The GROWER
THE TECHNICAL JOURNAL FOR HORTICULTURE
AHDB
Issue No. 243
Dec/Jan 19

LIGHTING THE WAY

How might supplementary lighting have a beneficial effect on carbon dioxide uptake in the shaded lower canopy of tomato?

SMARTHORT 2019

Connect with the latest innovation in horticulture

Discover the latest high-tech advancements, meet the people behind the innovation and find out how to invest in the technology that could make a positive impact in your business.

Free two-day conference

6 and 7 March 2019
Stratford-upon-Avon

Book your place: bit.ly/SmartHort2019

#SmartHort2019

ahdb.org.uk

@AHDB_Hort

ACKNOWLEDGEMENTS

If you wish to get in touch with our team about any aspect of this publication please use the following contact details:

GENERAL ENQUIRIES

hort.info@ahdb.org.uk

EDITORIAL

Luke Garner
Technical Writing Manager
luke.garner@ahdb.org.uk

Lauren Colagiovanni
Marcomms Senior Manager – Horticulture
lauren.colagiovanni@ahdb.org.uk

KNOWLEDGE EXCHANGE

Debbie Wilson
Head of Knowledge Exchange – Horticulture
debbie.wilson@ahdb.org.uk

DESIGN

Zoe Shackleton
Graphic Designer
zoe.shackleton@ahdb.org.uk

SUBSCRIPTIONS AND MAILING

The CRM Team
comms@ahdb.org.uk

IMAGE CREDITS

Signify – cover

University of Essex – page 2

Andrew Lane – page 7

Tozer seeds – page 35

One point is awarded per annum for BASIS registered members for reading this magazine. From 1 June 2018 to 31 May 2019, please quote reference CP/67833/1819/j

This publication is brought to you by AHDB

For more information contact:

AHDB Horticulture
Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

T: 024 7669 2051

E: comms@ahdb.org.uk

W: horticulture.ahdb.org.uk

@AHDB_Hort

If you no longer wish to receive this information, please email us on the address above.

COMMENT

Hayley Campbell-Gibbons,
Chair of the AHDB Horticulture Board
hayley.campbell-gibbons@ahdb.org.uk

EMBRACING CHANGE

As Bob Dylan put it, "The Times They Are A Changin'". Once the UK leaves the European Union – whatever the terms – British businesses will be doing things differently. Immigration and employment rules will change, trading relationships will change, and government policy for farming will, you guessed it, change.

The ending of direct payments post-CAP isn't big news for the horticulture sector, which has no legacy of subsidy support. It's the recycling of those funds into payments that boost productivity that offer a massive opportunity for growers.

Having spent several years working in horticulture, visiting businesses across the UK, spanning all aspects of production, I know a bit about what motivates growers: making money.

The question most growers ask themselves before doing anything in their business is "Will this make me a profit?" and if it does, they are up for it. Not all farmers think this way. Horticulture stands out because growers are already market focused, and generally only do something if it makes financial sense.

That's why everything AHDB does and communicates must address the 'So what?' factor, and show growers that they are getting bang for their buck. AHDB also needs to keep pace with the rate and scale of change in the industry. I firmly believe that its role in accelerating the development and adoption of new research and technology to transform productivity and give British horticulture a competitive edge is vital. More so now than ever before.

It's our job to make growers the best employers, leaders, managers, producers and sellers they can be, by providing the information, tools and knowledge that growers need to get the best from their businesses and teams.

I want to hold horticulture up as a leading light; as a sector at the forefront of food production transformation and give it more presence and profile than ever before. If we get this right, the sector will accelerate through this period of change faster than any other.

AHDB

CONTENTS

CONTRIBUTORS

Discover more about the people who have helped to contribute to this issue of The Grower magazine

DR EWAN GAGE

Ewan is a plant physiologist based at ADAS Boxworth in Cambridgeshire. He completed his BSc in Botany at the University of Reading in 2008, and obtained a PhD in Molecular Plant Physiology from the University of Cambridge in 2012. He has been working at ADAS since 2015, predominately in the protected edible sector. His research focuses on optimising resources within the growing environment, exploring how light and CO_2 inputs can be used to manage crop responses and maximise yield returns. He also works in the postharvest sector, developing technological solutions for postharvest management of fresh produce.

Ewan helps to improve your plants' CO_2 uptake on page 10

GURKAN TUT

Gurkan is a biotechnologist and is based at NIAB EMR Kent. He completed his BSc (Hons) in Biosciences at Middlesex University in 2013, his research project involved: earthworm diet preferences from leaf species to shapes. Successively, he acquired an MSc in Biotechnology at University of Hertfordshire in 2014, and his research there focused on sensitivity of defence responses against the fungal oilseed rape pathogen *Leptosphaeria maculans*. Following this, Gurkan is now a final year PhD student at Cranfield University and his research revolves around optimising the use of biocontrol agents to improve control of Botrytis.

Get control of Botrytis with Gurkan on page 14

JASON POLE

Jason Pole manages technical communications for AHDB Cereals & Oilseeds. A former student of horticulture at the University of Reading – a period that included one year in Brazil researching cocoa production – he spent 10 years conducting horticultural research at the University of Warwick. In 2009, Jason joined AHDB Horticulture and managed cross-sector and hardy nursery stock research projects. In 2012, he joined AHDB Cereals & Oilseeds, where he specialises in communicating research outcomes to farmers using traditional and digital channels.

Jason wriggles into the subject of soil health on page 24

NEWS & **UPDATES**

IN **BRIEF**

SUPERVISORY SKILLS WORKSHOPS

New workshops to provide supervisory skills to the industry are being held around the UK, in response to a need identified as part of the SmartHort campaign to improve labour productivity. Book your free place at **horticulture.ahdb.org.uk/events**

STANDARDS SET TO DEVELOP FUTURE GROWERS

AHDB, NFU and industry have joined forces to set standards for three new apprenticeship schemes. Known as Trailblazers, they include a standard for a crop technician, and offer the opportunity for colleges and employers to work together to develop the next generation of skilled workers.

NEW INDUSTRY RESEARCH FACILITIES

Two new state-of-the-art facilities have been opened by CHAP (Crop Health and Protection) at Stockbridge Technology Centre. The Vertical Farming Development Centre will research how the latest technologies will impact the economics of vertical farming. The Advanced Glasshouse Facility will provide new research approaches to crop protection, including biopesticides.

REVISED RECOMMENDATIONS FOR HERBICIDES IN NURSERY STOCK

An update has been made to the original 'Practical weed control for nursery stock' guide, due to changes in herbicide regulations and approvals. The updated guidance can be found on **ahdb.org.uk/knowledge-library**

AHDB SET TO FLY FLAG AT **FRUIT LOGISTICA** AGAIN

Following several successful years at Fruit Logistica showcasing the best of British produce to the rest of the world, AHDB will be once again be returning to the exhibition hall in 2019.

Over 78,000 trade visitors attend Fruit Logistica each year from every link in the supply chain. It is a great opportunity to meet new and existing customers and grow your exporting potential.

AHDB is offering growers the opportunity to reserve individual tables that will incorporate their own branding.

For further details about how to book, contact **amanda.morby@ahdb.org.uk**

Fruit Logistica 2019 takes place in Berlin, Germany, from 6–9 February 2019.

PROPOSED CHANGES TO PERCHLORATE AND **CHLORATE REGULATIONS**

The European Food Safety Authority (EFSA) is currently reviewing the maximum residue levels (MRLs) for chlorate and perchlorate in fresh produce.

To help inform a UK position on the proposed changes, AHDB has been collating data from the horticulture and potato industry.

This is to ensure that EFSA gets a proper balance of chlorate and perchlorate fresh produce data from across EU countries to ensure the models used to set the MRLs reflect reality.

Chlorinated products are also used to disinfect crop harvesting and produce-processing equipment and surfaces to ensure that food is safe to eat.

ACTIVES LOSSES TEMPERED BY **SCEPTREPLUS SUCCESS**

Two new authorisations have been granted for UK growers, with new control options for Botrytis in stored cabbage and Septoria leaf spot on celery, following successful SCEPTREplus trials.

Serenade ASO has been approved as a post-harvest drench on stored cabbage, and Nativo 75WG has been authorised for celery. The research was undertaken as a priority, in response to the non-renewal of key actives, thiram and iprodione.

Several important actives have recently been voted for non-renewal in Europe, including Metam 510, Diquat, Pymetrozine and Fenamidone. SCEPTREplus and the AHDB EAMU programme continue to seek new alternatives and urge growers to get in touch on **EAMU@ahdb.org.uk**

TIME FOR A **BIOPESTICIDE REVOLUTION?**

To keep pace with the move to more sustainable integrated pest management (IPM), the horticultural industry needs to rapidly increase its knowledge of biopesticides.

With the continued withdrawals of conventional actives, as seen recently with the non-renewal of thiram, diquat, metam 510 and fenamidone, biopesticides are becoming more vital in the management of pest, weeds and diseases.

However, for biopesticides to be effective, a better general understanding of this new crop protection technology is needed to change some current practices of application, storage and handling.

Gill Prince, University of Warwick, researcher for AMBER, stresses: "It is important to remember that many biopesticides are living organisms, so they need to be treated differently from conventional chemistry."

WATER VOLUMES

Horticulture has different practices compared with wider arable practices, as water volumes are often being applied at around 2,000 L/ha, whereas arable farmers rarely exceed rates of 200 L/ha.

There are several reasons behind the differences, but Andrew Lane, Silsoe Spray Applications and a researcher for AMBER, argues growers could benefit from reducing volumes, and for low crops the optimum is likely to be no more than 600 L/ha.

Andrew says: "People seem to believe that simply by throwing more water at the crop you will get better coverage, but that isn't the case and can lead to excess run-off."

There are simple steps that growers can make to help to reduce their water volumes, from regular calibration, thorough cleaning, and checking for damage, which could make a big difference.

Gary Woodruffe, Bordon Hill Nurseries, says: "We have recently made an investment in a boom sprayer to help with our application. This has helped to reduce our pesticide use by around 30 per cent and significantly reduced the labour hours involved in applying the spray."

STORAGE

Growers need to consider shelf life, and certain products will need to be stored in refrigerators, because heat, or even short exposure to direct sunlight, can kill the natural organisms in the product. Gill recommends that growers speak to their distributors to ensure their product is being kept in the optimal condition throughout the delivery.

Christine O'Sullivan, Silsoe Spray Applications, researcher for AMBER, is encouraging growers to consider just how clean their spray tanks are. She explains: "Even with a thorough three-tank clean, you can see a lot of residue from conventional chemicals in standard dye tests.

Ideally, Christine recommends growers should consider investing in a separate tank for biopesticide use to avoid contamination issues.

AMBER is a five-year project to help growers improve the performance of biopesticides, visit **bit.ly/AMBERproject**

SOFT FRUIT SECTOR SET FOR ENERGY SAVINGS

GrowSave, which has been successfully delivering energy-saving advice to the protected cropping industry for over 10 years, will now cover soft fruit grown under protection.

GrowSave specialises in sharing technical knowledge on glasshouse structures, ventilation, lighting, heating, storage and cooling, boilers, pumping and climate control.

Visit **growsave.co.uk** for more information

grow save
helping horticulture save energy

AN ENTENTE CORDIALE **FOR OUR TIME**

Claire Donkin reports on the key talking points from the British Herbs Study Tour to France and the beginnings of an exciting new relationship

The British Herbs (BHTA) study tour was the culmination of a couple of years of relationship building between the BHTA and Iteipmai, the French membership driven technical institute for perfume, medicinal and aromatic plants. Though the idea of a study tour had been discussed for some time, drafting the trip programme was a challenge. British Herbs' members have such widely diverse crops, end markets and products. What trip could be created, outside of the UK season, which would be of value to members growing broad acre herbs for processing and drying, pot herbs for multiple retailers, plants for essential oil extraction and field production of niche herbs for restaurants and caterers?

VIVE LES HERBS!

In September, we went to France for three days to see if we could do just that. The Iteipmai Chemille research institute was the first stop, where we saw methods of breeding niche crops for grower or market-specific requirements, recent work on key pests such as basil downy mildew (*Peronospora belbahrii*) and some impressive analytical equipment, specifically used for the quantification and characterisation of volatiles from aromatic crops. Some caution was needed here as there is meaningful difference between the oil profiles desired for culinary herbs and those for essential oil crops, but the resource and expertise was impressive. Although there are many similar analytical tools available in the UK, it was the interpretation and context provided, alongside the analysis, which we found most of interest. Another fantastic resource housed at Iteipmai is their library. This contains hard copy reports, PhD theses, books and papers on the topic of aromatic and medicinal plants. It has also been maintained in modern form through online subscriptions and records. Members of Iteipmai can request reports to be drawn together from the library on any topic of interest. We considered this an invaluable tool for Iteipmai members, as good information is hard to find in such niche crop production – nitrogen responses of three different types of fenugreek, anyone?

The trip also catered for protected cropping in a visit to Bioplants, where there was a lot of discussion on the true meaning of sustainability in horticulture. The unit produces pot herbs in a similar system to that seen in the UK but these organic herbs were grown with minimal heat and supplementary light. Pots were biodegradable, as were sleeves; the growing media was peat-reduced and feeds biologically derived. The very different retail environment in France enabled commercial implementation of a number of techniques that in the UK situation have been nothing more than trials, until recently.

Where we saw more similarity to UK production and industry pressures was in the visits to Darégal and Herbes de Meaux. At these farms, we saw the same field production techniques used in the UK and many of the same issues and threats. Growers saw leek fly damage on chives, a potentially devastating late season problem that has yet to fully establish in British conditions. We also saw the ongoing consequences of the ever-reducing range of herbicides. Iteipmai and Darégal are working on identifying new herbicide options as their main plant protection priority. They were generous in their openness in discussing these with us and the different strategies they are attempting to implement, it was clear that across Europe most member states in our crops are evaluating the same potential actives. Darégal produces herbs for further processing into dried, frozen

and ready-to-use herb products. In organic crops, hand weeding can take as much as 50–100 hours per ha, and can rise to 200 hours for mint, in addition to using both mechanical and flame weeders. Employing the same techniques in conventional production would render the crop uneconomic, and mechanical weeding carries considerable microbial contamination risk. More selective herbicide options are needed.

The main observation for us, in such a diverse crop sector, where diversity comes not only from the sheer number of species we deal with, but from the production system and the end use, is whether there is any room for duplication? It could be argued that nowhere in modern horticulture is it an option. With pressure for efficiency in the face of labour challenges, reduced access to plant protection products and increasing pest and disease threats, we need to be using every available resource to keep our industry thriving.

BETTER TOGETHER

The key message we took from this trip was one of collaboration. Our French colleagues are facing many of the same threats we are.

Following the visit, British Herbs and Iteipmai have started the process of affiliation. We plan to become sister organisations and share events and communications with our members. We will share research strategy where appropriate and look at work streams. Darégal is already a member of British Herbs and we were joined on the trip by Albert Grotenfelt, our Finnish member. We have joined a working group with other European herb producers to start sharing residue data and build some testing programs for faster access to plant protection products. It should be said that much of this has been tried before, but the current situation for all European herb producers is so delicate that the need to work together is greater than ever before. Much of this is a gamble; we have set aside the issue of Brexit when considering the way we might develop our ongoing working relationships. However, even outside of the EU, we hope that the foundations put in place during this trip will lead to a closer working relationship for the herb industry across Europe.

For more information on AHDB events visit **horticulture.ahdb.org.uk/events**

> “We need to be using every available resource to keep our industry thriving”

SAME PROBLEMS, **DIFFERENT SOLUTIONS**

With a differing approach to managing onion crops, could a visit to Danish growers provide viable alternative ideas for UK growers?

Last year, AHDB took a group of BOPA members to Denmark to see how growers there manage their onion crops with significantly less plant protection products available than in the UK, as well as tighter rules on fertiliser use. In particular, members were keen to see the range of weed control techniques used that help to reduce herbicide use. Denmark has a large organic market – 14% of the total 1,500ha of onions grown in Denmark are grown organically. The study tour comprised of three visits to growers across Denmark who are farming both organically and conventionally.

VISIT ONE: SKIFTEKER, SVENDBORG

Delegates viewed organic crops in the field that had been grown from seed as well as transplants.

Annually in Denmark over 130ha of onions, mostly organic, are grown from transplants.

The transplant system was based on seven plants per module aiming to establish 800–900,000 plants per ha. This plant density is far higher than the UK standard of 500–600,000 plants. However the target bulb size that the Danish market demanded is also lower at 50–60mm rather than the increasing UK demand for 70–90mm onions.

Hand weeding of crops was also a key feature of the farm and the solar powered hand weeding machine was viewed in action.

As well as hand weeding, the organic crops were regularly mechanically weeded with a Treffler tine harrow as well as a more traditional steerage hoe. The theory being to keep moving soil ridging up around the plants before combing it down again with the tine harrow. On average the onions crops would be hoed/combed six times on a weekly rotation until plants became too big.

VISIT TWO: TORUP BAKKEGAARD, MIDDELFARTVEJ

Visit two focused more on conventional production of onions from sets and seed. Grower Claus Jacobsen explained his approached to weed control using herbicides including the repeat low dose approach using tank mixtures of Aclonifen + Bromoxynil every four to five days from crook stage onwards. This was applied using a boom sprayer equipped with an air sock. As well as herbicides, most onion crops would also receive two passes through with a tine harrow.

The fungicide program would be starting at seven true leaves (two to three weeks later than the standard UK timing) and again all applied using full air through the air sock on his boom sprayer. Water volumes used at spraying were also noticeably lower than standard UK practice, at 150–180L/ha.

Claus's attention to detail with regard to crop rotation was also noticeable. He steadfastly would not grow any onions on land that had ever been used for potato production due to the risk of potato volunteers as weeds.

With regard to fertiliser application, 220kg/ha of Di-ammonium Phosphate (DAP) was applied at time of drilling using a disc incorporation system mounted on the drill in front of the seed coulters.

VISIT THREE: MANSSON'S, BRANDE

The final visit was to Axel Mansson's near the town of Brande. Mansson's grow 1,400ha of vegetables, of which 600 is organic with a further 400ha in conversion. One of the first statements made by Manssons was that they made 'no real profit' from conventional farming (hence the further land conversion). The group was given a tour of the organic onion fields, the packhouse, NIR grader and stores as well as the 'garden of innovation'. A significant area of land was set aside to test new vegetable species cultivars and production techniques.

Mansson's were trying to move away from their dependence on hand weeding organic onions. This season they had been able to reduce the number of hand weeding passes down to just one, with some fields having no hand weeding at all. This had been achieved by use of a number of different hoe and tine in row cultivation techniques all using row vision or RTK guidance systems.

Onion crops at that time were being irrigated every four to five days with 14mm application using overhead guns and sprinklers. In a normal year the crop would receive eight applications in total. Average organic yields were 70t/ha of largely 40/60mm onions. Crops from seed drilled at 825,000 seeds per ha. Fertiliser was largely supplied through organic slurry directly injected between the rows.

Mansson's run an organic bio digestion plant with all the digestate going back onto the surrounding fields. The storage system also attracted much attention from the BOPA members.

The Vac-tech condensing drying system was curing the onions at 36°C, some 10°C higher than standard UK curing temperatures. This onion store used a heat pump system and promised 80% energy savings compared to more traditional propane gas heated stores.
One other benefit of the condensing drying system is its ability to remove significant crop moisture even when the crop is stored down at 0°C. This would be of benefit if there was a significant level of progressive rot in the onion batch that could be effectively dried up to prevent further spoilage. However, the initial capital cost of the system made members' eyes water more than the onions.

Slurry injection system

FOOD FOR THOUGHT

Overall BOPA members seemed very impressed and a little humbled by the standard of farming in Denmark. The organic crops in particular looked healthier and cleaner than many UK crops at that time of the year.

"This tour was a humbling reminder that there is a more sustainable approach to growing onions," said Tom Will, Vegetable Consultancy Services.

Also noticeable was the high levels of attention to detail the Danish farmers paid to their onion crops and the passion they all showed. The innovation and varying techniques of weed control and the combination use of herbicides, mechanical and hand weeding definitely gave UK growers and agronomists food for thought. Each of the growers visited were also packing the product and directly marketing and/or retailing it themselves in a very integrated supply chain.

LIGHTING THE WAY

Could supplementary lighting have a beneficial effect on carbon dioxide uptake in tomato? Dr Ewan Gage and Dr Barry Mulholland, RSK ADAS, reveal all in the results from their research

Carbon dioxide (CO_2) enrichment is standard practice for UK tomato production to achieve high marketable yields, with growers targeting CO_2 concentrations more than double current atmospheric levels. Other resources, light, water and nutrients, must, however, be carefully controlled if the maximum benefit is to be achieved from CO_2 application. Despite the tools available for growers to monitor and control the growing environment, conditions can vary widely within the crop, which impacts on CO_2 uptake and its conversion to yield. Leaves in the upper canopy are exposed to high light levels, but may encounter CO_2 concentrations that are 100–300 ppm lower than that found lower down in the canopy. As light is the main driver of photosynthesis, the upper 20% of the canopy fixes around 75% of the CO_2 absorbed by the crop. There remains a large shaded section of canopy that could be driven harder to promote an increase in whole-canopy CO_2 uptake that can be converted into yield.

CO_2 uptake in the lower canopy is affected by a number of factors. Older leaves will start to reduce their photosynthetic efficiency, because of senescence. Greater light availability will, however, provide more energy for CO_2 uptake, and also hinder senescence, allowing the canopy in the normally shaded layers, to make better use of CO_2 enrichment.

Light levels in the canopy can be increased by changing planting density, deleafing frequency or the use of diffuse glass; these methods are still linked to changes in external light levels. The development of light-emitting diode (LED) technology has provided growers with interlighting technology that allows the use of a low-energy, low-heat light source within the crop canopy. Project PE 021a set out to measure the effects of supplementary lighting on the ability of the lower canopy to use CO_2 and convert this into marketable yield and provide a measureable return on investment.

> “Fruit from the lit crop achieved greater flavour, texture and taste scores”

A trial established in a commercial crop of the cocktail tomato, cv Camarque, grown at APS Produce, Isle of Wight, compared a 348m^2 area of unlit crop with a 435m^2 area of crop lit with single generation 1 Phillips Greenpower LED interlighting units in the lower canopy. Both crop areas were planted in the same compartment in March 2017, and supplementary lighting was provided from 15 May to 11 September 2017 for six hours a day from sunrise.

Canopy CO_2 uptake was measured using a LiCor infrared gas analyser, which allowed precise measurements of CO_2 uptake over a controlled range of light and CO_2 levels, and measurements of yield and fruit quality were taken on a monthly basis from May to November.

Crop responses to interlighting were significant; leaves in the lower canopy of the lit crop had a higher concentration of chlorophyll, reduced leaf expansion and increased ability to use light and CO_2. The increase in leaf condition meant that leaves of the lit crop were able to absorb more CO_2 at a given light level compared with leaves of the unlit crop.

To quantify the effects of interlighting on CO_2 uptake, a model of photosynthesis was developed and used to predict crop CO_2 uptake over the trial period, which was combined with estimates of canopy area and records of CO_2 application to calculate the proportion of the applied CO_2 that was absorbed by the crop through photosynthesis (the CO_2 offtake). The unlit crop assimilated 5.7kg CO_2/m^2 compared with 7.0 kg CO_2/m^2 in the lit crop, indicating that supplementary lighting increased CO_2 assimilation by 23% over the trial period. LED interlighting increased marketable fruit yield by 5.6–13.4% compared with an unlit crop, when adjusted for differences in head density – differences in cultivation led to slightly lower head densities in one of control beds, but these were

insufficient to impact fruit size or the proportion of marketable yield. Fruit from the lit area was larger and had higher water content, as a percentage of dry matter. Taste testing panels rated the fruit from each area equally flavoursome in July, although fruit from the lit crop achieved greater flavour, texture and taste scores in September.

Project PE 021a has demonstrated that interlighting can be used to effectively drive photosynthesis in the lower canopy, enabling the crop to capture a greater proportion of CO_2 applied through enrichment. There remains however, much to learn about the use of interlighting to drive higher yields and improve grower CO_2 use efficiency. Growers may choose, for example, to use two interlighting units; doubling light inputs may further enhance CO_2 uptake potential, the choice being cultivar and site-specific. Extra light provision in the lower canopy could mean that plants can be grown at a higher density to achieve a greater leaf area, across which CO_2 can be absorbed, increasing yields further; this is an interesting question for growers and remains to be tested. Furthermore, a flat-line approach to interlighting was used in this trial, but could light application be more reactive? For instance, light provision may be more effective when used in the autumn or spring when external light levels are low, or in dim periods of the summer where interlighting use is linked to set thresholds of external light inputs. Project PE 021a has begun to demonstrate how the provision of two linked resources - CO_2 and light – in a commercial crop can interact, and how this interaction can be manipulated to achieve maximum returns on the provision of CO_2 for grower benefit. This project has paved the way for an efficient and effective integrated light and CO_2 management strategy for the production of all-year-round UK tomato crops.

> “The upper 20% of the canopy fixes around 75% of the CO_2 absorbed by the crop”

AHDB project code: PE 021a

Project lead: Ewan Gage, ADAS

AHDB contact: Nikki Harrison

EAMU LATEST

DISCUSSING DEFINITIONS

AHDB Crop Protection Scientist Bolette Palle Neve discusses the intricacies and importance of definitions

Bolette Palle Neve,
Crop Protection Scientist, AHDB
bolette.palle-neve@ahdb.org.uk

Many growers will be aware that the definition of an endocrine disruptor has been discussed extensively in Europe for the past seven years. The definition is critical, as the EU Regulation covering the approval of plant protection products states that substances considered to have endocrine disrupting properties will not be approved for use – unless human exposure can be considered negligible.

Following lengthy discussions, the definition has now been agreed and will come into force on 10 November. This means all future applications for new active substances or for renewals of current products will also be assessed according to this new definition. Additionally, all active substances still under consideration in Europe on 10 November will be assessed according to the new definition. We anticipate this will lead to the loss of some important plant protection products in the UK and my colleague, Spencer Collins, recently attended a conference in Barcelona where several areas of concern were raised. Spencer has also started a piece of work looking at where gaps may appear in growers' crop protection tool kit and this will be rolled out to all panel and grower groups as part of the crop protection risk register work, which has been initiated this autumn. The risk register identifies pest, weed and disease targets and links these to actives authorised for control in the UK. Each active also has a risk rating which shows growers if it is at risk of being lost in the near future. The risk rating is based on publically available information but has been pulled together to make it easier for growers to see where gaps may occur. This activity will also feed priorities into the SCEPTREplus project, where trials will be done to identify new solutions. We will report back on the risk register work in future editions of The Grower.

EAMUS IN FOCUS

Praxim

"The withdrawal of Linuron last year and the end-of-use date July 2018 has left the Narcissus bulb industry with few active herbicide ingredients to use on their crops; losing another active potentially left gaps in the weed spectrum that could not be controlled," explained Andrew Richards, J H Richards & Sons.

"I was aware of an application to CRD for label approval of metobromuron, which potentially wouldn't be decided until next year. I asked if it was possible that AHDB seek an urgent EAMU for the use of Praxim so growers had access to this useful herbicide for autumn use.

"The potential economic impact that the lack of weed control options would have on businesses would have far-reaching implications such as reduced yields due to competition from weeds, extra lifting costs, along with a huge increase in cleaning and separation costs. The EAMU obtained for Praxim will be a great help for growers as we await the label approval."

To discover all of the latest EAMUs visit **horticulture.ahdb.org.uk/latest-eamus**

To discover all of the latest EAMUs visit **horticulture.ahdb.org.uk/latest-eamus**

LIFE AFTER COPPER AND IPRODIONE

SCEPTREplus has been designed to address some of the most critical gaps in growers' crop protection toolkit. Here, AHDB's Joe Martin explains how disease trials have been finding solutions following the withdrawal of copper and iprodione

Only half-way through the four-year programme and SCEPTREplus is already delivering for growers. Here, we profile three successful trials from the programme:

ROOT ROT CONTROL IN HYDROPONICS

Phytophthora cryptogea and other oomycete root rot pathogens can cause severe deterioration of roots of deep water hydroponic plants, causing loss of vigour and yield. Growers currently have no access to conventional or biopesticide fungicides and so finding potential solutions to this disease was a high priority.

From the trials conducted at a novel hydroponic test facility at Stockbridge Technology Centre, two conventional fungicides gave excellent disease control.

One of the conventional products achieved high levels of control throughout the trial period, which either suggested some persistency of the product in the hydroponic environment, or more complete control of the inoculum during the application period.

The other gave excellent control during the application period and it is thought that repeated applications of the product may be required to achieve increased control at later assessment timings.

One biopesticide tested may also be useful but in this test phytotoxicity was observed. Lower rates may give less damage and still provide useful control.

BACTERIAL CANKER IN *PRUNUS*

Previously, control of the canker in Prunus trees was kept below economically acceptable levels by applying copper-based products to knock down bacterial population prior to leaf fall. New regulations mean that these are no longer available and therefore it was important to look at alternatives.

In the laboratory leaf test, six products showed promising results, comparable to or better than the current industry standard. These included two botanical-based products, two common sterilants (sodium hypochlorite and hydrogen peroxide), a small antioxidant-based product and also Serenade ASO.

Additional work is planned to evaluate products that stimulate plant defences to support plants against canker in cherry.

BOTRYTIS CINEREA CONTROL IN STORED CABBAGE

Controlling grey mould (*Botrytis cinerea*) in stored Dutch white cabbage was a priority for the project due to the loss of iprodione as a post-harvest application.

The trial, conducted at the Allium and Brassica Centre, has generated interesting results for a number of products.

Three conventional fungicides and one biopesticide have given positive efficacy effects post-trimming, including the number of marketable heads.

There were also differences in visual improvement, with five of the conventional products giving positive results.

Samples were taken following application to determine any potential residues in the stored cabbage. Discussions are ongoing with manufacturers to progress applications for EAMUs to give growers solutions as soon as possible. An EAMU for Serenade ASO has now been authorised following the trial and further applications have been submitted to CRD.

To see more results from the SCEPTREplus disease trials, visit **horticulture.ahdb.org.uk/sceptreplus**

SCEPTREPLUS

CONTROLLING BOTRYTIS WITH **BIOCONTROL AGENTS**

How can biocontrol agents best be used to improve the control of *Botrytis cinerea* in fruit and vegetable crops? Research student, Gurkan Tut, NIAB EMR, investigates

AHDB STUDENTSHIP

Biological control (biocontrol) is the use of organism(s) to eliminate or manage a pest, pathogen or disorder. Crop diseases are primarily controlled with chemical pesticides, but concerns over their environmental and health impacts are leading to increasing restrictions on the availability and use of these pesticides. Consequently, more attention has been gradually paid to exploit microbial organisms for biocontrol of plant diseases. For biocontrol to be effective, it is crucial to understand and predict the population density of biocontrol organisms/agents (BCAs), and how this changes with the application strategy and the environment.

This project focuses on *Botrytis cinerea*, the causal agent of grey-mould, an important pathogen across all sectors of UK horticulture. Using modern molecular techniques, populations of two BCAs (*Bacillus subtillis* and *Gliocladium catenulatum*) are being monitored in strawberry and lettuce crops in controlled conditions and in field conditions. This data is being used to develop models for predicting dynamics of BCA populations, which can be used to optimise biocontrol application strategies.

In the UK, there are two registered BCAs for Botrytis; Serenade, formulated with the bacterium *Bacillus subtilis* strain QST 713 and PreStop, formulated with the fungus *Gliocladium catenulatum* strain J1446. These BCAs each have specific modes of action against the target pathogen. Both BCAs compete for nutrients and space, but *Bacillus subtilis* primarily uses antibiosis, whereas *Gliocladium catenulatum* directly parasitises the conidia and hyphae.

As living products, a key aspect influencing biocontrol efficacy is their viability and dispersal post-application in commercial horticulture. There is a lack of knowledge on how the two BCAs colonise and survive on crops. Without such knowledge, improvements in application strategy (e.g. timing, mixtures, and concentrations) are very difficult to achieve.

Of particular interest is the impact of climatological factors on populations of both BCAs and the resulting biocontrol efficacy. In this project we have developed a new technique (PMA-qPCR) in the first year to quantify population sizes for these two BCAs. Next, we determined the response of *B. cinerea* to various doses of Serenade and PreStop on lettuce leaves, to estimate the LD50 dose. For Serenade, the LD50 value is 3 × 108 cfu/ml, and the corresponding value for PreStop is 3 × 108 spores/ml. This LD50 value can be used to interpret biocontrol efficacy for a given BCA population size on plant tissues. We now use PMA-qPCR technique to investigate BCAs survival, and spread between and within leaves under controlled conditions (various combinations of temperature and humidity for survival, and rainfall events for dispersal). Models will be developed from this data to predict BCA population dynamics to optimise biocontrol strategies.

Finally, we are collecting field data on BCA population size and will use this field data to validate and revise the models developed from controlled conditions. The final model/results may be presented as a factsheet to help growers in optimising the use of BCAs in their business.

AHDB project code: CP 140

Project lead: Xiangming Xu, NIAB EMR

AHDB contact: Joe Martin

A GOOD SERVICE MEANS **BETTER PRODUCTIVITY**

Evaluate and adjust the precision and accuracy of a water-powered proportional dilutor

- Improve performance of equipment
- Simple procedures to increase productivity
- Prevent wear, tear and damage

YouTube bit.ly/proportionaldilutor

Find our latest video and factsheet on calibrating a water-powered proportional dilutor here:

horticulture.ahdb.org.uk/publication/calibrating-water-powered-proportional-dilutor

WILT WORRIES

A loss of authorised treatments for Verticillium wilt in strawberry has left growers looking for alternative products to chemical fumigants. Dr Erika Wedgwood, ADAS, explains how AHDB research is leading that search

The loss of actives, such as methyl bromide, as well as the need for Emergency Authorisation of chloropicrin each year, has meant that growers tackling strawberry wilt, *Verticillium dahliae*, have had difficulties in recent years. As strawberry wilt can infect crowns via roots to reduce yields by 75%, an experiment was set up in AHDB project SF 157 to compare the use of biological alternatives to chloropicrin in a field soil on a commercial farm. The experiment was set up within a soil-grown strawberry plantation on raised beds with trickle irrigation, which had been treated with chloropicrin. Four

> “Strawberry wilt can infect crowns via roots to reduce yields by 75%”

biocontrol products were assessed in the experimental area, which had not been fumigated as the rest of the field. Each treatment was replicated five times and compared with an untreated control. The sandy loam soil used had a history of Verticillium wilt and, when tested for the presence of *V. dahliae*, scored between 2.6 and 5.6 propagules per gram of soil (depending on the area of the trial sampled). The cultivar Symphony was chosen as it is only moderately susceptible to Verticillium wilt and will display symptoms while still producing some fruit. More susceptible cultivars would die completely, providing less helpful results. The treatments included the incorporation of Anaerobic digestate solids, incorporation of Bio-Fence granules and application of a plant drench of Serenade ASO. A further treatment combined the soil incorporation of Bio-Fence granules with a drench of Serenade ASO. All four treatments were compared with an untreated control.

The incorporation of the Anaerobic digestate and Bio-Fence granules took place on 23 May and planting took place on 6 June, with the Serenade ASO biofungicide sprayed on the plants on 12 June. Full details of the treatment rates and incorporation methods are presented in the annual report of Project SF 157 which is available to read on the AHDB Horticulture website.

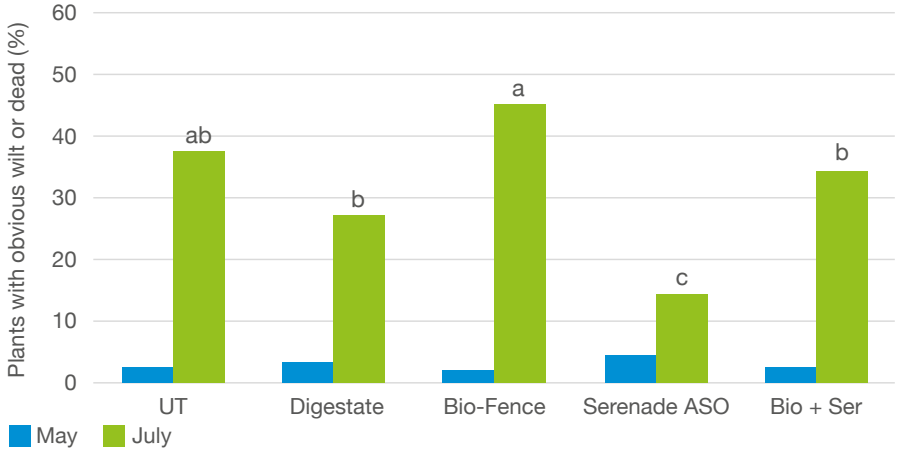

Figure 1. Percentage of plants with indices of 1 to 4 (from dead to showing obvious Verticillium wilt), at assessments in May and post-harvest in July 2018.

HOT WEATHER TAKES ITS TOLL

The planting period was exceptionally hot, and by 29 June 2017 some plants in the trial and the adjacent chloropicrin treated chloropicrin-treated grower’s crop had become scorched. More leaf margin scorch was seen in the Bio-Fence and digestate plots than in the Serenade ASO and untreated plots, perhaps indicating that, after the organic amendments, either a longer period had been needed before planting and/or longer ventilation. By 11 October most plots had dead plants, usually two or three out of 27, and the total number of established plants in each plot was recorded.

As expected, little fruit was produced in 2017 and, by September, there were only subtle symptoms of changing leaf colour to suggest Verticillium infestation in an occasional plant. Further records were made on 17 May 2018 and no more than a mean of one Verticillium wilted plant was seen in each the treatments.

Fruit harvesting in the field started on 11 June 2018, as the country entered an extremely hot few weeks, and was stopped after a further four harvests following 27 June.
Fruit was separated into Class 1,

Figure 2. Strawberry plants at different levels of infection from Verticillium wilt

Class 2 and waste. There were problems throughout the industry with fruit ripening faster than it could be picked, and berries desiccating on the stalks. No difference was found between treatments at any of the harvest dates, nor in total over all harvests, with a mean 11.5kg marketable fruit per plot. Mean berry weight on 27 June was similar across the treatments, a mean 12g. Allowing for the fact that some plots had fewer plants, the total marketable yield per plant was, on average, 492g, without any difference between treatments, so indicating neither beneficial nor detrimental treatment effects on yield.

By July 2018, plants had been put under stress by fruit production and also infected plants were less able to keep up with water demand in the heat, so causing them to succumb to Verticillium wilting. Plants were assessed for a combination of severity of wilting and plant vigour using a one to nine index, where dead plants scored index one through to an index of four with stages of obvious wilt, while plants of index five and six had wilt symptoms starting, and others appeared healthy, with a range of vigour recorded by indices seven to nine.

On 19 July 2018, whereas 15% of plants given the single application of Serenade ASO in June 2017 had crowns obviously wilting or dying from Verticillium (index four and below), the other treatments all had significantly more, with the greatest proportion (45% of plants) in the plots treated with Bio-Fence alone (Figure 1). Wilted plants comprised 34% of the plants to have received both Bio-Fence and Serenade ASO (significantly different from when either product was applied alone). It is possible that the Bio-Fence had weakened the plants, making them more susceptible to Verticillium. Over twice the number of plants were severely affected when left untreated, compared with plots that received only Serenade ASO, but the untreated was not significantly different from the other treatments, including those with digestate.

MORE TESTING AHEAD

Further results are due on this work, to help explain the apparent beneficial effect of Serenade ASO against Verticillium. Soil samples to enable Harris testing were kept, prior to treatment applications in May 2017, and further samples were taken in July 2018. It is possible that significantly fewer plants succumbed to Verticillium wilt in the Serenade ASO plots, as fewer *V. dahliae* microsclerotia were in the soil of these plots initially, rather than that the treatment reduced their viability. Therefore, pre- and post-Serenade ASO treatment samples will be assessed for microsclerotia viability, and compared with untreated plots.

AHDB project code: SF 157

Project lead: Erika Wedgwood, ADAS

AHDB contact: Scott Raffle

TIME TO **VENT?**

Ed Hardy, GrowSave, looks at the upcoming humidity control workshops and how you can benefit from the knowledge shared

Traditional approaches to humidity control tend to involve using the heating system while often simultaneously venting. For many, the increased cost of energy consumption was a price worth paying to maintain the desired humidity. However, this type of approach is now regarded as outdated and provides significant room for improvement in terms of energy efficiency and plant growth.

At the beginning of 2018, GrowSave held a basic humidity control workshop. The event was designed to introduce the factors affecting humidity within the greenhouse and how these may be influenced using the greenhouse structure, its installed technology and some basic control strategies. This event proved popular and, due to this demand, GrowSave will be running this course again in the early part of 2019.

An addition to the programme this coming year will be a partner workshop on advanced humidity control, which will build on the theory and basic scientific principles learnt in the initial training day. This second workshop will be aimed more at edibles growers and those ornamental growers using advanced climate control techniques, including principles of Next Generation Growing (NGG).

> “Too little air exchange can limit humidity changes and risks disease and reduced transpiration”

All air contains water and the quantity of water is termed its humidity, but things are never that simple. In current greenhouse environmental control, the grower must get used to terms such as Relative Humidity, Humidity Deficit, Absolute Humidity, Vapour Pressure Deficit and dew point. It is the interplay between these properties of air (and the water within it) that drives requirements for control.

Striking the right balance between allowing the plant to transpire and minimising heat or external influences to get efficient growth with good fruit yields or optimum flower production is difficult. By keeping the screen closed longer and insulating side walls, we are reducing natural air movement that in the past kept humidity under control by default.

Humidity can easily be controlled by replacing the warmer, wetter air inside the greenhouse with the (usually) drier but colder air from outside. What is key to this air exchange is making sure it is done at the right time and with the correct amount of ventilation. Introducing too much colder air risks over-cooling the greenhouse, with resultant high energy cost to return the greenhouse to the right temperature. Too little air exchange can limit humidity changes, and risks disease and reduced transpiration.

Some of the latest thinking under NGG involves strategies that many may feel nervous about. For example, using a screen that is capable of moisture transport through its fabric means that some dehumidification can be achieved with reduced direct air exchange. One of the techniques is to vent the airspace above the screen actively using both lee and windside vents. By venting above the screen, using small amounts of vent on both sides of the ridge, excess moisture can be removed from the air below the closed screen without resorting to pipe heat or screen gapping, thereby saving energy.

To effectively manage such a technique requires a measuring box or sensors positioned above and below the screen to ensure the right conditions are met. One of the measurements taken is the absolute humidity of the air (its actual water content), which can demonstrate the achievement of water movement through the screen and resultant conditions above it. This introduces more measurement variables to consider and increased control complexity.

In a relatively new development, a Dutch manufacturer has developed a 'ventilation jet' for situations where supplementary lighting is deployed. The ventilation jet comprises a fan above the screen attached to a vertical fan below the screen, so the air from above can be used to reduce humidity below.

It is possible to alter the humidity without external air exchange and many readers will be familiar with misting systems as a way of introducing more water into the greenhouse, which can also be used as a means of cooling. When greenhouse ventilation is being limited more often and greenhouses are better sealed, misting will be invaluable to keeping healthy plants. However, knowing how much water to apply will require a good understanding of the properties of air and humidity measures.

Work, funded by AHDB has also been carried out, to investigate the potential for mechanical dehumidification using refrigeration technology. There have also been installations of other dehumidification technologies using heat to drive them. While these have been successful in some cases, for some crops, using dehumidification equipment needs a change of control strategy and a good eye on crop performance to get the best results.

Air movement fans are sometimes described as humidity control technology, but these do not alter the humidity but rather keep air moving to prevent warm, humid air from settling around the plant. There are many different designs and types of fans available, including dedicated vertical air movement versions which go a long way towards creating a homogenous climate.

Pulling together all these techniques and technologies is the job of the greenhouse computer, pre-programmed with the properties of air, containing a version of a psychometric chart called a Mollier diagram. This diagram allows it to understand the various properties of humid air by calculating greenhouse temperature and humidity, using any one of the humidity measurements. However, the greenhouse computer must be programmed by the grower and it is therefore important the grower, who needs to understand their interrelationships.

grow save
helping horticulture save energy

A CHANCE **TO LEARN**

The GrowSave workshops are designed to arm growers, managers and supervisors with the techniques and methods required to maintain suitable humidity levels within the glasshouse. Often a welcome by-product of better control is reduced energy consumption and improved quality and yield, which are particularly valuable in light of the substantial increase in energy prices during 2018. While some strategies may push the boundaries of what many growers are comfortable with, such as accepting more water in the air, as detailed in NGG, even small changes can still give worthwhile improvements.

The workshops will be held at Roundstone Nurseries, with Basic Humidity control scheduled for 23 January and Advanced Humidity Control held the following day, 24 January 2019.

To book your free place, visit **growsave.co.uk/future-events**

REDUCING YOUR ENVIRONMENTAL IMPACT

The final part of our fertigation series focuses on wastewater, nutrient recovery, and reducing pollution, as AHDB's Georgina Key reveals

Our environmental impact is a hot button issue in the UK at the moment. When it comes to fertigation, growers usually clean and recycle water for the following reasons:

- Environmental regulation: as mentioned in part two of our fertigation series (see the Oct/Nov issue of The Grower), Dutch legislation means that growers now have to recycle 90% of their wastewater back into their systems. In the UK, most of England is in a Nitrate Vulnerable Zone (NVZ), which means growers sited in an NVZ need to take steps to prevent manure, fertilisers and soil getting into watercourses. They are conscious of their environmental impact
- Necessity: growers may choose to reduce costs and recoup fertilisers. Some growers in the south-east of England are already experiencing water abstraction restrictions and reduced flow rates so, as their Mediterranean counterparts (whose main issue is water scarcity), it makes sense to save and recirculate as much water as possible

The prolonged hot and dry weather experienced in the UK this year gives us a taste of what could be in store for our climate in the future, so investigating different wastewater recycling options is prudent.

A moving bed biofilm reactor

APPROACHES

Even if you do not plan to recapture your wastewater, it may be necessary to remove nutrients before discharging it onto fields or into surface water. One option is to use duckweed, which grows on the water surface and uses nutrients in the water for growth (nitrogen and phosphorus). It is most likely to be used in a settling pond. When it has established itself, duckweed covers the entire water surface and, due to reduced light penetration, can reduce algal growth as well. However, duckweed does not grow in all water conditions – the Fertigation Bible (see 'Next steps' box out) details the conditions required. To remove nutrients, simply extract the duckweed from the water surface (either by hand, or by using a submersible pump. Duckweed is a low-cost, low-maintenance option, but one disadvantage is that when temperatures drop to near freezing it will enter a hibernation phase.

Another option would be to install reed beds, which can help to lessen and diffuse agricultural/horticultural pollution. The length of the reed bed directly influences the amount of nutrients removed. They are most effective when part of a treatment system, rather than used alone (e.g. with a settlement pond or tank), and work best with an adequate water supply and some control of water levels (e.g. a ditch). Labour requirement for maintenance depends on the system installed; it can be as little as cutting the reeds back every few years. Life expectancy of a reed bed is roughly 20 years, which can be significantly extended by good management and more cost-effective on a larger scale.

The next few technologies are more innovative or expensive and more likely to be used in systems that capture and recycle water. One such technology is adsorption media for phosphorus (P), which works on the principle that P adsorbs onto (sticks to the surface of) iron. In this case, granular iron with a sand core is used as the adsorption material. A phosphate filter with a volume of 700 litres filled with 1,000kg of iron grains can treat 1m^3 of water a day (with a P load of 20mg PO4-P/litre).

The P-saturated grains can then be used as P fertiliser. There is less post-processing and there is no addition of chlorides compared with other P-removal techniques. The technology can also be used to remove other pollutants. This technology is better suited to smaller nurseries or farms with limited amounts of wastewater and less capital for larger installations.

Moving bed biofilm reactors works on a smaller footprint than an activated sludge process (wastewater treatment process using aeration, bacteria and protozoa to treat sewage or industrial wastewaters). Small plastic carriers each containing a biofilm are kept in motion in the water. As they move, the biofilms on the carriers pick up impurities from the water. The result is a high treatment capacity in a relatively small area. A 3m^3 reactor with carriers would cost around £3800, and would be able to treat the wastewater of 2–3ha with a maximum flow rate of 13m^3/day.

> “The prolonged hot and dry weather this year gives us a taste of what could be in store for the future”

Electrochemical phosphorus precipitation is another P-removal technology, but on a larger scale and is more expensive (about £180K). Wastewater runs into a tank containing a cathode and a ‘sacrificial anode’ made of magnesium. When an electric current is applied, the magnesium anode breaks down and reacts with the P and ammonium or potassium in the water, which then precipitate out of the water as P-salts. This process removes about 80% of the P, which can be reused as fertiliser. The technology can be expensive due to the amount of electricity it requires, but its modular nature means it can be scaled to fit the amount of wastewater produced, and no additional chemicals are needed.

Finally, constructed wetlands are artificial wetlands designed to mimic natural wetland processes, such as acting as a biofilter, or removing sediments and pollutants such as heavy metals from the water. They work over a larger scale and require planning permission. The result though is a system that can process about 100-litres of drain water/m^2 wetland each day. If the wetland were a large flow system, it would cost around £22/m^2, whereas an aerated wetland can cost up to £890/m^2. The system is relatively low maintenance and can last up to 15 years. A wetland is very efficient at removing nutrients in the first few years, and produces water with a consistent pH of 7–7.5. However, proper design and construction are essential, as is a source of carbon for the bacteria present in the system.

NEXT STEPS

The Fertigation Bible can be downloaded free of charge at **fertinnowa.com/the-fertigation-bible**

FERTINNOWA has information on technology that has come from other sectors or industries, which can be applied in horticulture. Find out more at **fertinnowa.com/technologies-exchanged**

For more information about Nitrate Vulnerable Zones, visit: **gov.uk/government/collections/nitrate-vulnerable-zones**

For advice on building reed beds, see: Building Research Establishment Good Building Guide No 42 (GG42) Reed Beds 2001. ISBN 1860814379

WHY DOES SOIL HEALTH MATTER?

How much do you really know about your soil and its health? Elizabeth Stockdale, NIAB, takes a closer look

Recent work on soil management carried out by AHDB Horticulture with grower groups across the country highlighted a lack of information on soil biology and soil health. Soil physics, chemistry and biology are interlinked and all play a role in maintaining productive agricultural and horticultural systems. While physical and chemical properties of soil are relatively well understood, the same is not necessarily true for soil biology.

Soils contain a very high diversity of organisms. Until recently, about 1% of all soil micro-organisms had been identified. Soil organisms interact with one another and the chemical and physical properties of the soil to drive soil processes, such as:

- Release and recycling of nutrients
- Forming and maintaining soil structure to manage water and aeration
- Both causing and controlling plant diseases and pests
- Nitrogen fixation or increasing nutrient availability through beneficial relationships with plant roots

Together, interactions between soil physical, chemical and biological factors contribute to soil health. In the same way that we measure our own health by our ability to carry out our normal everyday tasks, healthy soil can be recognised by its outputs/functions, i.e. healthy plants, animals and, ultimately, humans.

It is useful to consider whether we can recognise underlying indicators that help us identify when soil is in a healthy or unhealthy state – the equivalent of taking a soil's blood pressure and temperature. Because of the wide range of soil types, climates and farming systems in the UK, it is important to put such indicators into context.

AHDB's GREATsoils programme pulls these three factors together and provides valuable information on soil management for growers and agronomists. Funded in 2016, the Soil Biology and Soil Health Partnership aims to fill a gap in knowledge and help farmers and growers manage soil health better.

THE SOIL BIOLOGY AND SOIL HEALTH PARTNERSHIP, 2017-2021

Funded by AHDB and BBRO, the five-year Soil Biology and Soil Health Partnership is a series of cross-sector research and knowledge exchange projects. Each is designed to help farmers and growers maintain and improve the productivity of UK agricultural and horticultural systems.

The key output of the Partnership will be a toolkit including an integrated scorecard to help growers measure and manage soil health.

All the outputs will be designed in conjunction with farmers and growers so they can be easily understood.

The Partnership comprises eight scientific and six industry partners and this breadth of expertise provides a robust practical and scientific foundation. However, we recognise that farmers and growers have already taken the initiative to understand the health of their own soils and a great deal of work is already being done on farm to experiment with ways to optimise soil biology and health.

Therefore, from its outset, the Partnership has sought to work closely with farmers, growers and advisers to draw together and build on current knowledge and experience. Crucially, the Partnership will also involve key players in the agri-food sectors to direct the work and maximise the practical relevance of its findings in modern farming rotations.

FINDINGS SO FAR

In the first year of the programme, we have:

- Updated scientific reviews of soil biology and soil health
- Developed a model that provides an easily understood summary of the effects of soil management on soil biology and soil health
- Identified a set of methods to measure soil health on farm, which can be used to support practical decision-making
- Reviewed molecular-based approaches that can be applied to assess soil biological function

In recent years, a range of indicators for soil biology have been developed. It is now possible to measure soil chemical, physical and biological properties. Some of the best measures of soil physical structure and its stability can be completed in the field, whereas most chemical properties need samples to be sent away for analysis. The recommended biological indicators may be assessed in the field (earthworms) or sent away for analysis (soil respiration).

However, often these indicators have not been produced in parallel with the necessary guidance and tools to allow them to be easily used on farm. We have selected some indicators for testing, where we will focus on whether the target values/thresholds for soils/farming systems are correct, e.g. soil organic matter levels. We are also trying out new DNA-based indicators of the soil biological community in practice.

WHAT NEXT?

Over the next three years, we are working on pre-existing long-term soil management trials and on commercial farms to appraise the performance of the model and to evaluate a new soil health scorecard. This work includes trials on raspberry, onion and narcissus.

Seven long-term soil management trials have been identified which have treatments in place that target the main influences on biological function:

- Food source – nutrient and organic matter inputs, cropping choice and sequence
- Air and water supply – tillage systems and drainage
- Chemical environment – pH

Across these trials and commercial farms, a programme providing detailed monitoring of crop (yield, disease and weed constraints) and rotational soil health is now in place. Soil sampling takes place in the autumn post-harvest and after the soil has wetted up. A key part of sampling for rotational soil health is the linking of measures of soil physical, chemical and biological properties.

As soils need to be moist, sampling may take place post-cultivation/drilling of winter crops, but leaving a gap of at least one month after soil disturbance. Soil physical properties and numbers of earthworms are recorded in the field at the time of sampling and we are also collecting cores for the measurement of bulk density.

A bulk soil sample is collected to allow extended soil chemical and biological analysis using the NRM Soil Health package plus direct measures of soil organic carbon, total nitrogen, potentially mineralisable nitrogen, microfauna and nematodes. The same soil samples will also be used in the development and validation of DNA-based soil biological indicators.

To allow control of the factors under study, many research trials have specific and narrowly focused remits, often with limited acknowledgement of rotational impacts. Consequently, implementation and impact of soil management on farms has been less well studied.

The Soil Biology and Soil Health Partnership is deliberately taking another approach and is working with farmer and grower research-innovation groups to evaluate the impacts on soil biology and health across a broad spectrum of crops including field vegetables, climates, soil types and rotations.

Listen to AHDB's Jason Pole and Amanda Bennett discuss the GREATSoils project on our latest podcast, **cereals.ahdb.org.uk/podcast**

GREATSOILS

AHDB project code: CP 166

Project lead: Dr Elizabeth Stockdale, NIAB

AHDB contact: Dr Amanda Bennett

A WORM WELCOME

Jason Pole, AHDB Communications Manager, looks at how to correctly measure the health of your soil via worm counts

How to measure the health of a soil is the subject of much debate. There are 753 official soil types found across England and Wales, but it can seem that there are even more ways to measure the health of those soils.

Without doubt though, however it's done, measurement is a good thing. Testing the physical, chemical and biological properties of soils can reveal how they vary over time. If variation can be linked to changes in productivity, a valuable picture can be built up to guide soil management decisions.

One biological test gaining traction is the measurement of earthworm populations. These tube-shaped soil dwellers engineer the soil environment and are associated with significant benefits to plant productivity.

Although high numbers are a good thing, it's not all about quantity. Quality counts and, hence, should be counted. Up to 10 earthworm species are commonly found in agricultural soils and these can be grouped into three ecological types: epigeic, endogeic and anecic – with each group having a unique and important function. So before you lift a spade and slice the soil's surface, take a look at this guidance to help identify your soil's populations.

AGE DISCRIMINATION

Before worm groups can be identified, it is essential to know the difference between the juveniles and the adults. It's much easier to identify adult worms, so the juveniles need to be discarded from any count. Mature worms can be spotted if there is a clearly developed 'saddle' – which is the reproductive ring (see image below). It's important to note that size is not a good guide, as some very small (2cm) adult worms can be found.

EPIGEIC ADULTS (LITTER-DWELLING EARTHWORMS)

Small (<8cm), dark, red-headed, fast-moving worms. These play a key role in carbon cycling and are prey for native birds.

ENDOGEIC ADULTS (TOPSOIL EARTHWORMS)

Small to medium, pale-coloured and green worms (not red) that often curl up when handled (green worms may emit a yellow fluid). These play a key role in soil aggregation and nutrient mobilisation. They represent the most common earthworm group found in fields.

ANECIC ADULTS (DEEP-BURROWING EARTHWORMS)

Large size (>8cm), dark red or black-headed worms. These make deep vertical tunnels (up to 2m) and help improve aeration, water infiltration and root development. They forage the soil surface at night and are often found below surface earthworm casts or midden residue piles. Commonly found in grassland, they are often absent from ploughed fields and where there is no surface litter.

60-MINUTE EARTHWORM COUNTS

Spring and autumn are the best times to assess earthworm populations, especially during warm and wet spells. Simply follow these steps:

1. Dig out a soil pit (20cm x 20cm x 20cm) and place soil on a mat
2. Hand-sort the soil, placing each whole earthworm into a container (have a bottle of water handy for cleaning purposes)
3. Count and record the total number of earthworms
4. Separate earthworms into adults and juveniles
5. Return juveniles to the soil pit
6. Count and record the number of each type of adult earthworm
7. Return earthworms to the soil pit and backfill with soil
8. Repeat steps 1–7, until 10 soil pits per field have been assessed (follow a standard W-shape field-sampling pattern)

This guidance has been adapted from the AHDB 'How to count earthworms' publication. Co-author Jacqueline Stroud, Rothamsted Research, recently conducted a baseline earthworm survey at AHDB Strategic Farm East.

BASELINE BASICS

- Autumn (mid-October) 2017
- 149 hectares
- Nine fields
- 180 soil pits
- 179 soil pits contained earthworms
- 148 to 364 earthworms per typical arable field
- 61% to 84% of populations made up of juveniles
- Endogeic (topsoil) earthworms dominant
- Earthworm number often reduced by more intensive cultivations

> "Although high numbers are a good thing, it's not all about quantity. Quality counts and, hence, should be counted"

The AHDB website contains a wealth of GREATsoils information, including the earthworm publication, worm count test video and earthworm recording sheet. Visit **ahdb.org.uk/greatsoils**

GREATSOILS

LEADING THE WAY

We caught up with Ian Edwards, James Coles & Sons Nurseries, to find out why he attended AHDB's Professional Managers Development Scheme (PMDS), designed to create great leaders in horticulture

Name:
Ian Edwards

Company:
James Coles & Sons Nurseries

Job title:
Operations Manager

WHY DID YOU SIGN UP FOR THE PMDS COURSE?

Ian: I started my career at Coles straight from leaving school in 1987. My horticultural training had been self-taught or acquired within Coles. I thought this course would help me to develop and progress as a manager and benefit both myself and Coles in moving forward.

WHAT DID YOU EXPECT TO GET OUT OF IT AND DO YOU THINK YOU'VE ACHIEVED THIS?

Ian: I thought the course would help me gain more confidence in my approach to management and a more structured and professional style, which I certainly think I have achieved.

WAS THERE ANYTHING YOU LEARNED THAT PERHAPS YOU DIDN'T EXPECT TO WHEN YOU SIGNED UP FOR THE COURSE?

Ian: That all different types of occupations have roughly the same difficulties and struggles in finding a winning formula (staffing, training, change etc.).

ARE THERE ANY SPECIFIC BENEFITS YOU HAVE GAINED FROM ATTENDING THE PMDS COURSE?

Ian: I have definitely improved my confidence within my role at Coles. I also really learned a lot about 'Time Management and Delegation'. I can now make more effective decisions looking at the bigger picture as I always rushed into getting the job done and not all first thought out solutions are the best or correct. I have developed a more strategic way of thinking and working, thanks to the course.

In terms of delegation I found that I was always trying to help everyone and say yes all the time, and as a result, my day became long and I didn't really have time to focus on what I should be doing. This meant a lot of firefighting rather than fire prevention.

SO HOW HAS THE COURSE CHANGED YOUR HABITS AND THE WAY YOU DO THINGS IN YOUR BUSINESS?

Ian: I still try to help anyone who asks but the big difference is that I now point them in the right direction rather than just doing it for them (I think it's also called trust!).

DID YOU FIND IT USEFUL INTERACTING WITH OTHERS ON THE COURSE?

Ian: Yes, the group of people I attended the course with have been a great help through that time and right up until this present day. We have all kept in contact and every six months try to organise a progression get-together to see how we are all getting on and float any ideas or solutions to problems that have occurred. While attending the course we quickly became relaxed with each other and the sessions became very interactive and productive between us all. I personally could not have asked for a better group.

WOULD YOU RECOMMEND THE COURSE TO OTHERS?

Ian: I feel the PMDS course really helped to fine-tune what I already knew, with the added benefit of learning some new skill tools that have helped me to progress as a manager. I would recommend this course for anyone wishing to go down the management route.

> "I now point them in the right direction rather than just doing it for them"

For more information or to join the latest course, visit: **ahdb.org.uk/professional-managers-development-scheme-pmds**

WHY SHOULD I JOIN THE COURSE?

Designed to challenge and develop the skill base of managers and owners, the 14 month Professional Manager Development Scheme (PMDS) has three key objectives to raise your:

- Productivity, by using people (employed and external) more effectively
- Level of communication and people skills
- Confidence in dealing with difficult situations/problem-solving

COURSE BENEFITS:

Previous delegates on the PMDS scheme have seen wide-ranging benefits from attending.

These include:

- Increased production efficiency and subsequent reduced costs of production
- Enhanced time management, allowing them more time to concentrate on their own job
- Improved communication between staff, contractors and external people
- A formal leadership qualification: Institute of Leadership and Management (ILM) Certificate in First Line Management

RISE OF THE **MACHINES**

The world of automation and robotics is coming closer to reality, with speakers from around the globe presenting at the Smart Horticulture Asia conference, reports Grace Emeny

Grace Emeny

"This is becoming less of a tech issue, we have the robotics and the knowledge, this is a capital issue now."

Professor Salah Sukkarieh, University of Sydney, knows his technology when it comes to field robotics, so we took the opportunity to get his insight on developments on the other side of the world at the Smart Horticulture Forum in Hong Kong, as part of Asia Fruit Logistica.

The journey that UK growers are on, in large part due to labour challenges, is to adopt autonomous robots that will lead to autonomous operations, with industries such as mining and aerospace leading the way as examples of adopting such technologies, through a mixture of necessity and innovation.

Professor Salah presented his work to date, which includes automated crop intelligence using a variety of sensors to assess crop maturity, classification and position. This data can be used to map fields and focus effort and inputs to the right place at the right time.

Further developments of roving 360-degree view robots are analysing crops individually, providing data analytics and decision support systems for the grower.

Salah's activity also includes a focus on a modular approach to these technologies, to maximise efficiency in the right place within a process, with the development of off-the-shelf components to build low-cost agriculture robots for small-holder farmers and growers.

THE WORLDWIDE LABOUR ISSUE

The labour shortage issue has been well-profiled in the UK, the current situation is in the balance and clarity is lacking for the future. Speaking to growers and industry representatives from across the world, our problems with labour are far from unique, but we are recognised internationally as being in a particularly challenging position.

Take the Golden State, California, USA, for example. They are also suffering from labour scarcity, and the minimum wage has severely hampered many businesses dependent on labour from across the border in Mexico and further into South America. In fact, California was referenced as being up there with the UK as the two areas of the world with the biggest issue in terms of labour availability this year.

In New Zealand, alongside local workers and backpackers, a large number of their labour force comes from the Pacific Islands as part of their successful Recognised Seasonal Employer (RSE) scheme. Despite this, there are still issues with labour availability. With unemployment in New Zealand being close to record low levels and backpackers having a wider pool of jobs to choose from, a cap on the number of workers that can enter the country each year is causing labour shortages, and initiatives including sharing seasonal workers between businesses and even industries are being developed.

Countries such as Japan have a unique conundrum whereby labour is still largely readily available from within, but that workforce is made up of 65% of workers over

the age of 65, and the rate of new entrants to the industry is steadily declining. Back in Europe, from speaking to a French tree fruit grower, his assessment of French workers, although animated, was clear, 'they are not built for this, after an hour in the field, they've had enough.' One thing was obvious: everyone is increasingly concerned about labour, whether it be availability or quality.

THE OUTSIDERS ARE LOOKING MORE CLOSELY

Smart Horticulture Asia demonstrated that the level of interest from big name technology companies is rapidly increasing. This may well help to escalate investment and development and, in the longer term, address some of these global labour fears. The challenge for horticulture is to maximise this interest, and collaborate with tech companies to find solutions that can be applied across the industry.

Panasonic's world vision is one of robotics integrated into all modern life activities to tackle environmental, medical, resource, labour and food issues.

Although in the early stages of development, they took the opportunity in Hong Kong to present their work on creating a tomato harvesting robot – their first step towards enhancing the horticulture industry by adopting robotic technologies.

With Bosch, known for automotive parts and electronic appliances developing the 'Bonirob' for greenhouse management, Airbus investigating opportunities for remote sensing and Microsoft and Tencents involved in the Wageningen University autonomous greenhouse challenge, the potential for rapid development of new technologies in horticulture could be huge, with the involvement of companies with such broad experience and investment potential.

It's now time for us as an industry to work with these types of companies. Successful technology needs to take the biology into account, and it is part of our role to make sure this happens.

SMARTHORT 2019 CONFERENCE

SmartHort 2019 is a free two-day conference dedicated to driving innovation into horticulture.

Guest speakers from around the world will be sharing some of the most impressive and exciting technological developments that could change the way you grow, and examining the potential of such technologies in light of current labour shortages.

It is an opportunity to discover the latest high-tech advancements, meet the people behind the innovation and find out how to invest in the technology that could make a positive impact in your business, connecting innovators with the horticultural industry.

6–7 March 2019
Stratford-upon-Avon

To book your place, visit
bit.ly/SmartHort2019

> "Our problems with labour are far from unique, but we are recognised internationally as being in a particularly challenging position"

AHDB visited the Smart Horticulture Asia conference as part of our campaign to improve labour productivity. Please get in touch if you'd like to discuss SmartHort, **grace.emeny@ahdb.org.uk**

SMARTHORT

TOOLS OF THE **TRADE**

John Clarkson, University of Warwick, reveals more about the work aiming to develop molecular tools to identify and quantify multiple Fusarium species

The genus Fusarium comprises many pathogenic fungi, which can cause disease in plants, humans, and animals. *F. oxysporum* is the most economically damaging Fusarium species for horticulture and is a species complex comprising more than 70 special pathogenic forms known as *formae speciales* (ff.spp.) which are adapted to infect different crop plant hosts. These are a major constraint to the production of many food crops including onion, leek, lettuce, tomato, brassicas, asparagus, cucurbits, peppers, coriander, spinach, basil, beans, peas, strawberry and watermelon, as well as non-food crops such as carnation, column stocks and narcissus.

Control of *F. oxysporum* is challenging because the pathogen produces chlamydospores that survive in the soil for many years, resulting in the need for long rotations. In the past, control has mainly relied on soil sterilisation or fumigation but regulatory approval for use of these type of active ingredients has, in many cases, been withdrawn or threatened by further legislation. Other management strategies such as biological control have yet to be widely proven although two microbial products (Prestop, T34 Biocontrol) are currently registered for Fusarium disease control in the UK.

In some cases, plant resistance to *F. oxysporum* has been developed, but sometimes this has led to the evolution of new pathogen races that have broken this down. A notable example of this is the recent emergence of *F. oxysporum* f.sp. *lactucae* race 4 (FOL4) which has caused disease outbreaks in the UK for the first time.

THE IMPORTANCE OF PATHOGEN DIAGNOSTICS

In many cases it is difficult to identify which Fusarium species may be causing disease and these pathogens are notoriously difficult to identify by conventional means such as type of symptom, culture morphology on agar plates or microscopy, as even the same species can vary widely in appearance. For *F. oxysporum* in particular, even sequencing of genes that are widely used to identify different fungal species fails to distinguish between the different *F. oxysporum* ff.spp. or between pathogenic and non-pathogenic isolates. Hence new approaches are required to identify and quantify the key *F. oxysporum* ff.spp. affecting

horticultural crops. This is important, firstly to understand which Fusarium species or *F. oxysporum* f.spp. are the main cause of disease, and secondly to provide molecular tools that could be used to assess pathogen levels in seed, planting material, soil or in harvested crops going into storage (e.g. bulb onions). Furthermore, such tools can also be used to understand the biology and dynamics of Fusarium pathogens, for instance to recognise how long they survive in soil and if they colonise or even proliferate on crop plants used in rotations, without causing disease.

DEVELOPING DIAGNOSTICS FOR *KEY F. OXYSPORUM* FF.SPP.

The main aim of project FV POBOF 452 is to develop diagnostics for the key *F. oxysporum* ff.spp. affecting onion (*F. oxysporum* f.sp. cepae, FOC), column stocks (*F. oxysporum* f. sp. mathiolae, FOM) and narcissus (*F. oxysporum* f.sp. *narcissi,* FON). To do, this we carried out whole genome sequencing of these pathogens and, through bioinformatics analysis, identified unique genes in each one that are associated with pathogenicity. This has enabled us to develop specific quantitative PCR tests for FOC, FOM and FON and preliminary results have shown that we can now successfully detect these pathogens in infected plant and soil samples for the first time. Using the same approach we also identified FOL4 in lettuce samples sent in by growers, when this pathogen first emerged in the UK, and are continuing to monitor for any further outbreaks. As many Fusarium species occur in disease complexes with other pathogens, further work is now developing a 'DNA barcoding' approach whereby gene targets are amplified from DNA from soil/root samples that will allow simultaneous identification/quantification of all Fusarium species, different *F. oxysporum* ff.spp. and other fungal pathogens, as well as other members of the microbial community.

DEFINING *F. OXYSPORUM* INOCULUM LEVELS REQUIRED TO CAUSE DISEASE

A further aim of the project was to define the critical levels of FOC, FOM and FON inoculum required to cause significant disease development on onion, column stocks and Narcissus respectively. To do this we infested compost with different amounts of each pathogen, transplanted the appropriate host plant and monitored disease development under controlled glasshouse conditions. Results indicated that a minimum level of 1,000 colony forming units per gram of compost were required for both FOC and FOM to cause noticeable disease symptoms, while disease development was severe when concentrations of 100,000 and 1,000,000 colony forming units per gram were present. The requirement for a threshold level of inoculum to initiate significant disease may explain why in some intensive growing systems such as protected lettuce and column stocks, Fusarium disease is not initially observed and then suddenly causes extensive disease damage the following year as inoculum levels reach this critical threshold. Further work is now 'calibrating' results of the qPCR tests so that these can be related to the critical inoculum levels of each pathogen and hence potential to cause disease.

IDENTIFYING FUSARIUM PATHOGENS IN LEEK AND ASPARAGUS

As part of the project we also obtained samples of leek and asparagus with symptoms of Fusarium infection to understand the range of species that can potentially cause disease in these crops. Following isolation, DNA extraction, PCR and sequencing of part of a gene that can accurately distinguish different Fusarium species we identified *F. culmorum*, F. *avenaceum, F. oxysporum* and *F. proliferatum* in diseased leeks and *F. avenaceum, F. culmorum, F. equiseti, F. oxysporum* and *F. proliferatum* in diseased asparagus. With the exception of *F. oxysporum*, all these species are known to be generalist pathogens that can affect a range of crops. Tests are now underway to confirm which of these species are pathogenic in leeks, with preliminary results suggesting that *F. culmorum* is particularly virulent.

> "Further work is now developing a 'DNA barcoding' approach"

DEVELOPMENT OF FUSARIUM DISEASE AREAS

During this project, we also artificially inoculated a field area at Wellesbourne with FOC and a polytunnel at the Cut Flower Centre with FOM. Following planting, these areas had high disease levels in crops of bulb onions and column stocks respectively and have provided a valuable resource for validating the molecular diagnostic approaches we have developed for these pathogens. In addition these areas will also provide a means of testing new disease control products and resistant crop varieties in the future.

AHDB project code: FV POBOF 452

Project lead: John Clarkson, University of Warwick

AHDB contact: Dawn Teverson

INSIDER **INSIGHT**

PLANTING THE **SEED**

Commercial Director of Tozer Seeds, David Rogers, lets us peek behind the scenes of a commercial seed development business to answer your questions

Seeds. Although usually small, their size belies their significant importance. Without them the horticulture industry would be a shadow of itself, but what goes on behind closed doors at a commercial seed breeding company often remains a mystery to the average grower. Thankfully, David Rogers from Tozer Seeds has lifted the veil for The Grower readers in this exclusive interview, letting us reveal a little more about the decision-making processes that result in your finished products.

HI DAVID, BEFORE A SEED CAN BE PLANTED BY A GROWER, HOW LONG HAS IT USUALLY BEEN IN COMMERCIAL DEVELOPMENT FOR?

David: Plant breeding projects are long term. They start with establishing the breeding aims then searching for genetic variation in a screening trial or creating it through a wide cross. Parent plants with the desired characteristics are selected and cross-pollinated. Even a simple breeding programme would need seven to eight generations from the initial cross until the variety is uniform and stable. For an annual crop this would take 10 years and 15 plus years for a biennial. Seed production and product development might take another five years, leading to a period of fifteen to twenty years from conception to market.

WHAT ELSE CONTRIBUTES TO THE TIME IT TAKES TO GET TO MARKET? WHAT REGULATORY TESTS DO YOU NEED TO PASS?

David: In many countries, including the UK and the EU, new varieties need to be registered before they can be sold. The International Union for the Protection of New Varieties of Plants (UPOV) has established guidelines by which examination offices in various counties conduct DUS tests. The DUS test determines whether the new variety differs from all existing varieties within the relevant crop (Distinct), whether the breed is uniform (Uniform) and whether the breed remains consistent (Stable) during propagation. If a new variety satisfies the criteria of the DUS test it can be listed and then sold. It usually takes two to three years to register a new variety and it is possible to apply annually for authorisation to market a variety while it is undergoing a DUS test.

HOW DO YOU DECIDE WHAT SEEDS TO DEVELOP FOR WHICH CROPS AND WHAT VARIETIES? DO YOU USE GROWER FOCUS GROUPS FOR EXAMPLE?

David: We put a tremendous amount of effort into this and use a method of continual feedback. For each breeding programme we will have an internal Focus Meeting every year with contributions from breeders, PD staff, the commercial team and

> “Seeds that never made it to market are kept and have sometimes been used to respond to a change in customer requirements”

Name:
David Rogers

Company:
Tozer Seeds

Job title:
Commercial Director

seed production. We will discuss the worth of each programme and monitor its progress; each new variety progressing through trials must be considered and withdrawn if it is not performing well enough. The end of this process is seed production, we could have a very impressive new variety, but if it doesn't produce enough viable seed it will be discounted.

We also meet with growers and supermarkets to discuss requirements but our breeders usually need to look further ahead than our customers.

WHAT ATTRIBUTES ARE YOU LOOKING FOR WHEN DEVELOPING A NEW SEED VARIETY?

David: Each breeding programme will be looking for a variety of different attributes: yield is always a pre-requisite, and every variety needs to produce. Other common attributes shared over many programmes are disease resistance, bolt resistance, holding ability, uniformity, good vigour, good shelf life and 'processability'. More and more we are also looking for attributes that will appeal to the consumer, such as colour, flavour and appearance.

DO YOU HAVE A LOT OF LINES THAT PERHAPS HAVE GOOD ATTRIBUTES BUT AREN'T COMMERCIALLY VIABLE? WHAT HAPPENS TO THESE SEEDS?

David: All breeding programmes have lines that are rejected in the process. Many of these have good characteristics but do not meet the breeding objectives as specifically as the line that is progressed. One of the skills of the breeder is knowing which lines to drop. There can be many reasons why varieties are not progressed; sometimes we are wrong in our calculations about market requirements and a good variety fails to be taken up, or of course varieties can fail because better varieties appear from competitor companies – if this happens, we would look to sell off remaining volumes and then cease production.

The seeds with good characteristics that never made it to market are kept and have sometimes been used to respond to a change in customer requirements. One example is with the advent of packaging for runner beans: the required length dropped from 40cm to 30cm and we were able to look for shorter runner beans which had previously been rejected as too short.

WHAT ROLE DO YOU SEE YOUR COMPANY PLAYING IN HELPING THE INDUSTRY TO TACKLE CROP PROTECTION ISSUES SUCH AS DISEASE?

David: We have various disease resistance aims within our breeding programmes; mildew resistance within wild rocket is one that has been particularly successful in recent years. Of course, diseases will naturally evolve to break the resistance, leaving the breeder with a 'race-race,' such as we see happening in spinach and lettuce.

AHDB

BROADEN YOUR HORIZONS

Join AHDB at Fruit Logistica and export around the globe

6-8 February 2019, Berlin

Reserve a networking table on our stand.

Contact **amanda.morby@ahdb.org.uk**

ahdb.org.uk AHDB Horticulture TV @AHDB_Hort