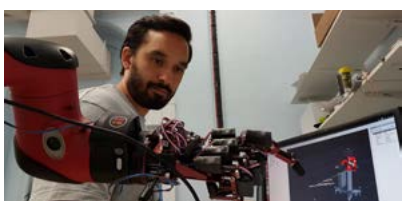
Ornamentals REVIEW

AHDB

2018

The potential of real-time nutrition monitoring in crops

Developments with growing media



Collaborative robots learn nursery skills

Poinsettias compared and controlled

Foreword

Martin Emmett
Hardy Nursery Stock Panel Chairman

Mike Mann
Bulbs and Outdoor Flowers and Protected Ornamentals Panel Chairman

Welcome to the 2018 edition of the Ornamentals Review, which summarises the current research AHDB is funding on behalf of growers of ornamental crops.

Consistent with previous years, the main emphasis of the research has been on crop protection, covering work on conventional plant protection products but increasingly on biopesticides too. However, we are mindful that resource-use efficiency, especially labour, is becoming an increasingly important industry issue and this is reflected in a number of the R&D and Knowledge Exchange programmes, such as the Growbot project, GrowSave and the developing Lean work programme. Other ongoing resource-use efficiency projects cover the development of new blends of growing media and soil and nutrient management, culminating in the publication of the revised RB209 guide last year.

Both panels have to continually consider how we can support industry to overcome both immediate and longer term challenges. In this respect, the crop protection projects fit into one of four categories:

- Strategic projects – that have the potential to identify completely new approaches to crop protection, such as the work developing biocontrol agents from naturally occurring bacteria on plants in project CP 120
- Prospective projects – that screen the latest crop protection products and technologies for efficacy against a range of pests, diseases and weeds, such as SCEPTREplus (project CP 165)
- Developmental projects – that seek to develop and improve existing technologies, such as the use of biopesticides in the AMBER project (CP 158)
- Reactive projects – such as the work we have done to address the immediate threat of agapanthus gall midge (HNS/PO 199) and aquilegia downy mildew (HNS 196).

Getting the priorities right is always challenging and we would like to acknowledge the commitment from panel members who are key to identifying the main challenges faced by the industry and evaluating the available options to address them. This task is greatly assisted by the feedback that is received at events, through the BPPC and CFC Crop Centres and via grower associations such as the BPOA and HTA.

If you would like to become more directly involved in any of our projects, we are always looking for grower co-ordinators for new projects. Please contact Georgina Key, AHDB R&D Manager, and she will be happy to advise you of the latest opportunities.

The AHDB Horticulture Board very strongly believes in the 'Panel System' as a way of guiding the way in which levy payers' money is invested for the benefit of the industry. The most effective way of doing this is by joining one of our two Ornamental Panels (see the back cover page), which between them cover the whole range of industry production. Each Panel meets just twice a year and is a great way to influence the work which your particular part of the industry believes is important and to also network with a wide range of other influential people.

Whatever crops you grow we wish you a successful production season during 2018.

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Connecting you to the latest research and knowledge

AHDB produces a range of materials and resources to help growers tackle the major issues facing the ornamentals industry.

Access to plant protection products

The AHDB minor use programme aims to minimise the impact of losses of plant protection products and to provide alternative solutions for UK growers.

As well as collaborating with agrochemical and biopesticide companies to identify novel products for screening trials, the programme also makes applications to extend the authorisation for minor use (EAMU) of existing products.

Growers will continue to receive EAMU email notifications as they become authorised and we have introduced a new monthly crop protection email newsletter, sharing industry developments.

SCEPTREplus

SCEPTREplus is a four-year crop protection programme to deliver applied research on high-priority disease, pest and weed problems. The first-year trials for ornamental crops looked at western flower thrips control on verbena, weed control in narcissus and aphid control using a model crop approach.

To stay informed about the trials' progress, visit **horticulture.ahdb.org.uk/sceptreplus** for blogs, news and galleries.

We also want your input to shape future trials. Please contact **joe.martin@ahdb.org.uk** to let us know your pest, weed and disease challenges.

Biopesticides

The AMBER project, led by University of Warwick to help growers improve the performance of biopesticides, will be running a free practical workshop in 2018 to help ornamental growers improve biopesticide application. More information and useful introduction guides to biopesticides can be found at **bit.ly/AMBERproject.**

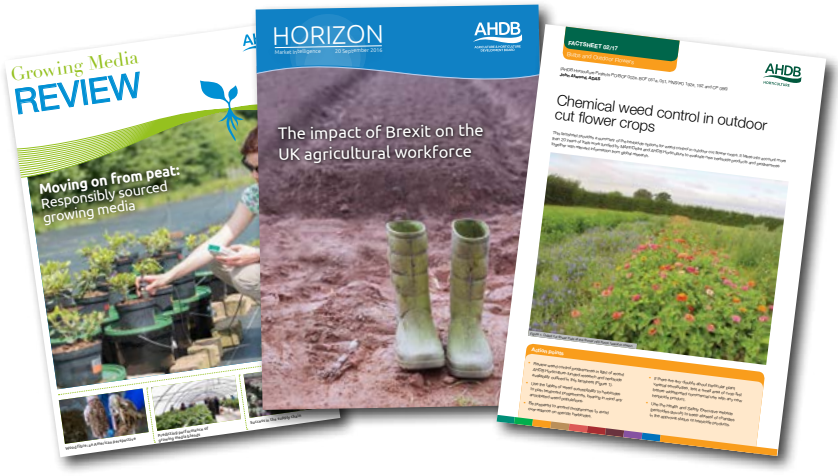
Horizon reports

AHDB has released a series of publications looking at the potential implications for the industry following the UK's decision to leave the EU. The analysis in the new 'Horizon' series, models potential impact scenarios on horticulture, reviews the potential impact on workforce and considers the implications for plant protection regulations. **www.ahdb.org.uk/brexit**

Robotics survey

An AHDB Horticulture survey has revealed that 82 per cent of UK growers believe recent developments in automation have helped reduce their reliance on labour.

Areas of production with particularly high manual labour inputs are high priority for future research and investment. Responses highlighted a need for developments in transplanting and planting, crop monitoring, application of crop protection products (including biologicals), transport systems, grading and packing. The full report is available at **horticulture.ahdb.org.uk/labour.**



Growing media

The Growing Media Review provides the latest industry progress and research in the work towards helping the horticulture industry reduce its reliance on peat.

The government paper, 'A Green Future: Our 25 Year Plan to Improve the Environment,' published in January 2018, has reconfirmed the target to end peat use in horticultural products by 2030.

AHDB has funded several research programmes to help the industry achieve this ambitious target, and the magazine offers a useful update on the progress the projects have made.

Further information is also available at **horticulture.ahdb.org.uk/growingmedia.**

Useful resources and publications

AHDB regularly publishes new and updated factsheets and guides to help provide growers with the latest research developments in practical terms. Recently published factsheets include 'Leaf and bud nematodes in hardy nursery stock', 'Chemical weed control in outdoor cut flower crops', 'Vine weevil control in hardy nursery stock' and 'Sampling methodologies and analysis interpretation for growers of hardy nursery stock'. You can access these for free at **horticulture.ahdb.org.uk/publications.**

The Cut Flower Centre and The Bedding and Pot Plant Centre publish regular blogs to keep you up to date with research trials progress. Visit **thecutflowercentre.co.uk** and **ahdbbppcblog.wordpress.com** to sign up. Each summer both of the respective Centres also stage popular open days to showcase ongoing trials and disseminate results.

We host a series of free practical workshops, seminars and conferences around the UK every year, helping to share the latest knowledge and research information with growers. Visit **horticulture.ahdb.org.uk/events** to find out what's happening near you and to book your place.

Follow us on Twitter **@AHDB_Hort**

Results round up

You will find full updates from ongoing and recently completed projects relevant to ornamental crops in subsequent sections. Here, we summarise the findings of projects completed in 2016, shortly after publication of the last edition of the Ornamentals Review.

Crop protection

The major three-year project CP 124, Managing ornamental plants sustainably, or MOPS, took a similar approach for ornamentals that the parallel SCEPTRE project had adopted for edible crops. It tested nine chemical fungicides and five biofungicides against powdery mildews and rusts, and six chemical insecticides and eight bioinsecticides against aphids, whitefly, western flower thrips, carnation tortrix and vine weevil – all on a range of protected ornamentals and hardy nursery stock subjects.

The project identified several effective products, some of which were new to industry and some of which were taken forward to secure EAMUs. These included the insecticide Mainman (flonicamid) and the biopesticides Met52 OD (*Metarhizium anisopliae*) and Botanigard (*Beauveria bassiana*); a novel biopesticide using orange oil as the active ingredient; and products based on insect-killing nematodes. For disease control, the fungicide Reflect (isopyrazam), for which an EAMU was subsequently achieved, and two novel biofungicides performed well in trials. The work also highlighted effective disinfectants and biological soil treatments. Most importantly, MOPS explored ways to integrate chemical and non-chemical techniques.

The new SCEPTREplus programme (CP 165), which started in April 2017, is continuing the work to find solutions to pest and disease issues in ornamental and edible crops.

A number of useful new treatments to control weeds in a range of ornamental crops were found in HNS/PO 192a. These included combinations of Stomp Aqua (pendimethalin), Goltix 70 SC (metamitron) or Gamit 36 CS (clomazone) for China aster, larkspur, sweet william, peony and wallflowers. Sodium bicarbonate was also confirmed to be an effective pre-emergence liverwort treatment in container-grown nursery stock and AHDB was able to obtain a basic substance approval for its use.

Two projects studied diseases that were new to the industry. HNS 191 gave growers a greater understanding of heuchera rust and how it is most likely to arrive on a nursery. Information on chemical control options, including both preventive and curative fungicides, was published in the AHDB Horticulture factsheet 'Control of heuchera rust'. HNS 196 generated significant new knowledge about likely sources and effective control of downy mildew on aquilegia. Trials on a range of fungicides confirmed that Fubol Gold (metalaxyl-M) gave the best level of preventive disease control.

There are few control measures for leaf and bud nematodes, but studentship CP 104, on novel approaches for the pest's management in hardy nursery stock, showed some insecticides to be effective when used in combination with plant elicitors. Control was only likely to be achieved, however, if the treatments were applied early in an infestation, when visible symptoms covered no more than about 15% of the leaf area. Further details are available in the factsheet 'Leaf and bud nematodes in hardy nursery stock'.

Other cross-sector pest and disease projects relevant to ornamentals included studentship CP 105 on integrated protection of horticultural crops through enhancing endogenous defence mechanisms, which explored ways to use plant elicitors for disease control in protected crops; and CP 157, which reviewed current knowledge about aerial oomycetes, important plant pathogens which include downy mildews, white blisters and certain *Phytophthora* species. It concluded that innovation in spore detection, disease forecasting and biological treatments were beginning to lead to the development of effective integrated strategies for controlling them.

Growing media

The amount of peat used in both professional and amateur growing media was monitored from October 2012 to May 2016 in project CP 100 to show the industry and policymakers how much progress is being made towards the goal of greater responsibility in sourcing growing media materials. Using data supplied by members of the Growing Media Association, the results found that in the professional sector, the proportion of peat used in growing media dropped from 72% in 2011 to 64% in 2015, while the actual volume of peat used fell from 934,000 to 690,000 tonnes. Wood-based ingredients and coir made up most of the replacement volume.

Crop management

The physiological disorder known as daffodil rust affects crop quality that can render the cut flowers unmarketable.

In 2014, AHDB agreed an extension, in BOF 076a, to work to identify its cause. It concluded that the development of daffodil rust tended to follow high soil moisture levels in the months before flowering but that there were no links with soil or leaf nutrient status. A species of the fungus *Stemphylium*, not previously recorded on daffodils, was also consistently isolated from typical rust lesions, but only as a weak pathogen so may only have been able to grow once the tissues had already been damaged. Two viruses, narcissus late season yellows and arabis mosaic, were identified on daffodil leaves but not specifically linked to rust lesions.

Another troublesome physiological disorder, pansy mottle syndrome, was investigated in PO 016a which looked at links with environmental factors during crop production, including temperature, humidity and light levels.
As part of the project, 40 batches of plants on four nurseries in different parts of the country were monitored between 2013 and 2015. Although there was no conclusive evidence, tentative links between incidence of the syndrome and high light levels, high temperatures and very dry air (measured as vapour pressure deficit) were found in 2013.

The cost of controlling soilborne fusarium is an issue in some cut flower crops, such as column stocks, so PO 020a examined a somewhat radical way to avoid the disease by using a hydroponics system to take production out of the soil altogether. Two years of trials showed that deep and shallow pool hydroponics do have potential for cut flower production, although the development of systems that could be used commercially now depends on engineering solutions – with plant support being a particular issue. The project also showed that it is possible to produce column stocks in tulip pin trays using a clay pellet substrate, but further trials and subsequent detailed costings would be needed to give growers confidence that such an approach could be viable.

Work in studentship CP 103 looked at the application of precision agronomy to narcissus production, focusing on planting rates and the positioning of the bulbs in the soil. It confirmed that the current practice of planting at a rate of 17 tonnes/ha and a depth of 15cm remains the overall recommendation, although the density could be increased to 27 tonnes/ha where flower, rather than dry bulb, production is the priority. Ensuring that each bulb is planted upright would result in a significantly better crop, but the random orientation that results with existing machinery is likely to remain the most practical and economic approach in the foreseeable future.

While technology already exists that would be capable of improving pest and disease control in lifted bulbs, it is unlikely to be a cost-effective investment in current market conditions, the project report suggests.

The results from three years of trials on evaluating the potential of plant growth regulators to limit growth of tree and hedging species, in project HNS 187, indicated that in a ‘typical’ year Stabilan 750 (chlormequat) was likely to be the most effective plant growth regulator on poplar, but it has proved difficult to find an effective but crop-safe rate of use for alder, birch and rowan and there has since been extensive changes to the product label.

The work also led to an EAMU for the growth regulator Cutaway (trinexapac-ethyl). In trials as part of the project, three applications of Cutaway proved very useful on rowan, resulting in a near-perfect crop. It was also judged useful on cherry and alder.

Maintaining crop protection options

Bolette Palle Neve, Crop Protection Scientist at AHDB, summarises efforts to develop EAMUs for the ornamentals industry.

We are aware that growers are under continued pressure trying to maintain product quality and minimise crop wastage with a dwindling range of available plant protection products and we work hard to attempt to plug the gaps. A number of important Extension of Authorisation for Minor Use (EAMUs) were secured for ornamentals in the past year. Some of these applications were a result of changes to labels for products such as Exemptor, Stabilan 750 and Pirouette where uses had become restricted. With the new EAMUs, we have managed to give growers more flexibility, although the current plant protection product regulation does not always allow us to retain the uses that growers have become accustomed to.

Through AHDB weed control project HNS 198 and collaboration with European colleagues, we have identified herbicides suitable for use in ornamental crops. As a result, we managed to obtain EAMUs for Laser, Logo and Sencorex Flow. Sencorex Flow will be particularly useful for field-grown nursery stock and rose growers, as well as for cut flowers from bulbs grown in the soil.

Much work has gone on behind the scenes to get access to chemical growth regulators for UK growers. We obtained an EAMU for Cutaway, however as the product is now not supported long-term, we have recently submitted an application for the alternative product Primo Maxx II. Following trials undertaken as part of PO 019a The Bedding and Pot Plant Centre, we have also submitted applications for the products Terpal and Canopy. We expect an outcome in early 2018.

The MOPS project (CP 124) identified some very useful fungicides for the control of powdery mildew.

Control has particularly become an issue following the loss of approvals for Systhane 20EW. An EAMU for the product Reflect was obtained and another one is in progress for the product Luna Sensation. The latter should also be a useful product for the control of *Botrytis*, especially as the use of products containing iprodione expires in early June 2018.

A number of useful products have been identified through the SCEPTREplus (CP 165) project in 2017 trials and we will be busy securing EAMUs for the use of these in ornamental crops during 2018.

EAMUs secured for ornamental crops during 2016 and 2017

Product	Active ingredient	EAMU No.	Crops	Target/use
Envidor	Spirodiclofen	0997/2016	Outdoor ornamental plant production	Spider mites
Reflect	Isopyrazam	1602/2016	Ornamental plant production	Powdery mildew
T34 Biocontrol	*Trichoderma asperellum* strain T34	1810/2016	Protected ornamental plant production and forest nurseries	*Fusarium* and *Pythium*
Devrinol	Napropamide	2044/2016	Ornamental plant production	Weed control
Cutaway	Trinexapac-ethyl	2140/2016	Ornamental plant production and forest nurseries	Growth control
Revus	Mandipropamid	2763/2016	Ornamental plant production	Downy mildew
Logo	Foramsulfuron + iodosulfuron-methyl-sodium	3437/2016	Ornamental plant production	Weed control
Laser	Cycloxydim	0437/2017	Ornamental plant production	Grass weed control
Exemptor	Thiacloprid	0555/2017	Ornamental plant production (incorporation)	Pest control
Amistar	Azoxystrobin	0888/2017	Protected ornamental plant production and outdoor forest nurseries	Disease control
Stabilan 750	Chlormequat	0910/2017	Protected ornamental plant production	Growth control
Starane Hi-Load HL	Fluroxypyr	1268/2017	Ornamental plant production and forest nurseries	Weed control
Pirouette	Paclobutrazol	1269/2017	Protected ornamental plant production (drench)	Growth control
Stabilan 750	Chlormequat	1416/2017	Protected ornamental plant production	Growth control
Fenomenal	Fenamidone + fosetyl-aluminium	1531/2017	Ornamental plant production (hydroponics)	Root rot control
Sencorex Flow	Metribuzin	1732/2017	Ornamental plant production	Weed control

120-day emergency authorisations were also obtained for Custo-Fume and K&S Chlorofume (for soil disinfestation) and Cuprokylt (for bacterial disease control in ornamental laurel and Prunus). Basic substance use was obtained for sodium hydrogen bicarbonate (for liverwort control in hardy nursery stock).

> Three case studies have been undertaken on farms to assess the viability of retrofitting dosing and filtration equipment to existing tank set-ups

A cleaner future for bulb tank treatments

Narcissus growers rely on hot-water treatment to control stem nematodes, bulb scale mites and fusarium basal rot in bulbs. Addition of the biocide FAM 30 to keep the water clean became standard practice after project BOF 061 showed that it could replace formalin, which is no longer permitted for this use. It is, though, more expensive and is rapidly depleted in hot-water tanks containing a high 'bioload' where the biocide is absorbed by organic debris in the water, so growers asked AHDB to investigate further alternative biocides or other kinds of treatment.

The project

This project is examining a range of candidate biocides, including chlorine dioxide, hydrogen peroxide and didecyl dimethyl ammonium chloride (DDAC), as well as physical techniques such as heat and UV treatment, for their effectiveness and ease of use against stem nematode and fusarium basal rot. Each treatment is being tested first in the laboratory and then in small-scale tanks before full-scale commercial trials of the most promising.

Any corrosive effects on the hot-water tank and pipework will be checked and any health and safety considerations taken into account. The feasibility and cost of retrofitting tanks with any equipment such treatments need will also be considered.

Results so far

In the laboratory tests, nematode and fusarium basal rot were almost completely controlled by chlorine dioxide at concentrations of 5ppm or more, by hydrogen peroxide at 1.5% or greater and by DDAC at 0.5% or greater. However, they were all considerably less efficient in dirty water, illustrating the detrimental impact of tank 'bioload'. Some form of filtration or separation is likely to be needed if chemical biocides or UV and heat treatments are to be used, so the project will investigate this too.

Heat treatment gave complete control at temperatures above 60°C, but there are two main practical issues to resolve before growers could adopt it commercially. Firstly, many hot-water tank systems have neither the heating nor storage capacity for such high-temperature treatments. Secondly, the bulbs couldn't be kept for long in the tank while being heated to such temperatures, so the water could only be heated between batches, meaning that fusarium spores could freely circulate within each individual batch while in the tank.

The UV treatment was not assessed in the laboratory because controlling the intensity and duration of exposure was impractical. The treatment was included during tank-scale testing undertaken in early 2017.

Three case studies have been undertaken on farms to assess the viability of retrofitting dosing and filtration equipment to existing tank set-ups. The systems were all different and represented different levels of sophistication, but in each case retrofitting of new equipment was considered to be straightforward, with little or no loss in system performance.

The capital costs for retrofitting alternative disinfection methods or making improvements to operational efficiency are relatively small, with one-off costs in the order of £10,000 to £20,000 depending on the size and complexity of the kit selected.

BOF 077: Narcissus: Investigation into the effects of a range of potential biocides in hot-water treatment

Term: January 2016 to December 2019

Project leader: Rob Lillywhite, University of Warwick

New ways to monitor and manage vine weevil

Withdrawals of widely used chemical plant protection products used in growing media against vine weevil larvae, and the current restrictions on neonicotinoid use, have made it harder for growers of ornamentals to control this pest. This project is enhancing our understanding of its biology and behaviour so that growers can achieve better results from integrated pest management.

The project

A number of trials within the project have been designed to find out more about how environmental conditions influence key aspects of vine weevil biology and behaviour, such as feeding by adults and egg laying – information that in turn enables crop protection measures to be targeted as effectively as possible. The project is also looking at practical methods for monitoring adults so that infestations can be detected early, and at improving guidance on integrated pest management approaches.

It is also responding to growers' need for more guidance on the use of Met52 granular bioinsecticide (*Metarhizium anisopliae* var. *anisopliae* strain F52), and to find an alternative way to apply biocontrol nematodes – as the recommended high-volume handheld spray is labour-intensive and expensive.

Results so far

Adult vine weevils start feeding and laying eggs as temperatures rise in spring. Laboratory experiments in controlled environments showed that feeding and egg laying occur at temperatures down to 6°C but with little activity at 5°C, suggesting that this may be close to the lower threshold.

Growers often check for vine weevil adults by searching through leaf litter and looking under pots or in other likely vine weevil 'refuges' during the day, and after dusk by inspecting the crop. Monitoring traps would make the task more convenient and cut the amount of time needed. Several types of trap have been compared in the project, including simple corrugated cardboard rolls, grooved boards and various commercial traps, most of which rely on the vine weevil's behaviour of finding a refuge in which to hide during the day. The most effective were a commercial pitfall trap, a modified trap designed for red palm weevil and a commercial vine weevil trap which had the highest catches – 10 per day from a population of 40 – but which unfortunately is currently unavailable here.

Work is now under way to see if an attractant could make the traps more effective. Previous research has focused on lures based on the odours produced by host plants or from weevil frass. The aggregation behaviour of vine weevils is thought to be stimulated by some form of pheromone, so in HNS 195 volatile compounds generated by vine weevil adults have been collected for identification and any that look promising as attractants will be tested.

Work on use of insect-killing nematodes has taken its lead from the soft fruit industry where growers apply the biocontrol through drip irrigation. As few nursery stock growers use drip, the trials compared a 'little and often' approach – applying reduced nematode rates through overhead irrigation – with the standard full rates applied as high-volume drenches.

Steinernema kraussei (Nemasys L) was applied at the recommended rate in September and October either as drenches or through an overhead irrigation system, or at reduced rates (20% and 40% of the recommended rate) by overhead irrigation five times from early July to late October.

Both of the reduced rates of nematodes applied 'little and often' by overhead irrigation were as effective as the full rate applied twice as a drench and could offer a less labour-intensive and more cost-effective treatment.

Further detail of this work with practical recommendations for growers can be found on a new video clip available on the AHDB Horticulture website at **horticulture.ahdb.org.uk**

If you're considering applying nematodes via overhead irrigation for vine weevil control, make sure you watch our new film which provides more details on the procedure: **horticulture.ahdb.org.uk/videos**

HNS 195: Improving vine weevil control in hardy nursery stock

Term: January 2016 to December 2019

Project leader: Jude Bennison, ADAS

Herbicide options for field-grown nursery stock

The loss of herbicides containing oxadiazon, such as Ronstar 2G, and restrictions introduced on the use of metazachlor, in products such as Butisan S, has led to an urgent need for new cost-effective weed control options for both container- and field-grown hardy nursery stock.

The project

The project builds on earlier AHDB-funded trials but has also included a review of weed control practice in other European countries to identify herbicides suitable for trials, alternative application methods and non-herbicide techniques.

Initial screening trials for pre-emergence and early post-emergence activity and for crop safety are being used to select herbicides for nursery trials. These include post-planting applications in field-grown herbaceous perennials and programmes on budded roses and in tree production. Band-spraying, where one treatment is applied over the crop and another between the rows in a single pass, has potential for use on tree seedbeds so is also being investigated in nursery-based trials.

Results so far

The review found relatively few new active ingredients likely to be useful for UK nursery stock production. Certain products based on iodosulfuron-methyl-sodium and co-formulated either with foramsulfuron or diflufenican appear promising; the former combination is already proposed for an EAMU.

Trials on field-grown herbaceous crops have tested five herbicides in various programmes on aster, geranium, iris and veronica.

All of those applied to the asters at planting and post-planting proved to be crop-safe. An experimental product tested as H25 was found to be the most effective.

None of the planting treatments in the geranium trial caused any serious damage to the crop; H25 and Flexidor 500 (isoxaben) + metobromuron were the best for weed control.

None of the treatments applied to irises at planting caused any lasting crop damage. Weed control was best from H25 while Flexidor 500 mixed with another experimental product (H43), Flexidor 500 + Venzar Flowable (lenacil) and Flexidor 500 + metobromuron all gave good control.

No phytotoxicity was seen from any of the treatments applied to veronica and H25 was again best for weed control.

Ten herbicide programmes were tested in the budded rose trial. Applications were made to the rootstocks at planting, after budding and after heading-back.

Of the treatments applied at planting, Stomp Aqua (pendimethalin) + Flexidor 500 + H43, Flexidor 500 + Logo (foramsulfuron + iodosulfuron-methyl-sodium) and Flexidor 500 + Samson Extra 6% (nicosulfuron) + experimental product H42 all provided equally good weed control. The Flexidor 500 + Logo combination, however, was too damaging to the rootstocks. Logo alone with an adjuvant was safer but weed control was poorer.

All of the post-budding treatments appeared crop safe, but the roses that had been treated with Flexidor 500 + Logo at planting remained very stunted at budding. Weed control was best from Flexidor 500 + Butisan S (metazachlor).

The best of the post-heading-back treatments was H42 + Stomp Aqua + Flexidor 500, giving complete control for more than six weeks. It did cause some slight bleaching to the leaves as the buds grew away but they recovered after six weeks. Other treatments such as Sencorex Flow (metribuzin) or H43 in a tank mix with Stomp Aqua + Flexidor 500 also gave good weed control with no phytotoxicity.

In the band-spraying trial, Goltix 70 SC (metamitron) was used as a residual pre-emergence row treatment over a seedbed of silver birch, while a number of residual herbicide treatments were applied between the rows. Unfortunately, all the inter-row treatments resulted in unacceptable germination of the birch and slower seedling growth because, it is thought, applying the inter-row herbicides over the grit-dressed bed surface resulted in more lateral movement of the herbicides than would have occurred on bare soil. The least damaging inter-row treatment was Flexidor 500 + Goltix 50 SC, which suggests that silver birch might tolerate a low rate of Flexidor 500 over the row.

HNS 198: Improving weed control in hardy nursery stock

Term: January 2016 to December 2020

Project leader: John Atwood, ADAS

Getting the best from biopesticides

Biopesticides are plant protection products based on living microorganisms, plant or microbial extracts, or pheromones and other 'semiochemicals' that modify pest behaviour. They generally pose a low health and environmental risk and many need no routine residue monitoring. All registered biopesticides have passed stringent efficacy tests – but in use some growers find their effectiveness compromised by factors such as application techniques, environmental conditions or because there is a lack of advice on how to get the best from them.

The project

Identifying what constitutes best practice, and helping growers to adopt it, is likely to improve the results from using biopesticides, so the project is recording growers' experiences and what can be expected from a biopesticide when applied on a typical nursery.

It will then look at what growers could do to improve the performance of biopesticides through, for example, timing and frequency of applications, nozzle selection, achieving suitable environmental conditions and integrating the products with other pest and disease management measures, such as biological and cultural controls. The improved regimes will then be tested on nurseries to demonstrate their impact.

Results so far

The first year's work focused on benchmarking the performance of biopesticide products against pests and diseases in trials on commercial protected crops. The biopesticides were applied by the host growers to naturally occurring outbreaks and according to the product manufacturer's standard instructions.

Prestop (*Gliocladium catenulatum* strain J1446) was tested against *Botrytis* on cyclamen and compared with a standard programme based on Rovral WG (iprodione) and Amistar (azoxystrobin). Prestop was better than the standard programme at reducing disease incidence and severity on leaves, but neither treatment gave complete control.

The trial has already led to guidance modification on mixing and application – emphasising the importance of spraying older leaves at the base of the plant and deep within the crown with Prestop. The significant spray waste resulting from the very high water volumes used for the product, combined with the wide plant spacing this particular crop needs, has also been noted.

Botanigard WP (*Beauveria bassiana* strain GHA) was tested in combination with Majestik (maltodextrin) against a range of pests, particularly western flower thrips on pot chrysanthemum, compared to the nursery's standard programme based on the biological control product Nemasys (*Steinernema feltiae*). Viable *B. bassiana* colonies were recorded on leaves after Botanigard had been applied, with most found on the upper surfaces. The results suggest that at the early stages of an infestation when thrips numbers are low, the Botanigard WP + Majestik treatment was as effective as the nematodes.

A third trial on the effect of biofungicides in integrated programmes for root rot pathogens on dianthus and choisya is still under way at the time of writing. The biofungicides T34 Biocontrol (*Trichoderma asperellum* strain T34), Prestop and Trianum G (*Trichoderma harzianum* strain T22) are being compared with and without the use of Previcur Energy (fosetyl-aluminium + propamocarb hydrochloride) and Hortiphyte (a phosphite fertiliser).

It is already clear from trials in AMBER that high spray volumes are unlikely to result in the most effective applications.

Visit **bit.ly/AMBERproject** to find out more

CP 158: Application and management of biopesticides for efficacy and reliability (AMBER)

Term: January 2016 to December 2020

Project leader: David Chandler, University of Warwick

Leaf bacteria on our side

Some of the bacteria that live on leaf surfaces have potential as biocontrol agents. A previous AHDB studentship (CP 082) tested 140 bacterial samples from a variety of plants and found three to be promising against aphids – *Pseudomonas fluorescens, Citrobacter werkmanii* and *Pseudomonas poae*, the latter causing a 70% reduction in aphid populations with no damage to the treated plants or non-target insects.

The project

This follow-up studentship aims to make the bacterium more efficient as a biological control agent using a process known as 'experimental evolution' in which the appropriate traits are identified and selected for in cultures. The process includes tests to check whether improvements come at no cost to other traits; for instance, a greater degree of toxicity to aphids may be at the expense of slower bacterial growth on the plant.

Student, Kristina Grenz is looking to increase the level of aphid 'kill' caused by *P. poae* and reduce the time it takes for the bacterium to be effective. She also wants to improve bacterial colonisation on leaves and extend its persistence on the plant to minimise the number of applications needed.

Results so far

Most of the work so far has concentrated on *P. poae's* ability to survive on leaves. Grenz has had some promising results in improving its ability to form biofilms – colonies able to adhere to surfaces and start communities that can withstand environmental changes, allowing the bacteria to survive longer on the plant.

CP 120: Understanding the impact of phylloplane biocontrol agents on insects

Term: October 2016 to September 2019

Project leader: Robert Jackson, University of Reading

PhD student: Kristina Grenz, University of Reading

Plugging the gaps

The project

SCEPTREplus is a programme of research designed to assess the effectiveness of new or emerging crop protection products.

The targets for SCEPTREplus are chosen following consultation with sector panels, grower associations and a GAP analysis survey, to help plug critical gaps in growers' crop protection armoury.

To improve efficiencies, and where appropriate, a model crop approach to trials is being taken, with results extrapolated on to other crops.

Results so far

The first-year trials for ornamental crops looked specifically at western flower thrips (WFT) control on verbena, weed control in narcissus and aphid control using a model crop approach.

Trials on WFT control have identified three biopesticides that worked as well as, or better than, the current industry standard, when used in combination with *Neoseiulus cucumeris*.

Azatin, a botanical biopesticide which is widely used in the Netherlands, was trialled under code, but will now be available to UK growers with an on-label approval from April 2018.

Botanigard WP, used in a tank mix with Majestik, has an existing approval, so can now be adopted in to growers' IPM programmes.

The further coded biopesticide will be taken forward for regulatory approval.

Trials are currently in progress for weed control and aphids.

Visit **horticulture.ahdb.org.uk/sceptreplus** to find out more.

CP 165: SCEPTREplus: Research for sustainable plant protection products for use in horticulture

Term: April 2017 to March 2021

Project leaders: Ed Moorhouse, Agrifood Solutions, and Rosemary Collier, Warwick Crop Centre

Agapanthus gall midge gives up its secrets

The agapanthus gall midge (*Enigmadiplosis agapanthi*) was discovered in the UK in 2014 having been previously unknown to science. Its larvae develop inside individual flower buds or inside the closed flower head sheath, leading to bud deformation, discoloration and, usually, failure to open. Severity can range from failure of a few buds to collapse of entire flower heads.

The project

Finding out about the pest's life cycle and biology, to help target control and to plot the midge's current distribution, was the project's aim. Some currently available chemical plant protection products, biopesticides and biological controls were tested for effectiveness too.

Results

The gall midge is active from mid-June to early October with several overlapping generations. Agapanthus flower heads can be infested at different stages of growth, so symptoms of attack are variable. A single flower head can host hundreds or even thousands of larvae. Fully grown larvae emerge and drop into the soil or growing media to pupate, the adults emerging after 10 to 14 days. Larvae left in rearing tubes over winter started to emerge in April in sheltered conditions.

Observations of 149 agapanthus varieties in the RHS 'award of garden merit' trial in 2015 indicated that there may be varietal differences in susceptibility to the pest.

The midge is most likely native to South Africa and there are reports of symptoms on wild and commercially grown plants there. In the UK, the midge is mostly restricted to the south of England, with isolated cases in the north. There are also established populations on Guernsey and Jersey.

Seven treatments were tested in trials, either as foliar sprays against flower-dwelling larvae or as drenches against the larvae that drop to the ground to pupate. None of the sprays gave significant control of larvae in flowers. The only treatment that reduced numbers of adults emerging from pupae to a statistically significant degree was a drench of Calypso (thiacloprid) – though background levels of pupae mortality were high in the trial.

HNS/PO 199: Biology and control of agapanthus gall midge

Term: July 2016 to June 2017

Project leader: Hayley Jones, RHS Wisley

Precise confirmation of rots due to oomycete pathogens

Reliable and affordable detection and diagnosis are key to effective management of root and crown rots – amongst a wide range of other diseases – caused by species of *Phytophthora*; and of damping-off diseases caused by *Pythium* species. Both types of pathogen belong to a large group of fungus-like organisms, the oomycetes.

The project

Test kits based on lateral flow devices that can identify the presence of a *Phytophthora* or *Pythium* in a sample are now available to growers. While useful, they are unable to identify which species are present or whether they are alive. Moreover, the antibodies these tests rely on can sometimes react to other closely related but harmless oomycetes – a 'false positive' result that could lead to unnecessary expense instigating control measures that were not needed.

This project is developing new antibodies for individual species or closely related groups of *Phytophthora* or *Pythium* pathogens and working on a test kit to show if the pathogens are viable, which would be useful for monitoring the effectiveness of treatment systems for nursery irrigation water through which oomycetes can spread.

It is also developing a rapid clinic-based test that would enable simultaneous diagnosis for a number of different oomycete pathogens in a single sample at the same time.

Results so far

Phytophthora and *Pythium* samples have been collected from nurseries to create a 'living library' of more than 100 identified isolates of pathogenic and non-pathogenic species. This culture collection will be used to confirm that the antibodies being developed are only detecting specific pathogenic species.

Most of the new *Phytophthora* antibodies the project has raised have passed through the first level of tests. One, for example, has been found capable of detecting only *Phytophthora* species plus the pathogenic *Pythium ultimum*; another detects only *Phytophthora cryptogea*, while there is also one that reacts to a number of closely related ones including *Phytophthora cinnamomi, Phytophthora rubi*, and *P. cryptogea*. It may be possible to deploy a combination of these antibodies in a test kit.

The first batch of 10 new *Pythium* antibodies are currently undergoing testing.

CP 136: Development and testing of single and multiplex diagnostic devices for rapid and precise early detection of oomycete root and collar rot pathogens for disease avoidance, management and control

Term: June 2015 to June 2018

Project leader: Tim Pettitt, University of Worcester

Root rot treatment remains elusive

Black root rot, caused by the fungal pathogen *Thielaviopsis basicola*, is a problem on many species of ornamental plants. Symptoms range from grey and brownish discoloration of the root with little obvious rotting, through to blackening and extensive root loss, followed by plant collapse and death.

Pansy and viola are particularly susceptible and the disease is frequently implicated in damage to hardy nursery stock such as choisya, holly and skimmia. Losses tend to peak in the summer as temperatures rise and plants come under greater stress.

Nursery hygiene is key to the control of the disease, but where growers need to use fungicides, the range available is very limited.

The project

This project set out to identify novel drench treatments with the potential to protect against or cure black root rot, in order to supplement the few products currently available for use on pot and bedding plants and hardy nursery stock. The treatments included conventional chemicals, plant defence elicitors and microbial products.

Results

Cercobin WG (thiophanate-methyl), T34 (*Trichoderma asperellum*) and a range of novel products were tested on viola and choisya.

Two novel products, applied preventively, reduced black root rot in viola, if preceded by T34 at seed-sowing. However, neither reduced disease levels when applied curatively, even after preventive applications of Cercobin WG or T34.

No other treatment programmes were effective and none of the treatments examined led to any significant reduction in black root rot infection in choisya.

HNS/PO 190: Evaluation of fungicides and novel treatments for the control of black root rot, *Thielaviopsis basicola*, in bedding plants and hardy nursery stock

Term: September 2013 to August 2017

Project leader: Erika Wedgwood, ADAS

Resistance monitored in impatiens downy mildew

Impatiens downy mildew, caused by the oomycete *Plasmopara obducens*, is a foliar disease specific to the crop. It had been well controlled by crop protection products based on metalaxyl-M until early 2011 when a strain resistant to the fungicide evolved. The industry responded by limiting production of impatiens from either cuttings or seed and no infections caused by the resistant strain were detected during levy-funded monitoring in 2012 or 2013.

The project

AHDB is continuing disease monitoring, by testing plants showing symptoms, which will warn of the presence of metalaxyl-M resistance and help growers decide which spray programmes to adopt.
The results also provide information on the prevalence, persistence and geographical distribution of resistance in the wider environment.

Results so far

In 2014, five samples of infected plant material were received from four locations (one nursery, three private gardens); the first sample arrived late in July and the last in mid-September. The detection of disease late in the season suggested that it had not arrived on the plants but had established from other sources. Metalaxyl-M-resistant strains of *P. obducens* were present on samples from two of the sites.

In 2015, two samples, both from private gardens, were received in late August, the inference again being that the plants were not the source of the infection.

Two samples were received in 2016 and one in 2017, all from nurseries; none were metalaxyl-M resistant.

PO 011b: Monitoring metalaxyl-M sensitivity of downy mildew infection of impatiens

Term: March 2014 to October 2018

Project leader: Phil Jennings, Fera

New test reveals a *Fusarium's* true identity

Some of the most devastating diseases of horticultural crops are caused by species of *Fusarium*. Some can affect a wide range of crops, others are highly specific. Accurate identification of the *Fusarium* species present, in samples of soil or diseased crops, is particularly important in order to choose the correct management approach.

The project

F. oxysporum is one of the most important species, with many pathogenic 'forms' that are specific to particular crops. These are particularly challenging to identify as, at the moment, even 'genetic fingerprinting' can't easily distinguish between the different pathogenic or non-pathogenic forms. This, along with the fact that there is a wide diversity of other pathogenic *Fusarium* species that can often occur together in a 'disease complex', has hampered both our understanding of the behaviour of these important pathogens and progress in finding effective disease management strategies.

The main aim of this project is to develop the means to detect, identify and estimate the numbers of different *Fusarium* species.

The relationship between *Fusarium* population levels and disease development is also being investigated in crops including narcissus and column stocks. More accurate genetic fingerprint tests will be designed for key *Fusarium* pathogens and will be used to study interactions that occur in mixed populations of pathogenic and non-pathogenic species and forms.

FV/POBOF 452: Biology and control of *Fusarium* diseases across multiple crops (phase 1)

Term: April 2017 to September 2018

Project leader: John Clarkson, Warwick Crop Centre

The value of cultural methods against bacterial diseases

Bacterial diseases are sporadic but often cause severe problems where they do occur, with few approved plant protection products effective against them. New approaches to control need to be tested, which may involve the adoption of new practices on nurseries.

The project

Steve Roberts's review looked at the international scientific and technical literature available on the biology and control of bacterial pathogens known to affect, or which could affect, UK crops, concentrating on those that growers and advisers told AHDB are the most economically important. The review included all previous levy-funded trials of crop protection products, disinfectants and seed treatments.

Results

The review concluded that the industry should be more proactive in seeking management and control options that don't rely on plant protection products. It summarises the availability and future prospects of chemical and biological controls and the potential for using crop varieties resistant to bacterial pathogens.

CP 174: Review of bacterial pathogens of economic importance to UK crops

Term: July 2017 to September 2017

Project leader: Steve Roberts, Plant Health Solutions

Latent infections tracked from the start

The apple canker fungus *Neonectria ditissima* (see project CP 141 below) can infect the tree during propagation but then become latent – the first canker lesions may not appear until two or three years after planting out. No diagnostic procedure is available yet for the early detection of this symptomless infection. It is believed that the fungus can grow and develop within the plant during this latent phase, a phenomenon shared with other pathogenic, benign or beneficial fungi, known as endophytism.

The project

Robert Saville believes that understanding the interactions between *N. ditissima*, other apple tree endophytes and the development of symptoms may shed new light on resistance mechanisms and possibly lead to novel biocontrol strategies based on beneficial endophytes. Identifying which plant tissues host the pathogen during the latent period will enable them to be targeted for sampling and diagnostic procedures.

The project is also working on the development of a lateral flow device to detect *N. ditissima*.

Results so far

By deliberately inoculating pruning wounds with *N. ditissima*, and then taking tissue samples from different parts of the plant at subsequent intervals and using them to try to culture the pathogen on artificial growing media, Saville has tracked how the pathogen spreads in trees.

Generally, it was found in the apparently healthy woody tissue beneath the cambium, both before and after the first canker lesions appeared. This means that when the entry point is a pruning wound, the pathogen becomes localised in the internal woody tissues of the branch, at least within the first two months after the initial infection.

Fungal endophytes of various species have also been collected and identified from four apple varieties to see if these populations have any impact on varietal susceptibility to canker.

CP 161: Understanding endophytes to improve tree health

Term: October 2016 to November 2019

Project leader: Robert Saville, NIAB EMR

Genetic clues to canker resistance

Those whose production includes fruit trees will know just how serious a problem *Neonectria* canker is on apple, as there are few effective control methods and most modern varieties are highly susceptible to the causal fungus *Neonectria ditissima*. Developing resistant varieties is a slow process due to the long plant breeding cycle, but understanding the molecular links between host resistance and pathogen virulence is key to finding resistances likely to prove long-lasting.

The project

Richard Harrison and Robert Jackson are working on identifying the genes responsible for the pathogen's ability to overcome the tree's defence mechanisms, while at the same time studying how those mechanisms work at a molecular level to see if there are specific differences in the tree's response to *Neonectria* strains of differing virulence. As well as identifying apple genes that could help in breeding programmes, they believe that identifying genes important in *Neonectria* virulence could lead to novel opportunities for control by blocking their effects.

Results so far

A range of apple tree varieties have been tested for differences in susceptibility to *Neonectria*.

The most resistant found so far is a clone of *Malus x robusta* (Robusta 5), a species distinct from *M. x domestica* to which most modern commercial varieties belong. Little is known about the species, but we do know that *Neonectria* is not a significant problem in the areas of China where it originates, indicating that its mode of resistance may be different from that of *M. x domestica*.

'Golden Delicious' was found to be the most resistant of the commonly grown dessert varieties. Unfortunately, crossing it with others displaying some resistance didn't consistently result in resistant offspring.

Genetic studies on the pathogen suggest it has no distinct races, so any resistance found is likely to be broad spectrum and durable.

CP 141: The molecular basis of pathogenicity of *Neonectria ditissima*

Term: October 2015 to October 2018

Project leaders: Richard Harrison, NIAB EMR and Robert Jackson, Reading University

Designs on responsibly sourced growing media

In response to both customer pressure and government policy, the horticulture industry has invested heavily over the past 20 years in finding ways to source its professional growing media more responsibly while reducing the amount of peat it uses. A huge range of materials considered as 'peat substitute' ingredients has been whittled down to just four: bark, coir, green compost and wood fibre. In the ornamentals sector, many nurseries use combinations of these to cut back the peat content of their growing media by between 10% and 50%, depending on the crop. AHDB, along with Defra and the growing media industry, continues to fund research aimed at giving growers more confidence that specific blends of ingredients can be used commercially with predictable results.

The projects

A horticultural fellowship project, CP 095, was established in 2012, in which researcher Gracie Barrett reviewed the chemical, physical and biological properties of growing media materials and undertook trials investigating how nutrient management using organic and inorganic fertilisers was affected by varying the proportions of ingredients in media designed for nursery stock.

Her work paved the way for CP 138, a five-year project funded by Defra, AHDB and the horticulture industry. The project was commissioned in response to the Sustainable Growing Media Task Force's report in 2012 that highlighted the need for research to demonstrate the technical and commercial viability of new growing media blends and help growers overcome barriers to using them. It takes a different approach from past research by creating and using a model based on the physical characteristics of the raw materials to predict their performance in blends, followed by extensive trials on crops, including vegetable transplants, bedding plants, nursery stock and strawberries to validate the predictions.

Results so far

Barrett used her review of ingredients to create 14 peat-reduced and peat-free experimental blends. She analysed their physical, chemical and biological characteristics and, in trials at RHS Wisley, assessed how well they performed with viburnum and hebe. While the properties of the blends varied widely, all but one proved capable of producing both crops to a good and uniform quality in the trial, demonstrating that a wide range of media could be used commercially.

In a subsequent trial on nutrient management, using only viburnum, the amount of nutrient leached from the different blends varied significantly, with up to five times more being lost from some compared with others – most of this occurred within the first 14 days after potting. The amount leached was not predictable and could not be related to any one physical property, such as water-holding capacity. Some of the blends proved to be 'over-fertilised' due to the inherent nutrient content of the materials, reinforcing the need to modify fertiliser rates when using them.

A trial looking at a possible alternative source of phosphorus, tested biochar infused with phosphate from sewage sludge. Barrett found no significant differences, either beneficial or detrimental, between this and a conventional phosphate fertiliser in the other five growing media blends.

In the early stages of CP 138, air-filled porosity, available water and bulk density were identified as the three key physical parameters governing growing media performance. Accurate procedures to measure these attributes in growing media materials were then developed. The measurements were used as the basis for a model that could predict the materials' performance in varying proportions in blends.

No combination of materials has been found that could exactly replicate peat, but the model predicted that certain blends of three components came very close, and when these were tested in both small-scale trials at ADAS Boxworth and large-scale trials on nurseries producing nursery stock, bedding plants and other crops, they proved to work well as prototype growing media. A series of workshops held as part of the project demonstrated the performance of these blends to growers in various sectors.

CP 095: Sustainable resource use in horticulture: a systems approach to delivering high quality plants grown in sustainable substrates, with efficient water use and novel nutrient sources

Term: November 2012 to November 2017

Project leader: Paul Alexander, RHS Wisley

Fellowship researcher: Gracie Barrett, RHS Wisley

CP 138: Transition to responsibly sourced growing media use within UK horticulture

Term: January 2015 to December 2019

Project leader: Barry Mulholland, ADAS

How to keep soils in good shape

Field-grown ornamental crops, including bulbs, cut flowers and nursery stock, rely on healthy soils. A comprehensive programme to improve growers' ability to manage soils was rolled out in 2015 after an AHDB review had identified where the industry's know-how could be improved.

Work was recommended in areas such as the soil parameters that growers need to monitor; soil amendments and nutrient applications; and the role of 'precision agriculture' in soil management. The programme combines research with knowledge exchange through a series of events, publications and web-based information.

The projects

CP 107b is helping growers to assess soil health and make decisions on any remedial action that may be needed. Practical, simple and cheap-to-use methods were reviewed in the first part of the project. Three have been field-tested by growers: earthworm counts; visual soil assessment tools; and NRM Laboratories' soil health tests, which cover biological, chemical and physical soil properties.

CP 107c is looking at how precision farming can be used to manage soil conditions and nutrition. A review of precision farming technology undertaken during the project's first year led to a series of 'demonstration projects' – including on field-grown trees – to test practical applications of the techniques with the most potential to improve soil and nutrient management.

CP 107d is constructing a centralised soil management information system to bring together existing and new data from research and from growers and agronomists so that it can be analysed to produce clear guidance on soil management practices and their outcomes for specific crops, soil types, locations and commercial and environmental situations.

Results so far: soil assessment

The field trials showed that soil assessment methods need to be tailored to the specific cropping system. For example, the visual assessment tool, originally developed for grassland, is proving less relevant to horticultural systems, particularly bed production systems, though it could be improved by better timing, for example when the soil has had chance to settle after bed-forming. It has turned out to be crucial to carry out earthworm counts in spring or autumn, when they are most active in the soil's top layers, and to take soil management practices into account when interpreting results.

In conjunction with the Innovative Farmers Network, year-long grower-led demonstration trials, or 'field labs', were run on issues such as use of cover crops in a shared rotation and the impact of digestate on soil health.

A programme of grower workshops, web-based seminars and demonstration days continues through to the end of the project. Specific events have covered soil management and soil health in nursery stock and cut flower production.

Results so far: precision farming

A survey to ascertain the soil structural conditions 'typical' in horticulture was undertaken in the first year. The results will inform guidelines for growers and establish a 'baseline' against which improvements made following the uptake of various precision-farming practices may be judged.

At the same time, the project team reviewed precision farming techniques and surveyed their use in horticulture, to select those most likely to improve crop nutrition and soil health, for more detailed study. Six demonstration trials at farms already working with the technology looked at canopy sensing for variable-rate nitrogen application, controlled traffic farming and options for soil mapping. Open days for growers were held at each site, one is planned at Wyevale Nurseries in May 2018. All event details, along with the advisory information based on the results from the programme, can be found on the **horticulture.ahdb.org.uk/greatsoils**.

Results so far: soil management information system

The project has so far focused on the collation of data, information and knowledge on soil management issues and their solutions from a wide range of sources, including growers, other relevant datasets such as Met Office records, and published research.

CP 107b: Growing Resilient Efficient and Thriving (GREAT) Soils

Term: April 2015 to March 2018

Project leader: Ben Raskin, Soil Association

CP 107c: The application of precision farming technologies to drive sustainable intensification in horticulture cropping systems

Term: April 2015 to March 2018

Project leaders: Lizzie Sagoo and Paul Newell Price, ADAS

CP 107d: Development of a soil management information system

Term: November 2015 to October 2018

Project leader: Jane Rickson, Cranfield University

The biology of healthy soils

This project is exploring the biological characteristics associated with 'healthy' soils and aims to use them to develop soil health indicators that growers and agronomists will eventually be able to use. A literature review to update the background state-of-the-art knowledge of soil biology and soil health in UK agricultural systems has already been completed. A list of 'molecular markers' for the presence of key soilborne pathogens and beneficial microbes has been agreed.

The biology of healthy soils

CP 166: Soil biology and health

Term: October 2016 to August 2021

Project leader: Elizabeth Stockdale, Newcastle University

Partnership keeps you abreast of fertigation innovations

The introduction of fertigation has led to a step change in the growers' ability to use water and nutrients efficiently by matching supply to crop demand. However, across Europe, growers face increasing competition for water with other users, while intensive cultivation can pose a threat to both surface and ground water quality. The industry is responding with R&D to develop more efficient and cost-effective methods and equipment for sustainable crop production and through novel ways of making the results available to growers.

The project

The main objective of this EU-funded project, in which AHDB is a partner, is to collect and make available to growers innovative ideas in water management and to help the industry develop further best practice in order to improve water-use efficiency and reduce the environmental impact of crop production systems that use fertigation. The project draws on the expertise of research organisations in 10 EU member states and in South Africa.

AHDB's role is to undertake one-to-one sessions with growers who use fertigation in various types of crops, including ornamentals, who are willing to share details of how they have achieved best practice and the novel technologies they use.

Results so far

More than 134 technological solutions have been reviewed so far. A series of free one-page guidance sheets is being prepared, which will contain practical information on how to implement the technology.

> "Fertigation has led to a step change in the growers' ability to use water and nutrients efficiently"

TF/PO 001: FERTINNOWA: Transfer of innovative techniques for sustainable water use in fertigated crops

Term: January 2016 to December 2018

Project leader: Raf De Vis, Proefstation voor de Groenteteelt, Belgium

Getting the measure of nursery stock nutrition

Controlled release fertiliser is the source of long-term nutrition for most container-grown hardy nursery stock crops. Although the products are designed to release nutrients over a defined period, the release pattern is still influenced by both temperature and moisture levels. Assessing when crops need more fertiliser, before symptoms of deficiency appear, can be difficult without laboratory analysis of samples of growing media or leaf tissue. Being able to monitor the nutrient status of plants on site would enable growers to adjust fertiliser applications before plants became visibly deficient.

The project

Equipment likely to prove suitable for nutrient monitoring on nurseries was reviewed and those that appeared the most practical were trialled. The equipment in the project varied from simple handheld 'dip sticks' for measuring sap nitrogen, to smartphone apps which relate leaf colour to nitrogen content, and portable meters which assess tissue nitrogen content, leaf chlorophyll or growing media EC as indicators of plant health.

An initial trial focused on buddleia, chamaecyparis, prunus, skimmia, tradescantia and viburnum to see how each responded to increasing levels of fertiliser, how the nutrient status of these plants was reflected in the results from the equipment and how the results compared to laboratory analysis.

A range of crops is being monitored at various nurseries in the UK using the same methods to confirm their usefulness under commercial conditions and as a starting point for the development of on-nursery monitoring protocols.

Results so far

The Green Index phone app and the chlorophyll fluorescence meter proved relatively easy to use, as did the Pro-Check EC meter for determining the growing media EC and moisture content. The main drawback with methods that analyse leaf sap was that it was almost impossible to extract enough sap from woody plants such as chamaecyparis. Coloured sap also interfered with the dip stick results.

Results from the phone app, the chlorophyll fluorescence meter and the Pro-Check meter potentially showed a good relationship with the laboratory analyses. The chlorophyll fluorescence meter revealed low leaf nitrogen levels two weeks before deficiency symptoms appeared.

HNS 193: Nutrient management in hardy nursery stock

Term: April 2015 to March 2018

Project leader: John Adlam, Dove Associates

Growth control with a light touch

Advances in LED lighting and in spectral filter plastic films and glass coatings offer growers new opportunities to manipulate light quality in tunnels and glasshouses, in order to manage plant growth and development to meet specifications and schedules that rely less on chemical growth regulators. The full effects of light quality on plant responses and on the behaviour of pests and beneficial insects are still not well understood. However, uptake of these new technologies is being held back by a lack of clear guidance.

The projects

CP 085 was a horticultural fellowship designed to enable researcher Phillip Davis to build up his expertise in light regimes for horticultural crops. He began by exploring the impact of different ratios of red/blue and red/far-red light on a range of crops and in the final year focused on the economic implications for growers of advances in the energy efficiency of LED lighting.

Davis looked in more detail at how LEDs can be used to manage aspects of crop growth and quality in CP 125, and at how insect pest monitoring is affected by different light wavelengths.

In CP 164, Simon Pearson is starting to construct a mathematical model capable of predicting how a crop would respond to any given set of light wavelengths or lighting regimes and, in particular, the long-term impacts of a light spectrum on yield and quality. The model will be designed to enable growers to use it to help them plan their own lighting regimes.

Results: LED efficiency

The most advanced LEDs use 36% less energy than 600W high-pressure sodium lamps. Any increase in LED efficiency also means more light for a given wattage, so fewer lamps are needed to achieve the same light level, hence lower installation costs. During the final year of CP 085, Davis designed a model for the supplementary lighting requirements of glasshouse crops and used it to simulate the effects of different lighting strategies on crop production costs.

Results: growth control and pest monitoring

Early on in CP 125, Davis showed that mobile or strobe LED set-ups intended to reduce a system's capital and running costs produced poor quality plants, so he went on to concentrate on the effects of different fixed intensities on plant quality, growth rate and running costs. He also looked at the diversity of plant responses to different light wavelengths.

Plants grew faster and quality improved as light intensity rose to about 200µmol per sq m per second, above which energy costs began to outrun the value of any crop gains. Growth was quickest under light mixtures containing around 10% blue light, but the most effective growth regulation was in mixtures of between 30% and 60% blue light. Far-red light brought forward flowering of some species by up to two weeks but caused stretching. Careful selection of the blue light percentage and far-red intensity can result in high quality plants which are fast to flower. Strike rates in cuttings were highest under 100% red light. Exposing mother-stock plants to LED lighting also greatly improved cutting quality and strike rate.

The colour of sticky traps used for insect pest monitoring – as perceived by both insects and humans – changes under different light wavelengths, as do the colours of flowers and leaves. So Davis tested a range of sticky trap colours for their effectiveness under the light regimes resulting from the plant growth response trials, and investigated the behaviour of aphids, two-spotted spider mites and biocontrol agents on a number of crops grown under different light treatments. The pests appeared to do less well under the LED light regimes used in the trials, but light quality was also found to influence the effectiveness of biocontrol agents. The results differed, however, between the various combinations of insect and crop species.

CP 085: Securing skills and expertise in crop light responses for UK protected horticulture, with specific reference to exploitation of LED technology

Term: October 2012 to September 2017

Project leader: Martin McPherson, STC

Fellowship researcher: Phillip Davis, STC

CP 125: Understanding crop and pest responses to LED lighting to maximise horticultural crop quality and reduce the use of plant growth regulators

Term: April 2014 to March 2017

Project leader: Phillip Davis, STC

CP 164: SPECTRA: Whole plant spectral response models

Term: July 2016 to June 2019

Project leader: Simon Pearson, University of Lincoln

Cut flower know-how from alstroemeria to zinnia

The past 20 years or so have seen a marked growth in UK flower sales, but our own production of cut flowers has been held back by a perceived lack of 'know-how'. With AHDB support, the National Cut Flower Centre, based at Rookery Farm, Holbeach St Johns in Lincolnshire, is trialling new ways of growing familiar crops and evaluating others that may have potential. It also acts as a showcase to promote what is available from within the UK to packers and retailers.

> "Ornamental brassicas were tested over two seasons to select new varieties for a high quality tunnel crop"

The project

For 2016 a range of crops was included in the work programme, including a continuation of trials on varieties of alstroemeria on which no royalties are levied, ornamental brassicas, China asters, column stocks and lilies. Among the potential new crops on trial were basil, caryopteris, cleome, craspedia, delphinium, eremurus, gomphrena, gypsophila, ornamental grasses, scabious, seed-raised fillers, solanum, solidago, trachelium, veronica and zinnia. Work also continued on herbicide evaluation.

Results

Tunnel-grown alstroemeria yielded about twice as many stems as the outdoor beds in 2014, about three times as many in 2015, and just under double in 2016. Yields varied markedly between varieties – 'Nina' performed best of the 12 tested, whether in the tunnel or outdoors and across the three years.

Ornamental brassicas were tested over two seasons to select new varieties for a high quality tunnel crop. Several performed well, but growers and packhouses have indicated they will continue with the well-tried 'Crane' series until there has been more experience with alternatives.

A 2016 planting of a new series of spray asters – 'Julie' and two numbered bloom types – served as a demonstration to packers and supermarkets. Samples were well received but timing and quality were judged little different to existing varieties.

A planting of column stocks was made in 2016 to demonstrate currently available varieties in the UK, and to investigate the effects of steam sterilisation on establishment and flowering. As expected, performance in the untreated soil was poorer than in the steamed area, but the difference was less marked than had been seen in previous trials.

The emphasis of the lily trials changed in 2016 to look at growing in blends of peat and wood fibre or cocopeat, in comparison with the standard peat-based medium or coir. Lilies grown in pure coir were stunted, but otherwise there were no indications of visual differences between plants in any of the other growing media, and all treatments were picked within a few days of each other.

The ornamental grasses proved to be the new crop that generated most interest among growers and their customers, particularly *Panicum elegans* 'Sprinkles' and *Stipa capillata* 'Lace Veil'.

Other new introductions that showed promise included *Caryopteris* 'Pagoda Lagoon' because of it's rich colour; craspedia, which had a good shelf life and also dried well, the flowers retaining their colour; *Delphinium* 'Trick' series as straight bunches or for use in bouquets; gomphrena, which was very prolific and may have potential as a filler; *Scabiosa* 'Scoop' series with an attractive range of flower colours, high yields and good vase life; and *Ammi majus, A. visnaga*, and *Daucus carota* as seed-raised fillers. Veronica also showed real potential as a cut flower.

Herbicide trials in 2016 focused on transplanted China aster and drilled sweet william. The tank mix of Stomp Aqua (pendimethalin) + Gamit 36 CS (clomazone) followed by Butisan S (metazachlor) was probably the best compromise between weed control and crop safety for China aster. On some sites Wing-P (dimethenamid-p + pendimethalin), either alone or followed by the mix of Venzar Flo (lenacil) + Flexidor 500 (isoxaben), might be an option. The recommended herbicide programme from the trial on drilled sweet williams was Stomp Aqua + Goltix 70 SC (metamitron) at drilling, followed by Venzar Flo + Flexidor 500 + Shark (carfentrazone-ethyl) post-emergence.

PO/BOF 002a: The National Cut Flower Centre trials programme for 2013-2017

Term: January 2013 to December 2017

Project leader: Lyndon Mason, LRM Horticultural Services

Cuttings, claddings and a new market for perennials

The Bedding and Pot Plant Centre was established in 2014 to carry out small-scale trials to help growers of protected ornamentals exploit new product opportunities, test new production methods and respond to other industry problems as they arise. The work is targeted at growers who produce finished plants on a typical small- to medium-size bedding and pot plant nursery. The Centre, at Baginton Nurseries in Warwickshire, hosts regular open days where growers can view and discuss the trials with plant breeders, retailers, consultants and researchers.

The project

This review covers work completed in the final year of the original three-year tranche of AHDB funding for the Centre (prior to the project extension, PO 019a). Trials looked at how to increase rooting of bought-in cuttings; glass coatings and spectral films to improve plant quality; and the potential to overwinter perennials under protection for early spring sales.

Trials which began in 2016, following reports of leaf chlorosis and spots on verbena at various nurseries, were extended to investigate possible links to irrigation regime, growing medium pH and trace element nutrition.

White hellebore varieties are already marketed in flower before Christmas so a trial was established in 2016 to see if cold storage could be used to manipulate the new coloured varieties to flower in time for the Christmas market too. A cold store malfunction damaged the plants, however, so this trial was repeated in 2017 and the results are still being analysed at writing.

Results: rooting cuttings

The wetting agent Omex SW7, the fungicide Signum (boscalid + pyraclostrobin), the biofungicide Serenade ASO (*Bacillus subtilis*), the rooting hormone Rhizopon AA and the sugar fructose were applied either as a quick or long dip prior to sticking, or as a spray after sticking, to imported unrooted geranium cuttings. Omex, Serenade and Signum dips improved rooting. A quick dip in Rhizopon improved rooting of six-day-old cuttings, but not of older cuttings.

Further trials of the most promising treatments have since been undertaken and results are being analysed at writing.

Results: spectral coatings and filters

Light transmission and spectral measurements were recorded over a season for a variety of glass-coating products from several suppliers. Diffusing or shading coatings had little influence on light spectrum but did affect the total amount of light transmitted. Those designed to lower glasshouse temperatures reduced transmission of wavelengths longer than 650nm (including infrared) and of UV light. The shade products were the least durable.

The work on films used polytunnels clad with Lumisol or Luminance, which diffuse light, and old or new installations of the spectral filter SunSmart Blue, compared with glass. Crop responses varied with species and the film. Cyclamen tended to be of poorer quality under the diffusing films, but this trend was not evident across all species. SunSmart Blue improved quality in five of the eight plant species tested, Luminance in four and Lumisol in two. Growth was generally more compact under the new SunSmart Blue film compared with the old film, except for cheiranthus and primrose.

Results: herbaceous perennials

This trial was designed to test the potential to extend the herbaceous perennial season and product range, enabling growers to offer a wider range of plants for early season impulse sales.

Nine perennial subjects were monitored throughout the winter and assessed for flower development, plant quality and height in weeks 13 and 14 (end of March, beginning of April), the target marketing date.

None reached the target marketing specifications on time, although five (*Campanula glomerata* Acaulis, *Campanula persicifolia* 'Takion Blue', *Prunella grandiflora* 'Freelander Blue', *Scabiosa japonica* var. *alpina* 'Ritz Blue' and *Silene alpestris* 'Starry Dreams') had developed flower buds or were just beginning to come into flower. The project team felt that adjustments to temperature and growth regulator regimes would enable these and potentially other species to be ready for the target date.

PO 019: The Bedding and Pot Plant Centre: new product opportunities for bedding and pot plant growers

Term: July 2014 to March 2017

Project leader: Jill England, ADAS

Longer storage life sought for acorns

Many oak species tend to set seed irregularly, producing good crops only every three to eight years. But the acorns' high respiration rate and sensitivity to loss of even small amounts of moisture from their tissues means propagation nurseries can't even out supply by drying and cold-storing them, as they can with many other species. It may be possible to extend the storage period by reducing water loss or by slowing respiration.

The project

The project took two different approaches to extending acorn storage life without significant loss of germination or vigour. The first tested a range of waxes – beeswax, soya wax and microcrystalline wax – to either partially or fully coat acorns before storage. The anti-transpirant Wilt-Pruf was also tested as a coating. The second compared three types of bag – polyethylene, polyester or biopolymer (perforated or unperforated) used in 'modified atmosphere' packaging by the food industry.

Results

Acorns entirely coated with soya wax germinated as successfully as untreated acorns before storage, but the thin, brittle coatings flaked off during storage so offered no advantage. Acorns entirely coated with beeswax or microcrystalline wax retained a moisture content close to the critical threshold even after being in store for 60 weeks – the length of the experiment – but viability declined over time. These waxes also hampered germination by trapping the emerging radicles. Acorns treated with the anti-transpirant had a similar storage life to untreated acorns.

The moisture content of acorns stored in polyethylene bags was still high after 60 weeks, but they quickly lost viability as oxygen became depleted in these bags and resulted in fermentation. Acorns stored in polyester bags also retained a high moisture content. Samples removed after 12 weeks germinated as well as untreated, unstored acorns but were prone to fungal infection, which caused large losses. Acorns in the biopolymer bags germinated poorly due to moisture loss. Moisture was lost more slowly from acorns in the unperforated bags, although there was some fermentation, particularly when stored for longer periods.

HNS 197: Application of post-harvest treatments to extend storability of pedunculate acorns (*Quercus robur*) without loss of viability or germinability

Term: October 2015 to September 2017

Project leader: Shelagh McCarten, Forestry Commission Research Agency

Collaborative robots learn nursery skills

One answer to the increasing cost and declining availability of nursery labour is more automation using robotics – provided we can overcome some of the unique challenges the industry presents.

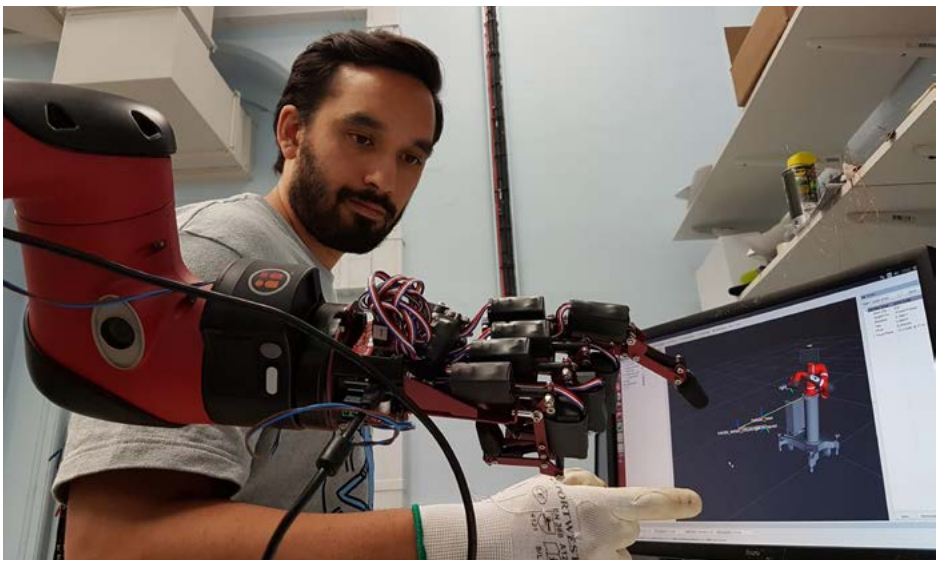
Some forms of automation, such as tray filling and transplanting machines, are already widely used. But when it comes to handling the crops themselves, progress has been slower because of the technological challenge of recognising and manipulating plant material and because of the need for robots to work safely alongside people.

Advances in so-called collaborative or 'soft robots' and in 'machine learning' mean that even tasks on ornamentals nurseries, such as taking cuttings and preparing plants for dispatch, could become more automated in the future.

The project

Aran Sena is exploring the use of collaborative robots in plant propagation and production, focusing on their application to small- or medium-size businesses growing relatively small batches of a wide variety of plants. For this reason, the project is working on tasks that are usually difficult to automate at a small scale, such as taking and grading cuttings, sticking and potting, and grading plant material, where the common factors are grasping and manipulating. The project is concentrating mainly on solving this aspect of the automation problem by looking at what is needed to separate a cutting or plant from a batch, grasp and lift it and then transfer it to a target location, using a single, general-purpose robot that can be moved around a nursery, rather than a specialised machine.

New technology that enables users with no specialist robotics knowledge to 'train' their robots is a key element of the project.



Results so far

Sena has visited several growers to understand the range of tasks that a nursery undertakes. Typical tasks have been broken down into a series of steps in order for a robot to complete the work.

Initial research has started on 'imitation learning', whereby the grower performs the task they want to automate while the robot monitors their actions through its vision system and through being connected to sensors embedded in a 'smart' glove that the grower wears.

HNS/PO 194: GROWBOT: A grower-reprogrammable robot for ornamental plant production tasks

Term: January 2016 to December 2018

Project leader: Matthew Howard, King's College London

PhD student: Aran Sena, King's College London

Poinsettias compared and controlled

The UK poinsettia trade relies heavily on relatively few varieties, but growers have become aware that some which have been on the market for several years are beginning to show traits that are variable or not typical.

Breeders, based in the USA and Europe, are responding by developing new varieties and revamping existing ones and it is important that these are trialled under UK growing and marketing conditions so that growers and their customers can select the most appropriate.

The project

'Infinity' is currently the variety most widely grown, followed by others such as 'Christmas Eve', 'Christmas Feelings', and 'Prima'. The UK market tends to demand slightly taller plants than those typically grown elsewhere in Europe, with clean red bract colours contrasting against dark green leaves. Prominent cyathia are frequently required, but without pollen. The project is testing a range of varieties, including pre-release lines, from the key plant breeders for their suitability for the UK market grown on three different locations in the UK.

Following recent use restrictions on the product label for Stabilan 750 (chlormequat) used to keep crops to retailers' size specifications, the project has also been examining ways to control growth with moisture deficit irrigation techniques, using technology adapted from the soft fruit industry applied to a commercial crop of poinsettias grown at Neame Lea Nurseries near Spalding.

Results

Crop performance during production and shelf-life testing was undertaken on a range of new varieties and on plants grown using the moisture-deficit irrigation regime.

> "The project has also been examining ways to control growth with moisture-deficit irrigation techniques"

PO 021a: New poinsettia genetics and controlled substrate moisture growing

Term: June 2017 to March 2018

Project leader: Simon Pearson, University of Lincoln

Specialist guidance on energy efficiency

Through GrowSave, AHDB Horticulture distributes energy saving information and supports growers of protected crops in their uptake of energy saving technologies. The programme is delivered by the specialist energy consultancy FEC Energy and steered by a group of growers from the protected edibles and ornamentals sectors. The work programme and the way in which information is communicated are kept flexible so the project can respond as the energy issues that the industry faces change over time.

The project

Energy saving guidance is offered at grower workshops and seminars – many of which are held on nurseries where techniques can be seen working – and in a range of technical publications, website updates, a newsletter and articles in AHDB's *The Grower* magazine. The programme includes benchmarking information to help growers compare their energy use.

Recent activity

During 2016/17, the programme featured a study tour, two seminars – on renewable heating and on optimising air movement for protected ornamentals – and two technical presentations at crop association meetings.

Three editions of the Energy News newsletter were published, along with technical updates on conventional and alternative sources of CO_2, climate-control sensors, cold storage and crop lighting.

Much of this information, as well as case studies and commentary on energy price movements and other topical issues, is available on the GrowSave website, at **www.growsave.co.uk**. The website is regularly updated and has recently been redesigned to include a new section covering renewable energy in much more detail.

PE/PO 011a: GrowSave: Energy and resource efficiency knowledge transfer for the protected crops sector

Term: August 2014 to July 2019

Project leader: Jon Swain, FEC Energy

Your voice, your future

Help steer the industry as an AHDB Horticulture panel member

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