Project title:	The National Cut-flower Trials Centre Programme for 2018 - 2022
Project number:	PO/BOF 002b
Project leader:	Lyndon Mason (Director, The Cut Flower Centre Ltd)
Report:	Annual Report (2018)
Previous report:	None
Key staff:	Lyndon Mason (Director, The Cut Flower Centre Ltd) David Robinson (Director, R Robinson & Son Ltd)
Location of project:	R Robinson & Son Ltd Rookery Farm Joys Bank Holbeach St John, Holbeach, Spalding Lincolnshire PE12 8SG Commercial nurseries as cited in the text
Industry Representative:	Mark Eves PS & JE Ward Ltd Belmount Nursery Roman Bank Terrington St Clement, King's Lynn Norfolk PE34 4HN

Date project commenced:	01 January 2018
Date project completed (or expected completion date):	28 February 2023

DISCLAIMER

While the Agriculture and Horticulture Development Board seeks to ensure that the information contained within this document is accurate at the time of printing, no warranty is given in respect thereof and, to the maximum extent permitted by law the Agriculture and Horticulture Development Board accepts no liability for loss, damage or injury howsoever caused (including that caused by negligence) or suffered directly or indirectly in relation to information and opinions contained in or omitted from this document.

[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.

[Name] Lyndon Mason

[Position] Project Leader and Director

[Organisation] The Cut Flower Centre Ltd

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

CONTENTS

GROWER SUMMARY

Headline

- A new strain of downy mildew was a serious issue on column stock crops grown in 2018, and ultimately work facilitated by the CFC, culminated in the production of a technical note (CFC/AHDB Information Sheet 11 *Maintaining successful control of downy mildew in protected crops of cut flower column stocks*) outlining future management strategies for the disease.
- Herbicide trials on direct seeded, outdoor Larkspur have identified a new product, HDC H23, to have potential in future programmes, once the herbicide has obtained the relevant approval.
- *Ammi visnaga* and *A. majus* and *Daucus carota*, (ornamental carrot) are in demand, are relatively easy to grow, and should be considered a potential new crop for the UK.
- Asclepias varieties are novel and attractive cut flowers with potential for the UK, but the vase life (VL) needs to be verified with additional trials in 2019.
- New varieties of the 'Scoop' series of Scabious show good market potential, however there is a need to consider the cost and method of harvesting to determine the viability of production in the UK.
- The use of different planting and pinching dates was successful in achieving a better continuity of Veronica, but was not successful with all flower colours.

Background

The UK traditionally has a relatively low *per capita* consumption of cut flowers compared with other western European countries, however between 1988 and 2016 imports of cut flowers rose from some £122 m to about £750 m. This increase in consumer spending, combined with the advent of relatively cheap 'Spanish tunnels', to protect crops during production, and environmental demands to cut 'air-miles', should have provided UK cut flower growers with

opportunities to expand production. That this did not happen is generally ascribed to a lack of 'know-how' and a culture of buying-in from 'across the water'. (However, Brexit may provide greater opportunities for UK growers such as impacting changes in the sterling exchange rate against both the Dollar and Euro).

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 information on new product development, novel or alternative cut flowers for production outdoors or in 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 year included: ongoing trials examining Fusarium control in column stocks production in conjunction with Warwick University, evaluation of new herbicide products for field-grown crops and reactive trials examining current important industry issues. During 2018 the latter enabled the CFC to quickly investigate the downy mildew outbreak in column stocks, commission sensitivity testing by Fera and recommend a revised spray programme to address the issue of poor control on some nurseries.

Summary

Ammi majus and *A. visnaga*

Seed raised fillers have been of interest to the industry for a few years now and some such as Bupluerum are now grown commercially. However both *Ammi majus* and *A. visnaga* have so far only been adopted by smaller scale 'artisan growers'. The 2018 trial examined continuity of supply with plantings occurring from week 20 through to week 32. As a general observation *A. majus* took six to seven weeks to flower while *A. visnaga* took eight to nine

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

weeks. The 2018 trial clearly demonstrated that continuity can be achieved by sequential planting and that good stem length is possible (except on the week 32 planting). Previous trials have also shown that Ammi can be produced outdoors with adequate irrigation and that outdoor crops tended to be more compact and less vigorous, but still produced a marketable stem. Of the two species, *A. visnaga* perhaps has the most potential because the stems are easier to harvest (*A. majus* tends to produce a mass of heads that tangle into each other) and the end product is more compact and manageable. VL tests, on Ammi species in previous trials, found a long (over 10 days) VL with both. Unless the CFC receives any specific request, 2018 will be the last year that Ammi will be trialled, although it is still planned to investigate other fillers from the Umbelliferae family such as Didiscus, Pastinaca and Smyrnium, which will be planted in 2019.

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

Asclepias is not a commercial crop in the UK, but it is an attractive flower and is grown as a cut flower elsewhere in the world. Grown in a tunnel, the most promising variety in 2018 was *Asclepias curassavica* 'Apollo Orange' which produced prolific and attractive, orange-red inflorescences on long stems over a period of about four weeks. While only two plantings were made in 2018, it would appear that continuity of flowering can be achieved by successive planting dates as the week 20 planting started to flower in week 29 and the week 26 planting started to flower in week 35. Other varieties trialled did not appear suitable owing to either stem length issues, flower bud abortion or problems with the flower quality. Visually, the product has obvious potential, although in both the 2017 and 2018 trials VL was an issue owing to problems with water uptake, and this requires further investigation on the overwintered crop in 2019.

Astrantia major

Astrantia was planted for the first time in 2018 at the CFC with a trial of a new series – 'Sparkling Star' series. The plants will hopefully produce a cut flower crop in 2019 when vase life and market potential will be assessed.

Column stock – late planted variety trial

There has been industry interest in the Japanese varieties of cut flower column stocks for some time now but there has been very little commercial uptake owing to issues of not being able to select the double flowered seedlings by machine, as is the case with the current widely grown commercial varieties. The double flowered seedlings cannot be selected by leaf colour after a period of cooling, selection currently has to be done based on slight variations in leaf shape and other subtle differences, by a trained expert. Even then, attaining an 85% level of selection is deemed to be an achievement. The hand selection process and the higher than normal percentage of singles make these an expensive crop to produce and there has to a significant commercial advantage in their production.

One such advantage could be the ability to extend the season of the flowering crop into the summer months when it has been reported that the Japanese varieties are less prone to flower initiation problems at higher temperatures. To investigate this further, a range of Japanese varieties including 'Arrow', 'Avalon', 'Cheerful', 'Iron', 'Noble' and 'Venus' along with the traditional varieties of 'Anytime' and 'Mathilda' were planted in week 29. The 2018 season, with long periods of temperatures in excess of 30°C, tested the varieties and showed that while there were issues with flowering, most of the Japanese varieties did initiate a bud and started flowering in week 36. The 'Mathilda' series initiated no flowers at all and the more resilient 'Anytime' series showed erratic initiation with very few marketable stems.

Unfortunately despite initiating flowers, a number of the flowers spikes on the Japanese varieties were either distorted or too short leading to only 15 to 25% of stems being marketable. Those that did reach a marketable state produced very strong flower stems, in

excess of 60 cm in length, which generated sufficient confidence to investigate them further in 2019. It is proposed that four plantings will be made in weeks 18, 20, 22 and 24 to determine how they perform in less challenging conditions, when the temperature should not be as extreme as those experienced by the 2018 trial, to see if a premium priced product can be generated.

Daucus carota

Small plots of *Daucus carota* 'Dara' have been planted and grown at the CFC in previous years. Only a small number of stems were produced from these earlier trials but they did generate some industry interest. In order to try and determine the true commercial potential of Daucus, plugs were sourced from Florensis in 2018 and a number of successional plantings were made from week 20 to week 32. Similar to the *Ammi majus* trial, the crop took about six to seven weeks from planting to flower and the week 32 planting produced stems that were too short to be marketable. The trial generated interest both at the CFC Open Day and also through samples taken by, or sent to, the industry throughout the season.

One of the potential disadvantages of the crop as a supermarket product could be the wide range of flower head colours and sizes produced which would make it difficult to meet a specific specification. However, if this could be overcome by perhaps using Daucus in a more flexible bouquet specification, it could have real potential as a new product for UK growers. It is already widely grown and used by 'artisan growers'. The crop appears as if it can be harvested at a wide range of maturities, but post-harvest work would need to be undertaken to determine the optimum maturity stage to maximise VL.

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

Echinacea is not known as a commercial cut flower crop in the UK, but it makes a colourful cut flower, offered in other countries. A large variety trial 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 for assessment in 2019.

Eucomis autumnalis

Eucomis was planted at the CFC in previous years using plants grown from seed and propagated on site. However, the seedlings failed to make a marketable crop before the tunnel had to be cleared. As the crop had previously been identified as having potential as a cut flower, a new trial was planted in 2018 using both (large) corms, planted in week 20 and home propagated seedlings planted in week 26. During 2018, only a percentage of the corms produced a flower stem (starting in week 29) with the seedlings growing very slowly and only producing a small plant by the end of the season. While not enough stems were produced to assess the crops' true market potential, some of the flowers were used in floral displays such as at Leeds Castle, Kent and anecdotal reports indicated a good vase life. Further assessments will be made in 2019.

Lysimachia fortunei

While Lysimachia is not currently grown commercially in the UK, there are a number of cut flower varieties listed on the Dutch auction, including 'Abraham', 'Elisabeth', 'Jumbo', 'Mambo', 'Marilyn' and 'Martha'. The Lysimachia trial was requested by growers who viewed the previous CFC Veronica trial in 2017, owing to the similarity of their flower forms. Of the two varieties supplied to the CFC in 2018 (and planted in week 21), 'Jumbo' performed the best, as 'Mambo' suffered from severe chlorosis and necrosis of the leaves. The reason for this problem remains unidentified and it is not known if other varieties would show a similar problem if grown in the same soil type.

The long, strong stems which started flowering in week 31, generated industry interest, especially for use in floral displays, but there was a query about whether the curved nature of the flower stem would be suited for use in supermarket bouquets, although this was one of its attributes most loved by the floral designers who used samples of the CFC product. Other varieties such as 'Marilyn' may produce straighter flower stems. The performance of the

second year crop will be assessed in 2019 and additional VL work will be undertaken.

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

Scabious are mainly known in the UK as herbaceous perennial plants. In 2016, the CFC was offered a range of new varieties from Danziger (the 'Scoop' series) and HilverdaKooji. Both series had an attractive range of flower colours, high yields and good VL, and were well received by the industry, having good potential for use by retailers in mixed bouquets. In 2018, the Scoop series was examined again owing to the fact that a large number of new varieties had been introduced. Some of these new introductions were well received by the industry especially 'Red Velvet' which has a vibrant coloured bloom held on strong and long stems. The trial was planted in week 18 and the first flowers were harvested in week 28. The crop then flushed very heavily through the very hot period at the end of July and into August. However, the hot weather seemed to 'exhaust' the plants and by mid-August only a small number of weak stems were being generated and this was mirrored by other trial crops in the UK and also commercial crops in the Netherlands. A decision was therefore taken to cut back half of each bed with some varieties being cut back to the ground and others cut back to about 50 cm. By mid-September the varieties that were cut back to 50 cm were producing a second strong flush of flowers but those that were cut back to the ground took a further two weeks to regenerate. (Note it was not necessary to cut back the plants in trials staged in 2016 and 2017 which did not have to endure same temperatures).

As with previous years, the cost of harvesting was an issue, but in 2018 it was decided to harvest at 50 or 55 cm stem length and leave the side shoots as part of the stem. This served to both speed up the cost of harvest and also produced a bulkier bunch of flowers. It had been decided that 2018 would be the final year that Scabious would be trialled, but towards the end of the season one of the CFC management group members, who also hosted trials, received requests from local packers (whom had been importing stems from the Netherlands) to investigate the crop further during 2019. As a consequence, a range of varieties from both

Danziger and HilverdaKoji will be planted in 2019 along with parallel trials on growers nurseries.

Veronica longifolia

The ‘Spark’ series of Veronica featured in earlier trials, but at the time its lightweight stems and restricted production window made it unlikely to be economic to grow in the UK. Following renewed interest in this crop (and fillers in general), plots of the new ‘Skyler’ series were trialled in 2016. When grown in a tunnel, flowering was prolific, with straight stems and well coloured flowers, and overwintered plants produced two flushes the following year. However, because the window of production was still relatively short it was recognised that seasonal extension would need to be investigated (via scheduling and plant pinching) to gain the interest of growers. The 2018 trial showed that with the ‘Skyler’ series, both different planting dates and pinching dates were successful in extending the season of the pink and white flowered varieties, but for the blue flowered variety only the planting date had any effect. At this stage it is not known if the blue flowered varieties of other Veronica series behave in the same way as the ‘Skyler’ series. The 2018 crop will be overwintered in order to both provide samples for the industry and to undertake further VL tests, because even though there is anecdotal evidence that samples taken by the industry in 2018 had a good vase life, no data was obtained via a recognised VL facility. It is not anticipated that any new plantings of Veronica will be undertaken by the CFC.

The new five year CFC project has allocated an annual percentage of the overall funds to enable work to be undertaken on important current industry issues. In 2018 these funds were used to address issues concerning downy mildew control on column stocks (*Matthiola incana*) and enabled the problem to be actioned quickly. Column stocks are currently the main non-bulb, protected UK cut flower crop with around 18 million stems being grown in 2018. Downy mildew (*Peronospora parasitica)* has always been a disease associated with column stocks but was generally prevented or easily controlled by a regular spray programme using a few

fungicides, including products that contain metalaxyl-M. However, in early 2018 crops grown in the Netherlands suffered from a very severe infection of the disease which was not controlled by standard spray programmes. In mid-May, problems with disease control were reported on UK column stock crops, with a number of larger businesses reporting problems over the same weekend. Despite adoption of the usual range of fungicide products, growers found that the disease was causing severe crop damage with infections appearing almost overnight. Even a reduction in the spray interval did not appear to control the disease.

With the help of the CFC and an independent industry consultant, growers then radically modified their spray programmes in terms of introducing new fungicide active ingredients and also reducing the interval between spray applications. Even these measures did not totally eliminate the problem, and many businesses found that they had some level of crop infection right to the end of the 2018 season. It was clear that this was a new highly aggressive strain of downy mildew and that further investigation was required.

After a CFC organised meeting at the end of June, it was agreed by the industry that a number of fungicides should be subjected to sensitivity testing using a number of different isolates of downy mildew gathered from different nurseries. Samples were collected from a total of five nurseries, one in Northern Ireland, one in Cornwall, two in Norfolk and one in Lincolnshire, representing a wide geographic spread within the UK. The samples were inoculated by Fera onto fresh column stocks seedlings to build up inoculum before undertaking the sensitivity testing.

The results of the sensitivity testing showed that at the fungicide rates used, none of the products applied gave 100% control of all five downy mildew isolates. The greatest level of control was achieved from the application of Paraat (dimethomorph), where 90% control or greater was achieved for three of the five isolates. Percos (ametoctradin + dimethomorph) was the second most effective product with greater than 80% control achieved for three of the five isolates. In the case of both fungicides it was the isolates collected from Ireland and

Norfolk which showed most ‘tolerance’. The only other product to give any significant level of control was Revus (mandipropamid), where greater than 70% control was achieved for three of the five isolates. Very limited control was achieved following the application of HDC F253, Signum (boscalid + pyraclostrobin) and Subdue (metalaxyl-M).

Products containing metalaxyl-M would normally be expected to give very good control of downy mildew pathogens. The lack of any control by Subdue, and only partial control by Fubol Gold (mancozeb + metalaxyl-M), suggests that all five isolates were tolerant/resistant to metalaxyl-M. The improved level of control achieved by Fubol Gold was assumed to be a result of mancozeb in the formulation.

The results of these trials have been used to produce a detailed technical note entitled CFC/AHDB Information Sheet 11 ‘*Maintaining successful control of downy mildew in protected crops of cut flower column stocks’*. This can be downloaded from either the CFC or AHDB websites.

Column stocks - improving control of Fusarium wilt

Column stocks are a mainstay of glasshouse cut flower production in the UK. In 2017, as part of a new AHDB funded project on *Fusarium oxysporum* control in horticultural crops, an area sufficiently infested with *F. oxysporum* was needed as an experimental site for trials and was set up at the CFC in the tunnel previously used for column stocks trials. The soil was infected with *F. oxysporum* f. sp. *mathioli* culture and one day later the tunnel was planted with plug-plants of a range of column stocks varieties, together with Lisianthus and Brassica plants, included for checking the host-specificity of the Fusarium culture. The 2017 trial demonstrated that the soil in the tunnel had an apparently even spread of pathogenic fungus throughout it.

In 2018, a fully replicated variety trial was planted in the tunnel using most of the currently available commercial column stocks varieties grown in the UK as well as a few plots of Lisianthus. The purpose of the trial was to update the previous data obtained from a similar

trial undertaken at J A Collison & Sons in 2015 by including varieties introduced since that date, such as ‘Mathilda’. However, the trial was late planted (in order to try and tie in the results with the CFC August Open Day), which meant that the plants were exposed to the heat wave experienced during July and August. The result of this was that plants in most of the plots expressed a severe level of Fusarium within three to four weeks of planting and it was therefore not possible to identify any subtle differences in Fusarium susceptibility between the different varieties. Despite this, the trial did serve to demonstrate the species specificity of Fusarium, not a single Lisianthus plant succumbed to Fusarium despite the massive disease pressure that was present in the trial.

Herbicides for outdoor Larkspur

In conjunction with ADAS, a fully replicated trial was undertaken to investigate nine different herbicide combinations on a direct seeded crop of outdoor larkspur sown in week 22. Assessments were made throughout the growing period of the crop.

Although emergence of the Larkspur across the trial was variable, it was possible to identify some differences between the treatments. In terms of crop emergence, HDC H23 pre-sowing followed by Defy (prosulfocarb) 4 L/ha post-sowing gave the highest number of germinated seedlings per 1.5 m row, and also had the lowest weed cover (8.3%), which suggests that this is a promising treatment.

HDC H23 pre-sowing, followed by Defy 3 L/ha (T3), Dual Gold (s-metolachlor) 0.78 L/ha + Gamit 36 CS (clomazone) 0.25 L/ha and Stomp Aqua (pendimethalin) 2 L/ha + Gamit 36 CS 0.25 L/ha also gave reasonable weed control, and crop emergence was similar to the untreated control, which suggests that these treatments may also be suited to Larkspur production. The lowest emergence rate was seen in plots treated with Stomp 2 L/ha + Defy 4 L/ha, and this reflects the results from the previous trial in 2015.

Stomp Aqua 1.5 L/ha + Gamit 36 CS 0.15 L/ha did not give particularly good weed control at this lower rate, and neither did metobromuron, although crop emergence was not reduced. It is likely that metobromuron would need to be mixed with another herbicide product in order to achieve sufficient levels of weed control.

Lily - alternatives to peat-based growing media

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

The 2018 trial continued this work, investigating a 30% peat-reduced mix and a peat-free mix as well as a reduced volume per crate of a standard grower mix. Statistically, in terms of stem weight and length there was no difference between any of the mixes trialled in 2018. However, visually there was a large difference between the peat-free mix when compared to the other mixes as regards leaf size and colour, with the peat-free mix producing both smaller and paler leaves to the extent that the crop would have been unmarketable. Clearly more work is needed on the formulation or the nutritional needs of the crop when using such a mix.

Zinnia and Dahlia (vase life improvements)

Applications of the high calcium water soluble fertiliser Calmax during production had no effect on stem strength and vase life of Zinnia and no impact on vase life of Dahlia.

Financial Benefits

This is the first 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. More so as it is the first year of the trial none of the new products

examined will yet be in production so it is not possible to give a financial value for this aspect of the project in 2018.

The main financial benefit to the industry from the 2018 CFC project has been from the work on downy mildew in column stocks. While it is impossible to put an exact figure on the savings, it is known that in the Netherlands many hundreds of thousands of stems of column stocks were lost as a result of the disease. The UK grows about 18 million stems of column stocks annually which at an average of 24 p per stem makes a total industry value of around £4.3 m. If as a conservative estimate, the CFC project reduced crop losses by 10% this would represent a saving of £430,000 in 2018 alone. As an example, one grower initially found the problem in a glasshouse containing 600,000 plug plants, and taking into account the speed of infection, there was concern that without the necessary amendment to the spray programme at least 50% of the crop would have been lost, resulting in a loss of around £72,000 in that glasshouse alone.

The potential new herbicide programmes identified by the 2018 Larkspur herbicide trials will ultimately represent a financial gain to the growers in terms of labour saving, but this cannot be realised until HDC H23 obtains the relevant approval.

Action Points

The following should be considered within future crop planning:

- Production of Asclepias, Lysimachia, Scabious and Veronica could be suitable novel, niche ventures for UK cut flower growers.
- *Ammi visnaga, A. majus*, *Daucus carota* 'Dara' (ornamental carrot) are potentially economic, direct-drilled fillers for production in polythene tunnels or outside.
- 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 + aerobic 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 debate and developments regarding the use of peat-free and peat-reduced growing media.

- Column stock growers should be aware of the threat of the new strain of downy mildew, and obtain a copy of the recent AHDB / CFC Information Sheet 11 *Maintaining successful control of downy mildew in protected crops of cut flower column stocks*.
- Larkspur growers should consider how the various herbicide programmes examined in the 2018 trial can be applied to their own individual business and keep up to date with the progress of the coded product HDC H23.

SCIENCE SECTION

Introduction

Defra statistics show there has been a huge increase in imports of cut flowers since the 1990s, despite all the economic difficulties experienced during the period. From 1988 to 2013 cut flower imports (excluding those from the Channel Islands) to the UK rose from £122 m to £663 m *p.a*., and again to £750 m *p.a.* by 2016 (Defra Basic Horticultural Statistics 2014; Defra Horticultural Statistics 2017). Over the same period total UK cut flower exports and re-exports rose from £6 m to £26 m and then £29 m.

Despite the opportunities for UK growers for import substitution, cut flower production in the UK has not responded. The value of UK grown cut flowers has remained static at around £50 m *p.a.*, the bulk made up of glasshouse crops (including forced bulbs) and field-grown daffodil, with around £5-10 m *p.a.* of other outdoor cut flower crops. The area of 'other bulbs and flowers' (excluding daffodil and gladiolus) grown in the open in England (which includes those in Spanish tunnels), fell from 1,274 ha in 1988 to 638 ha in 2004 and 620 ha in 2008 (Defra 2008 Survey of Vegetables and Flowers – England). In 2008 (the last year for which these data are available) the 'other bulbs and flowers' category comprised 'other bulbs, corms, rhizomes and tubers' (64 ha), pinks and sweet williams (56 ha), foliage (46 ha), dried flowers (25 ha), natural-season Chrysanthemum (16 ha) and 'all other flowers (inc. Asters)' (413 ha). Since the last official publication of these figures, UK Chrysanthemum production (both indoor AYR and indoor and outdoor natural season) has declined further while sunflowers, Peony and foliage production have all increased, dried flower production mainly comprises Larkspur (and a few other species) for the confetti industry and column stocks is now the most important non-bulb protected flower crop.

As well as potential for import substitution, UK grown product has 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 outdoors or in tunnels to stimulate UK production.

Over the past few years the CFC has concentrated on new product development (NPD) and despite a wide range of potential products being identified, it has proven difficult to commercialise some of these new products 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, the new five year trials programme (2018 to 2022) has a broader remit seeking to address technical issues such as identifying new pest, disease and weed control measures (in the form of Fusarium control and herbicide evaluations in 2018) 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 a summary technical note in early 2019). NPD will still be an important element of the overall CFC project, but it will be balanced by other relevant programmes of work.

Materials and Methods

Protocols

By arrangement with David Robinson (managing director, R Robinson & Son Ltd), the trials programme was hosted at Rookery Farm, Holbeach St John, Spalding, Lincolnshire. The National Cut Flower Trials Centre (t/a Cut Flower Centre Ltd; CFC) is directed by project

leader Lyndon Mason and overseen by a management group comprising representatives of growers, packers, retailers and AHDB Horticulture. Practical arrangements 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 treatments to be made. Crop protection advice was provided by a BASIS and FACTS registered consultant who liaised closely with the project leader as well as visiting the site on a fortnightly basis during the main trial season.

The experimental programme is agreed with the CFC management group and amended annually, taking into account views received from the industry about technical issues that need to be addressed as well as possible NPD subjects. Information from the reviews of new cut flower crops and overseas cut flower trials, undertaken as part of the previous CFC project, was also used to identify suitable NPD candidates.

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 (7.9 m wide × 38.1 m in length; Haygrove Ltd, Redbank, Ledbury, Herefordshire), a triple-span 'Pro-Tech' tunnel (overall 22.7 m wide × 38.0 m in length; Pro-Tech Marketing Ltd, Ironbridge, Telford, Shropshire) and a 600 m^2 adjacent area of outdoor beds provided with anti-rabbit fencing. Since it is an exposed site, wind-breaks of 2.5 m-high polypropylene netting are provided at each end of the 'Pro-Tech' tunnel. The tunnels are covered with a standard polythene film and, as is usual, in order to protect the structure of the tunnels, the polythene covers are removed for the winter each October. The Soil Survey of England and Wales' *Soils of England and Wales* describes the soil at the centre 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. Soil samples were taken after steaming 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 2 for nitrogen, 4 for phosphorus, 3 for potassium and 4 for magnesium. Before planting in 2018 the 'Haygrove' tunnel received 30 g/m^2 ammonium nitrate (as 'Nitram') only; 'Pro-Tech' bay 1, first half 15 g/m^2 ammonium nitrate only; bay 1, second half, 30 g/m^2 ammonium nitrate and 50 g/m^2 sulphate of potash; bay 2, first half 50 g/m^2 sulphate of potash only; bay 2, second half, 30 g/m^2 ammonium nitrate and 50 g/m^2 sulphate of potash; bay 3, first half, 30 g/m^2 ammonium nitrate and 50 g/m^2 sulphate of potash; bay 3, second half, 50 g/m^2 sulphate of potash only and the outside area 30 g/m^2 ammonium nitrate, 110 g/m^2 triple superphosphate and 50 g/m^2 sulphate of potash.

Plant material and planting

Plants were obtained as plug-plants ('plugs') or seeds, and some as rooted or un-rooted cuttings, liners, bulbs or rhizomes as appropriate. Seeds were either germinated in module trays and transplanted, or direct-drilled. Most plants were transplanted into labelled plots along 1 m-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 to ensure 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 2018 are listed below, with '+' indicating a tank-mix.

For aphid, capsid and downy mildew control, Signum + Gazelle SG (pyraclostrobin and boscalid + acetamiprid) to all crops, week 25.

For caterpillar control, DiPel DF (*Bacillus thuringiensis kurstaki* ABTS-351) to all crops in week 25.

For slug control Iroxx (ferric phosphate) to all crops in week 25.

For powdery mildew and aphid/capsid control, Takumi + Chess SG + potassium bicarbonate (cyflufenamid + pymetrozine + potassium bicarbonate) to all crops in week 26.

For downy mildew control, Fenomenal + HortiPhyte (fenamidone and fosetyl-aluminium + HortiPhyte) to all Matthiola plantings in week 26.

For caterpillar control, DiPel DF (*Bacillus thuringiensis kurstaki* ABTS-351) to all crops in week 27.

For downy mildew control, Fubol Gold WG (mancozeb and metalaxyl) to all Matthiola crops in week 27.

For aphid and Pythium control, Calypso + Subdue (thiacloprid + metalaxyl M) to the Daucus plots in week 27.

For powdery mildew control, Amistar (azoxystrobin) to all crops in week 28.

For downy mildew control, Previcur Energy + HortiPhyte (propamocarb and fosetyl aluminium + HortiPhyte) to all Matthiola plantings in week 28.

For aphid and powdery mildew control, Signum + Gazelle SG (pyraclostrobin and boscalid + acetamiprid) to all crops, week 29.

For diamond back moth and aphid control, Decis + DiPel DF (deltamethrin + *Bacillus thuringiensis kurstaki* ABTS-35) on all Matthiola plantings in week 29.

For downy mildew control, Fubol Gold WG (mancozeb and metalaxyl) to all Matthiola plantings in week 29.

For downy mildew control, Amistar + HortiPhyte (azoxystrobin + HortiPhyte) to all Matthiola plantings in week 30.

For powdery mildew control, Nimrod + Takumi SC (bupirimate + pymetrozine) to all crops in week 30.

For caterpillar control, DiPel DF (*Bacillus thuringiensis kurstaki* ABTS-351) to all crops in week 30.

For powdery mildew and aphid control, Signum + Decis (pyraclostrobin and boscalid + deltamethrin) to all crops, week 31.

For downy mildew control, Previcur Energy + HortiPhyte (propamocarb and fosetyl aluminium + HortiPhyte) to all Matthiola plantings in week 31.

For two spotted spider mite and thrips control, Dynamec + Majestik (abamectin + maltodextrin) to Scabious and Asclepias in week 31.

For thrips control, Tracer + Attracker (spinosad + Attracker) to Asclepias, Monardia and Zinnia in week 31.

For powdery mildew aphid control, Signum + Mainman (pyraclostrobin and boscalid + flonicamid) to all crops in week 31.

For two spotted spider mite and thrips control, Amistar + Dynamec (azoxystrobin + abamectin) to all Scabious and Lysimachia plantings in week 33.

For thrips control, Tracer + Attracker (spinosad + Attracker) to Asclepias, Monardia and Zinnia in week 33.

For capsid control, Gazelle SG (acetamiprid) to all Ammi crops in week 33.

For powdery mildew control, Nimrod + potassium bicarbonate (bupirimate + potassium bicarbonate) to all Phlox, Asclepias, Dahlia, Zinnia and Larkspur in week 33.

For downy mildew control, Fubol Gold WG (mancozeb and metalaxyl) to all Matthiola plantings in week 33.

For powdery mildew control, Signum + potassium bicarbonate (pyraclostrobin and boscalid + potassium bicarbonate) to all Phlox, Asclepias, Dahlia, Zinnia and Larkspur in week 34.

For downy mildew control, Fenomenal + HortiPhyte (fenamidone and fosetyl-aluminium + HortiPhyte) to all Matthiola plantings in week 34.

As a general insecticide Decis (deltamethrin) to all crops, week 34.

For powdery mildew control, Nimrod + potassium bicarbonate (pymetrozine + potassium bicarbonate) to Phlox, Asclepias, Dahlia, Zinnia and Larkspur in week 35.

For downy mildew control, Amistar + HortiPhyte (azoxystrobin + HortiPhyte) to all Matthiola plantings in week 35.

For downy mildew control, Signum + DiPel DF (pyraclostrobin and boscalid + *Bacillus thuringiensis kurstaki* ABTS-351) to all Matthiola plantings in week 36.

For Botrytis control, Scala (pyrimethanil) to all lilies in week 36.

For two spotted spider mite and thrips control, Dynamec + Majestik (abamectin + maltodextrin) to Scabious and Lysimachia in week 36.

For Botrytis control, Signum + potassium bicarbonate (pyraclostrobin and boscalid + potassium bicarbonate) to all lilies in week 38.

For Botrytis control, Switch (cyprodinil and fludioxonil) to all lilies in week 39.

For Botrytis control, Stroby + potassium bicarbonate (kresoxim-methyl + potassium bicarbonate) to all lilies in week 41.

For Botrytis control, Switch + potassium bicarbonate (cyprodinil and fludioxonil + potassium bicarbonate) to all lilies in week 42.

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 analysis of variance. In the analysis of variance tables the value of P (probability) indicates the statistical significance of the source of variation (say, growing medium, herbicide treatment or cultivar). In the tables *, ** and *** indicate significance at the 0.05, 0.01 and 0.001 levels of probability, i.e. that the result obtained could be expected to have occurred by chance in one in 20, one in 100 or 1 in 1000 instances, respectively; NS indicates not significant (P>0.05).

Less formally, but importantly, the plots were assessed at intervals by the CFC management group and others from the industry. In the case of preliminary demonstrations, emphasis was placed on photographs and grower comments. Numerous samples of products were made available to the industry to gather feed-back and for promotion. In 2018 samples of new products grown at the CFC were also provided to Jonathan Mosley's British Flower Bus which demonstrated the wide range of flowers available from British growers. The Flower Bus attended many of the RHS shows including Tatton Park and sites including Wisley and Hyde Hall.

Trials at commercial nurseries

As appropriate, some evaluations were carried out at commercial nurseries, either because conditions at the CFC were unsuitable or in order to assess crops on a larger scale or more 'commercial' basis. However, no CFC trials were conducted at commercial nurseries during 2018.

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 returning 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 five days.

Before carrying out a VL test, the chain from grower to consumer is simulated using appropriate conditioning solution, a few days' cold storage and retail store conditions. Testing takes place in a VL test room, and as there is a shortage of such facilities it was impractical to use a single test room throughout this project. Nevertheless, VL test protocols have become standardised, with the basal part of the stem removed before placing the stems in a clean vase of about 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. VL tests in 2018 were carried out by Laura Tebby (Superflora), MM Flowers and Emma Bradford (Floralife and Oasis Grower Solutions). In the results section the VL quoted refers only to the number of days in the vase, not including the preparatory stages.

Some informal visual evaluations of vase life in a 'display situation' were also undertaken by Helen Chambers of Evolve Flowers. Unfortunately a trolley of a wide range of samples (including Asclepias, Lysimachia, Ammi and Daucus), that was submitted for vase life testing late in year, was 'lost in transit' and unfortunately this did not come to light until the Project Manager was collating all of the vase life results at the end of the year.

Results

The new product development work carried out in 2018 is summarised first, followed by downy mildew sensitivity testing in column stocks, ongoing Fusarium trials work, herbicide evaluation trials for outdoor Larkspur, alternative growing media for box grown lily and vase life improvement trials for Zinnia and Dahlia.

Ammi majus and *A. visnaga*

Various seed raised fillers have been investigated in previous years at the CFC and some of these such as Bupleurum and Carthamus are now grown on a small commercial scale and many others such as Anthriscus and dill are grown by a number of 'artisan growers'. Ammi has also been included in previous CFC trials, but despite apparent market interest it has not yet been grown on any scale by the industry. So a decision was taken to include it one last time at the CFC to examine its potential to continuously generate flower stems from a number of successive plantings. As a consequence, in 2018 *A. majus* 'Graceland' and *A. visnaga* 'Casablanca' were planted in a Spanish tunnel in weeks 20, 23, 25, 29 and 32. Plugs of commercially grown varieties were obtained from Florensis and the trial was planted through wires at a density of 24 plants/m^2. Details of the picking dates are show in Table 1 for *A. majus* and Table 2 for *A. visnaga*. As a general rule, *A. majus* took around six to seven weeks to produce the first marketable stems, *A. visnaga* took eight to nine weeks (Figures 1-4). Each sowing continued to crop over two to three weeks. Both species produced long stems in excess of 60 cm, although harvest was not easy owing to the tangled nature of the plant growth (especially on the case of *A. majus*) and this should be taken into account when pricing

up the crop for market.

Table 1. Details of 2018 demonstration of *Ammi majus*

Location	Rookery Farm
Variety	*Ammi majus* 'Graceland'
Plant longevity and hardiness	Annual, fully hardy (some Ammi are biennial)
Format(s) and supplier(s)	Plugs from Florensis
Propagation and pre-planting treatment(s)	None
Planting or sowing date(s)	Plugs transplanted week 20, 23, 25, 29 and 32
Plots	3 m-long plots
Planting/housing site(s)	'Pro-Tech' tunnel bay 3
Layout	Demonstration plots
Planting spacing(s)	25 plants/m^2
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	No problems evident
Picking stage(s) and market specification(s)	When the umbel is showing colour
Picking and recording date(s)	Week 20 flowered from week 27 onwards Week 22 flowered from week 29 onwards Week 25 flowered form week 31 onwards Week 29 flowered from week 35 onwards Week 32 flowered from week 39 (although too short to be marketable)
Records taken	Observations and samples
VL testing	Not in 2018

Figure 1. *A. majus* planted week 20 and flowering week 27

Figure 2. *A. majus* planted week 29 and flowering week 35

Table 2. Details of 2018 demonstration of *Ammi visnaga*

Location	Rookery Farm
Variety	*Ammi visnaga* 'Casablanca'
Plant longevity and hardiness	Annual, fully hardy (some Ammi are biennial)
Format(s) and supplier(s)	Plugs from Florensis
Propagation and pre-planting treatment(s)	None
Planting or sowing date(s)	Plugs transplanted week 20, 23, 25, 29 and 32
Plots	3 m-long plots
Planting/housing site(s)	'Pro-Tech' tunnel bay 3
Layout	Demonstration plots
Planting spacing(s)	25 plants/m^2
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	No problems evident
Picking stage(s) and market specification(s)	When the umbel is showing colour

Picking and recording date(s)	Week 20 flowered from week 29 onwards Week 22 flowered from week 31 onwards Week 25 flowered form week 33 onwards Week 29 flowered from week 37 onwards Week 32 flowered from week 41 (although too short to be marketable)
Records taken	Observations and samples
VL testing	No

Figure 3. *A. visnaga* planted week 20 and flowering week 29

Figure 4 *A. visnaga* planted week 25, growth stage in week 36

It is not anticipated that the CFC will undertake any further work on Ammi unless requested by the industry.

Asclepias (milkweed, silkweed) (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 were undertaken in 2018 as detailed in Table 3.

Table 3. Details of 2018 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 ('Apollo orange', 'Soulmate' and *A. tuberosa*) and then a second sowing of 'Apollo orange' and *A incarnata* 'Carmine Rose' and 'White' in week 19
Planting or sowing date(s)	Transplanted week 20 and the second sowing transplanted in week 26
Plots	Variable for the first planting and 3 m-long for the second planting
Planting/housing site(s)	'Pro-Tech' tunnel bay 2
Layout	Demonstration plots
Plant spacing(s)	25/m^2
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	Prone to two-spotted spider mite so prophylactic sprays are required
Picking stage(s) and market specification(s)	When 30 to 50% of the buds have opened
Picking and recording date(s)	Week 20 planting flowered from week 29 onwards and the week 26 planting from week 35 onwards although most of *A. incarnata* 'Carmine Rose' and 'White' flowers became necrotic or aborted before reaching picking stage
Records taken	Observations
VL testing	*A. curassavica* 'Apollo Orange' tested week 32 by Superflora had a VL of six days, but the sample was already wilting prior to dispatch. Placement of a later batch into fresh water immediately after cutting improved performance.

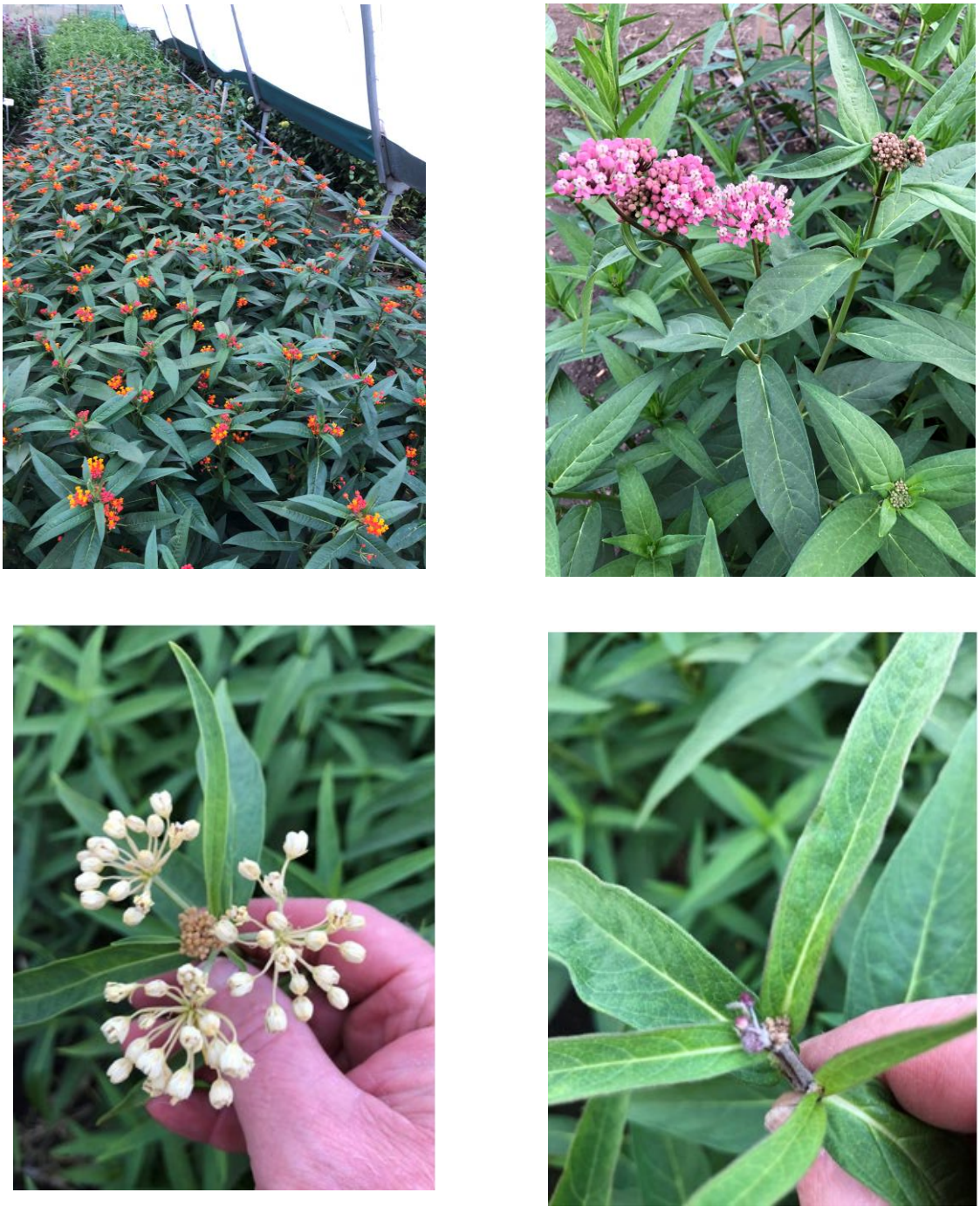


Figure 5. Asclepias in demonstration plots in 2018, week 26 planting and growth stage at week 38. Top left *A. curassavica* 'Apollo Orange', top right *A. incarnata* 'Carmine Rose', bottom-left *A. incarnata* White' bottom right showing aborted buds.

Both plantings established and grew well with no obvious losses, but only *A. curassavica and A. incarnata* produced flower stems of a suitable length for cutting. 'Apollo Orange' produced

prolific, attractive, orange-red inflorescences from week 29 onwards from the week 20 planting and from week 35 onwards from the week 26 planting. Both plantings produced good strong stems in excess of 70 cm and continued to crop over a four week period. The week 20 plantings of 'Soulmate' also produced a similar result to 'Apollo Orange', but was less prolific in terms of stems produced. Both *A. incarnata* 'Carmine Rose' and 'White' (week 26 planting) initially produced a handful of good quality stems but after week 37 the flowers either became necrotic or aborted (Figure 5), hence most were unmarketable. It was assumed that this was an adverse reaction to the very hot weather, but 'Apollo Orange' showed no signs at all of these problems.

Astrantia major

Astrantia has never been investigated by the CFC and 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 Pink Star' and 'Sparkling Red Star'. These were delivered in week 28 and planted at 8/m^2 (Figure 6).

Figure 6.Week 28 planting of Astrantia plugs

Figure 7. Astrantia trials in week 38, two weeks before the tunnel covers were removed

Due to the late planting of the trial, no marketable stems were produced in 2018 and the crop

will be overwintered into 2019 (Figure 7) when further assessments will be made.

Column stocks (Matthiola) – late planted variety trial

The main current 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 mechanically 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 plants 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 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' (for full details see Table 4).

Table 4. Details of 2018 late planted column stock variety demonstration trial

Site	Rookery Farm
Varieties	'Anytime', 'Arrow', 'Avalon', 'Cheerful', 'Iron', 'Noble', 'Mathilda' and 'Venus'
Plant longevity and hardiness	Frost sensitive annual
Format(s) and supplier(s)	Plugs from Globe Plants and Florensis
Propagation and pre-planting treatment(s)	None
Planting or sowing date(s)	Transplanted week 27
Plots	Variable depending on how many plugs were supplied.
Planting/housing site(s)	'Pro-Tech' tunnel bay 1
Layout	Demonstration plots

Plant spacing(s)	64/m^2
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	None evident, but intensive spray programme in place
Picking stage(s) and market specification(s)	With about 50% of florets open
Picking and recording date(s)	Started picking in week 36
Records taken	Observations concerning VL
VL testing	No

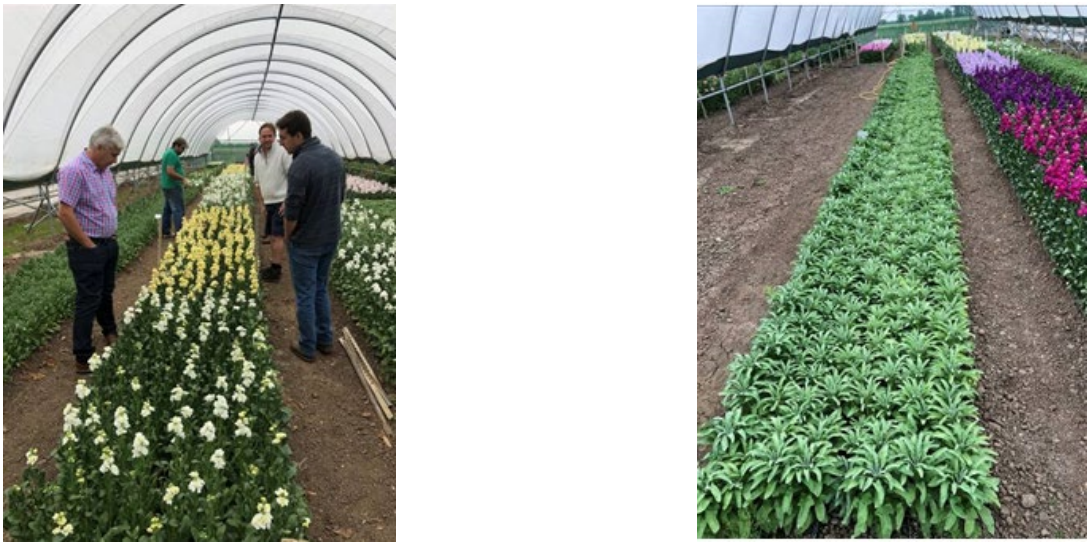


Figure 8. Harvested stems of Japanese varieties of column stocks showing the different level of flower formation. Top left ‘Avalon Yellow’, top right ‘Iron Marine’, middle left ‘Arrow White’, middle right a mixed bucket, bottom left grower walk on 4 September 2018 and bottom right bed of ‘Mathilda’ with no bud initiation

All of the various Japanese varieties of column stocks successfully initiated buds despite growing through one of the hottest periods on record (where temperatures regularly exceeded 30°C) and commenced flowering in week 36. However, as can be seen in Figure 8 there were a range of flower spike lengths, with only 15 to 25% (depending upon variety) achieving marketable quality. Those that did develop a full spike achieved a stem length in excess of 60 cm and while no weight measurements were taken, the stems were visibly heavier and stronger than those from the ‘Anytime’ series which only produced flowers sporadically and most of these were short and weak. This fact was remarked upon by growers who attended an evening walk to look at the trial on the 4 September 2018. None of the varieties in the ‘Mathilda’ series initiated any buds.

The 2018 trial demonstrated the potential of the Japanese varieties for UK production and growers have expressed a desire to investigate them further in 2019.

Daucus carota

Daucus carota 'Dara' (ornamental carrot) was the subject of a small tunnel demonstration plot in 2016 and 2017 and it generated much interest from growers because of its distinctive flowers. Previous trial plots had been direct seeded, but had produced a variable stand of seedlings due to erratic germination. In 2018, it was therefore decided to use plugs supplied by Florensis and see if continuity of flowering could be achieved by plantings that mirrored those of the Ammi in weeks 20, 23, 25, 19 and 32.

Table 5. Details of 2018 demonstration of ornamental carrot

Location	Rookery Farm
Variety	*Daucus carota* 'Dara'
Format(s) and supplier(s)	Plugs from Florensis
Plant longevity and hardiness	Annual or biennial, fully hardy
Propagation and pre-planting treatment(s)	None
Planting or sowing date(s)	Plugs transplanted into beds weeks 20, 22, 25, 29 and 32
Plots	3 m-long plots
Planting/housing site(s)	'Pro-Tech' tunnel bay 3
Layout	Demonstration plots
Plant spacing(s)	25 plants/m^2
Post-planting treatment(s)	One layer of support netting
Pests, diseases and disorders	No problems observed
Picking stage(s) and market specification(s)	When the umbel is showing colour and stages beyond
Picking and recording date(s)	Week 20 flowered from week 27 onwards Week 22 flowered from week 29 onwards Week 25 flowered form week 31 onwards Week 29 flowered from week 35 onwards Week 32 flowered from week 39 (too short)
Records taken	Observations and samples
VL testing	Not formally but anecdotal reports indicated that it achieved a good vase life

The 2018 trials showed that the duration from planting to the production of first marketable stems was very similar to *Ammi majus* at six to seven weeks. However, depending upon the stage of harvest, cropping could continue for in excess of four weeks for each sowing. Daucus produced a wide range of different sized and different coloured flower heads ranging from almost white through to crimson as can be seen in Figure 10. The stems were mostly very strong and apart from the week 32 planting, regularly exceeded 60 cm in length. The crop generated a lot of interest during the CFC Open Day and subsequently a number of samples were taken by, or distributed to, various packers and supermarkets and favourable reports were fed back to the Project Manager. It was reported that Daucus achieved a good vase life but unfortunately no actual results were formally received by the CFC from any of the tests undertaken by industry.

The 2018 trial clearly demonstrated the market potential of Daucus and that flower continuity can be achieved by sequential planting. It could potentially be grown in tunnels, cold glass or outside but further work may be required on stage of harvesting to ensure that an adequate vase life is achieved.

Figure 9. *Daucus carota* planted week 20 and flowering week 27 (photograph taken in week 29)

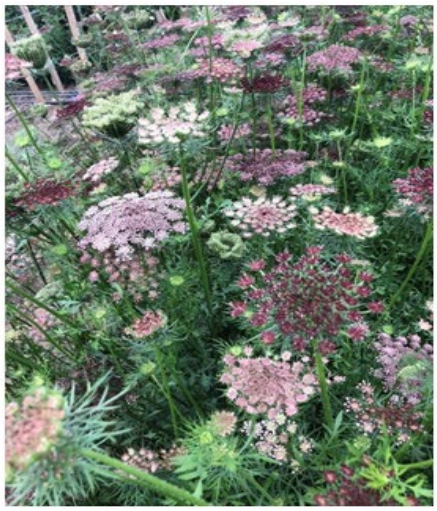


Figure 10. *Daucus carota* planted week 25, flowering week 35 onwards showing the range of flower colours/stages

Echinacea (coneflower) (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 as detailed in Table 6. Note that examples of Rudbeckia, a closely related genus also known as coneflower, have been grown previously at the CFC.

Table 6. Details of 2018 demonstration of Echinacea cultivars

Location	Rookery Farm
Varieties	'Green Jade', 'Marmalade', 'Sombrero Hot Coral', 'Summer Cocktail' and 'Virgin'
Plant longevity and hardiness	Perennials, fully hardy
Format(s) and supplier(s)	9 cm liners from various sources
Propagation and pre-planting treatment(s)	N/A
Planting or sowing date(s)	Transplanted week 38
Plots	1 m-long
Planting/housing site(s)	'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)	Not available
Picking and recording date(s)	Not until 2019
Records taken	Observations in 2019
VL testing	Not until 2019

Figure 11. Echinacea in demonstration plots planted in week 38

As all the plants were planted in September 2018 they will not provide any results in terms of flower production until 2019.

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 (Table 7) were purchased as large corms and planted in week 20. Seedlings were also planted in week 26.

Table 7. Details of 2018 Eucomis variety trial

Site	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, seedlings sown week 16 and planted week 26
Plots	Various depending upon the amount of planting material
Planting or housing site(s)	'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.
Picking stage(s) and market specification(s)	Various
Picking and recording date(s)	The seedlings did not produce any flower stems during 2018 and the corms only produced a single stem beginning in week 29
Records taken	Observations
VL testing	Not in 2018

Figure 12. Week 20 planting of large corms of a range of Eucomis varieties

Figure 13. Plug plants (top) of Eucomis planted in week 26 from a week 16 sowing

The seedlings grew very slowly both in the plug and after planting out and had still only produced a small plant by the time the polythene tunnel cover was removed. The corms by contrast grew vigorously and most varieties had produced a single strong stem per corm by the end of the season.

Figure 14. First Eucomis flowers in week 29

Figure 15. Eucomis stem from the CFC used in a floral display at Leeds Castle

The trial is being overwintered into 2019 when further assessments will be made.

Lysimachia fortunei

Cut flower Lysimachia is a new crop to the UK and a request was made to investigate it at the 2017 Open Day because of its similarity to Veronica which was also included in the 2017 and 2018 trials. During 2018 two varieties ‘Jumbo’ and ‘Mambo’ supplied by Armada were planted in week 21 at a density of 25/m^2.

Table 8. Details of 2018 Lysimachia demonstration

Site	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 (and overwintered to 2019)
Plots	4 m-long
Planting or housing site(s)	'Pro-Tech' tunnel bay 2
Layout	Demonstration plots
Plant spacing(s)	25/m^2
Post-planting treatment(s)	One layer of support netting. Plants pinched three weeks after planting
Pests, diseases and disorders	Mainly two-spotted spider mite evident, but kept under control by a spray programme. 'Mambo' also suffered from chlorotic and nectrotic patches which got worse as the crop matured.
Picking stage(s) and market specification(s)	About 50% of flowers open
Picking and recording date(s)	The first flowers were picked in week 33 and continued to produce flowers until week 41
Records taken	Observations
VL testing	Not formally, but anecdotal reports indicate that it achieved a good vase life. More work will be undertaken in 2019

The plugs established well and produced very strong shoots after pinching (Figure 16). Initially there was no obvious difference between the two varieties but as they matured 'Mambo' showed weaker growth with signs of chlorotic and necrotic patches on the foliage (Figure 17). This problem became progressively worse and eventually made the stems unmarketable. 'Jumbo' did not show any signs of this issue and produced very strong stems with most achieving or exceeding 60 cm.

Figure 16. Examples of harvested stems of *Lysimachia* ‘Jumbo’

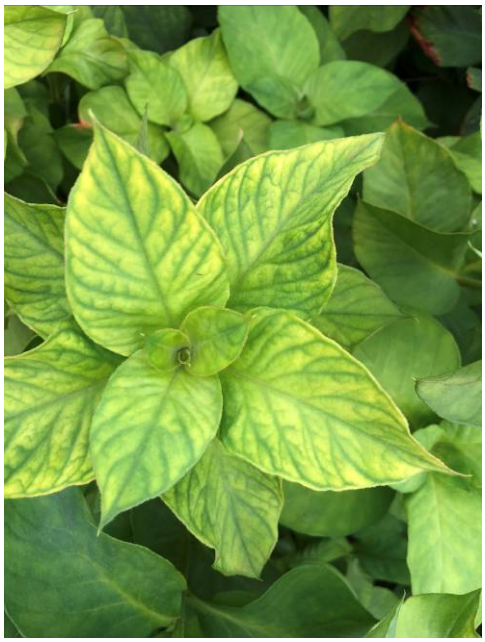


Figure 17. *Lysimachia* ‘Mambo’ showing leaf chlorosis and necrosis

The trial was cut down to soil level in week 41 and the crop will be overwintered into 2019.

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

Scabious are well-known as vigorous garden plants with prolific, attractive flowers in a wide range of colours, and are often used as cut flowers. In 2016 and 2017 substantial

demonstration trials were set up at the CFC, using cutting-raised plants of a new series from Danziger ('Scoop' series) as well as series of varieties available from HilverdaKooji. The introduction of a substantial number of new varieties to the Scoop series resulted in a request to undertake a further demonstration trial in 2018 (see Table 9 for more details) which was planted in week 18.

Table 9. Details of 2018 demonstration of Scabious

Varieties	'Scoop' series - 'Blackberry', 'Blackberry Summer', 'Candy', 'Cherry Vanilla', 'Lavender', 'Lavender Hoop', 'Lollipop', 'Marshmallow', 'Marshmallow Summer', 'Milky', 'Raspberry', 'Red Velvet', 'Soft', 'Strawberry', 'Tutti Frutti' and 'Vanilla'
Plant longevity and hardiness	*S. atropurpurea:* biennial or short-lived perennial, fully hardy *S. caucasica*: perennial, fully hardy Some other Scabious are annuals or biennials and some are frost-hardy
Format(s) and supplier(s)	Plugs from Danziger ('Scoop' series).
Propagation and pre-planting treatment(s)	Potted into 50 module trays in week 16 because tunnel was not ready for planting.
Planting or sowing date(s)	Transplanted to tunnel week 18
Plots	3 m-long
Planting/housing site(s)	'Pro-Tech' tunnel bay 2
Layout	Demonstration plots
Plant spacing(s)	8/m^2 in two rows along bed
Post-planting treatment(s)	Pinched three weeks after transplanting. One layer of support netting
Pests, diseases and disorders	In 2018 they suffered from a severe attack of two spotted spider mite which was presumably exacerbated by the hot summer
Picking stage(s) and market specification(s)	When first whorl of petals opens
Picking and recording date(s)	First flowers from week 28
Records taken	Observations

VL testing	Samples taken week 30 from Lavender', 'Blackberry', 'Candy', 'Cherry Vanilla', 'Lavender', 'Lollipop', 'Marshmallow', 'Milky', 'Raspberry', Red Velvet' and 'Tutti Fruitti' tested by SuperFlora. Samples were also taken by MM Flowers for vase life testing

The plants established better than in 2017 and only needed pinching once, three weeks after planting. The first flowers were harvested in week 28 and then the plants flushed very heavily through the very hot period during July and August. However, the hot weather appeared to 'exhaust' the plants and by mid-August only a small number of weak stems were being harvested. This was mirrored by other trial crops in the UK and also in commercial crops in the Netherlands. A decision was therefore taken to cut back half of each bed with some varieties being cut back to the ground and others cut back to about 50 cm. By mid-September the varieties that were cut back to 50 cm were producing a second strong flush of flowers while those that were cut back to the ground took a further two weeks to regenerate. It was not necessary to cut back the 2016 and 2017 trial plants which did not have to endure the July and August temperatures.

Figure 18. Scabious ‘Scoop’ varieties in demonstration plots 2018 (week 32). Top left ‘Lollipop’, top right ‘Milky’, middle left ‘Softy’, middle right ‘Candy’, bottom left ‘Red Velvet and bottom right ‘Cherry Vanilla’

Figure 19. Mixed stems of Scabious harvested at different stages of development

Samples were taken of tunnel-grown ‘Scoop’ stems for standard VL testing in 2018. The varieties tested included ‘Blackberry’, ‘Candy’, ‘Cherry Vanilla’, ‘Lavender’, ‘Lollipop’, ‘Marshmallow’, ‘Milky’, ‘Raspberry’, ‘Red Velvet’ and ‘Tutti Fruitti’. The transit solution was Chrysal Clear Professional and the vases contained liquid Universal Flower Food. All varieties remained in acceptable condition during VL testing for between 11 and 12 days with no obvious differences between varieties. Tests by MM Flowers also indicated a VL of 12 days. As with previous years, the stem length and speed of picking remained issues with this crop. In 2018, a decision was taken to cut to either 50 or 55 cm and to retain the side shoots that invariable were present on stems of this length. Although this ultimately resulted in a reduction in the total number of stems picked, it did make a more substantial end product and speeded up the picking process.

Veronica longifolia

In 2017 a new range of Veronica was trialled (the ‘Skyler’ series) which is available as blue, white and pink flowered varieties. It produced long strong stems with a good sized, vibrant flower heads which generated quite a lot of market interest. However, the main issue with the crop was that it flowered as a flush which lasted about two to three weeks after which the plant then had to be cut down to the ground before a second flush occurred after to six to

eight weeks. It was therefore decided to investigate the possibility of improving the continuity of flowering by using different planting and pinching times in new plantings undertaken in 2018. Two plantings were made (see Table 10 for more detail) in week 18 and 25 and half of these were pinched two to three weeks after planting and then the second half two weeks later.

Table 10. Details of 2018 Veronica variety demonstration

Site	Rookery Farm
Varieties	'Skyler Blue' 'Skyler Pink' '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
Plots	2 m-long plots
Planting site(s)	'Pro-Tech' tunnel bay
Layout	Demonstration plots
Plant spacing(s)	25/m^2
Post-planting treatment(s)	Week 18 – first half pinched in week 21 and second half pinched in week 23 Week 25 – first half pinched in week 27 and second half pinched in week 29
Pests, diseases and disorders	Small amount of powdery mildew and whitefly evident, but both kept under control by the spray programme
Picking stage(s) and market specification(s)	With a maximum of 30 to 50% of florets open
Picking and recording date(s)	Week 18 planting – crop pinched first flowered weeks 28 to 30 with a second flush in weeks 36 to 38 Week 18 planting – crop pinched second flowered weeks 30 to 32 with a second flush week 39 Week 25 planting – crop pinched first flowered weeks 33 to 35, but no marketable second flush

	Week 25 planting – crop pinched second flowered weeks 36 to 38 but no marketable second flush
Records taken	Observations and samples and stem lengths
VL testing	Yes, via MM Flowers

As would be expected, the different planting dates achieved different flowering times, but only the pink and white flowered varieties achieved differential flowering through pinching. The two week difference in pinching date resulted in approximately a two week delay in flowering. Unexpectedly, the blue flowered variety did not respond to pinching and the crop flowered at the same time regardless of pinching date. As a result, they were harvested and cut down at the same time resulting in the second flush of blue also flowering together. This was observed in the crops from both planting dates.

The first flower flush from the week 18 planted crop produced very strong stems in excess of 60 cm. The second flower flush and the first flush of the crop planted in week 25 produced visually slightly weaker stems with a stem length of between 55 and 60 cm in length. The crop planted in week 25 which flowered between weeks 33 to 38 did not produce a marketable second flush in the tunnel but a second flush may have been possible under glass.

Figure 20. Veronica varieties in demonstration plots 2018. Top left ‘Skyler Pink’, top right ‘Skyler Blue’ showing both pinching dates flushing together, bottom left, ‘Skyler White’ and bottom right mixed colours in a bucket

VL work, undertaken by MM Flowers, showed an average VL of 12 days across all three colours but further work would be advisable in 2019.

The 2018 planting will be overwintered into 2019 to provide material for additional industry samples and undertake further vase life tests.

Trials to address specific industry issues.

Column stocks - downy mildew sensitivity testing

As part of the new programme of work, a percentage of the overall project budget will be allocated on an annual basis to address important topical and unforeseen industry issues that need urgent resolution. In 2018 these funds were used to address an issue with downy mildew control in column stocks (*Matthiola incana*). Column stock is currently the main non-bulb protected UK cut flower crop with around 18 million flower stems being grown in the UK in 2018. Downy mildew (*Peronospora parasitica)* has always been a disease associated with column stocks but it could be prevented or easily controlled by a regular spray programme

using a few fungicides, including products containing metalaxyl-M. However, in early 2018 column stocks grown in the Netherlands suffered from a very severe infection of downy mildew which was not controlled by standard spray programmes. In mid-May, column stocks grown in the UK also started to succumb to the disease, with a number of the larger cut flower businesses reporting the issue on the same weekend. Despite applying the usual range of fungicides, the disease continued causing severe damage with infections appearing almost overnight. Even a reduction in the spray application interval did not seem to rectify the problem.

With the help of the CFC and an independent industry consultant, UK growers then radically modified their spray programme in terms of both introducing new fungicide active ingredients and reducing the interval between spray applications. Even these changes did not totally eliminate the problem and many businesses found that they had some level of crop infection right to the end of the 2018 season. It was clear that this was a new and highly aggressive strain of downy mildew and that further investigation was required. Following a CFC organised meeting at the end of June, it was agreed by industry that a number of fungicides should be subjected to sensitivity testing using a number of different disease isolates obtained from various nurseries. Samples were collected from a total of five nurseries, one in Northern Ireland, one in Cornwall, two in Norfolk and one in Lincolnshire, representing a wide geographic spread within the UK. The samples were inoculated by Fera onto fresh column stocks seedlings to build up inoculum before undertaking the sensitivity testing. (Downy mildew is an obligate parasite and such tests can therefore only be undertaken on live plant tissue rather than *in-vitro*).

Each downy mildew isolate was screened against nine fungicides thought to have activity against downy mildew pathogens (Table 11). Fungicides were applied as protectant treatments at the rates shown in Table 11, one day prior to inoculation with *P. parasitica*. Three replicate plants were treated for each fungicide/isolate combination.

Plants were assessed for infection 12 days after inoculation by counting the number of infected leaves on each of the treated plants and comparing to the untreated control plants.

Table 11. Details of the fungicide products, active ingredients and rates used in the Fera downy mildew sensitivity trial

Product	Active ingredient	Content	Approval	Dose rate	Water volume (ha)	Conc
Fenomenal	Fenamidone + fosetyl-aluminium	60g/kg + 600g/kg	EAMU 1990/13	2.25kg/ha	1000L (min 1000L)	2.25g/L
Fubol Gold	Mancozeb + metalaxyl-M	640g/kg + 38.8g/kg (64%w/w + 3.88%w/w)	EAMU 2288/13	1.9kg/ha	1000L (min 250L)	1.9g/L
HDC F253	-	-	Not Approved	0.5L/ha	1200L (600-1200L)	0.42ml/L
Paraat	Dimethomorph	500g/kg (50%w/w)	EAMU 2585/11	3kg/ha	1000L (min 600L)	3g/L
Percos	Ametodractin + dimethomorph	300g/l + 225g/l	EAMU 0819/13	0.8L/ha	1000L (max 1000L)	0.8ml/L
Previcur Energy	Fosetyl-aluminium + propamocarb hydrochloride	310g/l + 530g/l	EAMU 1845/13	2.5L/ha	1000L (min 200L)	2.5ml/L
Revus	Mandipropamid	250g/l	EAMU 2763/16	0.6L/ha	1000L (min 200L)	0.6ml/L
Signum	Boscalid + pyraclostrobin	267g/kg + 67g/kg (26.7%w/w + 6.7%w/w)	EAMU 2141/12	1.35kg/ha	1000L (min 200L)	1.35g/L
Subdue	Metalaxyl-M	465.2 g/l	On label (not approved for downy mildew)	1.25L/ha	10,000L(drench only)	0.125ml/L

The level of disease control achieved by the nine fungicides screened is shown in Figures 21, 22 and 23.

At the fungicide rates tested, none of the products applied gave 100% control of all five downy mildew isolates. The greatest control was achieved following the application of Paraat (dimethomorph) (Figure 22), where 90% control or greater was achieved for three of the five isolates. Percos (ametoctradin + dimethomorph) was the second most effective product with greater than 80% control achieved for three of the five isolates (Figure 21). For applications

of both Paraat and Percos it was the isolates collected from Ireland and Norfolk which showed greater ‘tolerance’ to the fungicides.

The only other product to give any significant level of control was Revus (mandipropamaid) (Figure 23), where greater than 70% control was achieved for three of the five isolates.

Limited control was achieved following the application of Subdue (metalaxyl-M), Signum (boscalid + pyraclostrobin) and HDC F253 (Figures 21, 22 and 23 respectively).

Products containing metalaxyl-M would usually give satisfactory control of downy mildew pathogens. The lack of any control by Subdue, and only partial control by Fubol Gold, suggests that all five isolates were resistant to metalaxyl-M. The level of control achieved by Fubol Gold was assumed to be due to the presence of mancozeb in the formulation.

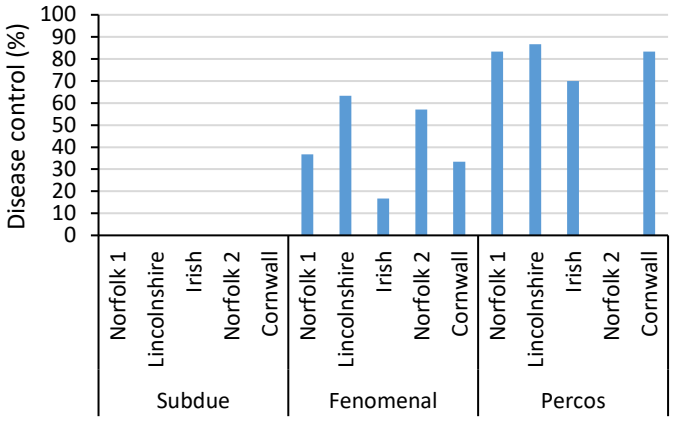


Figure 21. Relative control of downy mildew achieved following application of Subdue, Fenomenal and Percos to each disease isolate

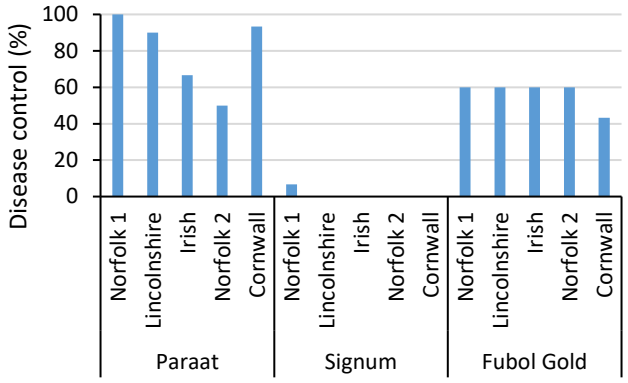


Figure 22. Relative control of downy mildew achieved following application of Paraat, Signum and Fubol Gold to each disease isolate

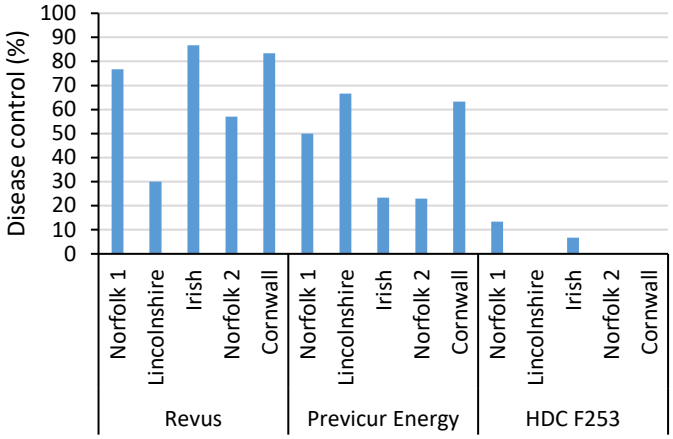


Figure 23. Relative control of downy mildew achieved following application of Revus, Previcur Energy and HDC F253 to each disease isolate

The full Fera report can be found in Appendix 1.

A second trial was undertaken in the autumn of 2018 using a different range of fungicides, including a number of coded products that the AHDB SceptrePlus project had identified as having potential against downy mildew.

The downy mildew isolates collected from Norfolk and Ireland for the first trial were used in the second screening trial because these isolates had proven to be the most tolerant of the fungicides applied, showing a reduced sensitivity to dimethomorph.

Both downy mildew isolates were screened against nine fungicides (Table 12). Fungicides were applied as protectant treatments, at the rates shown in Table 12, one day prior to inoculation with *P. parasitica*. Three replicate plants were used for each fungicide/isolate combination.

Plants were assessed for infection 12 days after inoculation, by counting the number of infected leaves on each of the treated plants and comparing to the untreated control plants.

Table 12. Fungicide product, active ingredient and application rate used in the second Fera downy mildew sensitivity trial

Product	**Active ingredient**	**Content**	**Dose rate**	**Water volume (ha)**
HDC F260	-	-	0.5 L/ha	1000 L
Paraat	Dimethomorph	500 g/kg	3 kg/ha	1000 L
Stroby WG*	Kresoxim-methyl	500 g/kg	0.3 kg/ha	1000 L
HDC F257	-	-	0.7 L/ha	1000 L
HDC F259	-	-	0.5 kg/ha	1000 L
Infinito**	Fluopicolide Propamocarb hydrochloride	62.5 g/L 625 g/L	1.6 L/ha	400 L
HDC F254	-	-	2.5 kg/ha	1000 L
HDC F253	-	-	0.5 L/ha	1000 L
HDC F258	-	-	0.45 kg/ha	500 L

*Label approval but not for downy mildew, **EAMU 2251/14

The level of disease control achieved by the nine fungicides screened is shown in Figure 24. Generally, the data show that the isolate from Norfolk was more tolerant of the fungicides examined, similar to the first trial.

At the fungicide rates tested, none of the products applied gave 100% control of the two downy mildew isolates. The greatest control was achieved following the application of HDC F260 (Figure 24), where 90% control or greater was achieved for the two isolates. HDC F254 and Paraat were the only other fungicides to give any level of control for the two isolates.

Data collected for Paraat and HDC F253 from the second trial substantiated that recorded in the first.

Limited control, was achieved following the application of Stroby WG (kresoxim-methyl), HDC F257, HDC F259, Infinito (fluopicolide + propamocarb hydrochloride), HDC F258 and HDC F253. The full report of this trial can be found in Appendix 2.

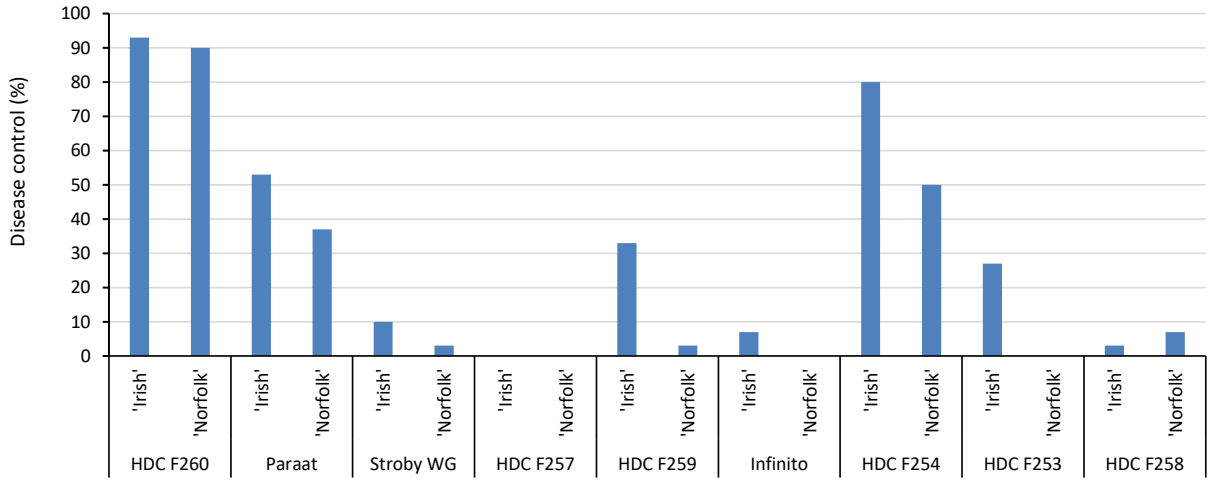


Figure 24. Relative control of downy mildew achieved following treatment of a range of fungicides to two disease isolates

The results of these trials were used as a basis to produce a detailed technical note entitled AHDB/CFC Information Sheet 11 *Maintaining successful control of downy mildew in protected*

crops of cut flower column stocks. This can be downloaded from either the CFC or AHDB websites.

Column stocks - improving control of Fusarium wilt

As part of a new AHDB funded project on *Fusarium oxysporum* in horticultural crops, primarily onions, daffodils and column stocks (FV/PO/BOF 452), an experimental site sufficiently infested with *F. oxysporum* was needed as a permanent site for trials investigating Fusarium control in stocks. This was set up at the CFC in 2017 when the soil was infected with *F. oxysporum* f. sp. *mathioli* culture (produced at Warwick Crop Centre, Wellesbourne) by spreading the inoculum over the soil surface and raking it in by hand. The tunnel was then planted up with a wide range of commercial varieties of column stocks to demonstrate that there was a sufficient and evenly distributed level of inoculum within the soil. The results observed in terms of plant infection confirmed this, which was the main aim of the work in 2017.

During 2018, a fully replicated trial was planted in week 25 using most of the column stocks varieties currently grown in the UK as well as a small number of plots of Lisianthus (to confirm disease specificity). The purpose of the trial was to determine the susceptibility of commercial varieties of column stocks to *Fusarium oxysporum,* building on a similar previous trial, but this time including several new recently introduced varieties. The trial was planted through a black polythene mulch in order to suppress weed growth (the tunnel had not been sterilised for three years) using a single layer of 12.5 cm x 12.5 cm wire netting at a density of 64/m^2. Three runs of lay flat irrigation pipe were placed under the mulch in each bed.

Figure 25. Planting up the Fusarium trial in week 25

Figure 26. Established plants two weeks after planting in week 27

Unfortunately, the planting date coincided with the heat wave experienced in the summer and temperatures in excess of 30°C stressed the plants. This, combined with the late planting date (selected to tie in with the CFC August Open Day) and the use of the black plastic mulch led to perfect conditions for Fusarium to rapidly establish in the crop. This resulted in the presence of disease symptoms throughout most of the plots three weeks after planting (Figure 27). By week 30 most of the plants within each plot were dead (Figure 28).

Figure 27. Severe symptoms of Fusarium three weeks after planting in week 28

Figure 28. The trial in week 30 with most plots devastated by Fusarium five weeks after planting

Genetic investigations into Fusarium indicate there are a range of host specific pathogenic races of *F. oxysporum* and the race which infects column stocks should be specific to Matthiola. Lisianthus was planted in the trial as it too is susceptible to *F. oxysporum* but research indicates it shouldn't succumb to the Matthiola race. The 2018 trial clearly demonstrated that this is the case, not a single Lisianthus plant succumbed to the disease despite the extreme weather conditions during the trial period (Figures 29 and 30).

Figure 29. Lisianthus plot in contrast to the plot of dead stocks in week 36

Figure 30. Close up of a lisianthus plot in week 36

Another interesting observation made during the 2018 trial was that an area in the middle of the second replicate grew away more vigorously than all of the other plots and the column stocks in this area still had green tissue present 10 weeks after planting (Figure 31 and 32).

Figure 31. Area in the middle of the second replicate showing live plants in week 29

Figure 32. The same area with plants still showing a small amount of green tissue in week 36

During week 29, staff from Warwick University took various soil samples from a number of plots showing high levels of Fusarium damage, from the Lisianthus plots and from plots containing live column stocks plants as shown in Figure 31. Polymerase chain reaction (PCR) tests (a test designed to detect and measure genetic material) were undertaken on all of the samples and unsurprisingly *F. oxysporum* f. sp *mathioli* was detected in every sample although in a much lower concentration in the area of live plant material (Figure 33).

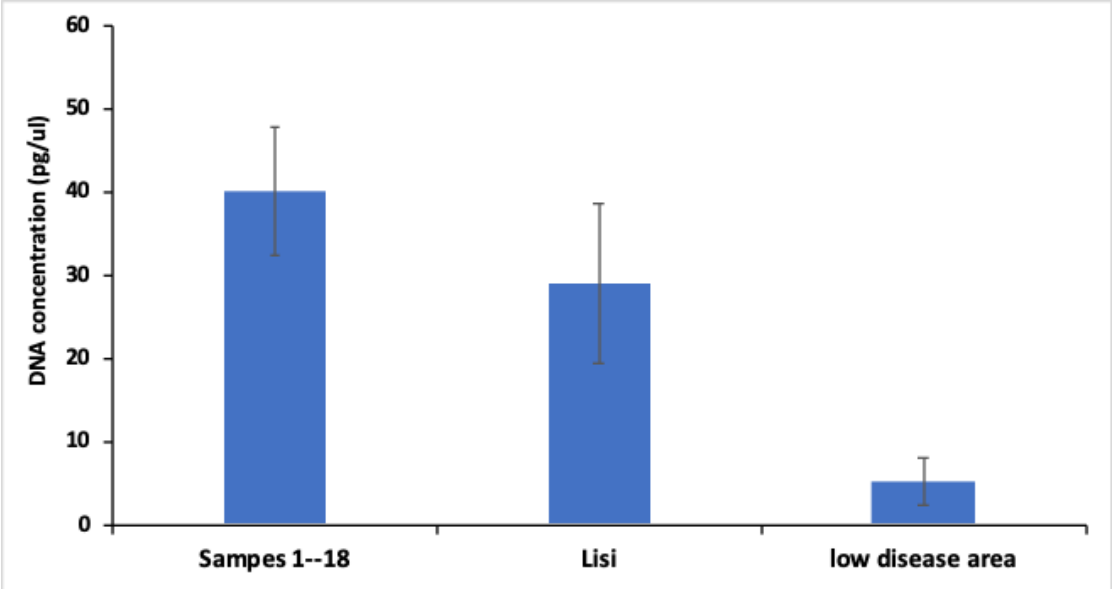


Figure 33. Levels of *F. oxysporum* f. sp *mathioli* DNA concentrations in the areas showing high levels disease symptoms (samples 1-18), Lisianthus plots (Lisi) and areas of lower disease symptoms (low disease area)

It is difficult to draw conclusions from the results of a single year trial, but other work undertaken at Warwick University has shown that there is a direct relationship between the amount of inoculum in the soil and the level of disease development and expression. The results shown in Figure 33 support this, as significantly less inoculum was recovered from the areas of lower disease symptoms.

Herbicides for outdoor Larkspur

The Larkspur herbicide trial carried out in 2018 was designed to determine the efficacy and crop safety of a number of products applied pre- and post-crop sowing in various programmes. It built on the trials undertaken during 2015 at the CFC as part of project HNS PO 192a. Overall, nine herbicide treatments were trialled either alone or in combinations. A full list of products and active ingredients can be found in Table 13 along with the current approval status of each.

Table 13. Herbicide products used in the Larkspur trial, 2018

Product	Active ingredient	Approval status
HDC H23	Confidential	Not approved
Defy	800 g / L prosulfocarb	EAMU outdoor[1]
Dual Gold	960 g / L s-metolachlor	EAMU outdoor[2]
Gamit 36 CS	360 g / L clomazone	EAMU outdoor[3]
Metobromuron	500 g / L metobromuron	Not approved
Stomp Aqua	455 g/L pendimethalin	EAMU outdoor

[1]Pre-emergence only

[3]Pre-emergence and early post-emergence only

[2]Use only permitted during May

The Larkspur trial was carried out at the CFC during May and July 2018 using the variety 'Giant Imperial Mix'. Seed was sown by hand at a rate of 2 g/m to ensure a suitable level of germination. The replicated trial was a fully randomised block design with 10 treatments, including an untreated control (Table 14). Each plot was 3 m long and 1.2 m wide and consisted of four rows of plants.

Table 14 Detail of herbicide treatments applied pre or post-sowing – 2018

Trt.	Pre–sowing	Rate kg/ha or L/ha	Post-sowing	Rate kg/ha or L/ha
1	Untreated	-	Untreated	-
2	HDC H23* (incorp)	X	Defy	4
3	HDC H23* (incorp)	X	Defy	3
4	HDC H23* (incorp)	X	Gamit 36 CS	0.25
5	Untreated	-	Dual Gold + Gamit 36 CS	0.78 + 0.25
6	Untreated	-	Stomp Aqua + Gamit 36 CS	2 + 0.25

7	Untreated	-	Stomp Aqua + Gamit 36 CS	1.5 + 0.15
8	Untreated	-	Stomp Aqua + Defy	2 + 4
9	Untreated	-	Stomp Aqua + Defy	1.5 + 3
10	Untreated	-	Metobromuron*	-

* Products used under an experimental permit

Prior to sowing, the site was marked out and the pre-sowing treatments were applied on 30 May. The treatments were applied to the soil using an OPS sprayer and a 1.5 m boom with 02f110 nozzles, to achieve a medium spray quality at 200 L/ha. The treatments were then incorporated into the soil using a rake, and lightly irrigated.

The trial was sown on the same day, and the post-sowing treatments were applied on 31 May. The same sprayer and boom were used, to achieve a medium spray quality at 200 L/ha. All treatments were lightly irrigated afterwards.

The trial was monitored weekly for phytotoxic effects. Percentage weed cover was assessed six weeks after treatment (WAT) (9 July 2018) and then the trial plots were hand-weeded on 15 July, and crop emergence was assessed 10 WAT (6 August 2018). Data was analysed using analysis of variance.

Crop emergence was rather slow, and when the trial was assessed at 10 WAT, emergence across all plots was still quite variable, even in the untreated plots. As Larkspur seed is generally slow to germinate, it is possible that weed cover within the trial, particularly in the untreated, affected crop emergence. The trial was monitored throughout for signs of phytotoxicity, however no phytotoxic effects were seen in any of the treated plots. Although it was possible to pick out some potential treatment differences in crop emergence and weed control, due to the variability within treatments the results need to be treated with caution.

Weed cover

A weed assessment was carried out six WAT, and the results can be seen in Figure 34. Although differences between treatments were not significant (p=0.584), weed cover was much lower in some treatments compared with the untreated (27.7% weed cover). HDC H23 pre-sowing followed by Defy 4 L/ha (T2) gave the best weed control (8.3% weed cover). HDC H23 pre-sowing followed by Defy 3 L/ha (T3), Dual Gold 0.78 L/ha + Gamit 36 CS 0.25 L/ha (T5) and Stomp Aqua 2 L/ha + Gamit 36 CS 0.25 L/ha (T6) also gave reasonable weed control. Stomp Aqua 2 L/ha + Defy 4 L/ha (T8) and metobromuron (T10) did not give particularly good weed control.

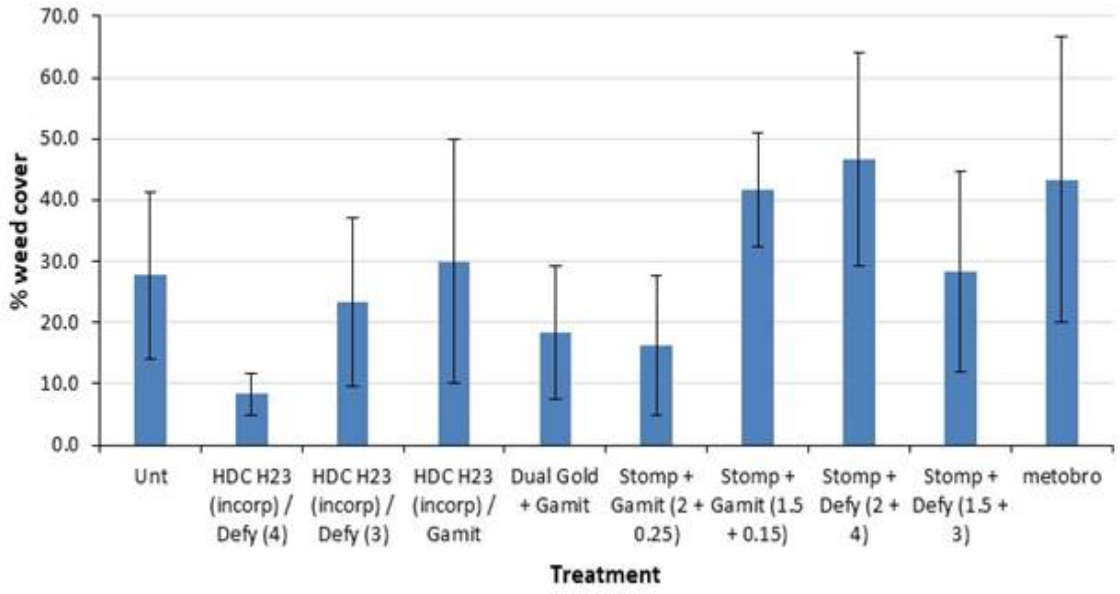


Figure 34. Average percentage weed cover per plot for each treatment six WAT (9 July 2018). Differences between treatments are not significant (p =0.584). (Unt = untreated)

Crop emergence

Crop emergence was variable across the trial, including in the untreated plots. An assessment was completed 10 WAT once the plots had been hand weeded and the results can be seen in Figure 35 and Figure 36. Differences were not statistically significant (p =0.998), with the

number of emerged seedlings per 1.5 m row similar to the untreated (60.3 seedlings on average). The lowest emergence rate was seen in plots treated with Stomp 2 L/ha + Defy 4 L/ha (T8; 58.5 seedlings on average), and the highest emergence rate was seen in plots treated with HDC H23 pre-sowing followed by Defy 4 L/ha post-sowing (T2; 63.7 seedlings on average).

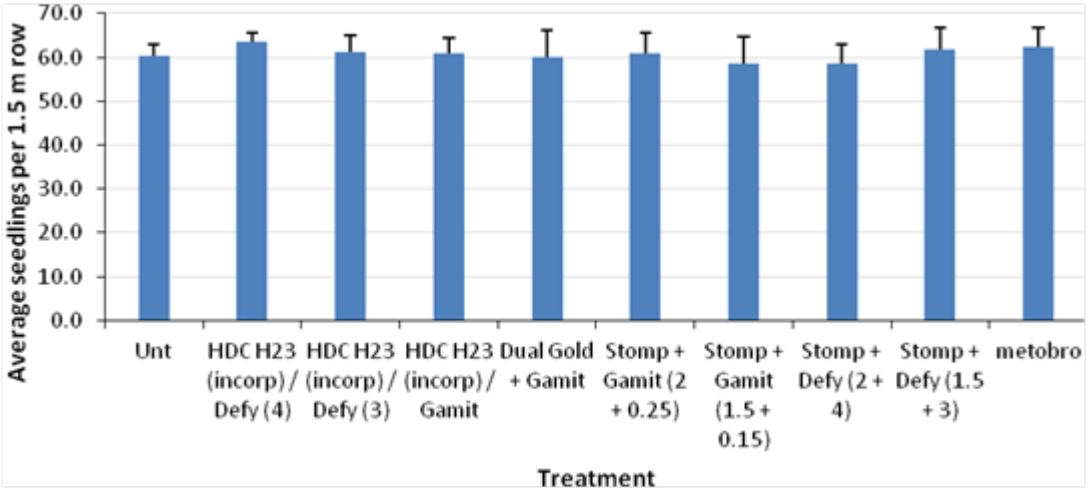


Figure 35. Average number of emerged seedlings per 1.5 m row for each treatment 10 WAT (6 August 2018). Differences between treatments are not significant (p =0.998). (Unt = untreated)

Figure 36. Crop emergence 10 WAT (8 August 2018). Left to right; Untreated control, HDC H23 pre-sowing followed by Defy 4 L/ha and Stomp Aqua 2 L/ha + Defy 4 L/ha

Phytotoxicity

Throughout the trial, no signs of crop phytotoxicity were recorded in any of the treated plots. However, due to the weed suppression early on in the trial, which slowed down emergence, this result must be treated with a degree of caution.

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 discover more responsibly sourced peat-alternatives in the production of lily cut flowers, and this has been an objective of CFC trials. With the increasing availability of green-waste (GW) and anaerobic digestate (AD) over this time, 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 2018 in the production of lily 'Dynamite' (Oriental group) in two mixes, along with a grower's peat-based medium for comparison (Table 15).

Table 15. Details of 2018 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 treatment(s)	None
Planting or sowing	Planted in standard lily crates using the following media: 1. 'Mix 1' peat 550 L (30% dark peat, 60% light peat and 10% sod peat) + 400 L Forest Gold, 50 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' 400 L Forest Gold, 300 L Cocopeat, 300 L bark fines, 100 kg clay granules, 0.4 kg base fertiliser 15-10-20+TE, 50 L dry AD, 0.2 kg Add-N and 1kg lime/m^3 3. Grower's peat-based medium (normal quantity volume - 30 L per crate) 4. Grower's peat-based medium (reduced volume - 17 L per crate)
Planting or sowing date(s)	Bulbs planted end of week 26
Plant spacing(s)	15 bulbs/crate
Layout	Five replicate crates per growing medium, arranged in three blocks
Post-planting treatment(s)	Crates placed in cold-store (9°C) for just over four weeks. The liquid feed regime was the same as for the remainder of the tunnels and was applied at each watering (see 'Materials and Methods')
Planting/housing site(s)	Crates moved to 'Pro-Tech' tunnel bay 3 at the beginning of week 31, then into a heated glasshouse in week 38
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 42
Records taken	Total stem length before trimming and stem weight after trimming to 60 cm (on a random sample of 12 stems per replicate), flower and foliage quality
VL testing	No

The bulbs were planted in week 26 (Figure 37) and then placed on a pallet in a cold store for four weeks (Figure 38).

Figure 37. Bulbs planted 15 per crate in week 26

Figure 38. Crates placed in a cold store for four weeks

The crates were stood down in the third bay of the multi-span tunnel in week 31 (Figure 39) and arranged in three replicates (Figure 40).

Figure 39. Standing down of the crates in week 31

Figure 40. Trial in place in the tunnel

During week 38 the trial was moved into a heated glasshouse in order to protect the plants from any inclement autumnal weather. The crop flowered in week 42 (Figures 41 and 42) and assessments were made on 15 stems from each treatment in each replicate. The overall stem length was measured and then the stem was cut to 60 cm before being weighed. A summary

of the results is shown in Figure 43.

Figure 41. Lily trial pre-harvest in week 42

Figure 42. Close up of a crate of lilies just before harvest

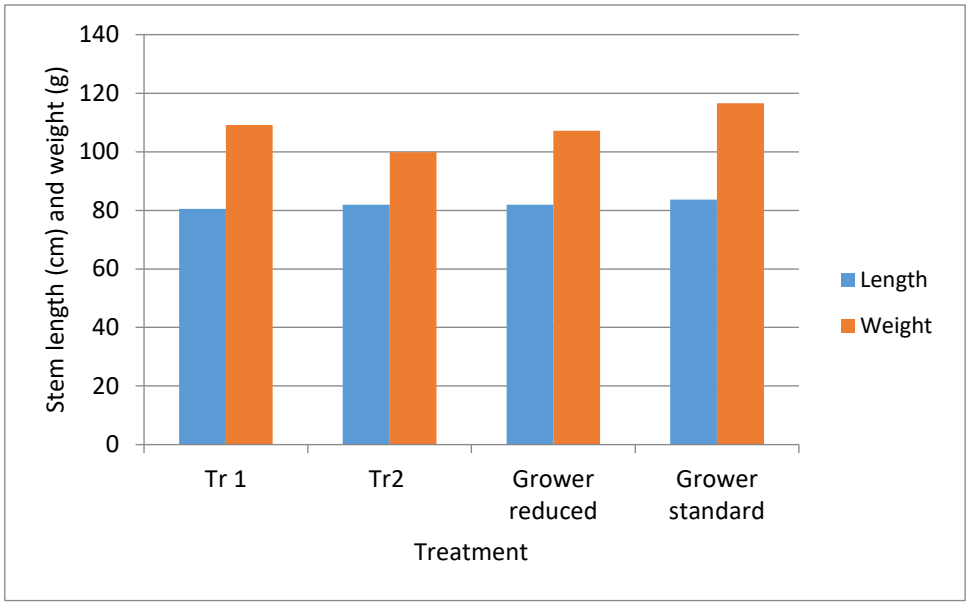


Figure 43. Stem length and trimmed weight of lily 'Dynamite' produced in two alternative growing media (Tr 1 – Mix 1 and Tr 2 – Mix 2) and in typical grower's peat-based medium at reduced (Mix 3) and standard (Mix 4) crate quantities of peat

The peat-reduced mix (Mix 1) produced stems with average length of 80.4 cm and weight of 109.1 g; the peat-free mix (Mix 2) produced stems with average length of 81.9 cm and weight

of 99.1 g; the reduced crate quantity standard grower mix (Mix 3) produced stems with an average height of 81.9 cm and weight of 107.1 g and the normal crate quantity standard grower mix produced stems with an average height of 83.6 cm and weight of 116.1 g. A standard T test showed that statistically there was no difference between the treatments although visually, the peat-free mix (Mix 2) showed marked differences especially in the colour of the leaf which was a much lighter green (Figures 44 and 45) and would in fact have made the crop unmarketable in a commercial situation. It is not known if this could have been avoided if the plants in this mix had been subject to a different fertiliser regime.

Figure 44. Peat-free mix (left) showing paler leaves compared to standard grower mix (right)

Figure 45. Single stem taken from peat-free mix (left) and standard grower mix (right)

Zinnia and Dahlia (vase life improvements)

Trials have been undertaken at the CFC on both Zinnia and Dahlia in previous years and while both were very well received; the key issue was the VL of each species which was consistently too short for either to be considered as a supermarket product. The main reason for the poor VL (especially in the case of Zinnia) was a physical issue known as 'necking', a premature collapse of the stem just below the actual bloom. During 2018, the CFC management group was made aware of trials that Omex had undertaken using the high calcium water soluble fertiliser Calmax, which was claimed had improved the VL of some flowers. Therefore, in conjunction with Floralife, the possibility of improving the VL of Zinnia and Dahlia was investigated via regular applications of calcium applied as Calmax during production, to strength the flower stem. A planting was made of three Dahlia varieties and four Zinnia varieties (Table 16) in week 21 and Calmax was applied weekly at a rate of 2 ml/L applied to run off from week 26 to week 35.

Table 16. Details of 2018 Dahlia and Zinnia vase life trials

Site	Rookery Farm
Varieties	Dahlia 'Black Fire', 'Eveline' and 'Sylvia'. Zinnia 'Benary's Giant Lime', 'Queen Lime Red', 'White' and 'Wine'
Plant longevity and hardiness	Annual
Format(s) and supplier(s)	Rooted cuttings for the Dahlia and seeded plugs for the Zinnia
Propagation and pre-planting treatment(s)	None
Planting or sowing date(s)	Planted week 21
Plots	1 m long for the Dahlia and 2 m long for the Zinnia
Planting or housing site(s)	'Pro-Tech' tunnel bay 3
Layout	Demonstration plots
Plant spacing(s)	6/m^2 for the Dahlia and 25/m^2 for the Zinnia
Post-planting treatment(s)	One layer of support netting Plants pinched three weeks after planting

Pests, diseases and disorders	Aphids, two spotted spider mite and powdery mildew adequately controlled with a regular spray programme
Picking stage(s) and market specification(s)	Various
Picking and recording date(s)	The first flowers were picked in week 33 and flowering continued until the week the tunnel covers were removed in week 39
Records taken	Observations
VL testing	Yes.

All of the actual VL work was undertaken by Floralife and this included the harvesting, transport simulation, observations in the VL room and interpretation of the results. The full report produced by Floralife is presented in Appendix 3. The main conclusion of the trial was that the application of Calmax had no noticeable effect on the VL or neck strength of Zinnia, although it did increase stem length. In this trial neither the treated nor untreated stems were severely affected by necking at bunch processing. As result of harvesting the flowers after the first whorl had opened it was possible to extend the VL to four days, but this was still short of the required minimum. The Dahlias still didn't make it to VL in an appropriate condition to undergo testing, so were discontinued.

Even though the trial did not show that the application of Calmax improved the VL of either Zinnia or Dahlia, there was a very noticeable growth enhancement in the treated plants compared to the untreated ones (Figures 46 and 47). However, as the trial was not replicated, such observations need to be treated with caution and growers should undertake their own trials before deciding if such a use is appropriate for their cropping situation.

Figure 46. Calmax treated zinnia plots in week 35

Figure 47. Untreated zinnia plots in week 35

Discussion

Ammi majus and *A. visnaga*

Seed raised fillers have been of interest to industry for a few years now and while some, such as Bupluerum, are now grown commercially, Ammi has only been grown by 'artisan growers'. The 2018 trial clearly demonstrated that continuity can be achieved by sequential planting and that a good flower stem length is possible. Previous years trials have also shown that Ammi can also be produced outdoors with the provision of adequate irrigation and that such outdoor crops tended to be less vigorous but still capable of producing marketable stems. Of the two species *Ammi visnaga* perhaps has more potential than *A. majus* because the stems are easier to harvest (the latter tends to produce a mass of heads that tangle into each other) and produces a more compact and manageable end product. VL tests on Ammi species in previous years trials found a long (over 10 days) VL. The varieties grown in 2018 were the same as those produced in the Netherlands and sold through the Dutch flower auction. Unless a specific request in the future is submitted, 2018 is intended to be the last year that Ammi will be included in the CFC trials, although there are plans to investigate other fillers from the Umbeliferae family including Didiscus, Pastinaca and Smyrnium which will be planted in 2019.

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

Relatively unknown in the UK, when tunnel grown the most promising variety in trial was *Asclepias curassavica* 'Apollo Orange' which produced prolific and attractive, orange-red inflorescences on long stems over a period of about four weeks. While only two plantings were made in 2018, it would appear that continuality of flowering can be achieved by successive planting dates. Other varieties trialled did not appear appropriate owing to stem length issues, bud abortion or problems with flower quality. Visually this crop has obvious potential, although in both the 2017 and 2018 trials VL was an ongoing problem owing to issues with water uptake requiring further work. Further investigations by Emma Bradford of Floralife found the following:

Stage of harvest: cut stems when one-half to two-thirds of the florets are open. Stems are prone to wilting, so harvest early in the morning and handle promptly.

Expected vase life: in university trials in the U.S.A, cut Asclepias curassavica 'Silky' mixed flowers lasted nine to 11 days and Asclepias tuberosa 'Oro' lasted 10 days. In industry trials, 'Oro' had a VL of nine days.

Grower, wholesaler, and retailer treatments: use of a holding solution added two days to the VL to 'Silky', but had no effect on 'Oro'. Ignore all of the various handling suggestions for species that produce latex, such as flaming the end of the stem or inserting in boiling water. After harvest place cut stems into water to allow the latex to dissipate, and then move to fresh water. Repeat if stems are recut.

Storage and shipping procedures: stems can be stored at 40F (5C).

There is anecdotal evidence from industry that placing the stems in fresh water immediately after planting did in fact improve the VL, but no formal VL assessments were made owing to the samples being lost in transit. This will be investigated in 2019 with the overwintered crop, but currently Asclepias would seem to have potential as new crop for UK growers.

Astrantia major

Astrantia was planted for the first time in 2018 at the CFC with a trial of a new range of varieties including ‘Sparkling Pink Star’ and ‘Sparkling Red Star’. The plants should produce their first crop in 2019 when their VL and market potential will be assessed. At a CFC Management Group meeting in late 2018 the Project Manager was informed that Astrantia is currently “on trend” and the trial is therefore very timely.

Column stock (Matthiola) – late planted variety trial

There has been interest in the Japanese varieties of column stocks for some time but there has been very little commercial uptake owing to the issues of not being able to select double flowered seedlings by machine, as is the case with the current widely grown commercial varieties. The hand selection process 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. One such advantage could be the ability to extend the season of the column stock crop into the summer months when it has been reported that the Japanese varieties are less prone to flower initiation problems during higher temperatures.

The 2018 season with weeks of temperatures in excess of 30°C was certainly a stern test for the varieties and showed that while there were issues with flowering, most of the Japanese varieties did initiate a flower bud whereas the widely grown ‘Mathilda’ series initiated no flowers at all and the more resilient ‘Anytime’ series showed erratic initiation with very few marketable stems. The flowering issues recorded centred around inadequate flower spike length and flower bud distortion, leading to only 15 to 25% of flower stems being marketable. Those that did produce a normal flower had very strong stems in excess of 60 cm in length which generated confidence to investigate them further during 2019.

In 2019 it is planned to make four plantings in weeks 18, 20, 22 and 24 to determine how they perform in less challenging conditions when the temperature should be less extreme, the

premise being to use the stronger stems in bouquet work as a premium product and to see if a market exists for the single flowered stems. They will also be included in the Fusarium susceptibility variety trial.

Daucus carota

Small pots of *Daucus carota* 'Dara' have been produced from seed and planted at the CFC in previous years. Only a few stems were produced from these earlier trials but they did generate some interest from industry. In order to try and determine the true commercial potential of Daucus, plugs were sourced from Florensis in 2018 and a number of successional plantings were made. The trial generated a lot of interest both at the CFC Open Day and also through samples sent to industry throughout the season. One of the disadvantages of the crop as a supermarket product could be the wide range of head colours and sizes generated, both of which would make it difficult to grow to a demanding specification. However if this could be overcome by perhaps using Daucus in more flexible bouquet work, it could have real potential as a new product for UK growers. The crop is already widely grown and offered by 'artisan growers'. The crop appears as if can be harvested at a wide range of maturities but appropriate post-harvest work would need to be undertaken to determine the optimum maturity stage to maximise vase life.

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

A large Echinacea variety trial is currently being undertaken by 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 will flower and be assessed during 2019.

Eucomis autumnalis

Eucomis has been planted at the CFC in previous years using plants grown from seed and propagated on site. However, the seedlings failed to make a marketable crop before the tunnel had to be cleared. As the crop had previously been identified as having potential as

cut flower, a new trial was planted in 2018 using both (large) corms and home-propagated seedlings. During 2018, only some of the corms produced flower stems with the seedlings growing very slowly and only producing a small plant by the end of the season. While not enough stems were produced to assess the true market potential of the crop, some of the flowers were used in floral displays and anecdotally achieved a good VL. Further assessments will be undertaken in 2019.

Lysimachia fortunei

While Lysimachia is not currently grown commercially in the UK, there are a number of cut flower varieties listed on the Dutch auction, including 'Abraham', 'Elisabeth' 'Jumbo', 'Mambo', 'Marilyn' and 'Martha'. A trial of Lysimachia was requested by delegates at the 2017 CFC Open Day who viewed the Veronica trial, as their respective flower forms are similar. Of the two varieties supplied to the CFC in 2018, 'Jumbo' performed better than 'Mambo', the latter suffered from severe chlorotic and necrotic patches on the leaves. The reason for this problem remains unidentified and it is not known if other varieties would show similar problems if grown in a similar way.

The long, strong stems produced interest among industry especially for floral display work, but there was a question mark about its suitability for use in supermarket bouquets because of the curved nature of the flower spike (although this was one of the flowers' attributes most loved by some designers who used samples of the CFC product). Other varieties, such as 'Marilyn', may produce straighter flower spikes. The performance of the second year crop will be assessed in 2019 and formal VL work will be undertaken.

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

In 2016 new Scabious series from Danziger and HilverdaKooji were offered to the CFC. Both series had an attractive range of flower colours, high yields and good VL, and were well received by industry, having good potential for use by retailers in mixed bouquets. In 2018, the 'Scoop' series was examined again owing to the fact that a large number of new varieties

had been introduced. Some of these new introductions were again well received by industry especially ‘Red Velvet’ which has vibrant coloured blooms held on strong and long stems. As identified in previous years, harvesting costs are an issue, so in 2018 it was decided to harvest to either a 50 or 55 cm stem length and leave the side shoots on as part of the flower stem. This served to both speed up harvesting and led to a more substantial bunch of flowers. The plan was for 2018 to be the last year that Scabious would be trialled, but towards the end of the season one of the CFC Management Group members, who had also undertaken trials, received requests from local packers (who had been importing stems from the Netherlands) to investigate the crop further in 2019. As a consequence, a range of varieties from both Danziger and HilverdaKoji will be planted in 2019 along with parallel trials on growers nurseries.

Veronica longifolia

One series, ‘Spark’, featured in earlier trials, but at the time its lightweight stems and limited flowering window made it unlikely to be economic to grow in the UK. Following renewed interest in this crop (and fillers in general), plots of the new ‘Skyler’ series were trialled in 2016. When grown in a tunnel, flowering was prolific with straight flower stems and well coloured spikes. Overwintered they produced two flower flushes the following year. However, because the flowering window was still relatively short it was recognised that seasonal extension would need to be investigated, by scheduling planting and pinching plants, to gain the interest of industry. The 2018 trial showed that with the ‘Skyler’ series adjusting both the planting and pinching dates successfully extended the season of the pink and white flowered varieties, but for the blue flowered variety only the planting date had any effect. At this stage it is not known if the blue varieties of other series behave in the same way as the ‘Skyler’ series. The 2018 crop will be overwintered in order to provide additional samples for industry, however it is not anticipated that any new plantings of Veronica will be undertaken at the CFC.

Column stocks – downy mildew sensitivity testing

The CFC was able to quickly respond to the disease issue, liaising with cut flower growers, propagators and seed houses. With the help of extra funding from Florensis, Pan American Seeds and Globe Plants, the CFC was able to commission Fera to undertake two fungicide sensitivity trials to investigate products with current approval for the control of downy mildew as well as others that have shown promise in the AHDB-funded SceptrePlus project but are not yet currently approved. The culmination of all of this work was the discovery of tolerance/resistance to products containing metalaxyl-M, a review of current spray programmes used by industry and the publication of a detailed technical note in January 2019 entitled CFC/AHDB Information Sheet 11 *Maintaining successful control of downy mildew in protected crops of cut flower column stocks*. The CFC will continue to monitor the impact of this disease during 2019 with the aim of commissioning additional work as required.

Column stocks – improving control of Fusarium wilt

While not achieving the anticipated results, the 2018 trial did serve as a reminder to industry as to just how devastating Fusarium can be and how symptoms are exacerbated by hot weather. And while previous trials have shown that there are distinct varietal differences in susceptibility to the disease with column stocks (many of the red and blue flowered varieties are known to be particularly susceptible), this trial demonstrated that none of the current commercially grown varieties exhibit any level of true resistance to *Fusarium oxysporum* f. sp. *mathioli*. The results obtained from the soil samples taken by Warwick University do give an indication that, as would be expected, the rate of infection is related to the level of spores in the soil at the time of planting, areas with higher spore counts showing quicker and more severe infection of the plants.

The trial also demonstrated the host specificity of the Fusarium races, the isolate used, originally extracted from column stock, did not infect any of the Lisianthus plants within the trial, a crop that is known to be very susceptible to *Fusarium oxysporum*. The trial will be

repeated in 2019 but planting will occur earlier (week 18) and through white rather than black mulch to minimise environmental stress. Plots of the new Japanese varieties (such as 'Iron' and 'Venus') will also be included as these originate from different genetics and their susceptibility to Fusarium is totally unknown.

Herbicides for outdoor Larkspur

Although Larkspur emergence across the trial was variable, it was possible to pick out some differences between the herbicide treatments. In terms of crop emergence, HDC H23 applied pre-sowing followed by Defy 4 L/ha applied post-sowing (T2) gave the highest number of germinated seedlings per 1.5 m row, and also had the lowest weed cover (8.3%), which suggests that this is a promising treatment.

HDC H23 applied pre-sowing followed by Defy 3 L/ha (T3), Dual Gold 0.78 L/ha + Gamit 36 CS 0.25 L/ha (T5) and Stomp Aqua 2 L/ha + Gamit 36 CS 0.25 L/ha (T6) also gave reasonable weed control, and crop emergence was similar to the untreated control, which suggests that these treatments may also be suited to Larkspur production. The lowest emergence rate was seen in plots treated with Stomp 2 L/ha + Defy 4 L/ha (T8), and this reflects the results from the 2015 trial.

Stomp Aqua 1.5 L/ha + Gamit 36 CS 0.15 L/ha (T7) did not give particularly good weed control at this lower rate, and neither did metobromuron, although crop emergence was not reduced. It is likely that metobromuron would need to be mixed with another product in order to provide effective weed control.

None of the treatments appeared to drastically reduce crop emergence, however, the general lack of phytotoxicity as a result of any of the treatments must be treated with caution, as this may have been affected by the flush of weeds early on in the trial.

Lily – alternatives to peat-based growing media

The 2018 trials have further demonstrated that boxed lily production is possible using peat-reduced media. However while the peat-free media used in 2018 produced a lily crop that was not statistically different in terms of stem weight and length, it had much lighter green foliage than the other mixes trialled and the crop would have been unmarketable as a result. It is possible that this could have been overcome by developing a bespoke fertiliser regime for the mix, but this was not investigated as part of the trial. The 'reduced volume grower own mix' also produced a marketable crop, but discussions with growers indicated that they would be reluctant to use such a technique owing to the reduced buffering capacity of the lower volume of growing media should issues occur with irrigation or crop nutrition.

Zinnia and Dahlia (vase life improvements)

Several years of Zinnia trials at the CFC have shown the 'Benary Giant' series to be superior to other varieties trialled as result of their overall vigour, attractive flowers, wide range of flower colours and long stems, but VL is problematic for Zinnia as the hollow stem often bends just below the flower. VL tests undertaken over a number of years appear to show that, under some circumstances at least, Zinnia is capable of an acceptable, borderline but overall unpredictable, VL. The 2018 trials, examining the application of Calmax during production, undertaken by Floralife indicated that while the programme of applications appeared to increase the over vigour of the plants, as well as enchancing stem length, the use of Calmax did not improve the VL of Zinnia. The same trial also examined the impact of Calmax applications on Dahlia, and again no improvement in VL was recorded, meaning that this crop still remains unviable as a cut flower to meet the demands of the supermarket VL specification.

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 carries news of events, notifications of handouts, reports and publications, and the latest Extensions of Authorisation for Minor Use (EAMUs).

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 8 August 2018.

Publications

CFC/AHDB Information Sheet 9 ‘Sunflowers (*Helianthus annuus* cultivars) as a field- and tunnel-grown cut flower crop’.

CFC/AHDB Information Sheet 10 ‘Alstroemerias (*Alstroemeria* hybrids) as a tunnel-grown cut flower crop’.

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

Acknowledgements

The Project Leader would like to express huge appreciation to David and Elaine Robinson (R Robinson & Son), CFC's hosts at Rookery Farm, and to their team, especially Verban Toromanov, for managing the trials and recording on a daily basis. Particular thanks are due to Sue Lamb (Lambs Flowers) for her vigorous promotion of the CFC and especially for her strenuous efforts in ensuring the many samples of CFC's novel cut flowers were made available throughout the cut flower industry.

Thanks to the current Management Group including: Philip Collison (JA Collison & Sons) and Sue Lamb (Lambs Flowers), Gordon Flint (New Horizon Flowers), Mark Eves (PS & JE Ward), Laura Tebby (Superflora), Rebecca Crompton (Flamingo Flowers), Emma Coupe (Waitrose), Frankie McKieenan (J Sainsbury), Wayne Brough (AHDB Horticulture) and Georgina Keys (AHDB Horticulture) for their dedicated work to ensure the ongoing success of this project. Special thanks also to Emma Bradford for all of her help and support with vase life trials.

We are indebted to all who have provided plants and seeds, the staff of Armada Young Plants, Danziger, Florensis, Globe Plants, Kolster, and Walter Blom.

And finally a huge thank you to Selchuk Kurtev for his invaluable help and support to both the CFC and the cut flower industry as a whole.

Appendix 1

Fera First Downy Mildew Sensitivity Trial

Fungicide Sensitivity Testing – Stock Downy Mildew

Report for The Cut Flower Centre Limited

May 2019




Dr Phil Jennings

Contents

1. Introduction

Downy mildews are some of the most destructive diseases of crops. Most downy mildew pathogens are host specific i.e. only one plant family. Pathogen species which cause downy mildew infections include Peronospora, Bremia, Plasmopara and Basidiophora. They infect a wide variety of greenhouse crops including pansy, snapdragon, impatiens, salvia, primula, verbena as well as cut flowers, including scabiosa and stock.

During 2018, there was widespread downy mildew infection of Stock plants (*Matthiola incana*) in the UK and Ireland. Downy mildew in Stock plants is caused by *Peronospora parasitica*. These infections proved difficult to control which raised the possibility of fungicide resistance.

There were two aims to this project

1) Screen isolates of Stock downy mildew, collected from five outbreak sites, for sensitivity to a range of fungicides known to have activity against downy mildew pathogens.
2) Test samples of *Matthiola incana* seed for the presence of *P. parasitica* DNA.

2. Materials and Methods

Fungicide Sensitivity screening

Isolates

Downy mildew infected Stock plants were sent to Fera from five outbreak sites (Table 1). On arrival at Fera, the disease was transferred onto fresh, disease free plants. Each isolate was maintained by weekly sub-culturing onto fresh plants.

Table 1. Suppliers of Stock downy mildew isolates

Site	Name
1	Norfolk 1
2	Lincolnshire
3	Irish
4	Norfolk 2
5	Cornwall

Fungicide treatment

Each Stock downy mildew isolate was screened against nine fungicides thought to have activity against downy mildew pathogens (Table 2). Fungicides were applied as protectant treatments, at rate shown in Table 2, one day prior to inoculation with *P. parasitica*. Three replicate plants were treated for each fungicide/isolate combination.

Plants were assessed for infection 12 days after inoculation, by counting the number of infected leaves on each of the treated plants and comparing to the untreated control plants.

Table 2. Fungicide product and application rate used in sensitivity screening of Stock downy mildew caused by *Peronospora parasitica*.

Product	**Active ingredient**	**Content**	**Approval**	**Dose rate**	**Water volume (ha)**	**Conc**
Fenomenal	Fenamidone + fosetyl-aluminium	60g/kg + 600g/kg	EAMU 1990/13	2.25kg/ha	1000L (min 1000L)	2.25g/L
Fubol Gold	Mancozeb + metalaxyl-M	640g/kg + 38.8g/kg (64%w/w + 3.88%w/w)	EAMU 2288/13	1.9kg/ha	1000L (min 250L)	1.9g/L
HDC F253	-	-	Not Approved	0.5L/ha	1200L (600-1200L)	0.42ml/L
Paraat	Dimethomorph	500g/kg (50%w/w)	EAMU 2585/11	3kg/ha	1000L (min 600L)	3g/L
Percos	Ametodractin + dimethomorph	300g/l + 225g/l	EAMU 0819/13	0.8L/ha	1000L (max 1000L)	0.8ml/L
Previcur Energy	Fosetyl-aluminium + propamocarb hydrochloride	310g/l + 530g/l	EAMU 1845/13	2.5L/ha	1000L (min 200L)	2.5ml/L
Revus	Mandipropamid	250g/l	EAMU 2763/16	0.6L/ha	1000L (min 200L)	0.6ml/L
Signum	Boscalid + pyraclostrobin	267g/kg + 67g/kg (26.7%w/w + 6.7%w/w)	EAMU 2141/12	1.35kg/ha	1000L (min 200L)	1.35g/L
Subdue	Metalaxyl-M	465.2 g/l	On label (not approved for downy mildew)	1.25L/ha	10,000L (drench only)	0.125ml/L

Testing of *Matthiola incana* seed for the presence of *Peronospora parasitica* DNA

Ten packets of *M. incana* seed (100 seed/packet) were supplied by Florensis for screening. Each packet was a different variety (Table 3).

Screening

DNA was extracted from fifty seed of each variety using standard methodologies. Two sets of primers, described by Brouwer *et al* (2003), were used for the detection of *P. parasitica* DNA. An initial screen, using downy mildew infected Stock leaves, was carried out to check that the primers would detect the *P. parasitica* isolate responsible for downy mildew on Stock plants.

Table 3. *Matthiola incana* seed varieties supplied for *Peronospora parasitica* screening.

Batch	*Matthiola incana* variety
1	Mathilda White
2	Mathilda Yellow
3	Opera Debora
4	Opera Francesca
5	Centum Pink
6	Centum White
7	Figara Lavender
8	Figaro Rose Light
9	Aida White
10	Fedora Deep Rose

3. Results

Fungicide sensitivity screening

Raw data for the trial are shown in the Annex to this report.

The level of disease control achieved by the nine fungicides screened is shown in Figures 1, 2 and 3.

At the fungicide rates tested none of the products applied gave 100% control of all five Stock downy mildew isolates. The greatest control was achieved was following the application of Paraat (Figure 1), where 90% control or greater was achieved for three of the five isolates. Percos was the second most effective product with greater than 80% control achieved for three of the five isolates (Figure 2). For applications of both Paraat and Percos it was the isolates from collected from Ireland and Norfolk 2 which showed greater disease levels. Both Paraat and Perco contain dimethomorph.

The only other product to give any level of control was Revus (Figure 3), where greater than 70% control was achieved for three of the five isolates.

No, or very little control, was achieved following the application of Signum, Subdue and HDC F253 Figures 1, 2 and 3 respectively).

Products containing metalaxyl-M would usually give 100 % control of downy mildew pathogens. The lack of any control by Subdue, and only partial control by Fubol Gold, suggests that all five isolates were resistant to metalaxyl-M. The control achieved by Fubol Gold was due to the presence of mancozeb in the formulation.

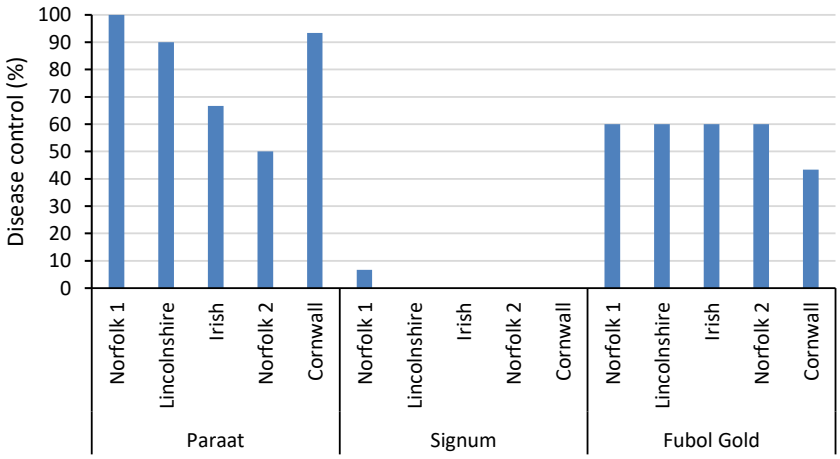


Figure 1. Stock downy mildew disease control achieved following application of Paraat, Signum and Fubol Gold.

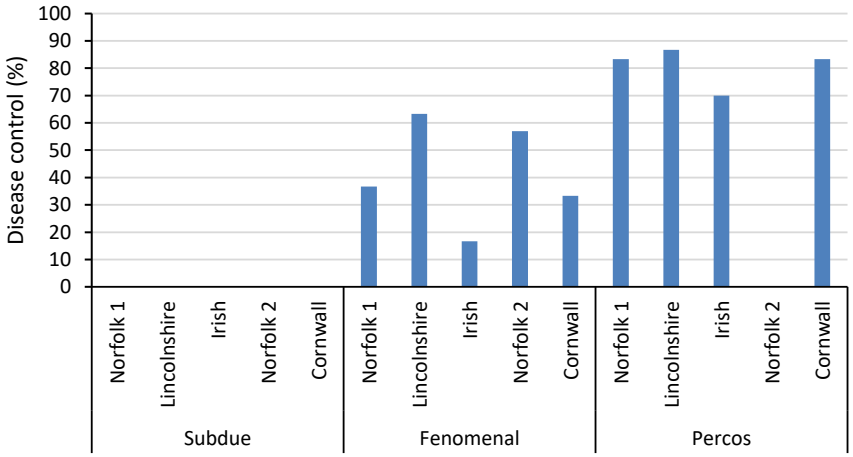


Figure 2. Stock downy mildew disease control achieved following application of Subdue, Fenomenal and Percos.

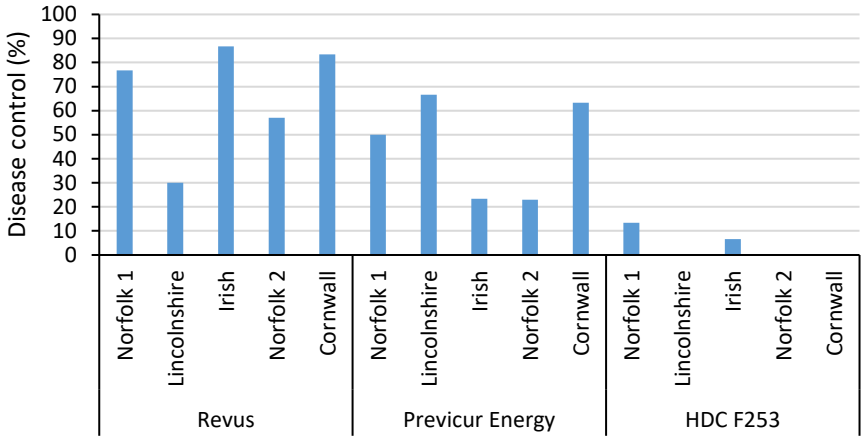


Figure 3. Stock downy mildew disease control achieved following application of Revus, Previcur Energy and HDC F253.

Testing of *Matthiola incana* seed for the presence of *Peronospora parasitica* DNA

Results of PCR reactions are presented as cycle threshold values or Ct values which represent the number of amplification cycles after which fluorescence, and therefore DNA, can be detected above a background level. Each amplification cycle breaks down the DNA strands and then rebuilds them, thus doubling the amount of target DNA each cycle. In each test 40 amplification cycles were carried out. The Ct value is inversely proportional to the amount of target DNA, so the lower the Ct value the more target DNA is present in the sample. A value of 40 (the maximum number of amplification cycles) indicates a negative result (either no DNA present in the sample, or the DNA present was not detected by the primer set). Generally, Ct values of 30 or less are considered strong positive reactions and are indicative of abundant target DNA in the sample. Ct values of 31-37 are positive reactions and indicate moderate amounts of DNA, whereas values 38-40 are weak reactions and indicate a minimal amount or no target DNA in the sample.

Two primer sets were tested on stock leaves heavily infected by *P. parasitica* to determine whether they could be used to detect *P. parasitica* DNA in seed. Both primer sets detected the presence of *P. parasitica* DNA in the leaf material (Table 4), however the level of detection seen with Primer set 2 was much lower than that for primer set 1 (36.9 compared to 18.6). Based on this primer set 1 was used to determine whether *P. parasitica* DNA was present in *M. incana* seed.

Table 4. Average cycle threshold value for *Peronospora parasitica* DNA in stock leaf material

	Average Ct value	
	Primer set 1	Primer set 2
Negative control (water)	40	40
Leaf negative (uninfected)	40	40
Leaf positive (downy mildew infected)	18.6	36.9

One seed batch, Figara Lavender, appeared to contain *P. parasitica* DNA (Table 5). From this test it is not possible to tell whether the presence of *P. parasitica* DNA will lead to infection.

Table 5. Average cycle threshold value for *Peronospora parasitica* DNA in *Matthiola incana* seed.

Batch	*Matthiola incana* variety	Average Ct value
1	Mathilda White	40
2	Mathilda Yellow	40
3	Opera Debora	40
4	Opera Francesca	40
5	Centum Pink	40
6	Centum White	40
7	Figara Lavender	36.3
8	Figaro Rose Light	40
9	Aida White	40
10	Fedora Deep Rose	40
	Negative control (water)	40
	Leaf negative	40
	Leaf	21.1

4. Conclusions

- No product gave 100% control of the five Stock downy mildew isolates screened.
- Products containing dimethomorph (Paraat and Percos) gave the greatest disease control.
- Revus gave control greater than 70% for three of the five isolates.
- Resistance to Metalaxyl-M was present in all five Stock downy mildew isolates.
- The Norfolk 2 isolate was consistently harder to control than the other isolates screened.
- Peronospora parasitica DNA was detected in one of the 10 seed lots tested. From this analysis it is not possible to determine whether the DNA is viable or whether it would lead to downy mildew infection.

5. Reference

Brouwer M, Lievens, B, Van Hemelrijck W, Van den Ackerveken, G, Cammue BPA, Thomma BPHJ (2003). Quantification of disease progression of several microbial pathogens on *Arabidopsis thaliana* using real-time fluorescence PCR. *FEMS Microbiological Letters*, 228, 241-248.

6. Annex

Product	Isolate	Rep	No. infected leaves (/10)
Subdue	Norfolk 1	1	10
		2	10
		3	10
	Lincolnshire	1	10
		2	10
		3	10
	Irish	1	10
		2	10
		3	10
	Norfolk 2	1	10
		2	10
		3	10
	Cornwall	1	10
		2	10
		3	10
Percos	Norfolk 1	1	1
		2	1
		3	3
	Lincolnshire	1	1
		2	2
		3	1
	Irish	1	4
		2	2
		3	3
	Norfolk 2	1	10
		2	10
		3	10
	Cornwall	1	1
		2	4
		3	0
Previcur Energy	Norfolk 1	1	5
		2	5
		3	5
	Lincolnshire	1	6
		2	2
		3	2
	Irish	1	8
		2	7

Product	Isolate	Rep	No. infected leaves (/10)
Fenomenal	Norfolk 1	1	5
		2	10
		3	4
	Lincolnshire	1	6
		2	5
		3	0
	Irish	1	7
		2	10
		3	8
	Norfolk 2	1	4
		2	7
		3	2
	Cornwall	1	6
		2	9
		3	5
Revus	Norfolk 1	1	2
		2	1
		3	4
	Lincolnshire	1	7
		2	4
		3	10
	Irish	1	2
		2	1
		3	1
	Norfolk 2	1	2
		2	3
		3	8
	Cornwall	1	2
		2	2
		3	1
HDC F253	Norfolk 1	1	9
		2	9
		3	8
	Lincolnshire	1	10
		2	10
		3	10
	Irish	1	10
		2	10

		3	8			3	8
	Norfolk 2	1	9		Norfolk 2	1	10
		2	9			2	10
		3	5			3	10
	Cornwall	1	7		Cornwall	1	10
		2	2			2	10
		3	2			3	10
Paraat	Norfolk 1	1	0	Signum	Norfolk 1	1	10
		2	0			2	9
		3	0			3	9
	Lincolnshire	1	0		Lincolnshire	1	10
		2	0			2	10
		3	3			3	10
	Irish	1	7		Irish	1	10
		2	2			2	10
		3	1			3	10
	Norfolk 2	1	2		Norfolk 2	1	10
		2	5			2	10
		3	8			3	10
	Cornwall	1	0		Cornwall	1	10
		2	2			2	10
		3	0			3	10
Fubol Gold	Norfolk 1	1	4	Inoculated control	Norfolk 1	1	10
		2	3			2	10
		3	5			3	10
	Lincolnshire	1	3		Lincolnshire	1	10
		2	3			2	10
		3	6			3	10
	Irish	1	5		Irish	1	10
		2	0			2	10
		3	7			3	10
	Norfolk 2	1	0		Norfolk 2	1	10
		2	4			2	10
		3	8			3	10
	Cornwall	1	8		Cornwall	1	10
		2	4			2	10
		3	5			3	10

Fera hereby excludes all liability for any claim, loss, demands or damages of any kind whatsoever (whether such claims, loss, demands or damages were foreseeable, known or otherwise) arising out of or in connection with the preparation of any technical or scientific report , including without limitation, indirect or consequential loss or damage; loss of actual or anticipated profits (including loss of profits on contracts); loss of revenue; loss of business; loss of opportunity; loss of anticipated savings; loss of goodwill; loss of reputation; loss of damage to or corruption of data; loss of use of money or otherwise, and whether or not advised of the possibility of such claim, loss demand or damages and whether arising in tort (including negligence), contract or otherwise. This statement does not affect your statutory rights.

Nothing in this disclaimer excludes or limits Fera liability for: (a) death or personal injury caused by Fera negligence (or that of its employees, agents or directors); or (b) the tort of deceit; [or (c) any breach of the obligations implied by Sale of Goods Act 1979 or Supply of Goods and Services Act 1982 (including those relating to the title, fitness for purpose and satisfactory quality of goods);] or (d) any liability which may not be limited or excluded by law (e) fraud or fraudulent misrepresentation.

The parties agree that any matters are governed by English law and irrevocably submit to the non-exclusive jurisdiction of the English courts.

Appendix 2

Fera Second Downy Mildew Sensitivity Trial

Fungicide Sensitivity Testing (2) – Stock Downy Mildew

Report for The Cut Flower Centre Limited

December 2018




Dr Phil Jennings

Contents

1. Introduction

Downy mildews are some of the most destructive diseases of crops. Most downy mildew pathogens are host specific i.e. only attack one plant family. Pathogen species which cause downy mildew infections include Peronospora, Bremia, Plasmopara and Basidiophora. They infect a wide variety of greenhouse crops including pansy, snapdragon, impatiens, salvia, primula, verbena as well as cut flowers, including scabiosa and stock.

In 2018, the UK and Ireland saw widespread downy mildew infection of Stock plants (*Matthiola incana*). Downy mildew in Stock plants is caused by *Hyaloperonospora parasitica* (syn. *Peronospora parasitica*; the literature also sites *Peronospora matthiolae* Gäum. as the species responsible for downy mildew on several *Matthiola* spp. These infections proved difficult to control which raised the possibility of fungicide resistance.

A previous screen of fungicides, commonly used in horticulture, against five Stock downy mildew (SDM) isolates showed that all were resistant to metalaxyl-M.

The aim of this project was to screen a wider range of fungicides for efficacy against two of the SDM isolates used in the first trial.

2. Materials and Methods

Fungicide Sensitivity screening

Isolates

The ‘Norfolk’ and ‘Irish’ SDM isolates collected for the first trial were used in this screen. In the first trial these isolates proved to be the hardest to control as, compared to the other isolates screened, they showed reduced sensitivity to dimethomorph.

Fungicide treatment

Both SSM isolates were screened against nine fungicides (Table 1). Fungicides were applied as protectant treatments, at the rate shown in Table 1, one day prior to inoculation with *P. parasitica*. Three replicate plants were treated for each fungicide/isolate combination.

Plants were assessed for infection 12 days after inoculation, by counting the number of infected leaves on each of the treated plants and comparing to the untreated control plants.

Table 1. Fungicide product and application rate used in sensitivity screening of Stock downy mildew.

Product	Active ingredient	Content	Rate	Water volume (/ha)
HDC F260	-	-	0.5 L/ha	1000 L
Paraat	Dimethomorph	500 g/kg	3 kg/ha	1000 L
Stroby WG	Kresoxim-methyl	500 g/kg	0.3 kg/ha	1000 L
HDC F257	-	-	0.7 L/ha	1000 L
HDC F259	-	-	0.5 kg/ha	1000 L
Infinito	Fluopicolide Propamocarb hydrochloride	62.5 g/L 625 g/L	1.6 L/ha	400 L
HDC F254	-	-	2.5 kg/ha	1000 L
HDC F253	-	-	0.5 L/ha	1000 L
HDC F258	-	-	0.45 kg/ha	500 L

3. Results

Fungicide sensitivity screening

Raw data for the trial are shown in the Annex to this report.

The level of disease control achieved by the nine fungicides screened is shown in Figure 1. Generally, the data show that the ‘Norfolk’ isolate was the harder to control than the ‘Irish’ isolate; this result compares with data from the first trial.

At the fungicide rates tested none of the products applied gave 100% control of the two Stock downy mildew isolates. The greatest control was achieved was following the application of HDC F260 (Figure 1), where 90% control or greater was achieved for the two isolates. HDC F254 and Paraat were the only other compounds to give any level of control for the two isolates.

Two compounds, Paraat and HDC F253, were also included in the first trial. Data for these compounds in the second trial were comparable to those obtained for the ‘Norfolk’ and ‘Irish’ isolates in the first trial.

No, or very little control, was achieved following the application of Stroby WG, HDC F257, HDC F259, Infinito, HDC F258 and HDC F253.

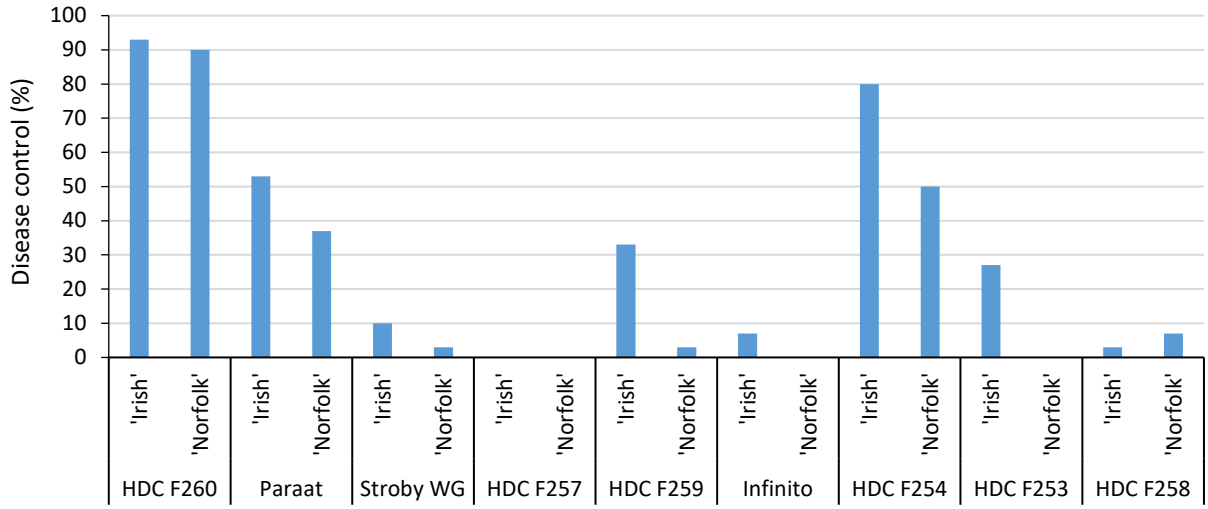


Figure 1. Stock downy mildew disease control achieved following fungicide treatment.

4. Conclusions

- The ‘Norfolk’ isolate was generally harder to control than the ‘Irish’ isolate.
- No product gave 100% control of the Stock downy mildew isolates used.
- Highest levels of disease control were achieved following application of HDC F260
- HDC F254 and Paraat were the only other products to provide any level of control of the two Stock downy mildew isolates used.

Chemical	Isolate	Rep	No. infected leaves/10
HDC F260	Irish	1	0
HDC F260		2	0
HDC F260		3	2
HDC F260	Norfolk	1	0
HDC F260		2	0
HDC F260		3	3
Paraat	Irish	1	5
Paraat		2	4
Paraat		3	5
Paraat	Norfolk	1	5
Paraat		2	9
Paraat		3	5
Stroby WG	Irish	1	10
Stroby WG		2	8
Stroby WG		3	9
Stroby WG	Norfolk	1	9
Stroby WG		2	10
Stroby WG		3	10
HDC F257	Irish	1	10
HDC F257		2	10
HDC F257		3	10

HDC F257	Norfolk	1	10
HDC F257		2	10
HDC F257		3	10
HDC F259	Irish	1	4
HDC F259		2	7
HDC F259		3	9
HDC F259	Norfolk	1	10
HDC F259		2	9
HDC F259		3	10
Infinito	Irish	1	10
Infinito		2	10
Infinito		3	8
Infinito	Norfolk	1	10
Infinito		2	10
Infinito		3	10
HDC F254	Irish	1	5
HDC F254		2	0
HDC F254		3	1
HDC F254	Norfolk	1	6
HDC F254		2	7
HDC F254		3	2
HDC F253	Irish	1	4
HDC F253		2	10
HDC F253		3	8
HDC F253	Norfolk	1	10

HDC F253		2	10
HDC F253		3	10
HDC F258	Irish	1	10
HDC F258		2	10
HDC F258		3	9
HDC F258	Norfolk	1	10
HDC F258		2	8
HDC F258		3	10
Inoc control	Irish	1	10
Inoc control		2	10
Inoc control		3	10
Inoc control	Norfolk	1	10
Inoc control		2	10
Inoc control		3	10
Uninoc control		1	1
Uninoc control		2	1
Uninoc control		3	0
Uninoc control		4	1
Uninoc control		5	1
Uninoc control		6	1

Fera hereby excludes all liability for any claim, loss, demands or damages of any kind whatsoever (whether such claims, loss, demands or damages were foreseeable, known or otherwise) arising out of or in connection with the preparation of any technical or scientific report , including without limitation, indirect or consequential loss or damage; loss of actual or anticipated profits (including loss of profits on contracts); loss of revenue; loss of business; loss of opportunity; loss of anticipated savings; loss of goodwill; loss of reputation; loss of damage to or corruption of data; loss of use of money or otherwise, and whether or not advised of the possibility of such claim, loss demand or damages and whether arising in tort (including negligence), contract or otherwise. This statement does not affect your statutory rights.

Nothing in this disclaimer excludes or limits Fera liability for: (a) death or personal injury caused by Fera negligence (or that of its employees, agents or directors); or (b) the tort of deceit; [or (c) any breach of the obligations implied by Sale of Goods Act 1979 or Supply of Goods and Services Act 1982 (including those relating to the title, fitness for purpose and satisfactory quality of goods);] or (d) any liability which may not be limited or excluded by law (e) fraud or fraudulent misrepresentation.

The parties agree that any matters are governed by English law and irrevocably submit to the non-exclusive jurisdiction of the English courts.

Appendix 3

Floralife Zinnia and Dahlia Vase-Life

Zinnia and Dahlia Trial

Summer 2018 CFC and Floralife Trial

Trial Outline

- Trial bed was split in two sections
- Three varieties of Dahlia (Sylvia, Eveline, Black Fire) and four colours of Benary's Giant Zinnia (Pink, Lime, White, Cerise) were planted in each of the sections
- One section was treated weekly with Calmax Ultra
- The other section was left untreated
- Stems were harvested weekly through August 2018 and the vase-life assessed

Zinnia & Dahlia Trial 2018

Dahlia Sylvia treated with Calmax

Harvest Stage

Dahlia

Zinnia

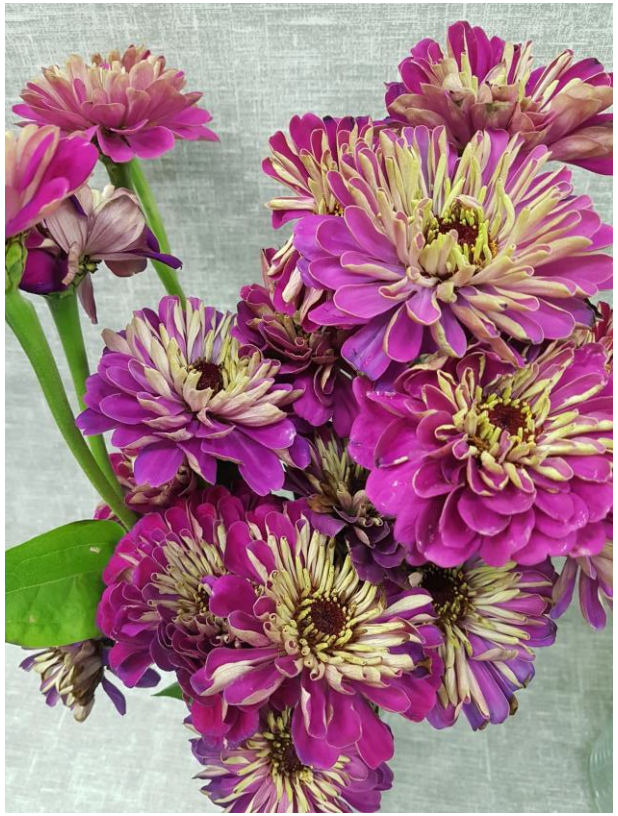
Trial Replicate 1

- Harvested on 26/7 and placed into a solution of eZdose economy
- Stems were then stored at 5°C for 72hrs
- On 30/7, stems were recut and placed on Express 200
- Stems were then stored in ambient on express 200 until 2/8
- On 2/8 stems were recut and placed on Express 300 for vase phase

First day of vase-life

(After 4 days store phase)

Treated with Calmax



First day of vase-life

(After 4 days store phase)

Treated with Calmax

First day of vase-life

(After 4 days store phase)

Treated with Calmax

First day of vase-life

(After 4 days store phase)

Untreated

First day of vase-life

(After 4 days store phase)

Untreated

First day of vase-life

(After 4 days store phase)

Untreated

Trial Replicate 2

- Harvested on 3/8 and placed into a solution of eZdose economy
- Stems were then stored at 5°C for 72hrs
- On 6/8, stems were recut and placed on Express 200
- Stems then stored in ambient on Express 200 until 9/8
- On 9/8 stems were recut and placed on Express 300 for vase-life phase

Day 6 of vase-life

Treated with Calmax

Day 6 of vase-life

Treated with Calmax

Day 6 of vase-life

Untreated

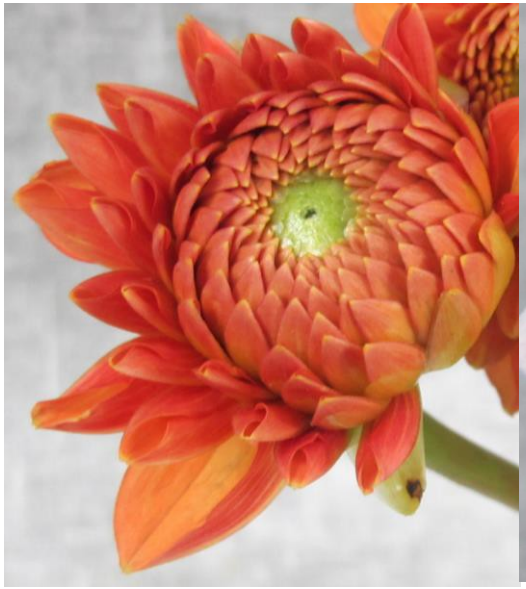
Day 6 of vase-life

Untreated

Trial Replicate 3

- Harvested on 9/8 and placed into a solution of eZdose economy (Harvest stage was brought back, see next slide)
- Stems were then stored at 5°C for 24 hrs (storage time was reduced)
- On 10/8, stems were recut and placed on Express 200
- Stems then stored in ambient on Express 200 until 14/8
- On 14/8 stems were recut and placed on Express 300 for vase-life phase

Harvest Stage



Dahlia

Zinnia

Day 1 of store phase

Treated with Calmax

Day 1 of store phase

Untreated

Day 1 of store phase

Untreated

Day 1 of store phase

Treated with Calmax

Day 1 of store phase

Untreated

Photos on 22/8 day 8 of vase-life

Photos on 22/8 day 8 of vase-life

Untreated

Conclusions

- The application of Calmax had no noticeable effect on vase-life, or neck strength, however, it increased the stem length of the Zinnia.
- The Zinnias from both treatments were not severely affected by bent necks during processing of the bunches.
- The application of Calmax had no noticeable effect on the vase-life of Dahlia.
- The Dahlias were unable to maintain vase-life through the store phase, so were discontinued after the store phase and were not observed any further.
- The recommended harvest stage of the Zinnia is after the first whorl of flowers has opened. Harvesting at this stage helped to extend vase-life to 7 days plus 4 days store phase (13 days total in ambient).
- The recommended cold storage time for Zinnias is 48 hrs maximum.
- The appearance of the Zinnias may have been affected by a pre-harvest pathogen as browning was observed on the tips of the petals and in some cases, leaf quality was poor.