flower stems were picked at the appropriate commercial stage for each crop, wherever practicable taking samples close to the peak cropping date. If applicable to the trial, the number of marketable stems picked was recorded (and converted to numbers per m^2), along with (for an appropriate random sample of each plot) picking dates, lengths and weights of flower stems (either overall figures or after trimming to a specified length) and other measurements as required (such as spike length or flower-head diameter). Other than as required by trimming, the stem lengths and weights quoted always refer to the total weights and lengths of the whole stem (including buds, flowers or inflorescences).

As appropriate to the practical nature of the project, demonstration plots were not usually replicated, but where replicated and randomised trials were used, the data were subjected to statistical analysis. In 2019, the statistical analysis was undertaken by Chris Dyer of ADAS using analysis of variance (ANOVA) which is the most appropriate technique for trials of this nature.

Less formally, but importantly, the plots were assessed at intervals by the CFC management group and others from the industry. In the case of preliminary demonstrations, emphasis was placed on photographs and grower comments. Numerous samples of products were made available to industry to gather feed-back and for promotion. In 2019, samples of new products grown at the CFC were also provided to Jonathan Mosley for use in his floral demonstrations at a number of UK shows including the Great Yorkshire Show, Harrogate Flower Shows and the RHS shows including Hyde Hall, Tatton Park and Wisley.

Vase life testing

Typically, flower stems are picked at a specific stage of floral development and placed promptly in buckets of water in a cold store, from which they may be withdrawn for bunching, trimming, placing in sleeves, packing, etc., before being returned to the store until required. The water in which flowers are held at the various stages may be augmented with appropriate conditioning solutions. Storage is followed by transport (sometimes refrigerated) to a packer,

intermediate warehouse or retail store. The product then reaches the sales floor, with its ambient temperature and lighting, and finally the consumer's vase. Retailers will often demand a guaranteed vase life (VL) of at least five days, but note that this five day period in the vase is in addition to all the time spent between picking and retail sale, which can typically last a further four to five days.

All VL tests in 2019 were undertaken by SuperFlora at Washway Road, Holbeach, Lincolnshire, using their standard VL protocol. Before carrying out a VL test, the chain from grower to consumer is simulated using appropriate conditioning solutions, a few days' cold storage and retail store conditions. Testing takes place in a VL test room which follows standard VL test protocols, with the basal part of the stem removed before placing the stems in a clean vase of about 1 L capacity, containing water with a proprietary flower food, in an environment at 20°C and 60% RH with fluorescent lighting at 1,000 lux for 12 h/day.

Testing typically involves daily checks of quality (such as petal desiccation, flower dropping, foliage yellowing and loss of water clarity) and determining the longevity of the product in an 'acceptable' state, defined by an agreed 'throw-out' criteria. In this report an unacceptable VL is taken as less than five days, five days is regarded as just acceptable (just reaching the minimum guaranteed period), six days is acceptable, over six days is good and greater than 10 days is long. In the results section the VL quoted refers only to the number of days in the vase, not including the preparatory stages. This is therefore the true VL that the consumer would expect to achieve once the flowers are placed in their vase at home. Some informal visual evaluations of vase life in a 'display situation' were also undertaken by Helen Chambers of Evolve Flowers.

Results

Asclepias (varieties of *Asclepias curassavica* and others)

Asclepias was one of the many flowers that performed successfully in the ASCFG trials in the USA and elsewhere, and was considered likely to grow well in the UK and be appreciated as

a novel cut flower. Examples were planted as demonstration plots in 2017 and as these showed promise, further trials of a wider range of varieties were undertaken in 2018 and these were then overwintered into 2019 as detailed in Table 1.

Table 1. Details of 2019 demonstration of Asclepias varieties

Location	Rookery Farm
Varieties	*Asclepias curassavica* 'Apollo Orange', *A. incarnata* 'Carmine Rose', 'Soulmate' and 'White', *A. tuberosa* 'Gay Butterflies' and 'Silkweed'
Plant longevity and hardiness	Perennials; *A. curassavica* is frost-tender, others are fully hardy
Format(s) and supplier(s)	Seed from Chiltern Seeds
Propagation and pre-planting treatment(s)	Sown into module trays week 15 of 2018, 'Soulmate' and *A. tuberosa* and then a second sowing of *A incarnata* 'Carmine Rose' and 'White' in week 19 of 2018. A new sowing of 'Apollo orange' was made in week 15 of 2019
Planting or sowing date(s)	Transplanted week 20 of 2018 and the second sowing transplanted in week 26 of 2018. Plants were cut down to ground level in October 2018. The 2019 planting of 'Apollo orange' was made in week 23
Plots	Variable for the first planting and 3 m-long for the second planting
Planting/housing site	'Pro-Tech' tunnel bay 2
Layout	Demonstration plots
Plant spacing(s)	25/m^2
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	Prone to two-spotted spider mite so prophylactic sprays were applied in 2019
Picking stage(s) and market specification(s)	When 30 to 50% of the buds have opened
Picking and recording date(s)	The overwintered 2018 plantings flowered from week 27 onwards. The 2019 planting of 'Apollo Orange flowered from week 36 onwards
Records taken	Observations
VL testing	Samples of *A. incarnata* 'Carmine Rose' and 'White' were tested in week 28 and *A. curassavica '*Apollo Orange' in week 37

Figure 1. Asclepias in demonstration plots in 2019, Top left *A. curassavica* 'Apollo Orange' in week 38 (planted week 23), top right *A. tuberosa* ', bottom-left *A. incarnata* 'Carmine Rose' bottom right *A. incarnata* 'White' all three shown in week 28

The week 28 planting established and grew well, and the 2018 crop overwintered successfully with no obvious losses (except for 'Apollo Orange'). In 2018 only *A. curassavica and A. incarnata* produced flower stems of a suitable length for cutting, but in 2019, the overwintered

planting of *A. tuberosa* also produced stems of over 50cm. The 2019 planting of 'Apollo Orange' produced prolific, attractive, orange-red inflorescences from week 36 onwards and continued to crop over a three week period. The overwintered crop of *A. incarnata* 'Carmine Rose' and 'White' and *A. tuberoa* produced good quality flower stems from week 27 onwards and continued to crop over a two week period. *A. incarnata* 'Carmine Rose' had a VL of between nine and ten days whereas the new 2019 planting of 'Apollo orange' only achieved a VL of 1 day owing to the foliage immediately wilting.

All plantings were cut down in week 30 but none of the varieties produced a second flush of marketable flower stems.

Astrantia (varieties of *Astrantia major*)

Astrantia has never been investigated by the CFC, but in 2018 the Project Manager was approached by Peter Collins of Botanical International with a view to set up trials examining two new varieties 'Sparkling Stars Pink' and 'Sparkling Stars Red'. There was a favourable market response to this crop in 2018 and with it being a perennial plant, they were overwintered into 2019.

Table 2. Details of 2019 demonstration of Astrantia varieties

Location	Rookery Farm
Varieties	*Astrantia major* 'Sparkling Stars Pink' and 'Sparkling Stars Red'
Plant longevity and hardiness	Perennials; Assumed to be fully hardy
Format(s) and supplier(s)	Plants supplied by Walter Blom
Propagation and pre-planting treatment(s)	Supplied as large plugs
Planting or sowing date(s)	Planted in week 33 of 2018 and overwintered into 2019
Plots	7 m-long plots
Planting/housing site	'Pro-Tech' tunnel bay 2
Layout	Demonstration plots
Plant spacing(s)	6 plants/m^2
Post-planting treatment(s)	One layer of support netting

Pests, diseases and disorders	In 2019, two-spotted spider mite attacked the crop so prophylactic sprays are advisable
Picking stage(s) and market specification(s)	When 30 to 50% of the buds have opened
Picking and recording date(s)	The overwintered 2018 planting flowered from week 24 and continued to produce good quality long stems up until 35
Records taken	Observations
VL testing	Tested in week 24 and week 28

Figure 2. Astrantia trials in week 38, 2018, two weeks before the tunnel covers were removed

Figure 3. Astrantia trial in full flower in week 28, 2019

The 2018 planting overwintered successfully with no plant losses and produced a flush of good quality marketable stems from week 24 to week 35. Stem length was consistently in excess of 65cm with a VL of between ten and 12 days. Overall the trial was trouble free with two spotted spider mite being the only P&D issue evident in 2019. The crop was cut back in week 41 and will be overwintered to enable one more year of assessments to be made in 2020.

Column stocks (Matthiola) - Fusarium susceptibility variety trial

Fusarium oxysporum is a major pathogen of column stocks, however there are differences in terms of susceptibility within the current commercial range of varieties. An attempt was made to quantify these differences in an extensive replicated trial undertaken on a commercial nursery in 2012, but since then there have been significant changes to the range of varieties that are grown. In order to address these changes, along with a desire to determine the Fusarium susceptibility of the new range of Japanese-bred varieties, a large replicated trial was planted in the Haygrove tunnel that had been inoculated with Fusarium two years earlier.

Table 3. Details of 2019 Fusarium susceptibility variety trial

Location	Rookery Farm
Varieties	'Aida' Apricot, Blue & Purple; 'Anytime' Sea Blue & White; 'Arrow' White; 'Avalon' White & Yellow; 'Centum' Deep Rose, Pink, Red, White & Yellow; 'Debora', 'Fedora' Deep Rose; 'Figaro' Lavender & Rose Light; 'Iron' Apricot, Cherry Blossom, Marine, Pink, Purple, Rose, White & Yellow; 'Mathilda' Blue, Pink, Rose, White & Yellow; 'Venus' Cherry Blossom & Pink and 'Vintage' Brown
Format(s) and supplier(s)	Plugs from Florensis and Global Plants
Propagation and pre-planting treatment(s)	N/A
Planting or sowing date(s)	Plugs planted in week 18
Plots	1m-long plots
Planting/housing site	Haygrove tunnel
Layout	Replicated trial (Appendix 1)
Plant spacing(s)	64/ m^2
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	Flea beetle and downy mildew were the main problems observed in 2019
Picking stage(s) and market specification(s)	Half of the flowers open
Picking and recording date(s)	Marketable stems in some plots from week 26 onwards
Records taken	Assessment of levels of Fusarium infection (0-10) and number of infected stems in week 25 and Fusarium assessment and number of marketable stems in week 27
VL testing	No

Figure 4. Overall view of the Fusarium trial immediately after planting in week 18

Figure 5. View of the trial after the final assessments in week 27

Figure 6. **‘**Iron’ Purple, showing a high level of resilience to Fusarium

Figure 7. In contrast, some varieties were devastated by the disease (‘Debora’)

The weather remained reasonably cool during most of the period of this trial which resulted in the Fusarium infection developing relatively slowly, unlike the rapid and devastating symptoms evident during the hot weather experienced in the 2018 trial. The slow development of the disease enabled differences in varietal susceptibility to be clearly observed with some varieties (e.g. 'Iron' Cherry Blossom) producing a high percentage of marketable stems. The following graphs show the level of Fusarium and number of marketable stems from assessments made on the 19th of June and 1st July 2019. In terms of the disease assessment used, 0 = no symptoms increasing in severity up 10 = complete plant death, where 4 represented the limits of marketability.

Figure 8. Average Fusarium score from the 19th of June assessment of the column stock Fusarium susceptibility variety trial

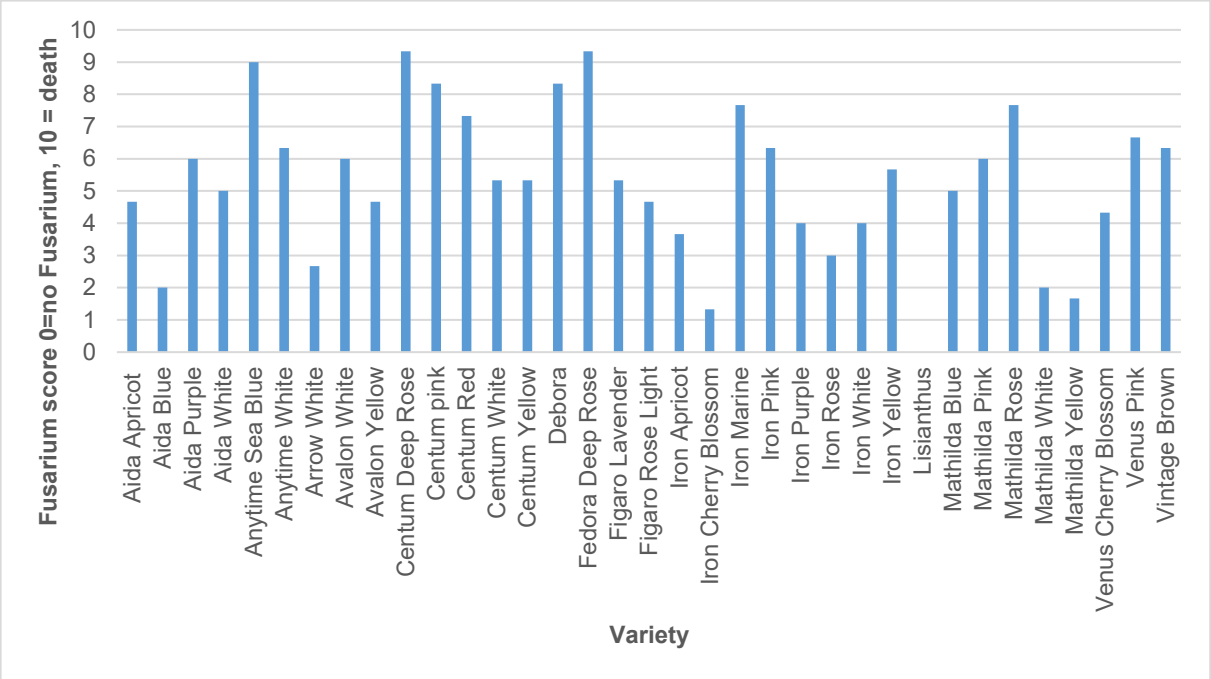


Figure 9. Average number of stems showing symptoms of Fusarium from the 19th of June assessment of the column stock Fusarium susceptibility variety trial

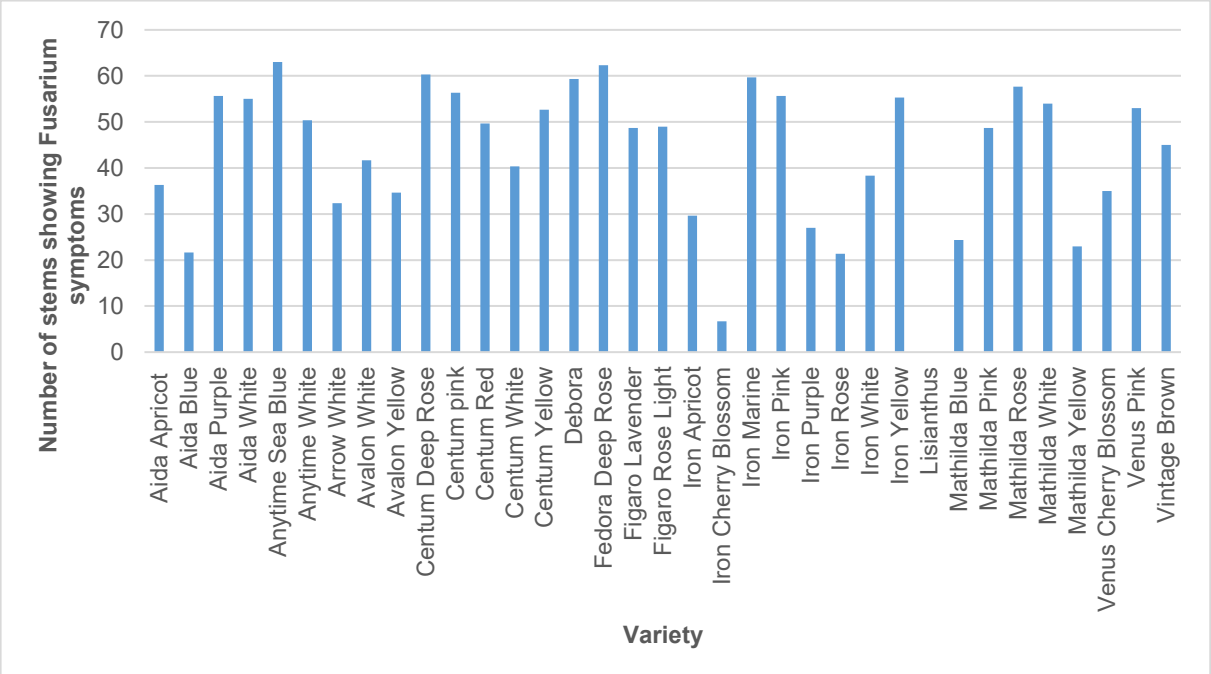


Figure 10. Average Fusarium score from the 1st of July assessment of the column stock Fusarium susceptibility variety trial

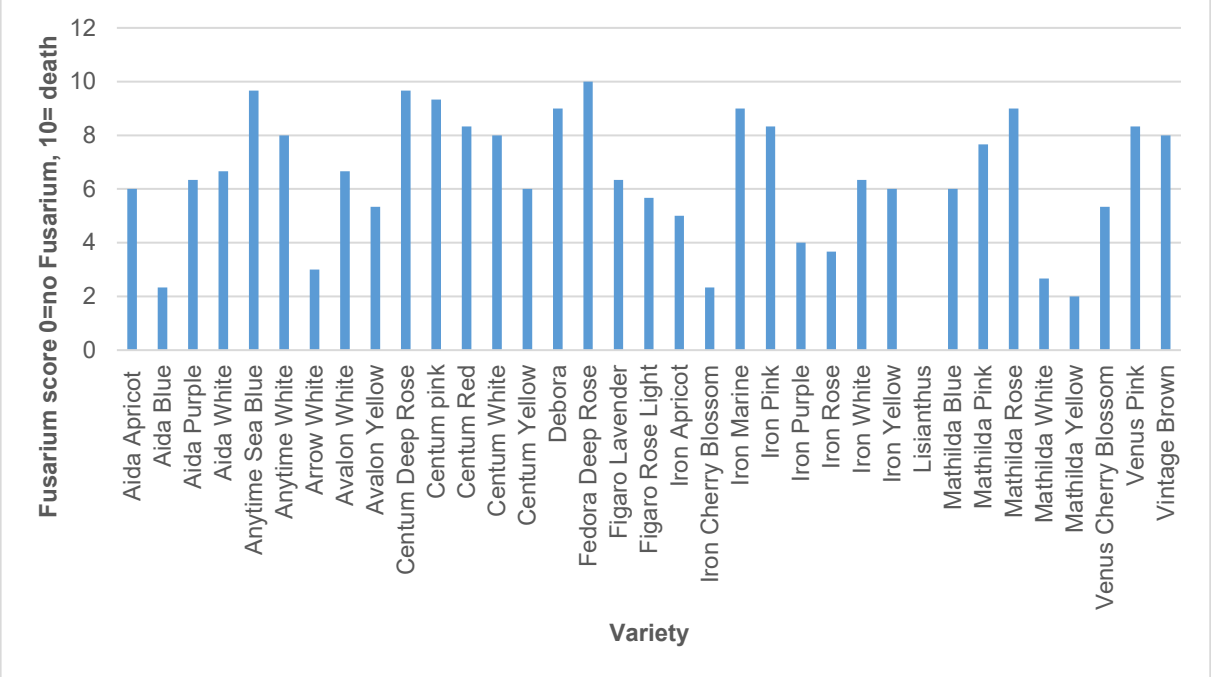
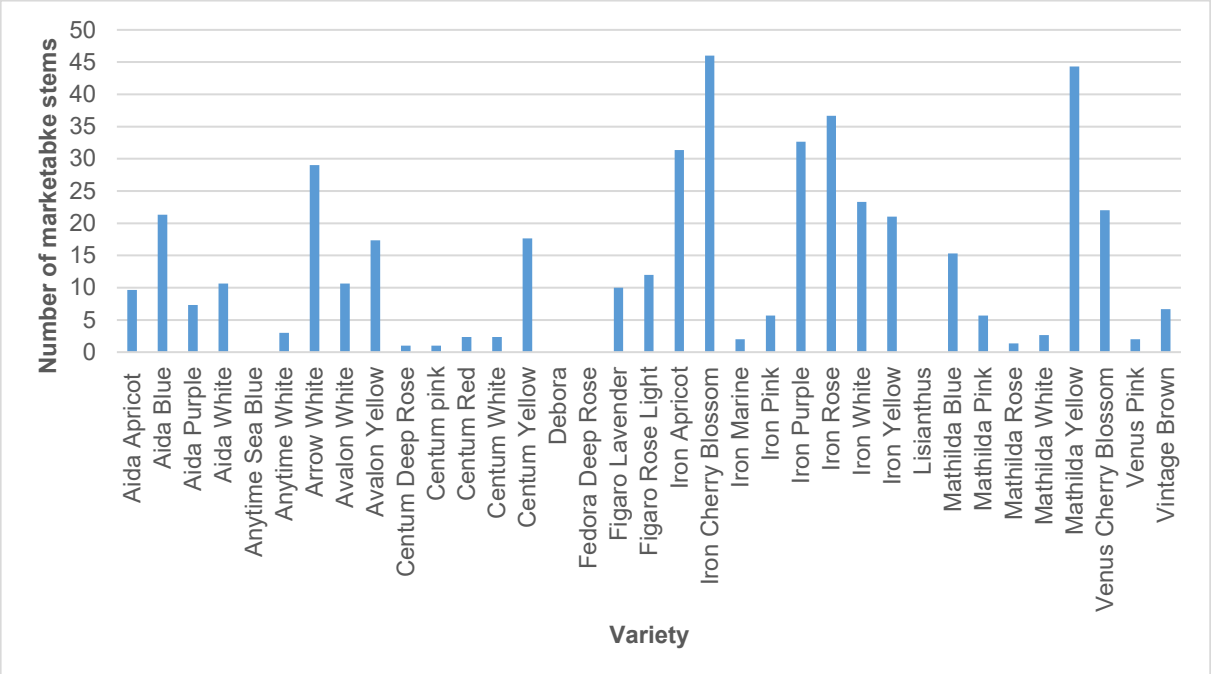


Figure 11. Average marketable stem count from the 1st of July assessment of the column stock Fusarium susceptibility variety trial



Column stocks (Matthiola) - Fusarium T34 trial

A recent AHDB funded trial investigating *Fusarium* on lettuce indicated that T34 Biocontrol (*Trichoderma asperellum* – strain T34, a biopesticide for the control of Fusarium) applied to the peat blocks at seeding gave a degree of control of the disease. In order to assess the potential of T34 to control Fusarium in column stocks, the CFC replicated this technique by direct seeding stocks into peat blocks. T34 was then applied to the blocks at seeding, immediately after planting into the Haygrove tunnel and then again 10 days later at a rate of 1g/10L of water per m^2.

Table 4. Details of 2019 Fusarium T34 trial

Location	Rookery Farm
Varieties	'Debora', 'Fedora' Deep Rose, 'Iron' Blue and Purple
Format(s) and supplier(s)	Seeds from Florensis and Sakata
Propagation and pre-planting treatment(s)	Blocks drenched immediately after seeding with T34 at a rate of 1g in 10L of water per/ m^2 of block area
Planting or sowing date(s)	Blocks sown with 'Iron' Blue and Purple at the beginning of week 15; 'Debora' and 'Fedora' Deep Rose sown at the end of week 16. Planted into the Haygrove tunnel in week 21
Plots	1.5m-long plots
Planting/housing site	Haygrove tunnel
Layout	Replicated trial (Appendix 1)
Plant spacing(s)	64/ m^2
Post-planting treatment(s)	One layer of support netting. Crop drenched at planting and then 10 days later with T34 at a rate of 1g in 10L of water per/ m^2 of bed area
Pests, diseases and disorders	Flea beetle and downy mildew were the main problems observed in 2019
Picking stage(s) and market specification(s)	N/A
Picking and recording date(s)	Fusarium levels assessed in week 28 and week 30
Records taken	Assessment of Fusarium infection score (0 to 10) of 24 stems in the centre of each plot
VL testing	No

Figure 12. Blocks sown and then drenched with T34 in week 15

Figure 13. T34 trial being planted in week 21

Figure 14. T34 treated plot of ‘Fedora’ Deep Rose in week 30

Figure 15. Control plot of ‘Debora’ in week 30

Owing to an issue with seed supply, the ‘Iron’ Blue and Purple were sown 10 days earlier than ‘Debora’ and ‘Fedora’ Deep Rose meaning that when planted in week 21 the ‘Iron’ plants were much larger than the ‘Debora’ and ‘Fedora’ plants. These larger plants (and also perhaps as a result of varietal differences of the ‘Iron’ series) flowered within 6 weeks of planting and did not show any signs of Fusarium infection and hence only the ‘Fedora’ and ‘Debora’ plots were included in the assessments (see Figures 16 and 17). In terms of the disease assessment used, 0 = no symptoms increasing in severity up 10 = complete plant death, where 4 represented the limits of marketability.

Figure 16. Assessment in week 28 of level of Fusarium infection from 24 plants located in the centre of each plot

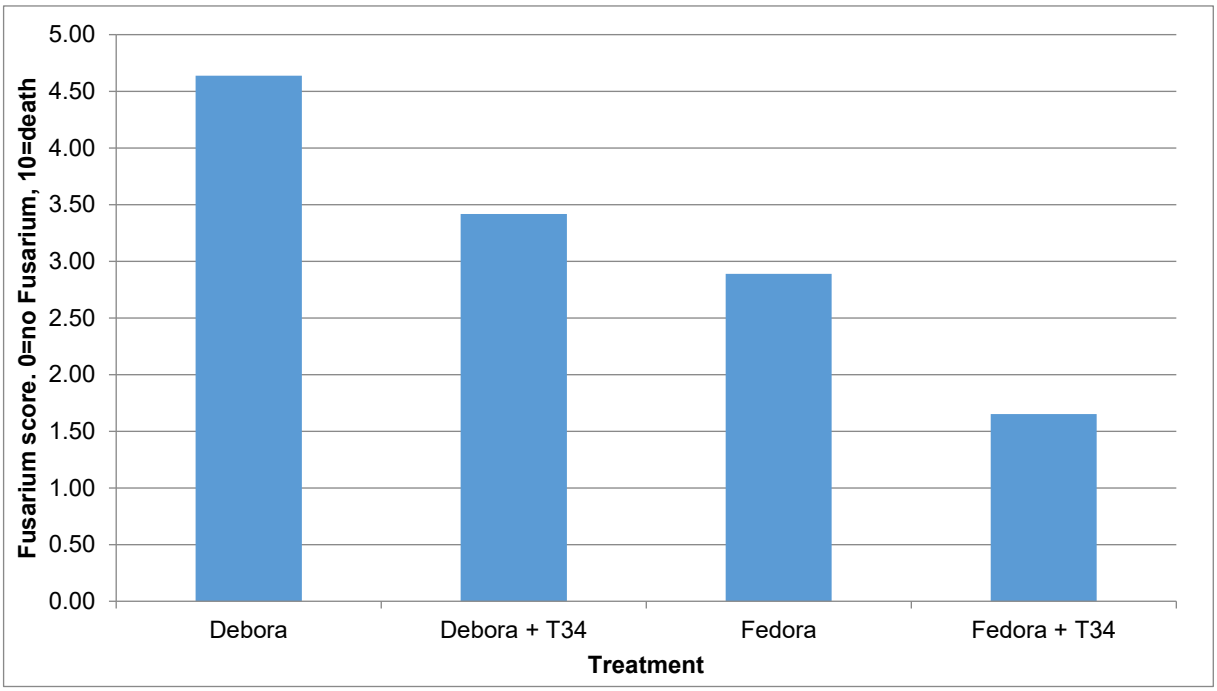
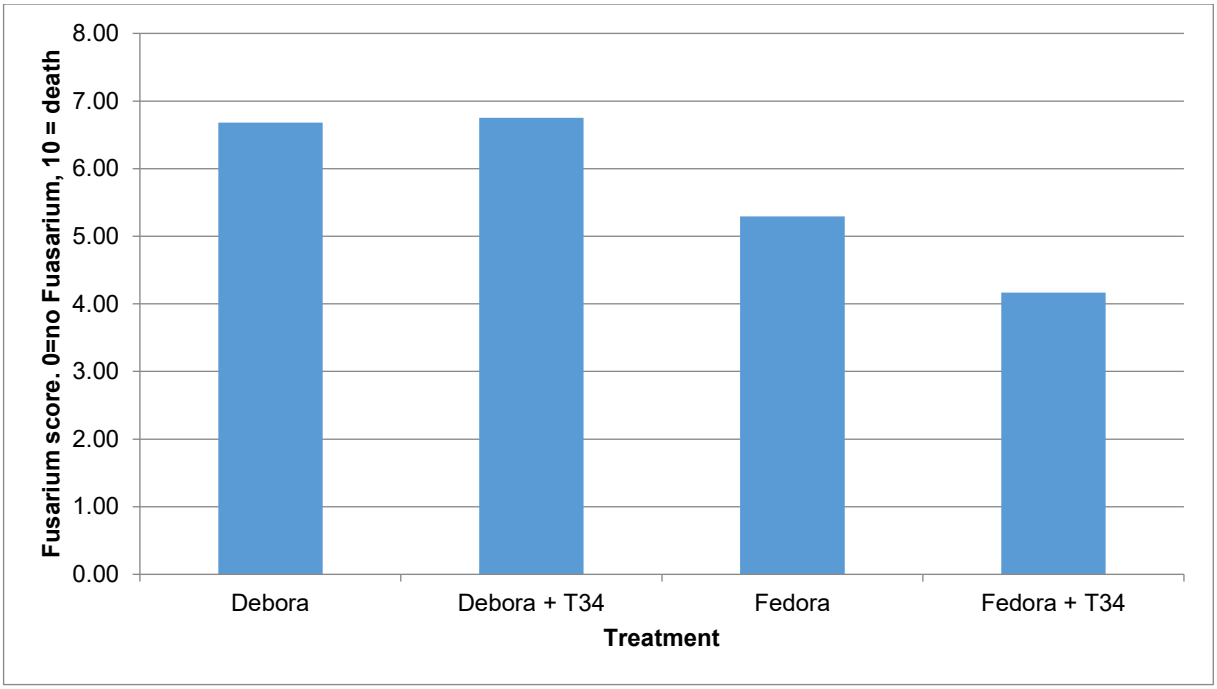


Figure 17. Assessment in week 30 of level of Fusarium infection from 24 plants located in the centre of each plot



While there appeared to be visual differences between the treatment plots (the week 28 assessment), none of the treatments were shown to be statistically significant different.

Column stocks (Matthiola) – Late flowering variety trial

Currently, the main commercially grown column stock varieties are bred by Pan American Seed. In the UK, only double flowered varieties are required, so any single flowering plants are selected out by subjecting the seedlings to a cold period and then removing the darker leaved single flowered plants and gapping up the doubles. This process is automated which makes it cost effective.

There are also a few varieties of column stocks that originate from Japanese breeding programmes. These are reputed to produce stronger and more vigorous stems and it has also been reported that, unlike the current commercially grown varieties, they reliably initiate flowers in hot weather. However, the double flowered seedlings can only be selected manually via subtle differences in leaf shape etc., making the process more expensive and less accurate. In 2018, the CFC was approached by a propagator, with a range of Japanese-

bred varieties, offering a number of trays of hand selected plugs for planting in week 27. The trial compared these with the main commercially grown late planted varieties - ‘Anytime’ and ‘Mathilda. The result of the 2018 trial demonstrated that the late planted Japanese-bred varieties formed flowers and produced a commercially acceptable flower stem length while the ‘Mathilda’ did not initiate any flower buds and the ‘Anytime’ produced short flower stems of variable quality. These positive findings resulted in an industry request for a more extensive trial in 2019 (for full details see Table 5).

Table 5. Details of 2019 Japanese-bred column stock variety trial

Location	Rookery Farm
Varieties	‘Anytime’ Deep Purple, Sea Blue & White; ‘Arrow’ White; ‘Avalon’ White & Yellow; ‘Figaro’ Lavender; ‘Iron’ Apricot, Cherry Blossom, Marine, Pink, Purple, Rose, White & Yellow; ‘Mathilda’ Pink & Yellow; ‘Venus’ Cherry Blossom & Pink and ‘Vintage’ Brown.
Format(s) and supplier(s)	Plugs from Florensis and Global Plants
Propagation and pre-planting treatment(s)	N/A
Planting or sowing date(s)	Plantings made in week 19, 21, 23 and 25
Plots	3m-long plots
Planting/housing site	‘Pro-Tech’ tunnel
Layout	Demonstration plots
Plant spacing(s)	64/m^2
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	Flea beetle and downy mildew were the main problems observed in 2019
Picking stage(s) and market specification(s)	Half of the flowers open
Picking and recording date(s)	Week 19 planting cropped from week 28 onwards Week 21 planting cropped from week 30 onwards Week 23 planting cropped from week 32 onwards Week 25 planting cropped from week 33 onwards
Records taken	Picking date, overall stem length and weight and weight when trimmed to 45cm. Ten stems of each variety from each planting were assessed
VL testing	Samples taken from each planting (see Figure 26)

Figure 18. Overall view of the Japanese-bred column stocks variety trial in week 28

Figure 19. Week 19 planting of Japanese-bred column stocks in flower in week 28

Figure 20. The full range of Japanese-bred column stocks varieties from the week 23 planting, harvested in week 32

Figure 21. 'Vintage Brown', a new colour of column stocks harvested in week 33 from the week 25 planting

Table 6. Average overall flower stem length, overall weight and weight when trimmed of ten random flower stems from the week 19 planting of the column stocks trial

Variety	Overall length (cm)	Overall weight (g)	Trimmed weight (g)*
'Arrow White'	62.2	79.9	39.3
'Avalon White'	61.7	72.8	35.3
'Avalon Yellow'	61.5	80.3	36.3
'Centum Yellow'	46.3	77.1	44.4
'Figaro Lavender'	50.2	95.8	50.3
'Iron Apricot'	55.6	92.2	51.7
'Iron Cherry Blossom'	57.0	91.9	47.5
'Iron Marine'	58.4	82.6	41.0
'Iron Pink'	55.7	77.1	41.9
'Iron Purple'	58.0	72.6	36.2
'Iron Rose'	59.4	71.6	37.1
'Iron White'	56.2	95.1	48.8
'Iron Yellow'	59.0	85.4	43.1
'Mathilda Pink'	56.6	91.1	42.8
'Mathilda Yellow'	46.5	73.5	39.1
'Venus Cherry Blossom'	55.4	80.3	43.0
'Venus Pink'	56.6	87.2	42.5
'Vintage Brown'	54.0	72.1	38.0
Mean	56.1	82.1	42.1
Mean of Japanese-bred varieties	**57.9**	**81.5**	**41.6**
Mean of traditional varieties	**49.9**	**84.4**	**44.2**

*trimmed to 45cm

Figure 22. Average overall stem length and weight when trimmed to 45cm of ten random flower stems harvested from the week 19 planting of the column stocks variety trial

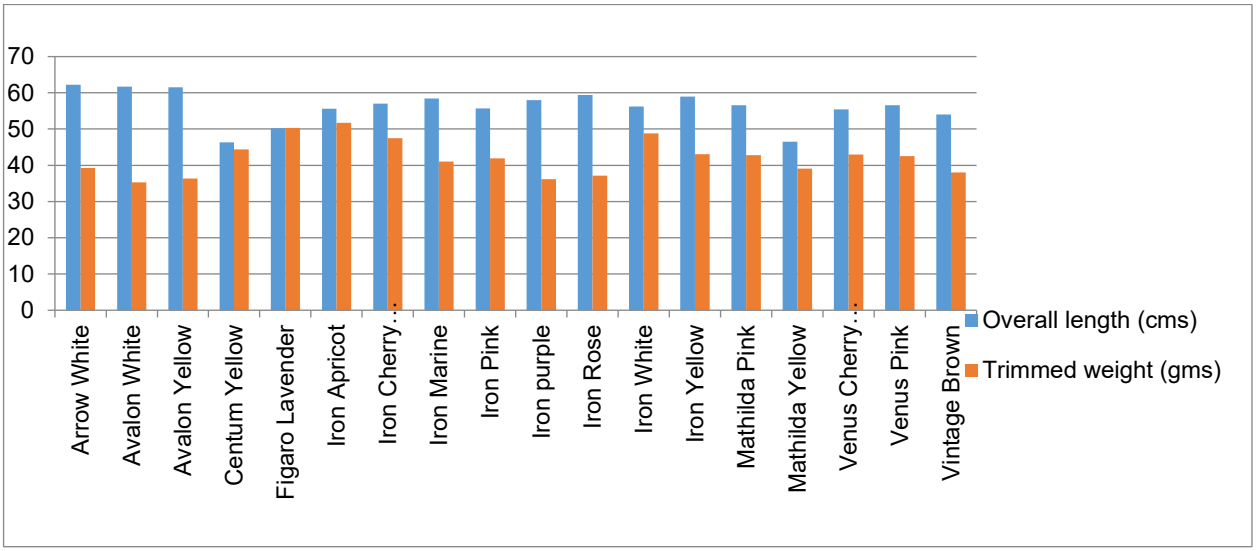


Table 7. Average overall flower stem length, overall weight and weight when trimmed of ten random flower stems from the week 21 planting of the column stocks variety trial

Variety	Overall length (cm)	Overall weight (g)	Trimmed weight (g)*
'Arrow White'	69.9	117.5	55.6
'Avalon White'	70.9	102.1	49.8
'Avalon Yellow'	68.5	112.4	52.6
'Iron Rose Pink'	59.1	74.5	46.9
'Figaro Light Rose'	47.5	92.3	49.7
'Iron Apricot'	58.4	97.5	58.9
'Iron Cherry Blossom'	61.2	100.4	55.8
'Iron Marine'	61.3	94.6	52.0
'Iron Pink'	58.2	69.9	45.4
'Iron Purple'	65.2	89.1	47.9
'Iron Rose'	66.6	108.6	52.8
'Iron White'	59.9	96.8	58.1
'Iron Yellow'	63.5	102.3	58.0
'Iron Deep Pink'	60.5	83.9	51.2
'Mathilda Blue'	52.4	79.3	42.8
'Venus Cherry Blossom'	61.2	100.4	55.8
'Venus Pink'	59.4	99.9	58.8
'Vintage Brown'	58.9	85.7	46.6
Overall Mean	61.3	94.8	52.2
Mean of Japanese-bred varieties	**62.7**	**96.0**	**52.9**
Mean of traditional varieties	**50.0**	**85.8**	**46.3**

*trimmed to 45 cm

Figure 23. Average overall stem length and weight when trimmed to 45cm of ten random flower stems harvested from the week 21 planting of the column stocks variety trial

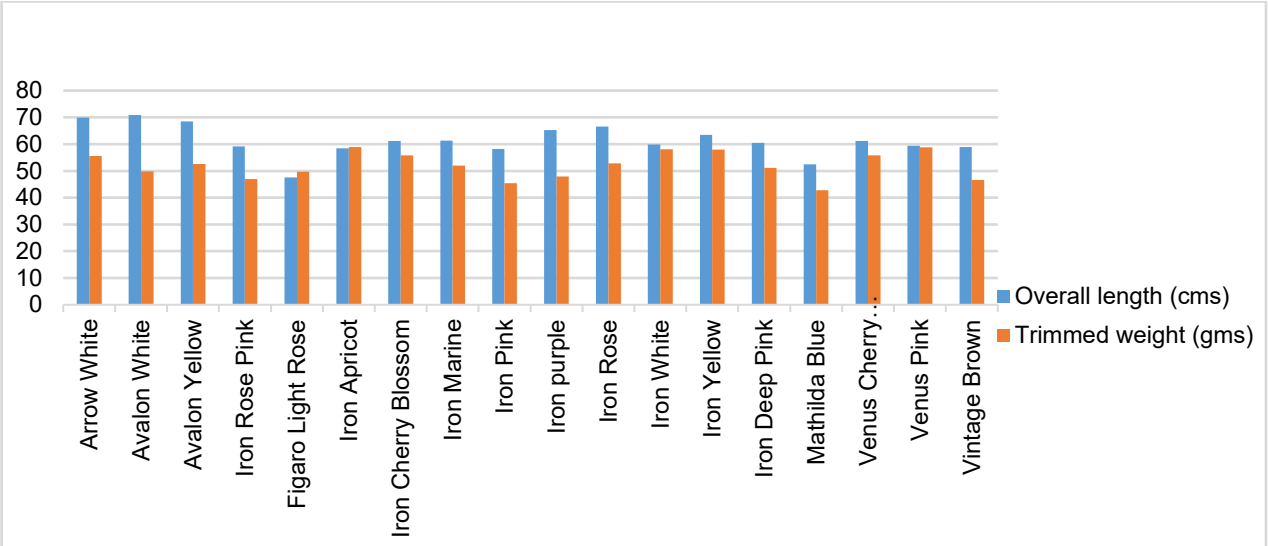


Table 8. Average overall flower stem length, overall weight and weight when trimmed of ten random flower stems from the week 23 planting of the column stocks variety trial

Variety	Overall length (cm)	Overall weight (g)	Trimmed weight (g)*
'Arrow White'	58.6	90.2	45.2
'Avalon White'	58.6	90.2	45.2
'Avalon Yellow'	58.0	83.0	38.2
'Figaro Light Rose'	48.9	93.0	46.8
'Iron Apricot'	52.4	78.6	44.2
'Iron Cherry Blossom'	59.7	95.5	47.3
'Iron Marine'	58.6	89.7	43.4
'Iron Pink'	63.3	101.4	48.2
'Iron purple'	62.0	78.1	39.7
'Iron Rose'	58.6	95.7	49.8
'Iron White'	60.6	78.3	40.3
'Iron Yellow'	60.4	79.3	40.7
'Mathilda Blue'	54.6	86.4	41.2
'Venus Cherry Blossom'	61.3	85.0	45.7
'Venus Pink'	59.1	88.6	46.4
'Vintage Brown'	56.5	84.6	43.3
Overall mean	58.2	87.4	44.1
Mean of Japanese-bred varieties	**59.1**	**87.0**	**44.1**
Mean of traditional varieties	**51.8**	**89.7**	**44.0**

*trimmed to 45 cm

Figure 24. Average overall stem length and weight when trimmed to 45cm of ten random flower stems harvested from the week 23 planting of the column stocks variety trial

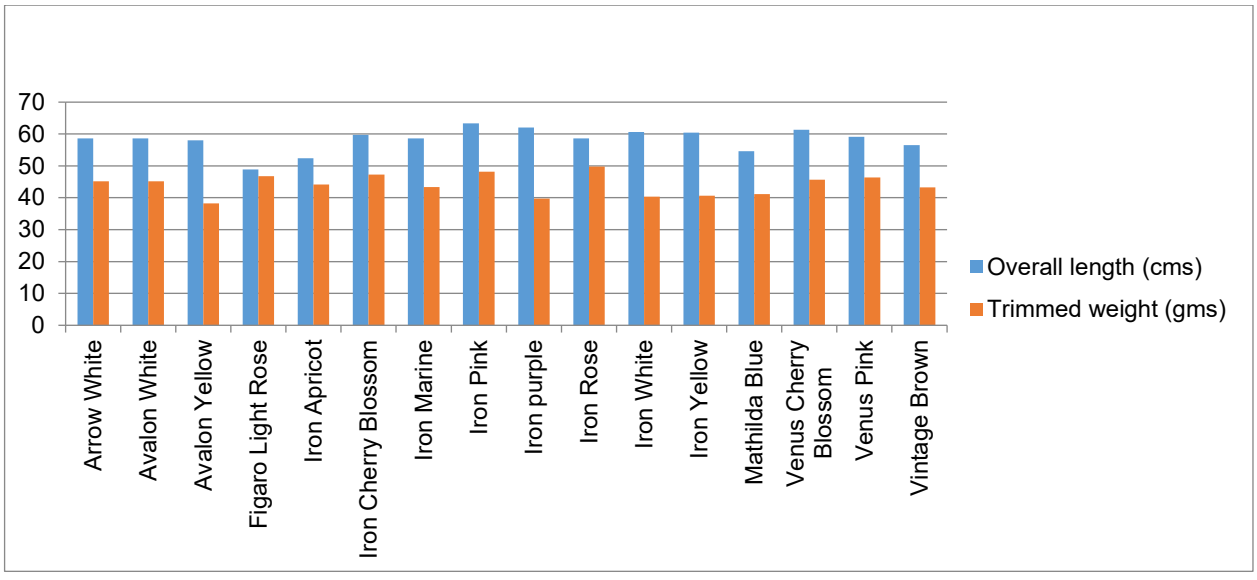
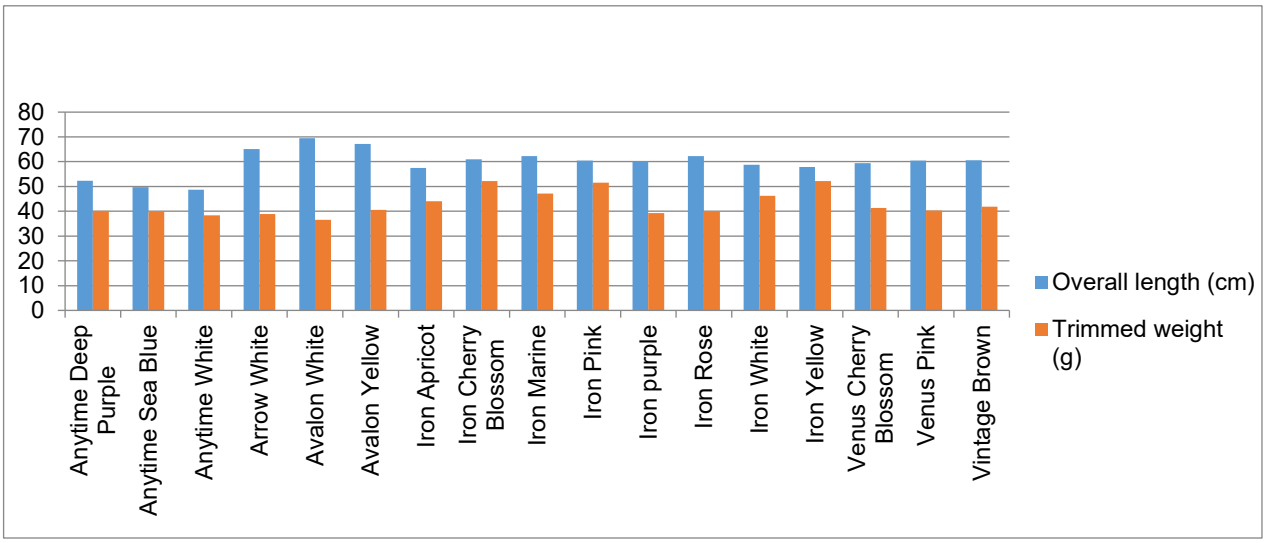


Table 9. Average overall flower stem length, overall weight and weight when trimmed of ten random flower stems from the week 25 planting of the column stocks variety trial

Variety	Overall length (cm)	Overall weight (g)	Trimmed weight (g)*
'Anytime Deep Purple'	52.3	86.6	40.2
'Anytime Sea Blue'	49.7	83.7	40.0
'Anytime White'	48.7	79.3	38.4
'Arrow White'	65.1	81.5	38.9
'Avalon White'	69.5	79.2	36.6
'Avalon Yellow'	67.1	82.3	40.6
'Iron Apricot'	57.5	76.5	44.0
'Iron Cherry Blossom'	61.0	92.2	52.2
'Iron Marine'	62.3	88.2	47.1
'Iron Pink'	60.4	91.7	51.5
'Iron Purple'	60.2	72.3	39.2
'Iron Rose'	62.2	75.2	39.9
'Iron White'	58.8	74.4	46.3
'Iron Yellow'	57.8	86.0	52.2
'Venus Cherry Blossom'	59.4	72.4	41.3
'Venus Pink'	60.4	78.8	40.3
'Vintage Brown'	60.6	91.8	41.8
Mean	59.6	81.9	43.0
Mean of Japanese varieties	**61.6**	**81.6**	**43.7**
Mean of traditional varieties	**50.2**	**83.2**	**39.5**

*trimmed to 45 cm

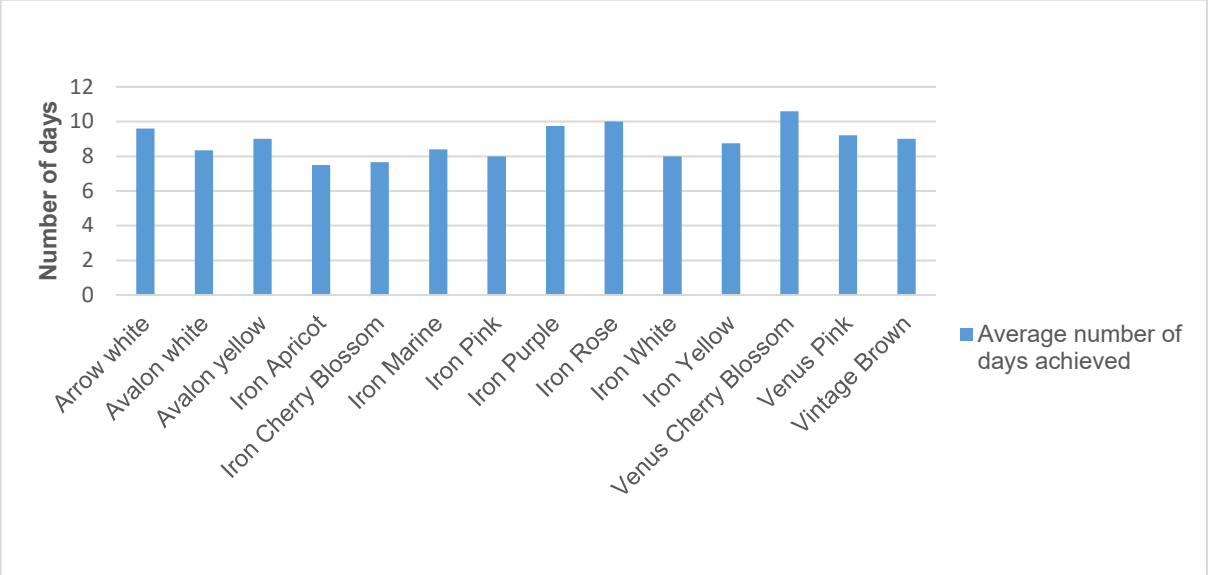
Figure 25. Average overall stem length and weight when trimmed to 45cm of ten random flower stems harvested from the week 25 planting of the column stocks variety trial



Samples were taken of all of the Japanese-bred varieties from all four of the planting dates.

A summary of the average VL results is shown below in Figure 26.

Figure 26. Average VL of the Japanese-bred varieties of column stocks from all four planting dates



All of the varieties exceeded the supermarket minimum VL guarantee of five days.

Didiscus (varieties of *Didiscus caeruleus*)

Didiscus caeruleus, also known as the lace flower, belongs to the Umbelliferae family. Its inclusion in the 2019 trial programme followed on from successful CFC trials of other members of the Umbelliferae family including Ammi and Daucus.

Table 10. Details of 2019 demonstration of Didiscus varieties

Location	Rookery Farm
Varieties	*Didiscus caeruleus* 'Blue Lace', 'Pink Lace' and 'White Lace'
Plant longevity and hardiness	Half-hardy annual
Format(s) and supplier(s)	Seeds supplied by Chiltern Seeds
Propagation and pre-planting treatment(s)	Sown into 104 plugs in week 15 and then transplanted into larger 45 plugs in week 20
Planting or sowing date(s)	Planted in week 23
Plots	3 m-long plots

Planting/housing site	'Pro-Tech' tunnel bay 1
Layout	Demonstration plots
Plant spacing(s)	25 plants/m^2
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	None observed in 2019
Picking stage(s) and market specification(s)	When 30 to 50% of the buds have opened
Picking and recording date(s)	Week 32 onwards
Records taken	Observations
VL testing	Not formally, but anecdotal reports indicate that it achieved a good vase life

Figure 27. Didiscus trials flowering in week 34

Figure 28. A harvested mixed bunch of Didiscus 'Blue Lace', 'White Lace' and 'Pink Lace' in week 34

Didiscus was not easy to propagate and the initial sowing into 104 plugs produced very variable growth. It was therefore necessary to grade the seedlings and pot on into larger 45 plug trays, grading the weaker and stronger plants in separate trays. Once planted out the plugs grew well but there was still evidence of variable vigour right through until flowering. The first marketable stems were produced in week 32 and continued through until week 34.

Didiscus produced attractive large flowers but the untidy nature of the flower stem made it difficult to harvest (Figure 28 shows this more clearly).

Echinacea (varieties of *Echinacea purpurea* and others)

Echinacea was another of the many flowers that performed successfully in the ASCFG trials staged in the USA and elsewhere, and was considered likely to grow well in the UK and to be appreciated as a novel cut flower. Examples were planted as demonstration plots in 2018 and overwintered into 2019 as detailed in Table 11. Note that examples of Rudbeckia, a closely related genus also known as coneflower, have been grown previously at the CFC.

Table 11. Details of 2019 demonstration of Echinacea varieties

Location	Rookery Farm
Varieties	'Green Jewel', 'Marmalade', 'Sombrero Hot Coral', 'Summer Cocktail' and 'Virgin'
Plant longevity and hardiness	Perennials, fully hardy
Format(s) and supplier(s)	9cm liners from various sources
Propagation and pre-planting treatment(s)	N/A
Planting or sowing date(s)	Transplanted week 38 in 2018 and then overwintered into 2019
Plots	1m-long
Planting/housing site	'Pro-Tech' tunnel bay 2
Layout	Demonstration plots
Plant spacing(s)	5/m^2
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	None evident
Picking stage(s) and market specification(s)	When petals starting to show colour
Picking and recording date(s)	Flowering from week 28 onwards
Records taken	Observations
VL testing	Not formally, but anecdotal reports indicate that it achieved a good vase life

Figure 29. Echinacea in demonstration plots planted in week 30; 'Sombrero Hot Coral' (left) and 'Green Jewel' (right)

All of the varieties overwintered well except for 'Green Jewel' which suffered losses of about fifty percent. The first flowering stems were harvested in week 28, with samples being taken by the industry over the next four weeks. There was limited interest in Echinacea as a supermarket product but the trial will be overwintered into 2020 in order to assess VL and yield potential.

Eryngium (varieties of *Eryngium alpinum, planum* and *yuccifolium)*

Eryngium has been investigated by the CFC in the past and following renewed interest from the industry a range of varieties were planted in a demonstration bed in 2019. The trial was planted through a Mypex cover in order to reduce weed pressure.

Table 12. Details of 2019 demonstration of Eryngium varieties

Location	Rookery Farm
Varieties	*Eryngium alpinum* 'Blue Bayou'*; E. planum* 'Magical Blue Falls', 'Magical Blue Lagoon', 'Magical Purple Stars', 'Magical Silver, 'Magical White Falls' and *E. yuccifolium* 'Magical Green Globe'
Plant longevity and hardiness	Fully hardy perennial
Format(s) and supplier(s)	Large plugs from Kolster bv
Propagation and pre-planting treatment(s)	N/A

Planting or sowing date(s)	Planted through Mypex in week 26
Plots	2m-long
Planting/housing site	Outdoor planting
Layout	Demonstration plots
Plant spacing(s)	10/m^2
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	None evident in 2019
Picking stage(s) and market specification(s)	N/A until next year
Picking and recording date(s)	A few flowers from week 42 onwards
Records taken	Observations
VL testing	Not until 2020

Figure 30. Eryngium in demonstration plots planted in week 26 (left) and flowering in week 42 (right)

The plants established well and grew away vigorously but as would be expected in the first year, only a few flowers were produced in 2019. The trial will be overwintered into 2020 to assess the full potential of the crop.

Eucomis (varieties of *Eucomis autumnalis*)

Eucomis had been trialled at the CFC in previous years, but only as a seed-grown crop and with limited success. In 2018 a number of varieties (see Table 13) were purchased as large corms and planted in week 20. Seedlings were also planted in week 26. Both the corm and seed-raised crop were overwintered into 2019.

Table 13. Details of 2019 demonstration of Eucomis varieties

Location	Rookery Farm
Varieties	'Bilcolor', 'Comosa', 'Playa Blanka' and 'Sparkling Burgundy'
Plant longevity and hardiness	Hardy perennial
Format(s) and supplier(s)	Corms from Harts Nursery and seedlings grown from seed obtained from Chiltern Seeds
Propagation and pre-planting treatment(s)	None

Planting or sowing date(s)	Corms planted week 20 of 2018, seeds sown week 16 and planted week 26 of 2018
Plots	Variable depending upon the amount of planting material
Planting or housing site	'Pro-Tech' tunnel bay 2
Layout	Demonstration plots
Plant spacing(s)	9/m^2 for the corms and 25/m^2 for the seedlings
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	None observed in either year
Picking stage(s) and market specification(s)	Various
Picking and recording date(s)	The seedlings did not produce any flower stems during 2019 and the corms only produced a single stem beginning in week 29
Records taken	Observations
VL testing	Not formally, but anecdotal reports indicate that it achieved a good vase life

Figure 31. *E. autumnalis* 'Sparkling Burgundy' in week 34

Figure 32. *E. autumnalis* 'Playa Blanca' in week 34

The seedlings were still very small by the end of 2019 and produced no flowering stems but by contrast, the corms produced very strong and tall stems in week 34, all in excess of 60cm, with the 'Sparkling Burgundy' stems being in excess of 90cm.

Gomphrena (varieties of *Gomphrena haageana*)

Gomphrena is another example of a cut flower produced abroad, but unfamiliar to UK customers. It is an annual/tender perennial plant bearing white, pink, purple or red solitary flower spikes at the stem tips and can be used fresh-cut or dried. Gomphrena was previously grown in demonstration plots at CFC in 2016, but renewed interest from the industry resulted in a further planting in 2019. The 2016 trial demonstrated that *G. globosa* do not produce stems long enough to be marketable, so the 2019 trial only consisted of varieties of *G.haageana*.

Table 14. Details of 2019 demonstration of Gomphrena varieties

Location	Rookery Farm
Varieties	'Carmine', 'Red' and 'Strawberry'
Plant longevity and hardiness	Tender perennials
Format(s) and supplier(s)	Seeds from EconSeeds
Propagation and pre-planting treatment(s)	Sown into plugs weeks 16
Planting or sowing date(s)	Transplanted weeks 23
Plots	2.5-4m plots
Planting/housing site	'Pro-Tech' tunnel
Layout	Demonstration plots
Plant spacing(s)	25/m^2
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	None evident
Picking stage(s) and market specification(s)	Various (best stage yet to be determined)
Picking and recording date(s)	Week 32 onwards
Records taken	Observations and picking dates
VL testing	Samples taken in week 37

Figure 33. *Gomphrena* in full flower in week 34

Figure 34. *G.haageana* 'Carmine' and 'Strawberry' harvested in week 34

The Gomphrena trial started flowering around week 32 and unlike the 2016 trial, where the plants initially produced short stems, the 2019 trial consistently produced flower stems in excess of 50cm long with a VL of 12 days.

***Lepidium* 'Green Dragon'**

Lepidium is a seed-raised filler that is grown in The Netherlands but was unknown to most UK growers. A new variety of Lepidium, 'Green Dragon', was offered to the CFC in 2019 and the trial was planted using both home propagated plugs (seeded at Rookery Farm) and plugs supplied directly by the breeder (Danziger). As the plugs supplied by the breeder were very small (see Figure 35), some were potted on into 45 plug trays before being transplanted. A number of plant spacing densities and planting dates were also investigated.

Table 15. Details of 2019 demonstration of Lepidium ‘Green Dragon’

Location	Rookery Farm
Varieties	‘Green Dragon’
Plant longevity/hardiness	Annual
Format(s) and supplier(s)	Seeds and plugs from Danziger
Propagation and pre-planting treatment(s)	Rookery propagated plugs sown in week 15
Planting or sowing date(s)	First planting transplanted in 23 Second planting transplanted week 25
Plots	3m-long plots
Planting/housing site	‘Pro-Tech’ tunnel
Layout	Demonstration plots
Plant spacing(s)	25/m^2 and 64/m^2
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	Flea beetle was the main problem observed in 2019
Picking stage(s) and market specification(s)	Various (best stage yet to be determined)
Picking and recording date(s)	Week 23 planting cropped from week 30 onwards Week 25 planting cropped from week 33 onwards
Records taken	Observations and picking dates
VL testing	Not formally, but anecdotal reports indicate that it achieved a good vase life

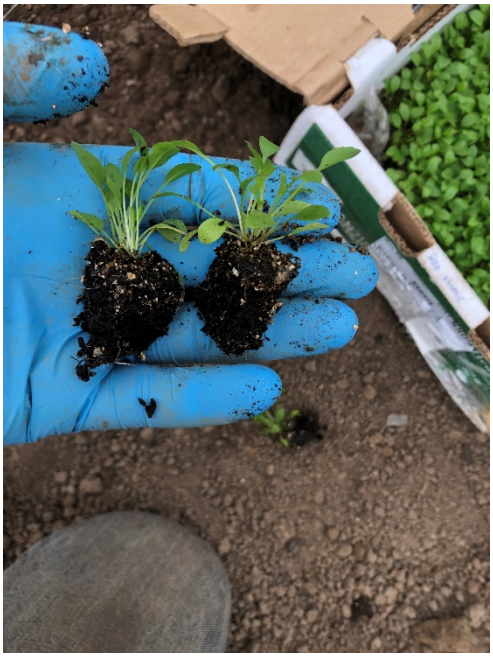


Figure 35. Plug plants direct from the plant breeder in week 25

Figure 36. Plug plants direct from the plant breeder planted in week 25

Figure 37. Lepidium in full crop in week 33

Figure 38. Close up of mature crop in week 34

All plug formats of this crop, including the small plugs supplied directly by the breeder, established well and grew away vigorously. This indicates that the small plugs can be planted directly into the final beds and do not need to be first transplanted into a larger plug. The time from planting to cropping was seven to eight weeks and the flower stem length was consistently between 60 and 70cm. The crop produces a very dense mass of stems and the most cost effective way of harvesting seems to be a single harvest followed by grading on the packhouse grading line. Owing to the profusion of flowering stems, the planting density of 25/m^2 was easier to harvest than the density of 64/m^2.

Lily - alternatives to peat-based growing media

Lily bulbs are generally grown in crates of growing medium in order to avoid any soil-borne pathogens associated with the glasshouse soil. For many years peat was used as the standard growing medium, either alone or mixed with other materials; more recently businesses producing significant quantities of this crop have developed their own bespoke peat-based media (referred to as 'grower's peat-based medium'). Due to environmental concerns over the possible loss of lowland peat bog habitats, there has been a continued search – going back at least to the 1980s - for alternative materials to use as growing media, or at least to use as diluents in peat-based media. In recent years there has been renewed interest from growers and their customers to adopt more responsibly sourced peat-alternatives in the production of cut flower lilies, and this has been an objective of CFC trials. With the increasing availability of green-waste (GW) and anaerobic digestate (AD) these materials have been of particular interest; other more familiar alternative materials included are wood-derived or based on coir.

The use of peat-free and peat-reduced mixes was further investigated during 2019 in the production of lily 'Dynamite' (Oriental group), along with a grower's peat-reduced medium and 100% peat based medium for comparison (Table 16).

Table 16. Details of 2019 alternative growing media trial for lily production in crates

Location	Rookery Farm
Variety	'Dynamite' (Oriental group)
Plant longevity and hardiness	Bulbous perennial, frost-hardy to fully hardy (young growth can be damaged by frost)
Format(s) and supplier(s)	14-16 cm grade bulbs (P Aker Flower bulbs)
Propagation and pre-planting treatments	Planted in standard lily crates using the following media: 1. 'Mix 1' peat 500 L (30% dark peat, 60% light peat and 10% sod peat) + 400 L Forest Gold, 100 L dry AD, 0.4 L wetting agent, 3 kg lime, 0.2 kg Add-N and 0.4 kg base fertiliser 15-10-20+TE/m^3 2. 'Mix 2' 100% peat (30% dark peat, 60% light peat and 10% sod peat), 0.4 L wetting agent, 4.5 kg lime and 1.0 kg base fertiliser 15-10-20+TE/m^3 3. 'Mix 3' 400 L Forest Gold, 300 L Cocopeat, 300 L bark fines, 100 L dry AD, 100 kg clay granules, 1kg lime, 0.2 kg Add-N and 0.4 kg base fertiliser 15-10-20+TE/m^3 4. Grower's peat-based medium (normal quantity volume - 30 L per crate)
Planting or sowing date(s)	Bulbs planted end of week 25
Plots	Five replicate crates per growing medium, arranged in three blocks
Planting/housing site	Crates moved to 'Pro-Tech' tunnel bay 2 at the beginning of week 29
Layout	Replicated trial (Appendix 1)
Plant spacing(s)	15 bulbs/crate
Post-planting treatment(s)	Crates placed in cold-store (9°C) for almost four weeks. Once housed in the tunnel, the liquid feed regime was the same as for the remainder of the tunnels and was applied at each watering
Pests, diseases and disorders	Small amount of virus symptoms evident
Picking stage(s) and market specification(s)	Buds starting to show colour
Picking and recording date(s)	Week 41
Records taken	Total stem length before trimming and stem weight after trimming to 70 cm (on a random sample of 15 stems per replicate), and foliage quality
VL testing	No

The bulbs were planted in week 25 (Figure 39) and then placed in a cold store for just under four weeks before being stood down in the second bay of the multi-span tunnel in week 29 and arranged in three replicates (Figure 40).

Figure 39. Bulbs planted 15 per crate in week 25

Figure 40. Trial stood down in the tunnel in week 29

The crop flowered in week 41 (Figures 41 and 42) and assessments were made on 15 random stems from each treatment in each replicate. The overall stem length was measured and then the stem was cut to 70cm before being weighed. A summary of the results is shown in Figure 43.

Figure 41. Lily trial pre-harvest in week 41

Figure 42. Close up of cropped lilies

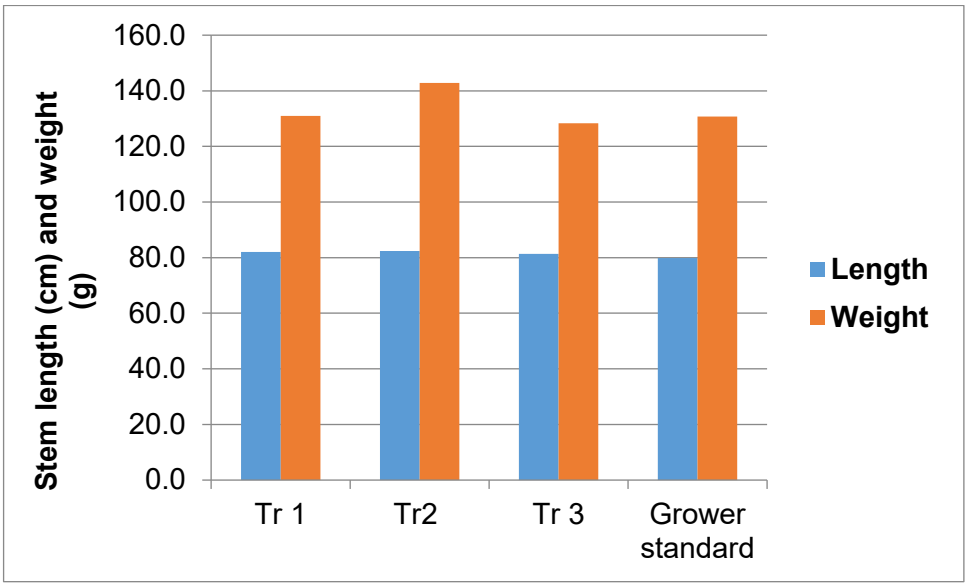


Figure 43. Stem length and trimmed weight of lily 'Dynamite' produced in three growing media blends (Tr 1 – Mix 1 Tr2 – Mix 2 and Tr 3 – Mix 3) and in typical grower's peat-based medium

The peat reduced mix (Mix 1) produced stems with average length of 82.0cm and weight of 131g; the 100% peat mix (Mix 2) produced stems with average length of 82.4cm and weight of 142.8g; the peat free mix (Mix 3) produced stems with an average height of 81.3cm and weight of 128.3g and the standard grower mix produced stems with an average height of

79.8cm and weight of 130.7g. An ANOVA analysis showed that there was no statistical significant difference between the treatment results.

All of the crates of the grower's own mix showed symptoms of leaf chlorosis and necrosis which became more pronounced as the crop matured (see Figures 44 and 45). A leaf tissue analysis indicated that this could have been caused by copper deficiency, but it was not possible to determine why this had occurred.

Figure 44. Gowers standard mix (left) showing paler leaves compared to the trial mixes

Figure 45. Close up of affected leaves from the grower's standard mix

Lysimachia (varieties of *Lysimachia fortunei*)

Cut flower Lysimachia is a new crop to the UK and at the 2017 CFC open day a request was made to investigate it because of its similarity to Veronica which was also included in the 2017 and 2018 trials. During 2018 two varieties 'Jumbo' and 'Mambo' were planted in week 21 at a density of 25/m^2. The crop was cut down in week 41 of 2018 and overwintered into 2019.

Table 17. Details of 2019 demonstration of Lysimachia varieties

Location	Rookery Farm
Varieties	'Jumbo' and 'Mambo'
Plant longevity and hardiness	Perennial, fully hardy
Format(s) and supplier(s)	Rooted cuttings in plugs from Armada
Propagation and pre-planting treatment(s)	None
Planting or sowing date(s)	Planted week 21 of 2018 (and overwintered to 2019)
Plots	4m-long
Planting or housing site	'Pro-Tech' tunnel bay 2
Layout	Demonstration plots
Plant spacing(s)	25/m^2
Post-planting treatment(s)	One layer of support netting. Plants pinched three weeks after planting
Pests, diseases and disorders	Mainly two-spotted spider mite evident in 2018, hence a prophylactic spray programme was applied in 2019. In 2018 'Mambo' also suffered from chlorotic and nectrotic patches but while still evident, this was minimal in 2019
Picking stage(s) and market specification(s)	About 50% of flowers open. A small trial investigating the removal of the lead bloom was also undertaken in 2019
Picking and recording date(s)	The first flowers were picked in week 26 and continued to produce flowers until week 35
Records taken	Observations
VL testing	Samples tested in week 35

The crop died back completely over winter and new shoots began to appear in week 14, with the first flower stems being ready to harvest in week 26, most achieving or exceeding 60cm in length. The trial continued to flower for a further seven weeks and this was extended to week 35 by the removal of the centre bud (see Figure 45). The centre bud can be removed at a very advanced stage of development allowing the side shoots to develop. The resulting final flower stem was in excess of 80cm long and produced a very bulky product with up to ten buds per stem. Such a large stem is unlikely to be suitable for supermarkets but could possibly achieve a premium price as a florist product. VL tests undertaken on the standard stems (which had not been disbudded) demonstrated a VL of 10 to 11 days.

Figure 44. Overview of the overall trial (left) and harvested stems of *Lysimachia* ‘Jumbo’ (right)

Figure 45. *Lysimachia* ‘Jumbo’ after removal of the centre bud (left), and (right) a single stem two weeks after disbudding

The trial was cut down to soil level in week 40 and the crop will be overwintered for one more year into 2020.

Phytotoxicity testing of recently approved pesticides

Through a process of trials and where appropriate, applications for EAMU's, the AHDB Sceptre and SceptrePlus projects have provided a range of additional pesticide options to growers. However, these products are used at growers own risk, with limited knowledge of potential phytotoxicity issues. In order to try and address this, the CFC has developed a new trial to investigate the potential phytotoxicity of pesticides recently approved through the AHDB Sceptre and SceptrePlus projects that are applicable for cut flower use. In 2019, the fungicide Frupica SC (mepanipyrim) gained an EAMU (1107/19) for the control of powdery mildew on ornamentals. A number of cut flower crops are susceptible to powdery mildew including Delphinium, Phlox, Solidago and Veronica. Varieties from these were planted in two blocks, one block receiving a spray programme comprising of Amistar (azoxystrobin), Frupica SC (mepanipyrim), Nimrod (buprimate) and Takumi SC (cyflufenamid) and the other block receiving the same programme but without Frupica SC. Frupica SC was applied at the rate stated on the EAMU 90ml/100L of water at a volume rate of 1,000L per ha (Appendix 2).

Table 18. Details of 2019 pesticide phytotoxicity assessment trial

Location	Rookery Farm	
Varieties	*Delphinum elatum* 'Guardian Blue', *Phlox paniculata* 'Magical PassionZ' and 'Magical SnowdropZ', *Solidago* 'Angels Glory' and 'Solar Glory', *Veronica longifolia* 'Skyler' Pink and White	
Plant longevity/hardiness	Various hardy perennials	
Format(s) and supplier(s)	Plugs from Florensis and Kolster	
Propagation and pre-planting treatment(s)	Week Number	Fungicide application to the blocks of plants
	26	Amistar + potassium bicarbonate
	27	Takumi SC + potassium bicarbonate
	27	Frupica SC*
	28	Amistar + potassium bicarbonate

	29	Frupica SC*
	31	Takumi SC + potassium bicarbonate
	32	Nimrod
	33	Frupica SC*
	34	Takumi SC + potassium bicarbonate
	35	Nimrod
	*Applied to one block only. Note Frupica applied three times in this experiment to specifically test for potential phytotoxicity. EAMU states that Frupica can only be applied a maximum of twice per crop (Appendix 2)
Planting or sowing date(s)	Planted in week 26
Plots	1m-long plots of each variety
Planting/housing site	'Pro-Tech' tunnel
Layout	Demonstration plots
Plant spacing(s)	25/m^2
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	Only a small amount of powdery mildew present on the block not treated with Frupica SC
Picking stage(s) and market specification(s)	N/A
Picking and recording date(s)	Ongoing phytotoxicity observations (0-10) with a final assessment made in week 36
Records taken	Phytotoxicity observations
VL testing	No

Figure 44. Phytotoxicity trial planted in week 26 (right bed)

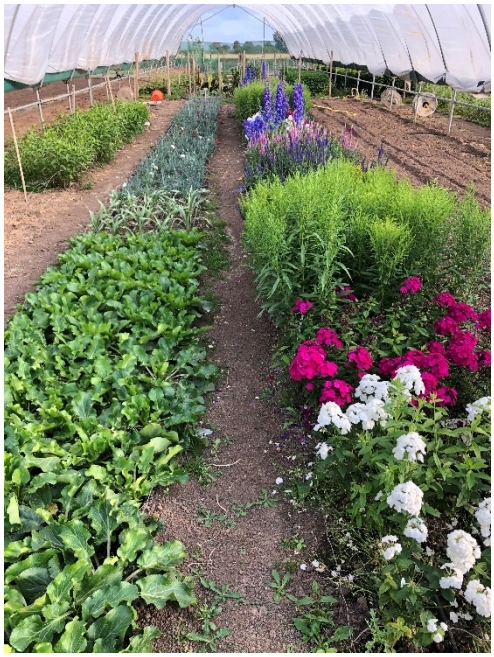


Figure 45. Same view of the trial in week 34

Figure 46. Phytotoxicity final assessment of Solidago in week 36

Figure 47. Phytotoxicity final assessment of Phlox in week 36

Observations were made throughout the life of the crop with a final assessment and photographs in week 36. No signs of phytotoxicity were present on any variety in either block. The only observable difference was the presence of low levels of powdery mildew in the block not treated with Frupica SC (possibly a result of three less fungicide applications).

Scabious (varieties of *Scabiosa atropurpurea*)

Scabious are well-known as vigorous garden plants with prolific, attractive flowers in a wide range of colours with the perennial forms already grown as outdoor cut flowers. In recent years, new ranges of *S. atropurpurea* have been introduced to the market with the 'Scoop' series generating the most interest from the industry over the last three years of CFC trials. New and improved varieties continue to be introduced, leading to the 2019 trials concentrating on a new range called 'Focal Scoop' which claim to have the advantage of longer stems and larger flowers. Some of the best performing varieties from the previous year's trials were also included in 2019. Other propagators of Scabious were invited to provide their varieties for trial, but declined to be involved.

Trials in previous years have indicated that an early planting date produces a more prolific crop because it allows the plant to establish a sturdy frame and good root structure before being put under stress during warmer weather conditions. With this in mind, in order to maximise their potential, the plugs were potted into 9cm pots in week 11, pinched four weeks later and the well branched plants transferred to the tunnel in week 20. Not all of the 'Focal' range were available for early planting and some were not delivered until week 23 (see Table 19 for full details).

Table 19. Details of 2019 demonstration of Scabious varieties

Location	Rookery Farm
Varieties	'Scoop' series - 'Blackberry', 'Candy', 'Focal Bicolour Pink', 'Focal Hot Pink', 'Focal Lilac', 'Focal Purple', 'Focal Purple Lace', 'Lavender Hoop Scoop', 'Lollipop', 'Milky', 'Red Velvet', 'Soft' and 'Tutti Frutti'.
Plant longevity and hardiness	*S. atropurpurea:* biennial or short-lived perennial, fully hardy

	Some other Scabious are annuals or biennials and some are frost-hardy
Format(s) and supplier(s)	Plugs from Danziger
Propagation and pre-planting treatment(s)	Potted into 9cm pots in week 11 and pinched in week 15
Planting or sowing date(s)	Transplanted to tunnel week 20, 'Focal Hot Pink', 'Focal Lilac' and 'Focal Purple Lace' planted directly into the tunnel from plugs in week 23
Plots	3 m-long
Planting/housing site	'Pro-Tech' tunnel bay 1
Layout	Demonstration plots
Plant spacing(s)	8/m^2 in two rows along bed
Post-planting treatment(s)	One layer of support netting. The Focal varieties planted in week 23 were pinched in week 26
Pests, diseases and disorders	No P&D issues in 2019
Picking stage(s) and market specification(s)	When first whorl of petals opens
Picking and recording date(s)	First flowers from week 27 onwards for the week 20 planting and week 32 for the week 23 planting
Records taken	Observations
VL testing	Sample taken in week 28 from 'Candy', 'Focal Bicolour Pink', 'Focal Purple', 'Lavender Hoop Scoop' 'Lollipop', and Tutti Frutti'; and further samples of 'Focal Bicolour Pink' and 'Focal Purple' taken in week 37

Figure 44. Scabious ‘Scoop’ varieties in demonstration plots 2019 (various dates). Top left; pinched, well branched plant in 9cm pot ready for planting, top right; first planting in week 20, middle left ‘Focal Bicolour Pink’, middle right ‘Focal Purple’, bottom left ‘Focal Purple Lace’ and bottom right ‘Tutti Frutti’

The plants produced in 9cm pots established well and produced a very heavy flush throughout the very warm weather in July. At the end of July (week 31) a decision was made to cut down half of each bed to around six inches from the ground in order to rejuvenate the crop and see if the flowering period could be extended. The half of the bed that was not cut down continued to flower until the crop was removed in week 41. The half that was cut down started to flower again in week 36 and produced stronger and more vigorous stems than the area that had not

been cut down. Some commercial glasshouse crops grown in 2019 continued to flower from July to December which was a six month harvesting period.

The week 23 plantings of ‘Focal Scoop’ produced weaker, shorter stems with smaller flowers than the earlier planted crops.

Figure 45. Left ‘Lollipop’ showing the area cut back in week 31 and right the same area after growth in week 36

Samples of the CFC tunnel-grown ‘Scoop’ stems for standard VL testing in 2019 included ‘Candy’, ‘Focal Bicolour Pink’, ‘Focal Purple’, ‘Lavender Hoop Scoop’ ‘Lollipop’, and ‘Tutti Frutti’. All varieties remained in acceptable condition during VL testing for between ten and 12 days, with no obvious differences between varieties.

Veronica (varieties of *Veronica longifolia*)

In 2018, a new range of Veronica was trialled (the ‘Skyler’ series), available as blue, white and pink flowered varieties. The trial demonstrated that when tunnel grown, a combination of different planting and pinching dates could achieve a three month flowering period. It is likely that this period could be extended further if the crop was grown in a glasshouse.

The 2018 planting was overwintered to assess its second year performance along with disbudding trials aimed at producing a heavier and more floriferous stem. In order to facilitate more air movement around the plant, the density was reduced from 25/m^2 to 12/m^2 by removing every other plant within each plot.

Table 20. Details of 2019 demonstration of Veronica varieties

Location	Rookery Farm
Varieties	'Skyler Blue', 'Skyler Pink' and 'Skyler White'
Plant longevity and hardiness	Like many other Veronicas, *V. longifolia* is perennial and fully hardy
Format(s) and supplier(s)	Rooted cuttings in plugs from Danziger
Propagation and pre-planting treatment(s)	None
Planting or sowing date(s)	Transplanted week 18 and 25 of 2018
Plots	2 m-long plots
Planting/housing site	'Pro-Tech' tunnel bay
Layout	Demonstration plots
Plant spacing(s)	25/m^2 reduced to 12/m^2 in 2019
Post-planting treatment(s)	N/A
Pests, diseases and disorders	Small amount of powdery mildew and whitefly evident, but both kept under control by an appropriate spray programme
Picking stage(s) and market specification(s)	With a maximum of 30 to 50% of florets open
Picking and recording date(s)	First flush from week 24 and a second flush from week 35
Records taken	Observations
VL testing	Samples of disbudded flower stems tested in week 37

The first flush of flowers was ready to harvest from week 24 and produced good quality, long and strong flowers stems in excess of 80cm. However, a number of the flowers showed a level of distortion, which resembled fasciation, caused by abnormal growth (see Figure 46 and 47) which would have resulted in over 50% of the crop being unmarketable. The cause of this abnormal growth was not clear but the problem did seem to also be evident on a wide range of garden Veronica during 2019.

Figure 46. Fasciation in ‘Skyler’ White

Figure 47. Fasciation in ‘Skyler’ Pink

The second flush of flowers was produced from week 35 onwards and showed no signs of the fasciation that was evident in the first flush. Following a suggestion from a packer member of the Management Group, the centre bud was removed from a number of stems (see figure 48) which successfully resulted in a longer, stronger flower stem with between four and six blooms. This was considered to be a better quality product for use in mixed bouquets and the technique will be trialled further after the crop is overwintered for a final year into 2020.Initial tests on the disbudded stems demonstrated a VL of between 11 and 12 days. More extensive tests will be undertaken in 2020.

Figure 48. Removal of the lead bud of 'Skyler Pink' in week 36

Figure 49. The same multi headed flower stem two weeks later

Discussion

Asclepias (varieties of *Asclepias curassavica* and others)

From the last two years trials, Asclepias does seem to have potential as a UK grown cut flower, but because of the VL, stem length and bud abortion issues experienced at certain times, it is not likely to be reliable enough to be used as supermarket product with further development work.

Astrantia (varieties of *Astrantia major*)

The 2019 trial demonstrated that this is a crop that once established produces a long flush of good quality stems with a long VL. Astrantia is a product that is generating a lot of interest among industry and is in demand by both the packers and end consumers. Growers would need to investigate the economics of production, but Astrantia does seem to have the potential to be developed as both a protected and outdoor new UK produced cut flower crop.

Column stock (Matthiola) – Fusarium susceptibility variety trial

The 2019 trial clearly demonstrated that there are large differences in the susceptibility of column stock varieties towards *Fusarium oxysporum.* Some of the older varieties are already known to be very susceptible (e.g. 'Centum Red' 'Debora' and 'Fedora Deep Rose') and this was confirmed in the 2019 trial. The 'Mathilda' series and the new Japanese-bred varieties expressed large differences in susceptibility between flower colours. Examples of this include 'Iron Marine' that produced only two marketable flower stems/m^2, whereas 'Iron Cherry Blossom' produced 46 marketable flower stems/m^2. Such differences were also evident in the 'Mathilda' series, the pink producing two marketable stems/m^2 whereas the yellow produced 45 marketable flower stems/m^2.

The results from this trial highlighted the less susceptible varieties which can be planted in situations where the crop will be under more disease pressure, such as from soils with a history of Fusarium disease, or in later plantings, where the crop will experience higher temperatures and therefore stress levels during production.

Column stocks (Matthiola) - Fusarium T34 trial

Visually the T34 treatment appeared to achieve some level of Fusarium control. However, statistical analysis showed that these differences were not significant as there were large variations between the scores within treatments. These differences were a result of planting non-selected seedlings, and as observed previously, the single flowered plants show a high degree of resilience to Fusarium, whereas many of the double flowered plants are susceptible. The trial planned for 2020 will address this issue by using only selected plants which will be produced and drenched with T34 in commercial sized plugs at the Florensis propagation nursery in The Netherlands.

It is however, interesting to note that the differences between the two varieties ('Debora' and 'Fedora') were statistically significant and this backs up previous commercial observations which have noted that while both of these varieties are prone to 'Fusarium', 'Debora' tends to be much more susceptible than 'Fedora'.

Due to the high level of Fusarium and weed population in the Haygrove tunnel, it is proposed to sterilise the soil in the tunnel with a low rate application of Basamid (dazomet) in the spring of 2020, to reduce (but not eliminate) the Fusarium inoculum present to levels that will enable more subtle differences in infection to be observed.

Column stock (Matthiola) – Late planted variety trial

In 2019, the four plantings made in weeks 18, 20, 22 and 24 demonstrated that the Japanese-bred varieties can produce a continuity of long flower stems. However, discussions with growers have highlighted that unless a reliable market outlet can be found for the single flowered stems, hence allowing the varieties to be grown as an unselected crop, the cost of hand selection would currently mean that the production of Japanese-bred varieties is not economically viable. It should be noted that a major Dutch propagator is currently investigating the possibility of mechanical selection of these varieties and the CFC will undertake appropriate additional trials if this proves successful.

Didiscus (varieties of *Didiscus caeruleus*)

Didiscus was included in the 2019 trials because it belongs to the same family as Ammi, Anethum and Daucus, all of which have proven successful in previous CFC trials. While the trial did generate a marketable crop, Didiscus was not easy to propagate or harvest, resulting in both uneven growth and untidy flower stems. This means that it is probably more a florist product because it would be difficult to cost effectively grade the flower stems into a consistent product required by the supermarkets.

Echinacea (varieties of *Echinacea purpurea* and others)

Most of the varieties overwintered successfully except for ‘Green Jewel’ which suffered 50% losses. Overall the trial generated marketable flowers, however the stage of harvest is difficult to determine and requires further work to ascertain. The crop will therefore be overwintered for one more year and trials which will concentrate on the ideal stage of harvesting and subsequent VL performance.

Eryngium (varieties of *Eryngium alpinum, planum* and *yuccifolium)*

Eryngium is widely used in mixed bouquets sold in the UK, however the large majority of the stems are imported, indicating that there is potential for import substitution. Product from the material planted in 2019 will be used to provide samples for UK packers as well as VL tests.

Eucomis (varieties of *Eucomis autumnalis*)

In 2019 the Eucomis seedlings were still too small to produce any flower stems whereas the corms produced strong, long flower stems. However, each corm only produced one flower stem, meaning that the price per stem required to make this crop economic would rule out its use as supermarket product (both as an annual and perennial crop). It does however, have potential for small scale production as a specialist crop producing a high value florist product. The trial will be overwintered for one final year into 2020.

Gomphrena (varieties of *Gomphrena haageana*)

The planting undertaken in 2019 produced a crop that was very prolific, with a good stem length and acceptable VL, receiving positive feedback from the industry. The speed and cost of harvesting is a potential issue, but the crop would lend itself to multiple sowing dates with the possibility of a single once-over harvest and this will be investigated in 2020.

***Lepidium* 'Green Dragon'**

The 2019 trial demonstrated that Lepidium is relatively easy to produce, but because of the dense and tangled nature of the mature crop it needs to be harvested once over and then graded by passing it over a packing line. Currently the main interest in this crop is from florist outlets, but it does have the potential for use as a filler in supermarket mixed bouquets.

Lily - alternatives to peat-based growing media

In conjunction with Bulrush Horticulture Ltd, the CFC continues to investigate a range of alternative growing media that can either replace or reduce the amount of peat used in growing media mixes for lily blooms produced in crates. The 2019 mixes demonstrated that

peat-free and peat-reduced mixes are capable of producing flower stems that are comparable to 100% peat and growers own lily media.

Lysimachia (varieties of Lysimachia fortunei)

While Lysimachia is not widely known among UK grower, the CFC trials have demonstrated that it can be successfully produced as a single flush perennial crop. The product did not generate much interest from the packers and supermarkets, but it was thought to have a good potential as a florist product. This is especially true of the disbudded stems that produced a very heavy and floriferous product that should command a premium price. The varieties used in this trial are no longer commercially available, but others are still available including 'Abraham', 'Elisabeth' and 'Helene'. Specialist growers could consider the production of small areas of Lysimachia (including disbudded product) for floral display work.

Phytotoxicity testing of recently approved pesticides

Three applications of Frupica SC (mepanipyrim) were made within a wider spray programme to plots of Delphinium, Phlox, Solidago and Veronica, all of which are powdery mildew susceptible. The powdery mildew spray programme was maintained up until harvest and no phytotoxicity was observed at any stage of production on any of the subjects. This would indicate that Frupica SC is a safe product to use on cut flowers when applied at the rate specified in the EAMU, but owing to the wide range of species produced and the various growing conditions provided, growers should always test Frupica SC on a small number of plants before applying it on a larger scale.

Scabious (varieties of *Scabiosa atropurpurea*)

Four years of trialling at the CFC and on growers' holdings have shown that the new varieties of Scabious (especially the 'Scoop' series) have good market potential, but there are issues with the production economics for supermarket sales. The positive attributes of the crop include a unique flower form, vibrant colours, high yield and a consistently good VL. However, the growth habit of the crop means that harvesting costs are an issue, and unless this is reflected in the final stem price, the large scale production of Scabious will not be

economically viable. At the current time, the crop is only being grown on a small scale by growers that are supplying premium markets (e.g. mail order) or direct sales to the public.

No further trials on Scabious are planned, unless the ongoing breeding work develops new varieties that have attributes that justify planting demonstration plots. A technical note summarising the CFC trials on this plant subject will be produced in 2020.

Veronica (varieties of *Veronica longifolia*)

The CFC trials and limited commercial plantings of Veronica have demonstrated that the crop has the potential for UK outdoor and protected production. However, Veronica is very prone to powdery mildew, necessitating an intensive spray programme throughout the life of the crop in order to keep the foliage clean. The high level of fasciation seen on the first flush in 2019 is a cause of concern and this will be monitored during 2020. The disbudding trials have demonstrated that Veronica can be transformed from a relatively lightweight product to a heavier, longer and more floriferous stem which has much more potential as a filler for mixed bunches.

Knowledge and Technology Transfer

Website

The CFC website (***www.thecutflowercentre.co.uk***) includes a weekly blog during the production season keeping the industry up to date about developments and trials at Rookery Farm. The website also carries news of events, notifications of handouts and reports.

Events

The CFC open days have consistently attracted 80–100 delegates and continue to be the only national event attended by a large proportion of UK cut flower industry including associated members of the retail sector. The event in 2018 was staged on 17th July 2019.

Publications

CFC/AHDB Information Sheet 11 '*Maintaining successful control of downy mildew in protected crops of cut flower column stocks*'.

Glossary

Fasciation - also known as cresting, is a relatively rare condition of abnormal growth in vascular plants in which the apical meristem (growing tip), which normally is concentrated around a single point and produces approximately cylindrical tissue, instead becomes elongated perpendicularly to the direction of growth, thus producing flattened, ribbon-like, crested (or 'cristate'), or elaborately contorted, tissue.

References

CFC/AHDB Information Sheet 11 '*Maintaining successful control of downy mildew in protected crops of cut flower column stocks'*.

Appendices

Appendix 1 – Trial layouts (for replicated/analysed trials)

Column stocks – Fusarium susceptibility trial

Variety Trial Rep 1	Variety Trial Rep 2	Variety Trial Rep 3
Iron Apricot	Anytime White	Mathilda Blue
Venus Cherry Blossom	Iron Purple	Aida Purple
Centum White	Centum Pink	Arrow White
Centum Red	Iron Marine	Aida Apricot
Iron Cherry Blossom	Figaro Lavender	Centum Yellow
Debora	Vintage Brown	Avalon White
Iron Rose	Mathilda Pink	Mathilda White
Anytime White	Lisianthus	Iron Purple
Venus Pink	Centum Deep Rose	Avalon Yellow
Mathilda Rose	Debora	Aida White
Aida Blue	Aida Apricot	Iron Yellow
Mathilda Blue	Avalon Yellow	Mathilda Pink
Iron White	Fedora Deep Rose	Iron Pink
Aida Apricot	Figaro Rose Light	Anytime Sea Blue
Centum Deep Rose	Centum Red	Iron Cherry Blossom
Aida Purple	Venus Cherry Blossom	Centum Pink
Fedora Deep Rose	Iron White	Mathilda Yellow
Figaro Rose Light	Iron Yellow	Lisianthus
Mathilda White	Mathilda Blue	Centum Deep Rose
Arrow White	Centum White	Debora
Centum Pink	Iron Rose	Venus Pink
Vintage Brown	Avalon White	Venus Cherry Blossom
Mathilda Pink	Iron Cherry Blossom	Fedora Deep Rose
Centum Yellow	Aida Blue	Iron Marine
Anytime Sea Blue	Iron Apricot	Figaro Rose Light
Aida White	Mathilda White	Mathilda Rose
Figaro Lavender	Iron Pink	Anytime White
Avalon White	Aida White	Iron White
Iron Marine	Mathilda Yellow	Iron Rose
Iron Pink	Anytime Sea Blue	Vintage Brown
Mathilda Yellow	Venus Pink	Aida Blue
Iron Yellow	Arrow White	Iron Apricot
Lisianthus	Mathilda Rose	Figaro Lavender
Iron Purple	Centum Yellow	Centum White
Avalon Yellow	Aida Purple	Centum Red

Columns stocks – T34 Fusarium trial

Iron Blue
Iron Blue plus T34
Debora plus T34
Iron Purple
Fedora
Debora
Fedora plus T34
Iron Purple plus T34
Iron Blue plus T34
Debora
Iron Blue
Iron Purple plus T34
Fedora plus T34
Fedora
Iron Purple
Debora plus T34
Iron Blue
Iron Blue plus T34
Debora plus T34
Iron Purple plus T34
Debora
Fedora
Iron Purple
Fedora plus T34

Lily - alternatives to peat-based growing media

Rep 3	Bulrush Mix 2
	Bulrush Mix 1
	Growers Own Mix
	Bulrush Mix 3

Rep 2	Bulrush Mix 1
	Bulrush Mix 3
	Growers Own Mix
	Bulrush Mix 2
Rep 1	Bulrush Mix 3
	Growers Own Mix
	Bulrush Mix 2
	Bulrush Mix 1

Appendix 2 – Extract from Extension for Authorisation for a Minor Use of a Plant Protection Product (EAMU) Frupica SC (mepanipyrim) 1294/2019

Field of use: **ONLY AS A FUNGICIDE**

User: Professional

Crops/situations:	Maximum individual dose: (litres product / ha)	Maximum total dose:	Maximum number of treatments: (per crop)	Latest time of application:
Protected and outdoor ornamental plant production	0.9	-	2	-

