AHDB

Ornamentals Review 2020

HORTICULTURE

Contents

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Foreword

Welcome to the 2020 Ornamentals Review supplement to AHDB Grower, which summarises the current research AHDB is funding on behalf of ornamentals growers.

The range of projects covered within the Review supplement reflect the current AHDB strategy, developed to address the key needs of industry. So the main emphasis has been on labour efficiency measures and automation, crop protection with a focus on integrated pest management, and resource use optimisation to ensure production inputs are used effectively while minimising the potential risk of environmental pollution.

Work programmes

The AHDB SmartHort programme aims to reduce labour requirements in horticulture by improving efficiencies and via the adoption of new technology and automation. The adoption of Lean working practices continues to be central to the programme, but recently a challenge has been issued to the Warwick Manufacturing Centre to develop a purpose-built autonomous guided vehicle to facilitate plant movement on nurseries (CP 187). Alongside this, the GROWBOT project has investigated the potential of 'learning from demonstration' to teach a robot to undertake complex, repetitive nursery tasks (HNS PO 194).

In terms of crop protection, the process of screening for new suitable active ingredients and crop protection products continues within SCEPTREplus (CP 165), while the push to improve our knowledge of biopesticides and their use is the challenge for AMBER (CP 158). Working in conjunction with these broader projects are more sector-specific targeted work, looking at weed and vine weevil control in hardy nursery stock (HNS 198 and 195 respectively), biocides for inclusion in bulb hot water treatments (BOF 77) and alternative plant growth regulators (PO 019a).

Peat-free growing media use has once again moved up the agenda and 2020 saw the fruition of the five-year joint-funded Defra/AHDB/industry project on responsibly sourced growing media, with the development of a growing media performance prediction model (CP 138). Alongside this, AHDB has commissioned two new projects on nutrient management for both container- and field-grown crops to optimise fertiliser use (HNS 200 and PO BOF 003).

Get involved

We are always looking for grower input, so if you would like to become more involved with projects or the panels, please contact Georgina Key, AHDB Ornamentals Research Manager, and she will be happy to advise you of the latest opportunities.

Two grower panels, the Hardy Nursery Stock Panel and Protected Ornamentals, Bulbs and Outdoor Cut Flowers Panel, represent the industry. Both panels continually consider how to proactively support the industry in the face of both imminent and longer-term challenges and help the industry adapt in this ever-changing environment. Each panel meets twice a year and both are a great way to guide the research and knowledge exchange that AHDB does for the industry and to network with a wide range of other growers.

Whatever crops you grow in your business, I wish you a successful production season during 2020.

Jamie Dewhurst
J & A Growers Ltd
AHDB Horticulture Board Member

Trial evaluating new fungicide products

Pests and diseases

Identifying and securing crop protection solutions for industry

With the continuing loss of crop protection products, Joanna McTigue, AHDB Crop Protection Scientist, explains the efforts undertaken to ensure UK growers have the essential crop protection products they need to remain competitive.

Funding projects that provide growers with a wide range of effective pest, disease and weed control options is one of the key objectives of AHDB. We are constantly working towards securing new and alternative crop protection products for horticulture. In the case of ornamentals crops, we work closely with growers on both the AHDB Hardy Nursery Stock and Protected Ornamentals, Bulbs and Outdoor Cut Flowers Panels and with the supporting scientific advisers to identify prominent pest, disease and weed problems that are of highest priority and increasing in prevalence.

In close liaison with the panels, a register of sector-relevant pests, diseases and weeds is regularly updated and linked with the products available for their control. The AHDB crop protection team then works with the Chemicals Regulation Division (CRD) and agrochemical manufacturers to keep track of those products that are at risk of losing their approval status. We also track the EU and UK approvals databases to identify any other changes.

Using all this combined information, we identify any potential active ingredient or product withdrawals and the ripple effect this will have upon the industry. By keeping one step ahead, we can try and proactively implement measures to find alternative solutions, before the products are lost, so growers aren't left without alternatives.

However, the loss of products is now far surpassing the number of new products coming to market, and many growers risk being left without any alternatives for critical pests, weeds and diseases. In these situations, we frequently submit Extension of Authorisation for Minor Use (EAMUs) and emergency authorisation applications to CRD, as many of the crops catered for by AHDB Horticulture are considered 'minor' crops by agrochemical manufacturers. Securing the use of new products has been achieved by building close working relationships with the staff at CRD, agrochemical manufacturers, the EU Minor Uses Coordination Facility, overseas regulatory bodies and other international minor use facilities to gather the information and safety data required for suitable candidate products.

The crop trials that are needed to generate the safety data to accompany an EAMU approval application carry a cost and are funded on behalf of the industry by AHDB Horticulture. In some cases, the data is already available in another country, but even then, we may have to pay a fee for use within the UK.

Work identifying effective integrated pest management (IPM)-compatible biopesticides and obtaining appropriate approvals for growers is becoming increasingly important in our crop protection programme, alongside the work we already do with more familiar types of crop protection products. Our SCEPTREplus programme is providing valuable crop efficacy and safety data required for candidate product approval.

In the two years since the last Ornamentals Review, we have secured 28 EAMUs to help industry in the control of aphids, thrips, whitefly, bacterial diseases, *botrytis*, powdery mildew and a range of weeds, as summarised below, by EAMU issue number:

Product	Active ingredient	EAMU No.	Crops/situation	Target/use
Terpal	Ethephon and mepiquat chloride	0151/2018	Ornamental plant production, container-grown crops	Growth control
Corzal SC	Phenmedipham	0376/2018	Outdoor ornamental plant production	Weed control
Primo Maxx II	Trinexapac-ethyl	0621/2018	Forest nursery and ornamental plant production	Growth control
Flipper	Fatty acids (C7-C20)	1854/2018	Protected ornamental plant production	Aphids, spider mites and whitefly
Serenade ASO	*Bacillus subtilis* (strain QST 713)	2356/2018	Ornamental plant production	*Botrytis*
Praxim	Metobromuron	2737/2018	Outdoor ornamental plant production, bulbs	Weed control
Inigo	Metobromuron	2745/2018	Outdoor ornamental plant production, bulbs	Weed control
Soleto	Metobromuron	2767/2018	Outdoor ornamental plant production, bulbs	Weed control
Lianto	Metobromuron	2768/2018	Outdoor ornamental plant production, bulbs	Weed control
Amistar	Azoxystrobin	3388/2018	Ornamental plant production	Disease control
Pitcher GR	Garlic extract	3744/2018	Protected and outdoor ornamental plant production	Leaf and bud nematode and vine weevil
Topas	Penconazole	0169/2019	Protected and outdoor ornamental plant production	Powdery mildew
Amylo X WG	*Bacillus amyloliquefaciens*	0428/2019	Ornamental plant production	Bacterial and fungal pathogens
Centium 360 CS	Clomazone	0743/2019	Outdoor ornamental plant production	Weed control
Prolectus	Fenpyrazamine	0784/2019	Ornamental plant production	*Botrytis*
Batavia	Spirotetramat	1058/2019	Outdoor ornamental plant production	Aphids
Frupica SC	Mepanipyrim	1294/2019	Protected and outdoor ornamental plant production	*Botrytis* and powdery mildew
Spinnaker	Prosulfocarb	1741/2019	Forest nursery production	Weed control
Spinnaker	Prosulfocarb	1746/2019	Ornamental plant production	Weed control
Regalis Plus	Prohexadione	2153/2019	Protected ornamental plant production	Growth control
Nativo 75WG	Tebuconazole and trifloxystrobin	2513/2019	Protected and outdoor ornamental plant production, container-grown crops	White rust and black root rot
Batavia	Spirotetramat	2597/2019	Protected ornamental plant production	Aphids, thrips and whitefly
Karma	Potassium hydrogen carbonate	3338/2019	Protected and outdoor ornamental plant production	Powdery mildew
Aphox	Pirimicarb	4195/2019	Protected ornamental, plant production, container-grown crops	Aphids
Aphox	Pirimicarb	4196/2019	Protected ornamental, plant production, container-grown crops	Aphids
Secardis	Fluxapyroxad	4348/2019	Protected and outdoor ornamental plant production	*Botrytis* and powdery mildew
Canopy	Mepiquat chloride and prohexadione-calcium	4484/2019	Protected and outdoor ornamental plant production, container-grown crops	Growth control
Devrinol	Napropamide	0168/2020	Outdoor and protected ornamental plant production	Weed control

A selection of different nozzle types on a boom application system

Getting the best from biopesticides

AHDB project code: CP 158 Application and management of biopesticides for efficacy and reliability (AMBER)
Term: January 2016 to December 2020
Project leader: Dave Chandler, University of Warwick

Integrated pest management (IPM) is now a required practice under the EU Sustainable Use Directive. In order to make IPM successful, it is vital that growers have access to a full range of control agents that can be used as part of an integrated approach and not just rely on traditional crop protection products. One group of alternatives are biopesticides. These are control products based on natural agents, and there are three types: living microbes, insect semiochemicals and botanicals. These types of pest control agent are based on living organisms and so it takes more knowledge and understanding to use them successfully compared with traditional crop protection products.

The project

AMBER was a five-year project which aimed to identify management practices to improve the performance of biopesticide products within an IPM programme. The project covered spray application and water volumes, developed our understanding of biopesticides and examined ways to improve efficacy.

Results

Making biopesticide spray application more efficient

The aim of this element of the project was to determine the lowest volume of water required to provide biopesticide efficacy. Research was undertaken to investigate the effect of different water volumes on the quantity of a tracer dye (used as a proxy for a biopesticide) retained on chrysanthemum plants, applied using a three-nozzle boom on a track sprayer. When applied at a constant dose, so that concentration reduces as volume increases, there was a clear reduction in deposit as water volume increased. Therefore, the most efficient way to deliver an active ingredient to this kind of plant is with as low volume and as high concentration as possible, meaning, in practical terms, there is much scope to reduce water volumes well below the 1,000 L/ha rate often used by growers. However, in all cases, the quantity of spray liquid reaching the underside of leaves was low – averaging around 5% of the total deposit on a leaf – and also very variable.

Understanding the persistence of biofungicides on crop foliage

There is currently a lack of information about how long microbial biofungicides survive after they have been applied to crops. Experiments were undertaken to investigate the survival of *Ampelomyces quisqualis* (agent of biofungicide AQ10, used against powdery mildew), *Gliocladium catenulatum* (agent of Prestop for management of *botrytis*) and *Bacillus subtilis* (agent of Serenade ASO for *botrytis* management). Biofungicides are recommended for application before, or at the first

Measuring spray uniformity

signs of, disease symptoms. If they do not survive for long, then they will have to be reapplied frequently.

The experiments found that there was a steep drop in the number of viable propagules of *A. quisqualis* recovered from leaves sprayed with AQ10 after four days. This biofungicide is parasitic on powdery mildew and because it does not survive on the plant for long in the absence of its host, the correct timing and frequency of application is very important for its efficacy. In contrast, *G. catenulatum* reproduced on the plant and about twice as many propagules were retrieved 7, 10 and 14 days after Prestop application as on the application day. This biofungicide works as an antagonist and competitor so is applied preventatively. Seven days following Serenade ASO application, *B. subtilis* bacteria were recovered in similar numbers to within hours of application, again showing good persistence.

Optimal biopesticide control strategies, using a pest control model

Microbial biopesticides are usually slower-acting than conventional pesticides as the speed of pest kill is affected by a wide range of variables, such as the pest's biology and the environmental conditions. This complexity means that biopesticides can give variable results depending on the situation in which they are used.

To address this complexity, a computer model was developed to simulate pest population dynamics over time and the impact of the biopesticide on the pest population growth. Glasshouse whitefly and an entomopathogenic fungi were used as the initial model pest and biopesticide. The model takes account of the main factors that influence the growth of the pest population, as well as factors relating to the ability of the biopesticide to limit pest growth, to make predictions about how the overall level of pest control is affected by all of these interacting factors. Using the prediction, the model can be used to make practical recommendations about the best ways for growers to use biopesticides. For example, how frequently, and at what time in the crop growing season, the biopesticide should be used.


Insect infected with entomopathogenic fungus

Vine weevil, the most serious pest of hardy nursery stock

Taking the holistic approach to vine weevil control

AHDB project code: HNS 195 Improving vine weevil control in hardy nursery stock
Term: January 2016 to December 2019
Project leader: Jude Bennison, ADAS

Vine weevil (*Otiorhynchus sulcatus*) is the most serious pest of UK container-grown hardy nursery stock (HNS). With the imminent withdrawal of thiacloprid (Exemptor), growers will have no crop protection products for use in growing media for the control of vine weevil larvae. Many growers of HNS are therefore now adopting biological pest control methods within integrated pest management (IPM) programmes.

There is also now more grower interest in controlling weevil adults as well as larvae, and there is a need for more information on the efficacy and timing of treatments that are compatible with IPM programmes.

The project

The project consisted of a number of trials to better understand the biology of the pest, help target control measures, develop a system to help monitor populations and activity within crops and control both the larvae and adults, using a range of IPM-compatible control measures.

Results

Biology and behaviour

Work undertaken early in the project showed that vine weevil adults are active and feed at 6°C and above. Overwintered vine weevil adults are likely to become active and start feeding, even outside, as early as March, although egg laying may not start until they have fed intensively for at least five weeks. With recent mild winters and the extensive use of polythene tunnels and glasshouses in the industry to protect crops, vine weevil adults may be active over a longer period of time than first thought.

Tracking vine weevil movement in trials

Monitoring

Initial trials had indicated that a commercial vine weevil trap produced by ChemTica showed promise when compared with a range of other monitoring tools (corrugated cardboard roll, upturned plastic tray, grooved board, pitfall trap, cockroach trap and modified palm weevil trap). Further trials, however, showed the potential of other traps (cockroach trap and banana weevil trap) and two novel vine weevil trap designs. The four most promising trap designs were tested in container-grown HNS crops on two commercial nurseries. Unfortunately, no weevils were caught, probably due to very low populations, but useful insights into the practical use of such traps were obtained.

The potential to increase the effectiveness of vine weevil monitoring tools through the use of plant lures was investigated. *Euonymus fortunei* and yew (*Taxus baccata*) foliage are particularly attractive to vine weevils and their addition to the ChemTica traps significantly increased catches of vine weevils, regardless of their previous feeding experience. However, the relative attractiveness of the baits depended upon the prior experience of the weevils, with a preference shown for the plant species on which the weevil had previously fed.

Research on attractants for vine weevil adults has to date focused on the volatile compounds produced by live weevils, those in weevil frass and volatiles produced by host plants. In the laboratory, it has been shown that a range of plant volatiles induce a response in vine weevils, but transferring this to generate a positive response in the field has been more difficult. However, a vine weevil attractant is now commercially available.

A wooden trap with grooves filled with a gel containing *Steinernema carpocapsae* (Nemasys C) is available from e-nema for control of adult vine weevils that seek refuge under the traps during the day, become infected and subsequently die. The traps are currently sold for home garden use but are too expensive for commercial use. An experiment to examine the impact of applying a gel formulation of *S. carpocapsae* to the base of plant pots or inside insect traps did not increase adult vine weevil mortality.

Control measures

A 'little and often' system for applying reduced rates of entomopathogenic nematodes through the overhead irrigation was tested and validated on a commercial nursery. Application of nematodes at 40% rate, five times between June and October, was equally as effective in reducing mean numbers of vine weevil larvae per plant as two conventional full-rate drench applications in September and October. This method of applying nematodes offers up to 50% cost savings compared with using standard high-volume drenches, due to reduced labour time, without compromising on efficacy.

The effect of temperature on the infectivity of Met52 (an entomopathogenic fungus) to vine weevil larvae was examined and a predictive day degree model was developed to predict infection. This estimated that no kill would occur below 11.6°C and that for 75% kill, 256 cumulative day degrees were needed, which could only be reached between June and August in some years and locations.

Experiments were therefore carried out on 17 cold-tolerant isolates of fungi. Only a small number of isolates developed at lower temperatures. The two most promising strains were tested against vine weevil larvae but were less virulent, so did not offer opportunities for further development.

Laboratory experiments tested the lethal and sub-lethal effects of IPM-compatible treatments against adult vine weevils. None of the treatments gave effective weevil kill. Tafari (pymetrozine) reduced egg hatch, while a spray of *Steinernema carpocapsae* led to short-term abnormal behaviour, after which the weevils recovered.

Vine weevil larvae

Making the most of the available options

AHDB project code: HNS 198 Improving weed control in hardy nursery stock production
Term: January 2016 to December 2020
Project leader: David Talbot, ADAS

Over the past number of years, several key residual herbicides have been revoked and restrictions placed on some of the remaining ones, making long-term, cost-effective weed control a real challenge for growers, especially those producing container-grown crops.

The project

The project builds on previous AHDB-funded trials and continues to screen a small selection of potential herbicide products for use in container-grown crop production and field-grown rose and tree production. A series of efficacy and phytotoxicity trials examined the potential of various product tank mixes and programmes of herbicides to achieve longer-term weed control.

Results

Weed control in budded rose production

The budded rose trial, consisting of nine herbicide programmes, was set up at a commercial nursery, on newly planted field-grown rootstocks. Applications were made to the rootstocks at planting, a follow-up treatment was made in the case of a number of the programmes, and then again after budding.

Of the post-planting treatments, the tank mixes which included Sencorex Flow (metribuzin) appeared to offer the most effective weed control; the average weed cover was still minimal when assessed nine weeks after application. The rose rootstocks showed no obvious symptoms of phytotoxicity after the application of these treatments.

The follow-up treatments of Logo (foramsulfuron + iodosulfuron-methyl-sodium) and Betanal maxxPro (desmedipham + ethofumesate + lenacil + phenmedipham) offered very good weed control. However, Logo appeared to cause yellowing and stunting to the rose stocks, whether applied alone or in combination with Betanal maxxPro.

Post-budding, Butisan S (metazachlor) and HDC H43 (pethoxamid) appeared similarly effective as tank mix partners for Flexidor 500 (isoxaben), both showing a significant improvement in weed control compared with the untreated plots, with no significant phytotoxic effects.

A further trial was set up at the same commercial nursery on recently headed-back field-grown rootstocks, which were budded the previous year. The trial consisted of six one-off herbicide treatments applied post-heading-back. It was found that all post-heading-back treatments applied to the roses were effective and crop safe; Stomp Aqua (pendimethalin) + Flexidor 500 + HDC H42 as a tank mix offered particularly good weed control.

Weed control in field-grown tree production

The specific aim of this trial was to test the crop safety of a number of residual herbicides as alternatives to Flexidor 500 when used post-planting. Seven treatment programmes were applied at rootstock planting, followed by standard post-budding herbicide treatments to four different plant genera – *Malus*, *Prunus*, *Quince* and *Sorbus*.

Sencorex Flow at the higher rate (1 L/ha) gave the most persistent level of weed control, followed by Sencorex Flow at the lower rate (0.875 L/ha). Stomp Aqua did not control the weed spectrum present when applied alone without complementary tank-mix partners. The only treatment that resulted in phytotoxic damage was HDC H44. However, by the end of the trial, all genera had grown away from damage and were considered commercially acceptable.

Prodcut safety over container-grown hardy nursery stock

Flexidor 500, Sunfire (flufenacet) and Centurion Max (clethodim) were applied to ten different plant genera during the summer, post-potting; while Flexidor 500, Sunfire and Defy (prosulfocarb) were applied to dormant plants in the winter.

None of the treatments applied after potting appeared to cause long-term phytotoxic effects. Growers should note, however, that Flexidor 500 may cause short-term scorch on *Hydrangea* and *Weigela*, and Sunfire could have a similar effect on *Buddleja*, *Hydrangea* and *Weigela*, as may Centurion Max on *Hydrangea* and *Spiraea*. Similarly, no significant phytotoxic effects were seen in hardy nursery stock plants treated while dormant.

The phytotoxicity work continued on a commercial nursery, examining individual products and tank mixes applied to 10 container-grown genera in June and October.

HDC H44 caused phytotoxic yellowing on a number of genera and commercially unacceptable damage persisted on five of them. HDC H46 resulted in initial damage on a number of genera; however, all of them largely grew away from the damage, with only slight damage by the end of the trial. Flexidor 500 at the 0.5 L/ha rate damaged *Cornus* and *Perovskia*; however, *Cornus* grew away from the damage and plants were considered commercially acceptable. *Perovskia* plants were not considered commercially acceptable by the end of the trial.

A number of treatments proved more damaging than Flexidor 500 applied alone, including a tank mix of Flexidor 500 and Centurion Max, where *Perovskia* were considered commercially unacceptable; a tank mix of Flexidor 500 and HDC H43, where both *Perovskia* and *Sambucus* were considered commercially unacceptable; and Flexidor 500 and Sunfire, where *Ceanothus*, *Hydrangea*, *Perovskia* and *Sambucus* were considered commercially unacceptable.

Unacceptable weed growth in container-grown crops

Hot water treatment tanks

Biocide options for hot water treatment explored

AHDB project code: BOF 077 Investigation into the effects of a range of potential biocides in hot water treatments

Term: January 2016 to December 2019

Project leader: Rob Lillywhite, University of Warwick

Hot water treatment (HWT) of narcissus bulbs is used to control pests and diseases and has been the standard industry approach for over 70 years. Formalin was commonly added to HWT tanks as a biocide to reduce any disease inoculum in the water. However, approval for this active ingredient was withdrawn in 2008.

Project BOF 061a identified FAM 30 (an iodophor disinfectant) as a viable alternative and its use has become standard practice in the UK. However, FAM 30 is expensive, compared with formalin, and growers do not always use it at the required rate – the issue is exacerbated as the product rapidly depletes in tanks under a high bioload.

Other biocide alternatives have been considered, but they were either less effective than FAM 30 or impacted by high bioload. Non-chemical biocidal approaches, such as UV and thermal treatment, have been used in other water-based treatment systems and appear to offer a viable alternative to chemical approaches, but their efficacy is known to be very dependent on water clarity, which is a problem with high bioload HWT.

The project

The aim of the project was to examine physical methods of water treatment (UV and thermal) and a range of candidate biocides (chlorine dioxide, hydrogen peroxide and dodecyl dimethyl ammonium chloride) for their efficacy and ease of use against Fusarium basal rot.

Results

Filtration and UV sterilisation

The investigation into filtration had two aims: firstly, to see if it offered a general clean-up of tank water to allow chemical treatments to work more effectively, and secondly, to clean tank water to allow UV sterilisation to be effective. A retrofitted filtration set-up did remove some of the contaminants from the tank; however, the filter mesh size used was not sufficient to remove the smaller soil particles and water flow was reduced as a consequence, which had a knock-on effect on the efficacy of the UV sterilisation treatment. Initial results show that neither filtration nor UV sterilisation appeared to have any negative effects on crop flowering following replanting of the treated bulbs.

Thermal treatment of bulbs

Short dips, of around five minutes duration, in the range of 60–65°C did reduce the incidence of rot, with few negative effects. The temperature is likely hot enough to provide control of surface pathogens and short enough to prevent physiological damage. However, dips at 70°C, or at 60–65°C for more than five minutes had a negative impact on bulbs. Given the logistical difficulty of handling large volumes of bulbs on farm, it is unclear at this stage whether, with such small tolerances and the potential for significant losses, this method of sterilisation is practical.

Chlorine dioxide

An automated dosing system was installed on the HWT tank of a commercial business. The system had concentration monitoring equipment to achieve a set residual level of chlorine dioxide in the water, sufficient to kill pathogens. Trials were conducted over a period of two weeks until a steady residual level of chlorine dioxide could be maintained (in this case 1.6 ppm). Laboratory analysis of the tank water confirmed that the system controlled 99% of all pathogens.

Fungicide concentrations

Fungicide concentration monitoring trials were undertaken on commercial nurseries to track how fungicide concentrations varied over time using growers' normal starting and refill quantities of fungicides. All the businesses used chlorothalonil as their main fungicide, although one used thiabendazole as well. It was found that after two days no operation had measurable levels of chlorothalonil that were greater than 35% of the dosed rate.

Thiabendazole showed a similar pattern to chlorothalonil, with an initial value of approximately 50% of the dosed rate, which then stabilised at a lower level after the first two days of dipping. Overall, these results support previous work that indicated a stable concentration of about 25% of the target concentration is achieved after two days and that active ingredients are 'lost' from the circulating dip during HWT, primarily due to adherence on the bulb surface, degradation and sequestration.

Minimising tank sediments and bioload through improved bulb cleaning helps to maximise residual levels and the efficacy of fungicides used in HWT.

UV treatment equipment

Understanding the genetics of *Fusarium* is key to its control

AHDB project code: FV POBOF 452
Investigations into the control of basal rots in crops
Term: April 2017 to January 2019
Project leader: John Clarkson, University of Warwick

Fusarium oxysporum is the most important and economically damaging *Fusarium* species for horticulture and can be a major constraint to the production of column stocks and narcissus. The *F. oxysporum* complex comprises a large array of more than 70 pathogenic subspecies which are adapted to infect different crops and plant hosts, as well as non-pathogenic isolates.

Control is challenging as spores survive in the soil for many years. Past approaches have relied on soil sterilisation or fumigation, fungicides or seed treatments, but their approval in many cases has been revoked.

The project

The project had two key aims: to develop molecular tools and resources for identifying and studying *Fusarium* and then to determine the effect of *Fusarium* inoculum concentration on disease development.

Results

Genomes of a pathogenic *Fusarium oxysporum* f. sp *mathiolae* isolate and also a range of *Fusarium oxysporum* f. sp *narcissi* isolates were sequenced and comparative analysis carried out with genomes previously sequenced for other *F. oxysporum* subspecies, to identify common and unique pathogenicity genes. These were then assessed for their suitability as potential diagnostic markers and quantitative PCR (polymerase chain reaction) tests developed for each pathogen. The project demonstrated the tests to be accurate, sensitive and applicable for testing of soil and plant samples. Data has also been generated that has begun to relate pathogen DNA levels to the number of spores in a soil sample – a first step to understanding how useful these tests can be for practical diagnostics and to determine inoculum levels in the field. However, further work is required to determine how these assays can be successfully implemented for assessing disease risk following testing of soil samples.

Based on the genome information, the feasibility of using a DNA barcoding approach to analyse *Fusarium* species within entire microbial communities was examined. Primers were developed for four genes and used to evaluate their ability in determining the presence and abundance of *F. oxysporum* subspecies in mixed DNA 'pools' from multiple *Fusarium* species and other soilborne fungal plant pathogens. This approach showed promise; however, there are some areas that still require development and optimisation.

The project determined the effect of inoculum concentration on disease development in stocks and narcissus to determine the critical levels required for significant damage to occur which could then be related to PCR results. The specific PCR tests allowed root colonisation of these pathogens to be explored for the first time and results have shown that this occurs and can be detected within a few days of the plants being introduced into infested soil – two to three weeks before symptoms begin to be observed on plants. These tests may therefore be useful not only in detecting *Fusarium* subspecies in soil in advance of the crop but also in crops already planted where plants could be sampled to assess the likelihood of symptom development.

Internal symptoms of *Fusarium*

Screening for new crop protection options

Disease control in narcissus event

AHDB project code: CP 165 SCEPTREplus – Research for sustainable plant protection products for use in horticulture
Term: April 2017 to March 2020
Project leader: Consortium of contractors

SCEPTREPLUS

Management of pests, diseases and weeds is a major concern for growers in the UK. Efforts to protect crops effectively are hampered in many instances by the limited number of control methods available and exacerbated by the revocation of crop protection products, limited development budgets in crop protection companies for new products on specialist or minor crops and incidences of resistance to some of the products that are approved.

The future for pest, disease and weed control will require growers to take a true integrated pest management approach and integrate conventional crop protection products with biopesticides, cultural methods, including using rotations, clean plant material, resistant varieties, pheromone technology, biocontrols etc. and physical controls, making treatment decisions based on accurate diagnostics and pest and disease forecasts.

The project

AHDB's flagship crop protection programme, SCEPTREplus, identifies and evaluates new crop protection products to find solutions for pest, disease and weed control issues, while generating new data to support product approvals.

Results (Year 3 of programme)

Control of white mould and smoulder in narcissus

White mould (*Ramularia vallisumbrosae*) and smoulder (*Botrytis narcissicola*) represent a significant disease risk to UK narcissus production. Both diseases occur shortly following leaf/stem emergence, affecting both the foliage and flowers. This results in a loss of marketable flower yield and a reduction in bulb yield. A field-based trial located in Cornwall was set up to identify alternative chemical and biological treatments to effectively manage these diseases.

All the coded products trialled significantly reduced white mould incidence and/or severity compared with untreated controls, and many gave a reduction in smoulder severity. Effective products gave comparable, but not better, control than the industry standard Tracker (boscalid + epoxiconazole). Some phytotoxic damage developed in all treatments, but this was minor and not of commercial concern.

Further work is required to establish the best fungicide programmes, incorporating the most effective products identified in this work.

Weed control in cut flower production (gladioli)

Outdoor crops of gladioli are usually treated with herbicides selected from the range used on bulb crops. However, products such as Sunfire (flufenacet) and Wing-P (dimethenamid-P + pendimethalin) have been tested on other cut flower crops and have an EAMU for use in outdoor ornamentals, so a trial was created to examine the crop safety of each, along with some new, potentially promising coded products.

In the trial, all the treatments appeared to be crop safe when applied to the soil just prior to crop emergence and did not have any negative effect on emergence, foliage colour, flower colour or yield. After ten weeks, the weed control attained was still good in eight of the coded treatments examined.

Although weed numbers were not significantly reduced by Sunfire, it must be noted that this product is predominantly for grass control and the weeds noted were broad-leaved weeds. However, it is encouraging that no crop damage was observed from this product.

Sencorex Flow (metribuzin), Wing-P and Springbok (dimethenamid-P + metazachlor) are all worth considering as pre-emergence residual herbicides on gladioli. Sunfire can also be considered, but would need to be tank-mixed with another product to ensure both broad-leaved weed and grass control was achieved. Tank mixes were not tested in this trial; any tank mix would be at the grower's own risk.

A strategic approach to manage apple canker

AHDB project code: TF 223 Integrated pest management (IPM) of tree fruit pests and diseases – Objective 2 – Canker
Term: April 2015 to March 2020
Project leader: Michelle Fountain, NAIB EMR

AHDB project code: TF 226 The role of endophytes in affecting symptom development of European apple canker caused by *Neonectria ditissima*
Term: October 2017 to December 2020
Project leader: Xiangming Xu, NIAB EMR

AHDB project code: CP 161 Understanding endophytes to improve tree health
Term: October 2016 to September 2019
Project leader: Xiangming Xu, NIAB EMR
PhD Student: Leone Olivieri

AHDB project code: CP 141 The molecular basis of pathogenicity of *Neonectria ditissima*
Term: October 2015 to October 2018
Project leader: Richard Harrison, NIAB EMR and Robert Jackson, University of Reading
PhD Student: Antonio Gomez Cortecero

European apple canker (Nectria canker), caused by the fungus *Neonectria ditissima*, is an important pathogen of apple trees. The lack of registered products for disease control has resulted in canker becoming a more serious threat in recent years. The pathogen can infect the tree during the propagation phase in nurseries and enter a latent phase, later developing into cankers on young trees once they are transplanted. In some years, up to 10% of trees can be lost to canker, therefore diagnostic strategies and control methods are of high importance.


Canker on an apple tree

The projects

Within Project TF 223, a diagnostic tool has been developed to detect symptomless latent infection; a number of rootstock/interstock combinations were assessed to measure any effects on canker; the effects of biological soil amendments were determined; novel methods to reduce canker have been explored; and various treatments for pruning wounds have been examined.

Project TF 226 investigated the role that endophytes (organisms such as fungi and bacteria that live between living plant cells) may play in the suppression of canker and how they may be used to reduce disease.

Project CP 161 attempted to ascertain if the canker fungus establishes itself in the tree as an endophyte before it changes to a pathogenic phase.

Project CP 141 examined the genetics of the pathogen to improve understanding of potential resistance.

Results

Early work successfully developed a diagnostic tool that is now being used within Project CP 161 with the intention of developing a sampling strategy to deploy the diagnostic tool to industry. In the rootstock trials, EMR006 has looked the most promising at reducing canker in the scion. In terms of soil amendment use in stool beds, the use of *Trichoderma* may have potential. Some success was achieved using Felco 19 secateurs with a chemical dispenser which treats pruning wounds at the time the cut is made. Treatments including tebuconazole and tebuconazole + BlocCade (a physical barrier) showed promised.

Laboratory work has confirmed a fungus (a strain of *Epicoccum purpurascens*) can significantly reduce colony expansion of the canker pathogen. Work is underway to find out if inoculating trees with this strain can affect canker development.

Artificial inoculation and reisolation experiments have demonstrated that *N. ditissima* can be isolated from apparently healthy wood tissue, but never more than 4 cm away from the inoculation point. The work also showed that when infection occurs at pruning wounds, the pathogen is localised in the internal woody tissues of the branch within four months following the onset of infection. Growers are therefore advised to completely remove infected areas of branches as soon as the first canker symptoms appear and that the pruning cut should be made at least 5 cm from the edge of the lesion.

The genome of *N. ditissima* has been sequenced and the next stage is to identify specific candidate genes that control pathogen virulence to allow a better understanding of the mechanism of infection.

Mulching offers hope of control

AHDB project code: HNS PO 199a
Development of novel control options for agapanthus gall midge
Term: October 2018 to September 2019
Project leader: Hayley Jones, RHS

Agapanthus gall midge, *Enigmadiplosis agapanthi*, is an invasive pest first found in the UK in 2014 in Surrey, but has since been found in most counties in southern England and has successfully overwintered in the UK.

Adult midge

It poses a risk to both container-grown plants and cut flowers, as midge infestations cause flower bud damage and death. Heavy infestations can lead to entire flower heads being aborted. The presence of midge larvae throughout the growing season indicates there are several overlapping generations. Larvae feed and develop inside the flowers and, when fully grown, emerge and drop into the soil or growing media and bury themselves to pupate.

It is likely that agapanthus gall midge overwinter as larvae and pupate shortly before emergence in the spring, as with other pest midge species.

The project

The project aimed to review cultural control methods for gall midge pests on various crops, identify knowledge gaps, including any strategies that might be exploited to enable effective control of agapanthus gall midge based on the previous project (HNS PO 199), and to assess novel methods for reducing crop damage and losses in field-grown agapanthus by disrupting the pest's life cycle.

Results

The evaluation of sticky traps and water traps for monitoring adult agapanthus gall midge demonstrated that water traps are the most appropriate monitoring device, catching many times more midges than either type of sticky trap. The field experiment testing a variety of spray programmes unfortunately yielded no useful results due to extremely low occurrence of midge symptoms in the study area in 2019.

The laboratory pot test of candidate control measures against the ground-dwelling life stage of the midge was much more successful. A drench of Calypso (thiacloprid) and Strulch (a mineralised straw mulch) both significantly reduced adult midge emergence. Another barrier treatment, Melcourt EcoBark, delayed emergence significantly but did not reduce the total number of adult midges emerging. The remaining treatments (black polythene barrier; Gnatrol (*Bacillus thuringiensis*); Klasmann Containermulch; Nemasys (*Steinernema feltiae*) and Pitcher GR (garlic extract) did not have a significant effect on midge survival, but some had a delaying effect on emergence.

Agapanthus gall midge flower damage

The evolution of new control methods

AHDB project code: CP 120 Understanding the impact of phylloplane biocontrol agents on insects
Term: October 2016 to September 2019
Project leader: Rob Jackson, University of Reading
PhD Student: Kristina Grenz

Aphids thrive in controlled environmental conditions. Due to their vast host range and rapid reproductive cycle, they can be difficult to eradicate once they have become established in a glasshouse system. Chemical insecticides are commonly used for control, but indiscriminate use can increase the chance of resistance developing, and some insecticides also harm beneficial insects, such as natural enemies and pollinators.

The use of biopesticides as a means of pest control is a rapidly developing field, and previous work investigated the potential for bacteria naturally occurring on plants to provide control of aphids and thrips. Previous investigations found the three most effective microbial agents were *Pseudomonas fluorescens*, *Citrobacter werkmanii* and *Pseudomonas poae* – the latter showing the greatest success at killing aphids, with a 70% reduction in populations, a deterrent effect on treated plants and no noticeable effect on non-target insects.

The project

The project aim was to take the next steps in investigating the potential for using *P. poae* as a biological control agent. Experimental evolutionary methods, in which the environment of the population can be manipulated to increase the likelihood of certain traits evolving, were used to make the bacteria a more efficient biocontrol organism. Key traits were identified, then, by artificially selecting for these traits, they were improved upon over several weeks. Trade-offs were examined to see if improving bacterial toxicity came at a cost, such as growth and persistence on the plant.

Results

Two traits were examined – virulence and persistence. Currently, 70% of aphids are killed by *P. poae* in 42 hours, and it was hoped that this can be improved upon by increasing overall mortality and reducing the time it takes for the bacteria to be effective. The ability of *P. poae* to form biofilms was also investigated. Biofilms are aggregations of bacteria that can adhere to surfaces and form communities. They offer bacteria more protection from the environment, allowing them to survive longer on the plant, and help create space in which to grow, aiding colonisation.

In the laboratory, one isolate, in particular, was found to form significantly stronger biofilms. However, this ability came at the cost of aphid virulence and survival on the crop plant. Subsequent work will continue to apply experimental evolution techniques to improve *P. poae* for aphid control.

Aphids are an issue on a wide range of crops

Olive tree infected with *Xylella fastidiosa*

Understanding *Xylella fastidiosa* at a genetic level

AHDB project code: CP 178 Population genetics to understand the mechanisms of *Xylella* pathogenesis to inform novel control measures
Term: October 2018 to September 2021
Project leader: Rob Jackson, University of Reading
PhD Student: Louisse Paola Mirabueno

The plant pathogen *Xylella fastidiosa* has garnered global attention due to recent disease outbreaks in mainland Europe, primarily on olive. However, *Xylella* can infect an extensive range of woody and herbaceous plants and is transmissible by a wide range of xylem-feeding insects, such as spittle bugs. A range of symptoms are produced, including leaf scorch, plant stunting, wilting and death.

Although *Xylella* has not been reported in the UK, it is a potential threat, as crops such as *Prunus* (cherries, almonds) and ornamental species (such as lavender) are known hosts. At present, there are no available control measures, and management strategies consist of the destruction of infected material and plant movement restrictions.

The project

By studying the genetic mechanisms of infection in different plant hosts, this project will aid in the development of novel control measures. The project will involve the detection and identification of *Xylella* from distinct locations and plant hosts gathered from across Europe. New genetic sequencing tools will be used to identify factors involved in pathogenicity. This will inform the development of highly specific control measures involving molecules that target and disrupt pathogenic factors, reducing the ability of *Xylella* to cause disease.

Results

The project so far has looked at the subspecies diversity of *Xylella fastidiosa* on a worldwide basis and focused on the disease and crops impacted in Colombia.

Xylella fastidiosa damage

Column stocks susceptibility to *Fusarium*

Breeding

Solutions for the cut flower industry

AHDB project code: PO BOF 002b
The National Cut Flower Trials Centre Programme for 2018–2022
Term: January 2018 to February 2023
Project leader: Lyndon Mason, LRM Horticultural Services

Multiple retailers and consumers seek novelty and favour UK-grown produce, where it is available at the right price, while demanding consistent quality. Between 1988 and 2016, imports of cut flowers rose from approximately £122 million to £750 million. This increase has provided opportunities to expand production of seasonal flowers in the UK.

The project

The Cut Flower Centre (CFC) was established in 2007 to deliver an industry-led programme of variety demonstrations and agronomic trials of cut flower species with market potential. Since its beginnings, it has evolved to address a wider range of issues beyond new product development, including *Fusarium* control in column stocks production, evaluation of new herbicide products and reactive trials examining important industry issues such as downy mildew control on column stocks.

Results

A selection of the new product development trials

A variety trial examined a range of new *Scabious* varieties from Danziger (the 'Scoop' series) and HilverdaKooij. Both had an attractive range of flower colours, high yields, good vase life and potential for use by retailers.

Continuity of supply of *Ammi majus* and *Ammi visnaga* was examined. Of the two species, *A. visnaga* has the most potential because the stems are easier to harvest and the end product is more compact and manageable.

A number of successional plantings of *Daucus carota* were made from week 20 to week 32. The crop appeared as if it can be harvested at a wide range of maturities, but post-harvest work needs to be undertaken to determine the optimum stage to maximise vase life.

Trials with *Veronica longifolia* 'Skyler' series showed that 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.

A range of new Japanese-bred column stocks varieties were compared against two traditional series for late harvest. Planted in week 29, most of the Japanese varieties did initiate a flower bud. Of the traditional series, 'Mathilda' initiated no flowers at all and the 'Anytime' series showed erratic initiation, with very few marketable stems. Unfortunately, a number of the flower spikes on

Scabious variety trial

the Japanese varieties were either distorted or too short, leading to reduced marketability.

Downy mildew control on column stocks

Downy mildew (*Peronospora parasitica*) has often been associated with column stocks but was controlled using fungicide products that contain metalaxyl-M. During spring 2018, several businesses reported downy mildew outbreaks, despite the adoption of the usual fungicide programmes.

Several fungicides were subjected to sensitivity testing using a number of downy mildew isolates gathered from different nurseries. These showed that none of the fungicides applied gave 100% control. The greatest level of control was achieved by Paraat (dimethomorph), followed by Percos (ametoctradin + dimethomorph). Very limited control was achieved by Subdue (metalaxyl-M), indicating a strong level of pathogen tolerance to this active ingredient.

Column stocks – improving control of fusarium wilt

CFC trials investigated whether fusarium wilt control could be improved in column stocks. As a result, a site was artificially inoculated with *F. oxysporum* f. sp. *mathioli*. A trial was then planted using currently available commercial column stocks varieties. As a result of the high temperatures experienced during the summer of 2018, most of the plants expressed severe levels of *Fusarium* infection within three to four weeks of planting. Severity was such that it was not possible to see any differences in *Fusarium* susceptibility between the different varieties. Despite this, the trial did serve to demonstrate the species specificity of *Fusarium*.

Herbicides for field-grown larkspur

Nine different herbicide combinations were tested over a direct-seeded crop of field-grown larkspur sown in week 22. Although the emergence of the larkspur across the trial was variable, it was possible to identify some differences between the treatments. HDC H23 applied pre-sowing, followed by Defy (prosulfocarb) 4 L/ha post-sowing, gave the highest number of germinated seedlings and also 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, Dual Gold (S-metolachlor) 0.78 L/ha + Gamit 36 CS (clomazone) 0.25 L/ha or Stomp Aqua (pendimethalin) 2 L/ha + Gamit 36 CS 0.25 L/ha, also gave reasonable weed control, and crop emergence was good, which suggests that these treatments may also be suited to larkspur production.

Lily – alternatives to peat-based growing media

CFC trials have tested alternative media in the past, including coir, cocopeat, wood fibre, 'Forest Gold', green waste, green compost and aerobic digestate. A peat-free and peat-reduced mix were compared with a peat-based medium. In terms of stem weight and length, there was no difference between any of the mixes. However, there was a large difference in terms of leaf size and colour between the peat-free and other mixes; the peat-free mix giving rise to smaller and paler leaves that made the crop unmarketable. More work is needed on the nutritional needs of the crop when using such a mix.

Maintaining the options for crop growth control

AHDB project code: PO 019a The Bedding and Pot Plant Centre – new product opportunities for bedding and pot plant growers
Term: April 2017 to March 2019
Project leader: Jill England, ADAS

UK bedding and pot plant businesses continue to be challenged by labour shortages, an ever-decreasing number of crop protection products and a downward pressure on price with increasing input costs, all while needing to meet the retailer's specifications and create sufficient profit to reinvest back into the business.

The project

The Bedding and Pot Plant Centre was established to carry out small-scale trials to help growers of protected ornamentals exploit new product opportunities, adopt new production methods and respond to other industry issues as they arrive. The project is targeted at growers who produce finished plants on a typical small- to medium-sized bedding and pot plant nursery. Work within the project is undertaken at Baginton Nurseries in Warwickshire, which also hosts regular open days.

Results

Evaluation of plant growth regulators for use on bedding plants

Product revocations and label changes to key products containing chlormequat and paclobutrazol have reduced the options for growth control using chemical plant growth regulators. Two trials screened a number of other products for their potential use on bedding and pot plants. In the first, products were applied as drenches prior to transplanting; in the second, treatments were applied either as sprays or drenches post-transplanting.

Pre-transplanting, none of the treatments examined were particularly suitable as drenches for use on *Dianthus*, resulting in either plugs which were too compact or phytotoxic damage. A wider range of products were suitable for use on geranium. Terpal (ethephon + mepiquat chloride) gave good growth control with no phytotoxicity, although flowering was delayed; Moddus (trinexapac-ethyl) at 0.15 L/ha showed potential, however the higher rate (0.3 L/ha) caused phytotoxicity; while Dazide Enhance (daminozide) and Pirouette (paclobutrazol) performed well. Pirouette worked well on pansy and Regalis Plus (prohexadione) showed promise on *Osteospermum*.

Post-transplanting, the most promising product used on *Dianthus* was Pirouette. However, further work is needed to determine the most effective dose rate for this species. Terpal applied as a spray was the most promising product on geranium and has potential for use at rates between 1.0–1.5 L/ha. Terpal and Pirouette applied as sprays had some potential on pansy; however, further work may be required to find the most appropriate rates. All of the new products produced too strong an effect when applied as drenches at the rates tested.

Evaluation of plant growth regulators and a new adjuvant for use on poinsettia

Chlormequat-based products are widely used in poinsettia production to manage plant habit and control height. Due to product revocations and label changes, only Stabilan 750 remains and this can now only be applied twice, at a reduced rate. Alternative chemical plant growth regulators are now needed for poinsettia in the short term to manage plant development and meet specification demands.

Open day event at Baginton Nurseries

Perennial scheduling trial

In this particular trial, the poinsettia variety 'Vega Red' was used, which is relatively vigorous, and as the trial was sited in a glasshouse where higher temperatures were maintained to achieve a specific customer height specification, it represented a challenge to the treatments applied.

The lower rates of Terpal examined (0.5 L/ha and 0.25 L/ha) may prove to be of greatest value to growers as they had no negative effect on bract size and shelf life (unlike the 1.0 L/ha rate) and provide the opportunity for a 'little and often' approach to growth control using plant growth regulators.

Bonzi (paclobutrazol) also achieved growth control and did not cause phytotoxicity. This product gave the greatest control at the highest rate examined (0.105 L/ha). The other products examined either did not control height at the rates used (to avoid phytotoxicity) or resulted in phytotoxicity.

When Stena, the adjuvant examined, was applied in combination with Stabilan 750 or Terpal, it effectively halved the dose rate required.

Forcing herbaceous perennials to extend the early spring market

There is an increasing trend and interest among growers to extend the herbaceous perennial season and product range so as to provide more flowering plants during early spring, ready for impulse sales. The purpose of this trial was to identify perennials that may be produced successfully under protection with minimal energy inputs, aiming to advance the natural marketing window.

Silene alpestris 'Starry Dreams', *Scabiosa japonica* var. *alpina* 'Ritz Blue' and *Geum coccineum* 'Koi' all required some attention to scheduling to bulk up plants for early marketing; for *Geum* in particular it would be possible to produce good-quality plants for marketing earlier than week 14. This could include, for example, earlier seed sowing or allowing a longer period under heat prior to the cold period. Conversely, *Arenaria montana* was too vigorous for production under the parameters of this trial and growth would need to be reduced through a combination of adjustments to scheduling and production temperature. *Campanula persicifolia* 'Takion Blue' produced plants suitable for marketing by week 14 and 16, although plant growth regulators would be required to control growth and produce a consistent plant height.

Plant growth regulator trial

Poinsettias for the UK market

AHDB project code: PO 023 Commercial evaluation of new poinsettia varieties
Term: June 2019 to January 2020
Project leader: Harry Kitchener, HK Consultancy

Poinsettias remain a key seasonal crop for UK growers and demand continues to grow from year to year. Concern regarding the presence of pests and diseases which are classified as quarantine organisms in the UK, in crops grown in Europe, is leading to more and more retailers sourcing varieties from the UK.

Growers must produce plants which meet their customer specifications, typically 4–5 heads/bracts and a height of 26–30 cm above the pot. Over 95% of the total volume sold are red poinsettias, more so within supermarkets compared with garden centres, which tend to have a greater range of bract colours.

Each year, poinsettia breeders bring new varieties to the market, aiming for brighter-coloured, longer-lasting plants that can be grown with minimal input and without chemical growth regulators, which can be grown at higher densities and are easy to sleeve without stem breakage.

The project

The aim of the variety trial was to compare, under a standard growing regime, a range of varieties from each plant breeder, which can be tracked and monitored through their growing phase and shelf life.

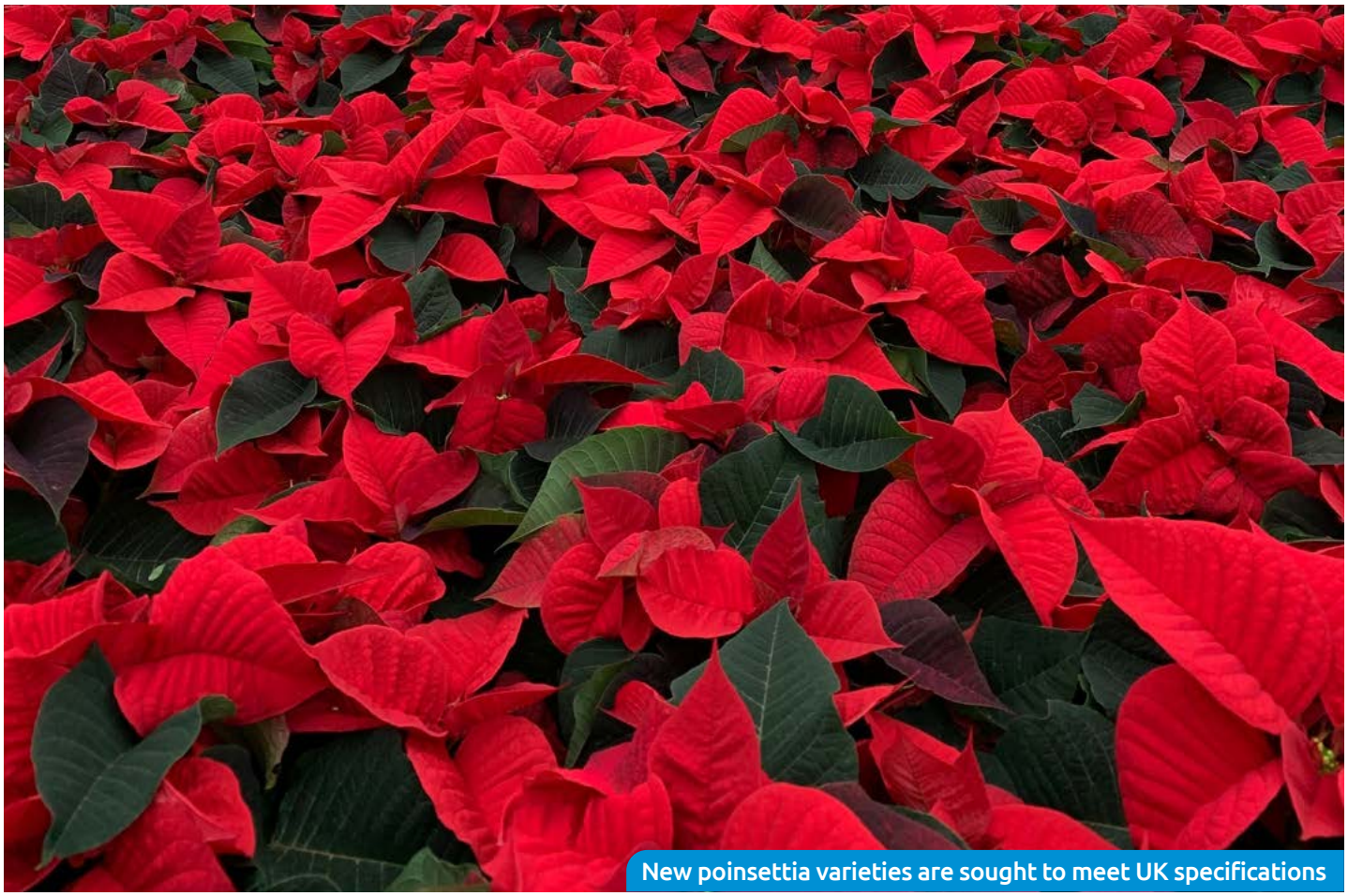
Such trials give UK growers the opportunity to meet and discuss the new introductions which they otherwise may not be aware of and to identify varieties to grow on their own nurseries. Retailers are also interested in attending the trials to see new varieties which are better suited to UK conditions, and particularly their shelf-life performance.

Results

Varieties supplied by Selecta performed the strongest in terms of their overall quality assessment, as undertaken by 29 growers at marketing in November. There was a preference for the varieties ‘Christmas Universe’ and a numbered variety. A new dark red ‘oak leaf’-type numbered variety from Beekenkamp also performed well, as did the variety ‘Ferrara’ from Dummen.

Assessments were repeated after shelf life in January. 17 growers scored the same numbered variety from Selecta as being the best-performing variety, followed closely by ‘Embla’ (from Dummen), ‘Christmas Universe’ (from Selecta) and two numbered varieties and ‘Blissful Red’ (from Beekenkamp). The standard varieties all scored equally well at the end of shelf life (‘Astro Red’, ‘Infinity Red’ and ‘Leona Red’).

There appears to be new genetics that can be grown with little or no requirement for chemical plant growth regulation and break very well to produce plants which meet market specifications, assisting growers to minimise their crop wastage.



New poinsettia varieties are sought to meet UK specifications

Poinsettia water deficit event

Production systems

Chemical free growth control

AHDB project code: PO 022 Developing precision and deficit irrigation techniques to reduce reliance on plant growth regulators and to optimise plant quality, uniformity and shelf-life potential in commercial protected pot and bedding plant production
Term: June 2019 to March 2023
Project leader: Mark Else, NIAB EMR

As a result of revocations, only a single plant growth regulator product containing chlormequat (Stabilan 750) is now available for use on poinsettias, and this product can only be used at a reduced rate and frequency. Other AHDB-funded trials (PO 019a) are examining alternative products in the short term, but in the medium to long term a method of growth control not involving plant growth regulators is required to permit the continued commercial production of poinsettias in the UK.

The project

Previous AHDB-funded work (PO 21 and PO 21a) identified that regulated deficit irrigation can be used to control stem height in poinsettias, which, with the help of growing media moisture sensors and data loggers, demonstrated that it is possible to control growth without reliance on plant growth regulators. However, further work is required to optimise this approach on poinsettia, and potentially extend it to other crops, and to include other approaches so that the industry has a suite of options to use.

Results

Regulated deficit irrigation was once again applied successfully to control the growth of poinsettias grown on flood benches, even at the commercial scale of application employed at Neame Lea Nurseries in Lincolnshire. The plants were monitored using graphical tracking to keep them within the required product specification. However, differences in varietal response were noted, and it appears that the procedure cannot be applied with the same level of success across all varieties.

During the trial, other practical aspects of the system were examined, this included confirming the suitability of the equipment used, testing the user interface and looking at the uniformity of the irrigation system employed so that a consistent stress could be applied across the crop.

The sensors, data loggers and telemetry used in the trial proved reliable and worked well. Remote access to real-time data improved decision making, and the grower dashboard user interface displayed a range of important data in an easily digestible format. Differences in the irrigation performance of the various systems used was noted. Variations in plant and pot weight (before and after irrigation) on the flood benches and benches with capillary matting were judged to be minimal and many of the issues could be addressed. However, capillary matting laid onto ground beds proved to be more variable, impacting the uniformity of stress applied.

In terms of shelf life, plants exposed to regulated deficit irrigation during production tended to have improved shelf-life performance.

Optimising nutrition for ornamentals

AHDB project code: **HNS 200 Developing nutrient management guidance for hardy nursery stock**
Term: April 2019 to March 2022
Project leader: Jill England, ADAS

AHDB project code: **PO BOF 003 Nutrient management for protected ornamentals, bulbs and outdoor flowers**
Term: September 2018 to December 2022
Project leader: Hilary Papworth, NIAB

A recent AHDB-funded nutrient trial

Iron deficiency in *Hydrangea*

A wide range of fertiliser types are used to provide plant nutrition for ornamentals crops. Water-soluble and foliar fertilisers provide an almost instant supply of nutrients to the plant; base and compound fertilisers provide nutrition over a period of weeks or months; while slow- and controlled-release fertilisers can supply nutrients for up to 18 months.

Although rates are available in manufacturers' technical information, there is no guidance in the current edition of the ***Nutrient Management Guide (RB209)*** for hardy nursery stock and protected ornamentals – the most recent recommendations being published in the 1988 edition.

As a result, there is potential for improved nutrient management practices to better control growth and scheduling and reduce potential nutrient loss from container-grown crops.

The projects

Project HNS 200 will focus on collating and generating data to provide nutrient management recommendations and best-practice guidance. Controlled-release and water-soluble fertiliser use in container-grown crops will be examined, particularly for plants grown over more than one season, either under protection or outdoors. Basic information on the nutrient requirements of field-grown trees at different growth stages will also be collected. Equipment to monitor plant nutrient status will be compared to improve monitoring, timing and application of fertilisers.

Project PO BOF 003 aims to improve nutrient management guidance for key crop types and growing systems within protected ornamental, bulb and outdoor flower production. New information will be generated to update and enhance the protected ornamentals section of the ***Nutrient Management Guide (RB209)***.

The project will address areas relating to delivery of nutrients to pot and bedding plants; managing the nutrient requirements of plants at different growth stages; nutrition within hydroponics; the effects of nitrate and ammonium as nitrogen sources; nutrient management for holding plug plants and crate-grown lilies; nitrogen applications to narcissus bulb flowers; the role of nutrient deficiencies in primrose leaf edge scorch; and current and novel approaches to plant nutrient monitoring.

Finding the trigger for PaMS

AHDB project code: PO 024 Investigating the causes of pansy mottle syndrome (PaMS)
Term: June 2019 to May 2020
Project leader: Jill England, ADAS

Pansy mottle syndrome is a physiological condition which has been reported since the 1960s. Typical symptoms include leaf distortion, mottling, leaf bleaching, stunting and apical blindness. The extent may vary from year to year on nurseries. Determination of the cause is complicated by the transient and intermittent nature of plant response, difficulty in replicating the symptoms and linking the cause with effect. Incidence has increased in recent years, prompting the need for more work to determine the influences on occurrence within the industry.

The project

This project aims to improve understanding of the environmental conditions that trigger pansy mottle syndrome symptoms through environmental monitoring of commercial-grown pansy crops, using wireless environmental sensor systems to predict plant stress. Analyses of data from these sensors will be used to determine the correlation between environment events and symptom expression. Gravimetric techniques will be used to determine the irrigation requirements of pansy plugs, which will be subjected to five irrigation regimes to demonstrate the implementation of best practice to avoid symptoms.

Pansy mottle syndrome on pansy

A selection of raw materials

Resource management

The quest towards responsibly sourced growing media

AHDB project code: CP138 Transition to responsibly sourced growing media use within UK horticulture
Term: January 2015 to December 2020
Project leader: Barry Mulholland, ADAS

In response to both customer pressure and government policy developments over the last 10 years, there has been a slow move away from peat as the only main constituent of growing media. Many ornamentals businesses have adopted peat-reduced media, but there is now a need to take the next step and move to peat-free media.

Four key raw materials have emerged with potential for use: coir, bark, wood fibre and green compost. However, the creation and testing of new blends is currently a relatively slow process, relying on various plant species or crop types as indicators of potential performance. Furthermore, industry needs more confidence and understanding of their use before large-scale adoption and use in commercial production can commence to any great extent.

The project

This project set out to create a model which can objectively and quantifiably predict the performance of a raw material or blend based on a number of physical characteristics which can be measured. The model doesn't negate the need for trials, but the number of screening trials can be significantly reduced as a result. A series of trials across all of horticulture were established to help populate the model, confirm predictions, provide confidence in the use of new media blends and ascertain the cultural adaptions required for their successful adoption.

Results

Predicting blend performance

The understanding and selection of growing media based on physical properties is important, because of the vast number of commercially available material types that constitute coir, bark, wood fibre and green compost. Based on three key physical parameters – air-filled porosity, available water and bulk density – the model, developed as part of the project, can identify blends which possess key, high-performing attributes, independently of plant response. Such attributes can now be determined for different raw materials and blends in a consistent way for the end user. A user-friendly interface has been generated for the model, which will be developed into a commercial testing service offered to industry.

Growing media trial at Double H Nurseries

Trials

The latest generation of peat-free growing media blends which were selected for their physical properties and which performed well in previous ADAS Boxworth-based experimental trials were carried through to commercial trial assessment in the final year of the project. Of the three blends selected, all produced plants that were comparable with the nursery standard across the different ornamental sectors.

This generation of blends used a different selection approach, utilising raw materials supplied by the growing media manufacturers which were new to the project. With no prior experience of how these materials would perform, blending could only be based on the physical characteristics of the materials. The blends worked well on commercial grower sites, demonstrating that modelling can be used to design new growing media products that are acceptable for use in commercial horticulture.

Experimental trials at ADAS Boxworth in 2019 used the back catalogue of available materials to test further peat-free blends, making greater use of wood fibre and bark. Again, a range of materials with different physical properties were used, resulting in good and poor results, which was important to develop and test the model.

The selection of materials using a modelling approach based on physical properties allowed the project to fully explore the performance of a wide range of blends. The work has demonstrated that mixes of raw materials can be sourced to create high-performing products and that there is potential to broaden the supply chain and fine-tune products to meet grower needs.

Plant assessment in a growing media trial

Keeping an eye on soil health

AHDB project code: CP 107b Growing resilient, efficient and thriving soils - GREATsoils
Term: April 2015 to March 2018
Project leader: Ben Raskin, Soil Association

Some current farming practices can lead to soil degradation, including compaction, declining soil organic matter content, nutrient leaching and erosion. Growers understand the importance of soil health, but when faced with difficult commercial demands, they are not always able to keep up to date with the latest research and best practice.

Improving the health of soils is fundamental to the agronomic, financial and environmental sustainability of horticultural enterprises. To do this, growers need clear methods and criteria to allow for simple, quick assessments and measurements.

The project

The project set out to evaluate soil assessment methods for growers, while improving their confidence in using different approaches for analysing soil health, and also to give them confidence in choosing suitable management options.

Results

The GREATsoils programme demonstrated that growers are keen to improve soil health. Over 750 growers, farmers and advisers attended 56 live events, which promoted soil health within the wider horticultural agenda, with articles in major publications, and events, presentations and talks given at various events.

The programme highlighted that small measures to improve soil health are worth the effort, such as using short-term green manures within a season, and identified the most useful and practical tools for soil testing across different horticultural production systems. It facilitated the collaboration of businesses to overcome the challenge of soil health management in shared rotations, where land is rented, to improve the soil health, and permitted constructive exchange of information between organic and conventional businesses, focusing on shared challenges and how to address them.

Use of soil pits to understand the physical nature of soils

GrowSave: the 'go to place' for horticultural energy savings

AHDB project code: PE/PO 011a GrowSave: energy and resource efficiency knowledge transfer for the protected cropping sector
Term: August 2014 to July 2019
Project leader: Jon Swain, NFUenergy

GrowSave has been delivering energy saving information and sharing the latest energy saving technologies with the UK protected cropping sector for over 10 years and it continues to encourage growers to take energy saving actions in their own business. The programme so far has focused on protected edible and protected ornamental sectors, with the inclusion of soft fruit from 2018.

The project

GrowSave functions as AHDB Horticulture's knowledge exchange platform and 'one-stop shop' for horticultural energy saving. The format of outputs and the project programme are kept deliberately flexible, to allow the project to respond to the energy issues that the industry is facing at any given time.

Results

The GrowSave website (**www.growsave.co.uk**) has continued to be regularly updated with the latest energy information for growers, including the latest energy trend prices and technical updates on a range of topics. Materials from GrowSave events, such as Next Generation Growing techniques, have also been made available via the website. There were over 10,000 website visits over the year and the most popular topics included LED lighting and variable speed drives.

Nursery based GrowSave event

A series of workshops and grower meetings have been delivered. These have concentrated on working with growers to identify issues and how to rectify them with energy efficient solutions. Recent topics included glasshouse climate control, air movement and humidity control. Three short videos on air movement in glasshouses have also been created and can be found on the AHDB website at **ahdb.org.uk**

Several technical updates have been written, which give information on how to optimise the glasshouse climate, featuring the topics of air movement, improving light transmission through glass and the use of sensors and data.

grow save
helping horticulture save energy

NFU ENERGY

Examining air movement via a smoke generator

Harvest automation spacing robots

Labour and logistics

Smart ideas for labour challenges

AHDB project code: SmartHort
Term: 2018–2019
Project leader: Neil Feddon, Feddon USP

For horticulture, labour can account for up to 70% of total variable production costs. The continuous rise in the national living wage is resulting in labour costs increasing substantially, at a time when margins are being squeezed by retailers. The geopolitical environment, such as Brexit and the strengthening of economies in countries from which many seasonal workers migrate, may also significantly impact the future availability of workers.


Robot arm for box making

The project

Increasing productivity and addressing the challenge of limited labour is at the heart of the SmartHort programme. Its core principles are increasing labour efficiency, improving management practices, supporting skills development and identifying new technologies that can be introduced into the workplace, such as autonomous guided vehicles (CP 187) and robotics. This will help the horticultural industry strive towards greater efficiency and get the best out of its resources and workforce.

Results

During 2019, AHDB established three strategic SmartHort Centres. These centres have a focus on increasing labour efficiency by introducing Lean business management principles – a practice that champions continuous improvement by systematically implementing small, incremental changes in processes in order to improve efficiency, quality and reduce waste.

In partnership with Fedden USP, the SmartHort Centres are aspiring for productivity improvements in the region of 25–40%. The three host businesses were selected following an open call and include: Haygrove Ltd, Herefordshire; Volmary Ltd, Cambridgeshire, and Thomas Thomson Ltd, Perthshire.

In total, there have been three events at each business over the year and all delegates have been guided through the process of Lean implementation and how to develop an action plan specific to their own business.

The SmartHort automation challenge

AHDB project code: CP 187 The application of advanced automation and robotic systems in horticulture

Term: February 2019 to January 2021

Project leader: Robert Harrison, Warwick Manufacturing Group

Plant movement on many nurseries can be a very labour intensive operation, both during production and dispatch. A number of autonomous guided vehicles (AGVs) are commercially available, but several are general function vehicles requiring modification before they can undertake nursery-specific tasks.

The project

Warwick Manufacturing Group and AHDB are working in collaboration with Crystal Heart Salad Company, Valefresco, and W.D. Smith and Sons on the 'Automation Challenge Project' to provide a form of AGV suitable for the many fetch-and-deliver or logistics-type tasks commonly required by growers. The aim is to transform on-site labour-intensive manual logistics into autonomous logistics. This will enable human resources to focus on value-added aspects of the businesses rather than spending time on non-value-added tasks.

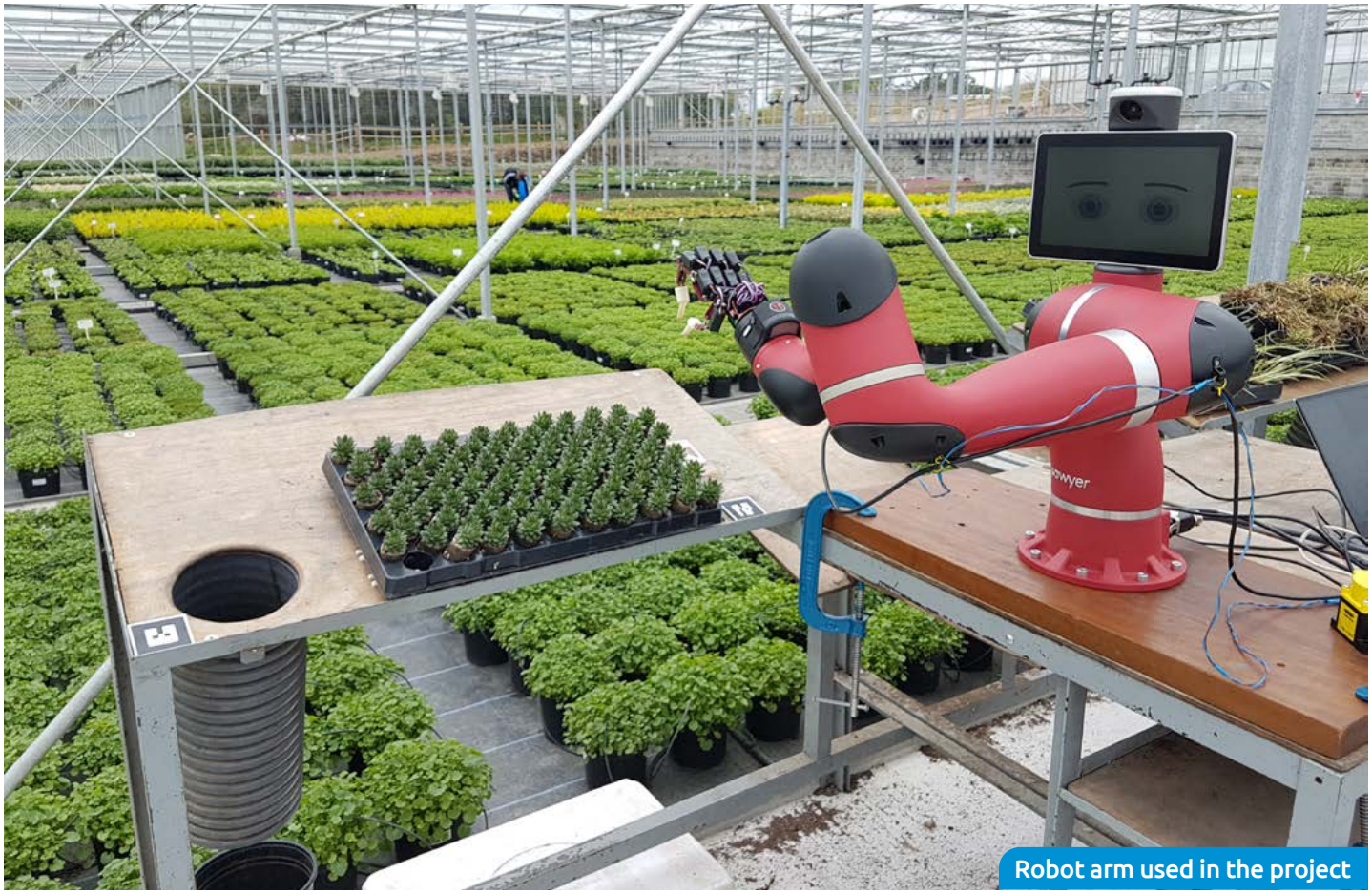
Results

In the first phase of the project, three selected businesses were visited to conduct an on-site technical feasibility study for deploying AGVs in glasshouses to transport plants around each site. A typical task surveyed involved collecting and delivering trays of plants to and from different production areas under glass or on outdoor beds, travelling over rough concrete or compacted soil surfaces.

Thirteen off-the-shelf AVG vehicles were reviewed to assess their suitability for carrying out the logistics operation undertaken on the three nurseries. Preliminary results show that the existing vehicles available will need to be significantly modified to adapt to the nursery requirements. Feasibility studies to establish potential impact on productivity, expected deployment costs and the likely return on investment are also underway.

Further work will determine whether to buy or build the vehicle and its subassemblies, system design, involvement of suitable partner technology companies, health and safety aspects and implementation and testing against a suitable nursery use.

Automated transport system



Robot arm used in the project

Task teaching for robots

AHDB project code: HNS/PO 194 GROWBOT: A grower-reprogrammable robot for ornamental plant production tasks
Term: October 2016 to September 2019
Project leader: Matthew Howard, King's College London
PhD student: Aran Sena

Robotics offers many opportunities for alleviating labour challenges in the horticulture industry. Current-generation robots have made robotics much more accessible; however, these developments fall short for the horticulture industry in many cases, due to the complexity and variety of products being handled.

The use of learning systems in combination with robotics is a possible solution, which allows robots to perform tasks that would be difficult to program directly. Using the approach of 'learning from demonstration', a robot can learn to perform repetitive tasks from a human teacher, without the use of any programming languages. However, the performance of the robot system is still dependent on the quality of the teaching provided by the person.

The project

GROWBOT was designed to improve understanding of to how to assess, guide and improve novice teaching performance, with the aim of placing advanced robotic capabilities directly in the hands of growers.

Results

Using an industrial collaborative robot, 36 nursery participants were tasked with teaching the robot how to pick plants from a 100-plant plug tray and deposit them into a disposal bowl. The group of 36 participants were split, depending on the feedback supplied. The 'no feedback' scenario was where participants were given no feedback or guidance on how the robot's learning was progressing to simulate a naïve teaching approach; 'replay feedback' was where the robot would repeat the task for the last demonstration given; 'batch feedback' was where the robot would perform the task for five designated testing points; and 'selected feedback' was where the participant was free to ask the robot to perform the task for any plant position at any time to simulate a more natural uninformed teaching interaction.

The results obtained show strong support for feedback provision to the teaching being an important element to effective learning. Replay and selected feedback were no better than no feedback. This suggests that repeating what has just been shown offers little insight to the robot learning status and that the participants were not able to naturally query the robot about its performance to gain a better understanding.

In addition to improving the performance of learning from demonstration-based robotics in real-world conditions, the research presented in this project provides foundations for a measured approach towards evaluating the teaching performance of the people who will be tasked with deploying robots in the workplace.

Ornamental skills survey identifies gaps and opportunities

AHDB project code: HNS POBOF 201
Ornamental horticulture sector skills survey
Term: March 2019 to August 2019
Project leader: Michael Oberreuter, Pye Tait Consulting

Recent research has found ornamental horticulture and landscaping to span some 569,000 jobs and contribute around £24 billion to national GDP. To ensure future growth, the ornamental horticulture sector needs to capitalise on technical innovation, ensure a flexible and adaptable workforce to meet seasonal demand, and have a clear pathway to a skilled career through schools, apprenticeships, technical and university education and relevant training routes. The starting point is robust and reliable industry-focused intelligence and knowledge sharing which can affirm and shed more light on hitherto anecdotal skills and training concerns that have surfaced in recent years.

The project

A detailed skills survey of around 1,000 businesses, supported by discussion forums, ascertained the skills needs of the ornamental horticulture industry across the UK. Results from the survey fed into the Ornamental Horticulture Round Table Group and wider sector to support the case for lobbying government and requests for funding, helped to inform on Migration Advisory Committee consultations and provided insight about the demand for, and gaps in, training within the horticulture sector. It is anticipated that this project will help in attainment of a sufficient labour force post-Brexit and a skilled career pathway into the industry.

Results

It was found that skills and labour issues were of key concern in the short to medium term. Significant skills gaps and shortages were highlighted. Difficulties in the recruitment of people with the right skills and attitudes were perceived by many as the top reason for the skills gap.

27% of businesses anticipated an increase in staff numbers over the next two years. Of these, a high proportion was concentrated in a number of large- and medium-sized businesses. This was noted at a time when, due to there being almost full employment in the UK, there is a challenging labour pool for employers.

It was reported that recruits to the sector often lack basic practical skills. 'T Levels' (two-year qualifications designed to give 16- to 19-year-olds a head start towards the career they want) could help in guiding more young people into the sector, but 85% of businesses in the wider sector were virtually unaware of them. The perceived low salaries in the sector exacerbate this recruitment. The sector may need to undertake a gradual increasing use of flexible working as a result, to accommodate the growing atypical workforce structures nationally.

The average age of workers was slightly lower than the UK average, nevertheless there were strong perceptions among employers that the workforce is ageing, possibly as a result of the low number of apprentices in the sector, the ageing of key job roles and the effects of the physically demanding nature of work.

All skill sets queried in the survey were perceived by employers as increasing in importance over the next three to five years. Of focus were health and safety, environmental awareness, irrigation management, basic machinery/equipment knowledge, as well as an understanding of crop protection and plant care.

The low number of apprentices indicates that talent pipelines into the sector need to be improved. The survey indicated that the average number of apprentices in business will stagnate at 0.7 over the next three years; this also suggests employers need help with understanding the apprentice model and the benefits to their business. The high use of in-house training and the lack of awareness of resources were additional indications of a low take-up of initiatives like apprenticeships.

Manual flower bunching

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