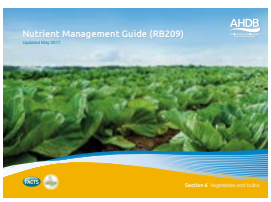
Field Vegetable REVIEW

2017

New weed control alternative

Development of automated broccoli harvester



New AHDB nutrient management guide RB209

Foreword

Martin Evans
Field Vegetables Panel Chairman

Welcome to the 2017 AHDB Field Vegetable Review.

We hope to take you through the last 12 months on all current and concluded research which AHDB Horticulture has undertaken for the field vegetable industry.

It has been a busy year with the launch of the new AHDB Horticulture strategy, providing us with the opportunity to feed into the direction of travel and help define the type of applied research our sector needs.

Crop protection and the loss of actives continues to be the persistent area of concern for most growers but with the new SCEPTREplus project well underway we hope to see some escalation of new products coming to the market. We are set to lose linuron next year, therefore, we have proactively focused our efforts on investigating alternatives. You can learn more about this work on page 9.

The programme of work we have funded on soils continues at a pace, with workshops and events taking place across the country addressing knowledge gaps in soil health and management while exploring the use of precision farming techniques.

We are also funding projects which are tackling some of our old foes such as cavity spot and Fusarium in a more fundamental way, getting back to the biology of the problem, and looking at a range of ways to help manage the issues. These range from diagnostics to population management and crop rotations.

Tackling labour shortages is not a new phenomenon for growers but one that has become more important with Brexit and the impact of the National Living Wage. Work on understanding automation and robotic use in the industry is being undertaken this year to feed into commissioning new work and horizon scanning best practice both domestic and overseas.

It is also the time of the year when we look to recruit new members for our research panel and you'll find more information in the accompanying AHDB Grower magazine. I look forward to welcoming new, thought-provoking panel members to complement our great crop of current ones, helping to drive the industry forward together.

New factsheets and guides are produced on a regular basis and are available to order or download through the website. Please ensure you keep all your key business contact details updated with AHDB so you receive all the communications.

I hope you find some insightful new areas to start to think about and bring results to your business.

Contents

This publication reports on the findings of AHDB-funded research projects only. Although it reports on the use of pesticides, it is not intended to endorse or recommend the use of any of the products or active ingredients listed. Only products officially approved for use as plant protection products should be applied to control pest, disease and weed problems. Before using any pesticides, growers should refer to the product approval and label recommendation and seek guidance from a BASIS qualified consultant.

Field vegetable panel

Martin Evans (Chairman), Freshgro

Current panel	Business name
Euan Alexander	Kettle Produce
Phillip Effingham	Greentech Consultants
Stephen Francis	Fen Peas
Robert Gibbs	Langmeads Group
William Iliffe	Southern England Farms
Philip Lilley	Hammond Produce
Keith Mawer	Strawsons
Stephen McGuffie	New Farm Produce
Sam Rix	PG Rix (Farms)
Andrew Rutherford	KS Coles
Rob Parker	G's Fresh UK
Christopher Ashby	Wessex Plants
Jim Smith	Barfoots
David Gray	Independent Advisor

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Preparing for the year ahead

As we approach the end of an eventful 2017, the AHDB team look at ways in which farmers and growers can stay ahead of developments, both business and political.

HORIZON

Brexit negotiations are firmly underway; however, until the moment the UK leaves the EU it remains a full Member State of the Union and therefore bound by all Treaty obligations, legislation and policy.

'Article 50' was triggered on 29 March 2017 meaning Britain should officially leave the EU no later than April 2019. During the two intervening years Britain will negotiate a deal for leaving the EU; a process that's likely to be lengthy and complicated.

To help guide and navigate the industry, AHDB have released a series of publications looking at the potential implications for the industry of the UK's decision to leave the EU. The analysis in the new 'Horizon' series examines trading relationships between the UK and the EU post-Brexit, the impact on the workforce, and the impact on protected food names and products, alongside examining the implications of World Trade Organization (WTO) rules. Visit **www.ahdb.org.uk/brexit** for more information.

CROP PROTECTION

Over the years changes in legislation and regulation of plant protection products has resulted in growers being left with no effective treatments for some critical crop protection situations.

The work carried out in the AHDB minor use programme aims to minimise the impact of such losses and to provide alternative solutions for UK growers. AHDB Crop Protection Managers Vivian Powell and Bolette Palle Neve work in collaboration with agrochemical and biopesticide companies to identify products for our project trials.

It is also a chance to find products for which we can extend the authorisation for minor use (EAMU). Widely recognised as an important service we supply to growers, it is an area we will continue to invest in to provide rapid remedial action. Growers will continue to receive EAMU notifications as they become authorised and we have introduced a new monthly crop protection newsletter, sharing new developments and what is on the horizon.

LEAN AND ROBOTICS

The high cost of labour and the uncertainty over the supply of workers is causing significant concern for growers. Labour accounts for between 30–70% of variable production costs in some areas of horticulture and the National Living Wage is driving up labour costs. Furthermore, while there is uncertainty about the future availability of migrant workers after Brexit, the pressure is already being felt with 78% of respondents to a BBC survey* saying recruitment for seasonal labour was more difficult in 2017 than in previous years.

The AHDB knowledge exchange programme is taking steps to help growers address this challenge, both in the short- and long-term. We are undertaking a research survey to establish the current use of automation and robotics in horticulture and to identify where future investment in technologies could be made to reduce labour costs, with selected businesses contacted for in-depth studies.

Automation and robotics may provide a longer-term solution, but to help growers find solutions to labour concerns now, a new programme has been launched to encourage the adoption of lean principles into horticulture businesses to help improve labour efficiencies.

A series of events to show how lean principles can help your business will be held for growers around the UK. To find out more about free AHDB events, visit **horticulture.ahdb.org.uk/events**

**BBC survey conducted between 16 May and 5 June 2017, sent to members of the British Leafy Salad Association and British Summer Fruits.*

New £1m partnership to address knowledge gaps in soil biology

AHDB and the British Beet Research Organisation (BBRO) have announced an ambitious new research partnership to develop practical soil biology management guidance.

The five-year partnership looks to improve on-farm understanding of soil health by benchmarking current academic and industry knowledge and building a far-reaching Knowledge Exchange (KE) programme in response.

It is part of AHDB's strategic commitment to accelerating innovation and productivity growth through coordinated research and development and knowledge exchange.

It will be led by NIAB in partnership with SRUC, ADAS, Fera, the Organic Research Centre (ORC) and the Game and Wildlife Conservation Trust (GWCT).

Dr Amanda Bennett, AHDB Resource Management Scientist, said, “Farmers and growers have themselves taken up the mantle and a great deal of work is being done out in the field experimenting with different approaches to optimising soil biology.”

She continued; “This exciting new partnership will work closely with farmers, growers and advisers to draw together and build on all that knowledge and experience to create accessible guidance and tools to help farmers improve their soils' health.”

AHDB is placing farm businesses at the centre of KE activity to maximise farmer engagement and uptake of best practice, as well as ensuring that new and potentially game-changing innovative technologies are introduced into the industry as quickly as possible under its ‘Research and Knowledge Exchange strategy 2017–2020’.

Field cut flower grower, Mark Eves, said, “Soil is our most important asset, however, we still as an industry have thirst for further knowledge and understanding. It is vital we recognise the complexities of all the living organisms in soil and I envisage that this project will collate all current knowledge and package it up smartly for growers to access.”

Download the new RB209

The new AHDB Nutrient Management Guide (RB209) is available to download as an app, offering best practice guidance on the application of mineral fertilisers, manures and slurries to crops and grassland.

Revision of the guide was overseen by the AHDB-led UK Partnership for Crop Nutrient Management and delivered by an ADAS-led consortium of experts from across the UK research community.

Dr Susannah Bolton, AHDB Knowledge Exchange Director, said, “This project underpins AHDB activity across a number of sector strategies, demonstrating the pivotal role we play in providing farmers and growers with key tools and information to improve their productivity.”

What it means for horticulture

New recommendations for baby leaf lettuce, wild rocket, coriander and mint have been added, with sweetcorn and leek recommendations revised. In fruit, guidance on the timing of nitrogen applications to blackcurrants and raspberries have been revised.

Stephen Francis, director of Fen Peas, said, “With such a diversity of crops within the horticulture remit it was always going to be a challenge to bring all the wide-ranging consensuses together but I believe we have achieved this aim.

“The whole process of stripping back RB209 has also led to many within the horticulture sector to re-examine what the crop requirements are and to align them to todays' environmental needs.”

Available on Apple and Android devices, the app can be found by searching for ‘RB209’ in the Apple and Google Play Store. The guide can also be downloaded as a navigable ‘smart’ PDF from the AHDB website - **www.ahdb.org.uk/RB209**

Generating new plant protection product approvals

Vivian Powell, Crop Protection Senior Scientist at AHDB, reflects on approvals for Extensions of Minor Uses (EAMUs) in 2017 for field vegetable crops.

Through close collaboration with growers, researchers, crop protection companies, Chemicals Regulation Division CRD and our counterparts in Europe, we have managed to secure 29 EAMUs and two emergency authorisations in 2017 to help boost plant protection options for the field vegetable industry.

The approval of Luna Sensation as a broad spectrum fungicide for lettuce was a great win for growers, following successful trials within SCEPTRE.

An urgent request for authorisation of a fungicide to control *Cercospora* leaf spot *(Cercospora beticola),* which was causing serious losses in red beet crops, resulted in an EAMU authorisation for use of 'Rubric' *(epoxiconazole).*

We were disappointed not to secure the approval for the use of 'Benevia 10OD' as an emergency authorisation for the control of diamondback moth on Brassicas this year, as we did in 2016.

We worked closely with the industry to try to secure an approval. However CRD have re-asserted their position that emergency authorisations will only be granted in response to need, if high numbers are reported.

Thankfully for growers, so far at least, we have not seen anywhere near the numbers of the pest this season.

An emergency authorisation however has been secured for 'Benevia 10OD' for control of onion thrips in allium crops.

We're aware growers are under continued pressure with a dwindling range of products available. We hope that, through trials in projects like SCEPTREplus, we can continue to identify new potential control options and obtain the data needed to continually secure EAMUs, ensuring the horticultural industry is resilient and thrives in the future.

EAMUs secured for field vegetable growers so far in 2017:

Herbicides

Product	Crops	Targets
Butisan S	Swede and turnip	Groundsel, Mayweed and shepherds purse
Devrinol	Baby leaf crops, lambs lettuce, red mustard and rocket	Range of broad leaf and grass weeds
	Choi sum, collard, oriental cabbages, celeriac, horseradish, swede and turnip	Range of weeds
Laser	Range of Brassicas, leafy salads, herbs, peas and beans	Range of grass weeds
	Celeriac, horseradish, Jerusalem artichoke, red beet, salsify and turnip	Range of weeds
Roundup Biactive GL	Asparagus	Annual and perennial grass and broad leaved weeds
'Starane Hi-Load HL	Sweetcorn	Volunteer potatoes and cleavers, common chickweed and common hemp-nettle
Stomp Aqua	Outdoor Lettuce	Annual meadowgrass, red deadnettle, chickweed and speedwells
Wing-P	Lettuce	Annual weeds

Fungicides

Product	Crops	Targets
Amistar	Outdoor edible cucurbits and inedible cucurbits	Powdery mildew, *Botrytis cinerea* and downy mildew
	Outdoor and protected celery	Rhizoctonia, Sclerotinia and *Botrytis cinerea*
	Outdoor salad onion	Downy mildew
	Outdoor oriental cabbage	Black rot and white blister
	Radish	Downy mildew and Rhizoctonia
	Celeriac	Sclerotinia
	Swede and turnip	Rhizoctonia
	Red beet	Root malformation disorder
	Parsnip	Powdery mildew and *Alternaria spp.*
	Horse radish	*Alternaria spp.* and white blister
Amistar Top	Horseradish, parsley root, parsnip and salsify	Black canker and phoma canker
	Asparagus	Stemphyllium and rust
	Chicory	Botrytis and sclerotinia
	Choi sum and oriental cabbages	Ringspot and Alternaria
Luna Sensation	Lettuce	*Botrytis cinerea, Sclerotinia minor, Sclerotinia sclerotiorum*, and powdery mildew
Quilt Xcel	Sweetcorn	Northern Corn Blight
Rubric	Red beet	Cercospora Leaf spot
Switch	Asparagus, courgette, summer squash, pumpkin and gherkin	Botrytis cinerea
Wakil XL	Carrot and parsnip seed	Damping-off diseases, eg Pythium

Insecticides

Product	Crops	Targets
Cythrin Max EC	Asparagus	Asparagus beetle
Decis	Fennel, celery, rhubarb	Caterpillars, flea beetle, aphids, cutworms and capsid
Eribea	Choi sum, collard, kohlrabi and oriental cabbages	Flea beetle and caterpillar
	Leafy vegetables and fresh herbs	Caterpillars, aphids and beet sawfly
Tracer	Celeriac, swede, turnip, courgette, melon, pumpkin and chicory	Caterpillars, thrips and leaf miners

Improving leaf quality and shelf life in lettuce

Optimising irrigation scheduling to match demand with supply under changeable UK growing conditions is challenging for many growers. Over-wet soils due to excessive rainfall or ineffective irrigation scheduling can promote postharvest midrib pinking and reduce shelf life in some varieties. Anecdotal evidence suggests that lettuce crops grown overseas with reduced water inputs often have better leaf quality and a longer shelf life than those grown under typical UK commercial conditions.

There is evidence that using precision irrigation (PI), deficit irrigation (DI) and/or alternate wetting and drying (AWD) has the potential to improve leaf quality and shelf life in cut lettuce leaves, but head fresh weights are often reduced by more severe DI treatments.

The aim of this project is to develop scientifically-derived PI, DI and AWD regimes that improve consistency of leaf quality and shelf life potential in Romaine (Scala) and Iceberg (Challenge) lettuce without reducing head fresh weight.

FV 454 Outdoor lettuce: Improving quality and shelf-life of Romaine and Iceberg crops using precision and deficit irrigation techniques

Term: April 2017 to March 2018

Project leader: Mark Else, NIAB EMR

Industry representative: David Edwards, Jepco Marketing

Project leader Mike Else, collaborating with the BLSA and Dr Jim Monaghan to help guide the programme of work, will be hoping that the benefits to the industry could include lower leaf water content and higher dry matter, enhanced leaf antioxidant potential, lowered propensity for postharvest midrib pinking, assured or extended shelf life and reduced pre- and post-harvest waste. Additionally, the project aims to also discover irrigation techniques that will help lettuce growers to demonstrate compliance with legislation, and provide a blueprint for using PI, DI and AWD to improve leaf quality and shelf life of other salad crops on a range of soil types.

Protecting peas from viruses

Globally, approximately 130 different viruses have been detected from pea crops. In the majority of cases these viruses are either not present in the UK or Europe (eg Cowpea mosaic virus), or are present in other plant hosts but have not been recorded from pea crops in Northern Europe. In total around 40 viruses are known to occur in the UK which have also been recorded with pea as a susceptible host. These range from viruses which are known to occur in the field (eg Pea seed-borne mosaic virus) to those which are unlikely to affect UK pea crops due to a lack of suitable vectors in the field (eg Tomato spotted wilt virus). However, there are also a significant number of these viruses which are present in the UK, and are commonly the cause of crop losses in other hosts. However there is limited knowledge regarding the status of most of these viruses on pea crops.

Research in other countries has attributed yield losses due to infection with Pea seed-borne mosaic virus (PSbMV) alone between 13% and 25%. While incidence of such viruses will vary from season to season, as well as geographic location, based on current production values this could represent an overall loss to the industry in excess of £12 million per annum. Despite the financial implications, the current distribution and impact of pea viruses in the UK is not known. Therefore, in project FV 453, Fera Science Limited's Adrian Fox will be looking to produce a literature review to identify potential viral threats to UK pea crops from viruses currently present in the UK and those viruses present in Europe which do not currently occur in the UK. The review will include reports covering loss estimation, management of viruses in pea crops, diagnostics and emerging issues.

FV 453 Pea viruses: Investigating the current knowledge on distribution and control of pea viruses

Term: April 2017 to September 2017

Project leader: Adrian Fox, Fera Science Limited

Attaining consistency in herb flavour

FV/PE 455 Herbs: determining the basis of variation in flavour

Term: October 2017 to September 2021

Project leader: Carol Wagstaff, University of Reading

At odds with consumer expectation of a consistently flavoured product, the flavour composition of herbs can vary according to differences in cultivar, agronomic practice, climate and growing season.

This is clearly an issue for herb growers, so AHDB-funded project 'FV PE 455 Herbs: determining the basis of variation in flavour' aims to understand why such variation occurs. This project will identify the extent of flavour variation in three commercially important herbs (basil, coriander and a perennial herb to be selected) so that growers can tailor their cultivation practices to optimise herb flavour in their growing system, whether in a protected or a field environment.

Current methods of addressing the problem do not exist within the industry; tasting is on an ad hoc basis, not set against quantitative standards, and it is not done in a way that allows results to be compared between seasons, sites or production methods. Relevant information from literature is not extensive and mostly relates to herbs produced for the essential oil industry.

Working in collaboration with a steering committee of growers, researchers will elucidate chemical profiles of culinary herbs under commercial production over three seasons, to understand how season, agronomic practices, cultivations systems and environment interact with this.

Flavour analysis will be done using Gas Chromotography-Mass Spectometry.

Knowledge exchange is planned such that growers will be trained how to qualitatively and quantitatively assess herb flavours using sensory panel assessment.

Claire Donkin, British Herbs Technical Officer, explained, "We can all recognise that flavour varies over the course of a season but as an industry don't have enough understanding of the links between agronomy and flavour to always actively manage these fluctuations. With this project we hope to increase our knowledge of how to grow for flavour and improve consumer confidence in our products, which could help drive sales."

Robots learn to lend a sensitive hand

CP 172: Robotic touch, sense, and learning of delicate vegetables

AHDBSTUDENTSHIP

Term: October 2017 to September 2020

Project leader: Fumiya Lida, University of Cambridge

With robotics technology becoming ever more sophisticated as a result of the advances being made by a range of industries, and costs falling as a result, automated harvesting is now a fast-moving area of research in horticulture.

There are clear advantages for field vegetables, which are still largely harvested by hand, particularly with the current uncertainty surrounding access to enough workers in the future. But the delicate nature of some crops, the market demands for blemish-free produce and the fact that an element of decision-making is involved makes it especially challenging.

The University of Cambridge's Biologically Inspired Robotics Laboratory, where this studentship is based, focuses particularly on robotics that take its lead from studies on animal biology. The laboratory's team has already designed a robotic arm equipped with artificial hands and various sensors, such as cameras, laser range-finders and tactile sensing devices, which can pick up and set down 'soft' objects and has undergone initial trials on lettuce crops at G's Growers. This new project will see the equipment, mounted on a mobile pedestal, further developed and modified to include data-processing so that the robot can 'learn', adjusting to variation in the size of lettuce head and adapting to different environmental conditions.

The scope of the investigation includes a look at other stages in the handling of the harvested product – such as inspection, overwrapping and packing – to see whether a robotic solution would be feasible.

The platform will be tested further in the field on lettuce types which differ in their shape and size, such as Iceberg and Little Gem, but trials may be extended to other vegetables, such as celery.

Keeping abreast of field veg pests

AHDB is a leading proponent of technologies that help to combat the risk of pest damage. Working in conjunction with Warwick Crop Centre, and sponsored by Syngenta, the Pest Bulletin has been providing regular updates on pest activity to growers for many years, via email, online blogs, reports and social media. The Pest Bulletin, written by Dr Rosemary Collier, director of Warwick Crop Centre, is sent out every Monday during the season of pest activity, usually April to October.

Key features for field vegetable growers include weather-based forecasts for cabbage root fly, carrot fly, pollen beetles and several aphid species which are important vectors of crop viruses. Additional real-time monitoring information is also available for a range of more than 20 crop pests collected at Warwick Crop Centre, Wellesbourne, including diamondback moth.

Keith Mawer, Agronomy Technical Manager at carrot growers Strawsons Ltd, said, "The Pest Bulletin gives an insight into what's happening at an early stage, it focuses attention and allows early intervention."

What happened in 2017?

In 2017 the Rothamsted Insect Survey forecasts of first flights by the peach-potato aphid and cabbage aphid indicated that aphids would be flying a little earlier than normal. For cabbage aphid, the main period of activity started at the end of May at sites in central and eastern England and, to date, numbers are lower than average. For peach-potato aphid, activity started in mid-May in central and eastern England – but later further north. Numbers were about average. As usual, very low numbers of currant-lettuce aphid were captured in the suction traps. Overall, numbers of black-bean aphid have been higher in 2017 than the previous year.

We left the carrot fly traps out all winter at Wellesbourne to monitor early fly activity and captured a few flies in March and early April. At present this is probably more of scientific interest than a threat to growers but shows how adaptable this pest may be. The main period of emergence of carrot flies from the overwintering population was, as predicted by the forecast, from mid-April through May.

> "Real-time monitoring information is available for a range of more than 20 crop pests"

The Rothamsted Insect Survey provided information on captures of four of the species of aphid that are potentially transmitting virus to carrot crops – peach-potato aphid, willow-carrot aphid and two species of parsnip aphid. Their activity varied from place to place but generally, one or more species was relatively abundant between mid-May and early July.

Migrating pests

In contrast to 2016, the diamondback moth hasn't been present in very high numbers so far in 2017. The new web page detailing migrant moth sightings in northern Europe (diamondback moth and silver Y moth) http://bit.ly/migrantmoth was set up this year as a result of Pest Bulletin information during 2016 and discussions with growers at the AHDB diamondback moth workshop in February. It showed that numbers of diamondback moth have been relatively low throughout northern Europe, with influxes into the UK in late May and late June. The large migration in 2016 was undoubtedly very exceptional, the last migration of such a size being 20 years ago in 1996.

"Sightings of silver Y moth in northern Europe have been very consistent during 2017, particularly in the Netherlands and Belgium. Moths have been seen since May but were most abundant during July. It will be interesting to see, at the end of the season, how this information ties up with growers' experiences," speculated Dr Rosemary Collier, director of Warwick Crop Centre.

You can view more about the Pest Bulletin here:
www.syngenta.co.uk/ahdb-pest-bulletin

Further information is also available through Rosemary Collier's Pest Bulletin blog, here:
http://blogs.warwick.ac.uk/rosemarycollier

You can access the AHDB Aphid news email updates here too

Promising new options for weed control

SCEPTREPLUS

SCEPTREplus tackles gaps left in growers' crop protection toolbox from the continued loss of actives.

First year trials of SCEPTREplus will see 10 trials take place for field vegetable crops in 2017. The four-year programme aims to secure approval of new plant protection products for growers and to help develop IPM programmes. Targets and crops were chosen in consultation with the Field Vegetable Panel, the industry steering group, and gap analysis conducted by AHDB in 2016.

For some targets, which are relevant to a range of crops including aphid control, we will be taking a model crop approach to trials, then extrapolating onto other crops.

Early results

Within the carrot and parsnip herbicide trials, which are looking for a replacement to linuron, metobromuron is proving very promising and is being tested in commercial tank-mixes on typical root crop growing soils to increase understanding of its use and performance. Growers who attended the carrot trial open day in June 2017 also discussed five treatments, in addition to metobromuron, which they thought were acceptable with regard to crop safety. These will be examined further.

Ian Holmes, company agronomist at Strawson Ltd. said, "Weed control has become more challenging with the loss of various active ingredients in the last few years, including metoxuron, pentanachlor and prometryn. In 2018 we will lose the use of linuron which has been a key component of both pre- and post-emergence weed control for many years and this will leave a big hole in the crop protection toolbox. Finding ways of filling this gap is crucial to future production."

"The SCEPTREplus work should provide useful data to support applications for products previously identified as having potential."

The celery trial is complete and, as well as gaining further information on the performance of metobromuron, a further product with promise has been identified. Work on other salad crops, such as wholehead lettuce and baby leaf salads, will be developed for 2018.

Sweetcorn trials are well underway and early indications suggest that up to five of the pre-emergence herbicide products tested are giving promising results in weed control and crop safety at a level acceptable to growers. Growers who attended the open day in July 2017 also highlighted plots sprayed with these treatments and discussions are underway to look into possibilities for future approvals.

Angela Huckle, researcher at ADAS who has conducted many of the herbicide trials, said, "Being able to discuss the results directly with growers has been invaluable. It has helped guide how we will plan trials for 2018, by understanding the level of crop safety growers will accept, key troublesome weed species to target and the control level required."

Future trials

Initial trial plans for 2018 include electric weeding for allium crops, screening pre-emergence herbicides for legumes, weed control in asparagus, and controlling charlock in Brassicas.

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

First year SCEPTREplus trials for field vegetable crops

	Target	Crop	2017 trial summary
Weeds	General broadleaf weeds and grasses	Carrots and parsnips	Replacement for linuron and testing of metobromuron
		Herbs	Crop safety and screening six products on 10 herbs
		Sweetcorn	Pre-emergence control, crop safety and efficacy
		Cucurbits	New actives and reviewing previous trials on courgettes
	Groundsel	Celery	Replacement for linuron and testing of metobromuron
Pests	Asparagus beetle	Asparagus	Creating a test protocol and evaluating new treatments
	Thrips	Leeks	Screen novel products
	Aphids	Model crop	Identify new treatments and screening novel products
Disease	Downy mildew	Model crop	Screen novel products on protected lettuce. Other crops including Brassicas to be trialled in year two
	Botrytis	Cabbage	Post-harvest application pre-storage, for control of botrytis on stored cabbage

A weed applicator that hits the spot

Responding to concerns about loss of herbicides and pressure to target pesticides better and in lower doses, project CP 134 aims to develop a herbicide ejector which will apply metered droplets to leaves of unwanted plants, building on the expertise at Reading, Precision Farm Robotics and Knight Farm Machinery.

Traditionally, growers have carried out plant-specific weeding by hand; individual plants are examined and if unwanted they are hoed or removed. Such a task can be dull, difficult and time-consuming, making it economically impossible on a large-field scale.

> “Precision targeting of glyphosate droplets in field trials with Savoy cabbages was shown to reduce amounts of herbicide applied by 94%”

The project

Precision targeting of glyphosate droplets to leaves of weeds is a leading edge procedure, and glyphosate is ideally suited to this task as not only must the herbicide be non-selective, but it must also move from the point of application to other leaves and the roots.

In this, the third year of the four year study, the research team has been applying droplets to the weeds by hand in UK-based trials while the droplet applicator is being developed. This has allowed them to test for efficacy, proof of concept and to evaluate the potential benefits of this method.

The droplets used were very small (1–2 microlitres), so that one teaspoon (5ml) would be enough to treat between 2,500 and 5,000 individual weeds if one droplet is placed on each weed. Nevertheless, these droplets are larger than those used when spraying so that there is no risk of either spray drift but nor are they large enough for spatter.

“This is a pioneering project, as we are exploring a combined engineering and chemical solution to weed control in field vegetables. By accurately targeting leaf-specific droplet applications, it is the ultimate in precision agriculture. The importance of the successful findings of the project cannot be over-stressed and it is, therefore, particularly important that systemic, broad-spectrum active ingredients such as glyphosate remain available to farmers and growers,” commented project leader Alistair Murdoch.

The results

This precision targeting of glyphosate droplets to leaves of weeds in field trials with Savoy cabbages was shown to reduce amounts of herbicide applied by 85% compared to a single inter-row spray and by 94% compared to a pendimethalin pre-emergence spray (Stomp Aqua®, 455g/l pendimethalin, CS, BASF plc).

Three sequential treatments with droplets three, five and seven weeks after transplanting the seedlings achieved the maximum crop yield and weed suppression. This strategy also mitigates the risk of herbicide resistance, since weeds surviving an initial treatment, would be retreated on a subsequent visit.

It will also be a relief to growers to know that the findings revealed that glasshouse trials showed efficacy of droplet applications of glufosinate-ammonium so that if approval for use of glyphosate were to be withdrawn, an alternative product is available.

What next?

An economic evaluation of the results is planned to be carried out in 2018.

CP 134: ‘eyeSpot’ – leaf specific herbicide applicator for weed control in field vegetables

Term: October 2014 to September 2018

Project leader: Alistair Murdoch, University Of Reading

Options to control coriander yield decline

One of the most frustrating aspects of growing coriander is the phenomenon of yield decline. Information from UK growers suggests that coriander yield declines by over 50% when the crop is planted in successive years in the same field, and can persist for up to eight years. Growers are often limited by the amount of available land for crop rotation, compounding the problem.

Interestingly, growers in southern Spain do not observe any signs of yield decline in their crops, despite repeated cropping on the same soil. It’s suspected this is due to the soils being ‘solarised’ over the summer period – a method that raises soil temperature and dries soil, probably resulting in partial soil sterilisation and a change to microbial communities.

> “Interestingly, growers in southern Spain do not observe any signs of yield decline in their crops, despite repeated cropping on the same soil”

The project

The overall aim of project CP 117a is to investigate potential soil management methods to prevent coriander yield decline. This project follows on from the success of project ‘CP 117 Coriander: investigating the cause and potential treatment of coriander yield decline’, which showed that the phenomenon can be reproduced under controlled greenhouse conditions using different coriander varieties and soil types, and also that root autotoxicity is unlikely to be the main cause of yield decline. One hypothesis from the observations of CP 117 would be that coriander growth under current horticultural production conditions (minimum tillage) results in the formation and persistence of a soil community that has the ability to reduce coriander yield. Therefore it’s possible that a perturbation of this community (eg by deeper soil tilling after coriander growth, soil amendment, desiccation or biofumigation) may prevent or reduce yield decline.

Given this background, project CP 117a will examine potential soil management strategies that change the soil microbial community present in the hope of reducing the yield decline effect.

CP 117a Coriander: potential management options for yield decline

Term: March 2017 to February 2018

Project leader: Ian Singleton, Edinburgh Napier University

Light used to scan for signs of stress

Technologies that may be capable of detecting the first signs of plant stress caused, for example, by drought or disease, before symptoms become visible, are already the subject of horticultural research. This is because of their potential to remove human subjectivity in crop monitoring, to automate some aspects of crop management and to improve pest and disease control by applying treatments earlier. Such technologies include 'electronic noses' that sniff out volatile compounds and thermal imaging which picks up changes in plant temperature.

Another approach that may have a similar application is to look for 'biomarkers' – changes in an organism produced in response to, or as a byproduct of, some kind of physiological disturbance.

The project

In this studentship Paul Skolik is working with two techniques, one which uses infrared light and another which uses laser light, which can identify changes in plant tissue from the changes in their unique 'spectral fingerprints' generated when attacked by pests or pathogens.

He has already shown that it's possible to obtain such 'fingerprints' from intact plants, for instance in the response of tomato leaves to physical damage and of rhododendron leaves to various degrees of leaf spotting. Further investigation will see him characterise the differences between healthy and mildly infected rhododendron leaves to see if he can pin down spectral biomarkers associated with tissue death from leaf spots before visible symptoms appear.

Skolik is also assessing the potential of these techniques to monitor the shelf life of produce. In experiments undertaken on shop-bought apples and cherry tomatoes, he found that in some cases spectral changes associated with loss of quality were not observed until several days after the sell-by date on the retail pack.

CP 119: Sensor-based pre-symptomatic detection of pests and pathogens for precision scheduling of crop protection products

AHDBSTUDENTSHIP

Term: October 2015 to September 2018

Project leader: Martin McAinsh, Lancaster University

> "In some cases spectral changes associated with loss of quality were not observed until after the sell-by date on the retail pack"

White tip tackled on several fronts

The oomycete pathogen responsible for white tip of leeks, *Phytophthora porri*, develops from swimming zoospores splashing onto leaves from soil and so thrives in wet conditions. Few fungicides are available to manage it, therefore, AHDB project FV 446 is exploring ways to improve control from several angles.

Chemical and biological products used against other oomycetes, such as downy mildews and potato blight, are being tested for their potential as foliar sprays and also as drenches in propagation to see if the plants' resistance to infection can be enhanced. Products that target the pathogen's resting spores in the soil are also being assessed.

Information on conditions for disease spread, gathered from literature and from field observations, will be used to assess the feasibility of using weather data to aid growers' decisions on if, when and what to spray.

FV 446 Leeks: white tip control *(Phytophthora porri)*

Term: April 2016 to May 2018

Project leader: Erika Wedgwood, ADAS

Results so far

Foliar-applied plant protection products were trialled on a site in the east of England last year but no significant differences were found in the incidence or severity of white tip between untreated and treated plots. The trial is being run this year on a site in the (usually wetter) western side of England. Temperature and rainfall records from in-field meteorological stations at both sites will be examined to see how the weather affected symptoms.

Varieties with known susceptibility to the disease, and others which anecdotal evidence suggests are more tolerant, were selected for testing, by deliberately inoculating with zoospores into water held in the leaf axils. By the end of the trial no statistically significant differences were seen in either disease incidence or severity.

Neither gypsum nor Limex nutrient treatments reduced the incidence of infection from resting spores in artificially inoculated growing media, at the rates and timings used.

Onion basal rot reveals its fingerprints

Basal rot in onions is caused by the soilborne fungus *Fusarium oxysporum f.sp. cepae*, just one of the many forms of *F. oxysporum* adapted to a specific host plant. But not all types of *F. oxysporum* are pathogens and some may even be beneficial.

The different forms are notoriously hard to tell apart, either by the symptoms they produce or their appearance in laboratory cultures, which makes it difficult for growers to manage the disease and researchers to investigate it.

The project

AHDB Horticulture was a partner in this Horticulture and Potatoes Initiative (HAPI) project which worked on the genetics responsible for pathogenicity in *F. oxysporum f.sp. cepae* and which could form the basis of a new test for the disease.

Results

Isolates of *F. oxysporum* from onions and from field soils were tested for pathogenicity and analysed for the presence of 'secreted in xylem', or six, pathogenicity genes. Just over half of the isolates proved highly pathogenic to onion and these all contained the same seven pathogenicity genes. The non-pathogenic isolates had none of them.

The SIX genes from each of the *F. oxysporum* forms have been sequenced and although some have the same genes in common, the DNA code for each is different. A new AHDB project (FV PO BOF 452) will use these results as the first stage in developing methods for detecting, identifying and measuring the numbers present of a range of Fusarium species.

Meanwhile, working with project partner Hazera Seeds, onion populations have been developed that show a range of basal rot resistance. Their genetics have been compared to identify genes and molecular markers associated with resistance. The markers will help accelerate the breeding of new varieties.

CP 116: Exploiting next generation sequencing technologies to understand pathology and resistance in Fusarium (Horticulture and Potatoes Initiative)

Term: October 2013 to March 2017

Project leader: John Clarkson, University of Warwick

Big data guides resistance breeding

Botrytis and Sclerotinia can both cause substantial losses in field-grown and protected lettuce, attacking late in the production cycle. There are few fungicides that growers can draw on for control, with some ruled out by their harvest intervals. Developing long-lasting resistance would be a more sustainable solution, but has so far proven difficult using traditional breeding.

The project

By studying lettuce's natural resistance to the pathogens and using modern data analysis – so-called 'big data' techniques – the research team is identifying the genes that can reduce the impact of infection and which could be exploited by commercial breeders.

Results so far

Around 100 types of wild and cultivated lettuces were screened for resistance or susceptibility to both fungi by inoculating their leaves with spores and measuring any lesions that arose.

Lines with varying levels of resistance have then been crossed and the groups of genes that correlate with differences in disease resistance among the progeny are being identified. Genetic markers associated with these genes can then be mapped.

At the same time, the team has used modern gene sequencing technology to track how genes respond to infection. Every gene within the plant can be simultaneously analysed, which has resulted in more than seven million measurements. All this data is being 'crunched' to predict genes which have a key role in activating the plant's defence response.

The team is now starting to test these predictions. Using 'genome editing' techniques, genes can be knocked out to see whether that affects the ability of the plant to resist infection. If the predictions prove accurate, they can then focus on identifying the markers associated with these genes which breeders will be able to use to accelerate the development of resistant varieties.

CP 152: A systems approach to disease resistance against necrotrophic fungal pathogens in lettuce (Horticulture and Potatoes Initiative)

Term: May 2015 to May 2018

Project leader: Katherine Denby, University of York

Capsids that are on the rise in celery

Recent incidences of damage in celery suggest that capsid bugs are becoming an increasing problem on this crop.

Three capsid species could be involved: common green capsid, European tarnished plant bug and what appears to be *Orthops campestris*. Invasion of crops is unpredictable and relatively little is known about aspects of biology that could point to more effective control.

FV 441 Celery: investigation of strategies to control capsid bugs in outdoor crops

Term: April 2015 to March 2017

Project leader: Rosemary Collier, Warwick Crop Centre

Current control in celery relies on a few broad-spectrum insecticides and the use of mesh covers in organic crops.

The project

The capsids responsible for damaging celery were identified and their lifecycles studied; strategies for their control were reviewed and treatments evaluated.

Results

The most abundant capsid species collected from plants in organic and conventionally grown celery crops, and from field margins, was identified as adult *Orthops campestris*. Common green capsid *(Lygus pabulinus)* and European tarnished plant bug *(L. rugulipennis)* were found alongside *O. campestris* in field margins.

O. campestris appears to be common on weeds of Apiaceae, the carrot and celery family, overwintering as an adult in field margins, and is most likely to complete three generations in a year. Destruction of wild hosts in field margins may reduce infestations by *Orthops spp*.

Of the insecticides approved for celery, lambda-cyhalothrin was the most effective against adult *Orthops spp*. Pyrethrins were ineffective. A laboratory study at Stockbridge Technology Centre showed the potential for various predatory natural enemies to control the capsid, feeding on nymphs in particular.

It is key that growers monitor crops and field margins to determine levels of *Orthops spp*. activity as this will help to time control methods. Fine mesh netting can be used to exclude *Orthops spp*. from susceptible crops but once a crop is uncovered, capsid bugs from field margins may move rapidly.

Stopping the rot

The bulb and salad onion sectors, at 8,945ha and 1,601ha respectively, were worth £97 million and £24 million in 2013 (Defra horticultural statistics, 2014). White rot can greatly reduce marketable yields and cause significant financial losses. Once a field becomes infested it is very difficult and costly to continue growing the crop as the sclerotia can survive for at least 20 years. It is estimated that a minimum of 2–3% of UK bulb onions are affected annually, equating to around £2.9 million of lost crop. In salad onions the level of damage is higher. If these losses were reduced by 50% through development of an integrated control approach, the value of bulb and salad onions would increase by £3.3 million annually. There is therefore an urgent need to identify and develop integrated strategies for effective and long-term management of the disease.

The project

The main aim of the first phase of the project was to review the recent research from across the world on Allium white rot, focusing primarily on physical, chemical and biological approaches to disease control.

A literature search was undertaken to review relevant scientific publications, conference reports, project reports (both AHDB and from overseas), and technical information concerning *Sclerotium. cepivorum* and its control. Published information on related sclerotial pathogens (eg *S. rolfsil* and Sclerotinia species) and other soilborne pathogens such as species of Verticilium and Fusarium was also included where relevant. ADAS carried out the majority of the review with support and editing provided by Warwick Crop Centre.

> “Outlay of around £500 would be worthwhile given crop values of over £10,000 per hectare”

The results

For chemical control, the review found that while tebuconazole has been widely used for white rot control in the UK, alternative chemistry such as azoxystrobin, boscalid, penthiopyrad and procymidone have good potential, seeing a 77%–95% disease reduction rate in US and Australian studies.

Despite extensive research across the world, when it came to biological control methods, only one microbial product (Tenet) is registered specifically for use against white rot, in New Zealand and Australia. However, a recent AHDB study (FV 219b) demonstrated that some UK registered biocontrol agents such as Serenade ASO *(Bacillus subtilis)* and Prestop *(Gliocladium catenulatum)* may reduce disease by 70–77%.

Meanwhile, studies into research around sclerotial germination stimulants revealed that *S. cepivorum* only germinates in response to sulphur-related chemical compounds released from the roots of Allium plants. One of these with a high stimulatory effect is diallyl disulphide (DADS) which has been used to artificially initiate germination in the absence of a host, resulting in up to an 80–90% reduction in viable sclerotia. Similarly, composted onion waste has also been used to achieve the same result but application rates and supplies are limited.

The study also looked into the use of soil disinfestation.

What does this mean for growers?

Allium white rot control needs to be sustainable and remain effective over the medium to long term, which is challenging due to the diminishing availability of effective fungicides/ chemical soil sterilants and the absence of other fully effective disease management options. Integrated disease management programmes that combine a wide range of management options such as soil type, inoculum reduction, and varietal susceptibility offer the greatest potential for long-term sustainable control of white rot.

Integrated control could, for example, include the use of anaerobic digestion solids in ASD (£125/ha) or germination stimulant (£180/ha) to reduce sclerotial inoculum followed by fungicide (£18/ha) or biological (£288/ha) treatments. The possible overall outlay of around £500 would be financially worthwhile given crop values of over £10,000 per hectare.

FV 449 Onions: Investigation into the control of white rot in bulb and salad onion crops

Term: April 2016 to September 2016

Project leader: John Clarkson, Warwick Crop Centre

Improving basil downy mildew understanding

Although widespread in Europe, basil downy mildew was new to the UK in 2010. In PE 024, Fera Science with Stockbridge Technology Centre (STC) and NIAB aim to plug some knowledge gaps about the disease through laboratory, glasshouse and field experiments, looking at sources of infection, the conditions that favour infection, and the most effective control methods.

PE 024 Basil: improving knowledge and control of downy mildew in protected and outdoor crops

Term:
September 2015 – October 2017

Key staff: Tom Wood, NIAB
James Townsend, STC

Project results so far

Initially the project looked at risk factors for infection of basil by *Peronospora belbahrii* (the basil downy mildew pathogen). Infection occurred at temperatures between 5 and 25°C depending on leaf wetness duration but negligible infection occurred at 30°C. Moreover, results suggested that basil downy mildew infection is only likely to occur in the dark and at relative humidity greater than 70%.

The project examined whether *P. belbahrii* was present in UK seed lots and if infected seed can act as a primary source of infection. Of 20 seed lots tested, all but one contained *P. belbahrii* DNA. Seed washings from all samples were checked for the presence of oospores. None were found, suggesting that the pathogen DNA was inside the seed rather than present as a surface contaminant.

Fourteen plant species from the same family as basil were inoculated with *P. belbahrii* to check if they were capable of harbouring the disease. Results demonstrated that agastache, lavender, sage and catnip can all act as alternate hosts for *P. belbahrii*.

Fungicides with the best potential for controlling basil downy mildew were tested to establish the most appropriate interval between applications. Fenomenal, Paraat and Revus offered good protective activity when applied up to 10 days before infection and so could be used in a weekly fungicide programme to prevent the disease.

Pea mildew races and resistance on the map

Current control of downy mildew in vining peas is limited to a seed treatment (which can no longer be used to protect peas drilled in February or March), crop rotations, and any tolerance that individual varieties can offer.

Some pea varieties are reported to underperform in some regions of the UK, however, because of the presence of different strains, or races, of the pathogen which can overcome a variety's tolerance to the disease.

The project

Identifying the different downy mildew races and mapping their UK distribution could help growers choose varieties less susceptible to infection in their area. Information from the project will be passed back to pea breeders to help them improve disease resistance in new introductions.

Results so far

PGRO was able to determine the race of 42 samples of pea downy mildew from infected plants during 2016.

Seedlings of four pea lines with known resistances and susceptibilities to 11 downy mildew races were inoculated with the pathogen samples, and presence or absence of any subsequent infection recorded. Thirteen different races were identified in the 42 samples analysed.

Seedlings of two potential breeding lines were also inoculated to see whether any of the samples could overcome their resistance genes. Eleven samples were able to overcome the resistance of one or other of the two, and one was able to overcome both.

Race 10 occurred the most frequently in 2016, found at eight of 12 sites sampled. At no site where more than one sample was collected were they all of the same race.

A range of commercial varieties were grown in field trials at six locations in 2016 to assess their susceptibility to the different races. Several showed greater susceptibility to the disease in some locations than in others.

FV 436: Pea downy mildew diversity in the UK

Term: April 2014 to March 2018

Project leader: Lea Herold, PGRO

Know how to keep soils in good shape

A comprehensive programme to improve growers' ability to manage soils, and hence the long-term sustainability of field crops, was rolled out in 2015 after an AHDB-funded review had identified where the industry's know-how could be improved.

Work was recommended in areas such as the soil parameters that growers need to monitor, and new 'smart technology' to measure them; soil amendments and nutrient applications; and the role of 'precision agriculture' in soil management.

The programme, known as GREATsoils, combines research with knowledge exchange through a series of events, publications and web-based information.

The projects

CP 107b is helping growers to assess soil health and make decisions on any remedial action that may be needed. Practical, simple and cheap-to-use methods were reviewed in the first part of the project. Three are being field-tested on five vegetable farms: earthworm counts; visual soil assessment tools; and NRM Laboratories' soil health tests which cover biological, chemical and physical soil properties. Soil health and soil testing information is being provided to growers through a series of publications, webpages and practical workshops.

CP 107c is looking at how precision farming can be used to manage soil conditions and nutrition in field vegetables and other soil-grown crops. A review of precision farming technology undertaken during the project's first year led to a series of 'demonstration projects' on farms – three in 2016 and three in 2017 – to test practical applications for various cropping situations.

Results so far: soil assessment

Early findings from the field trials of soil assessment methods suggest that each needs to be tailored to the specific cropping system. For example, the visual assessment tool, originally developed for grasslands, is proving less relevant to horticultural systems, particularly where growing on beds, though the project team believes it could be improved by timing, for example when the soil has had chance to settle after bed-forming.

It has turned out to be crucial to perform earthworm counts in spring or autumn, when they are most active in the soil's top layers, and to take soil management practices such as tillage into account when interpreting results.

Along with several additional methods, the tests are being assessed again in 2017 with some modifications in light of the first year's findings.

A series of soils 'field lab' trials began at the end of 2016 in conjunction with the Innovative Farmers network. These year-long grower-led demonstration trials cover topics such as use of cover crops in a shared rotation and the impact of digestate on soil health.

Andy Richardson, Allium & Brassica Centre, said, "More uniform cropping, improved yields and quality, more cost-effective harvesting and less waste would all result from the ability to manage the variation caused by changes in soil properties across a field. Project CP 107c is showing how growers can achieve that using the latest advances in precision farming technology."

Case studies have already been issued on the use of compost, soil testing for carrot production, soil management for asparagus and pH testing pitfalls. A series of grower workshops, web-based seminars and demonstration days started in 2016 and continues through to the end of the project.

www.ahdb.org.uk/greatsoils

GREATSOILS

CP 107b: Growing resilient, efficient and thriving soils

Term: April 2015 to March 2018

Project leader: Ben Raskin, Soil Association

CP 107c: Precision farming technologies to drive sustainable intensification in horticulture cropping systems

Term: April 2015 to March 2018

Project leaders: Lizzie Sagoo and Paul Newell Price, ADAS

> “The crop showed a significant yield response to nitrogen, ranging from 10 tonnes/ha without nitrogen fertiliser to 44 tonnes/ha at the highest rate”

Results so far: precision farming

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

At the same time the project team reviewed precision farming techniques and surveyed their use in horticulture, to select those most likely to improve crop nutrition and soil health, for more detailed study.

Three studies in 2016, in the form of demonstration trials at farms already working with the technology, looked at canopy sensing for variable rate nitrogen application, controlled traffic farming (CTF) and explored options for soil mapping.

Canopy sensing measures reflectance from the crop foliage, to produce a vegetation index. The trial looked at the potential for canopy sensing to guide variable rate nitrogen application to a Savoy cabbage crop.

There was a strong relationship between the vegetation index from crop scanning and the crop’s biomass and nitrogen uptake. The crop also showed a significant yield response to nitrogen, ranging from 10 tonnes/ha without nitrogen fertiliser to 44 tonnes/ha at the highest rate. The project team concluded that canopy sensing could serve as a basis to vary nitrogen applications although, in this study, the crop’s response was similar across the field – and variable rate applications will only be worthwhile if differing soil nitrogen levels are the main cause of variability in the crop. The variability in the crop canopy that the scanning picked up was probably due to other factors, and not nitrogen, in this trial.

CTF helps manage soil compaction by restricting machinery in the field to tightly defined ‘lanes’ controlled by GPS. Barfoots, which hosted the trial, has converted most of its operations to the system. The study included a comparison of the proportion of a field tracked by machinery before and after conversion, savings in fuel use and the impact on soil quality and crop variability.

Adopting CTF resulted in a reduction of up to 63% in the area of the field that was crossed by machinery. Detailed soil and crop measurements are being taken in the 2017 sweetcorn crop in two fields, one in its second year of CTF and the other in its sixth.

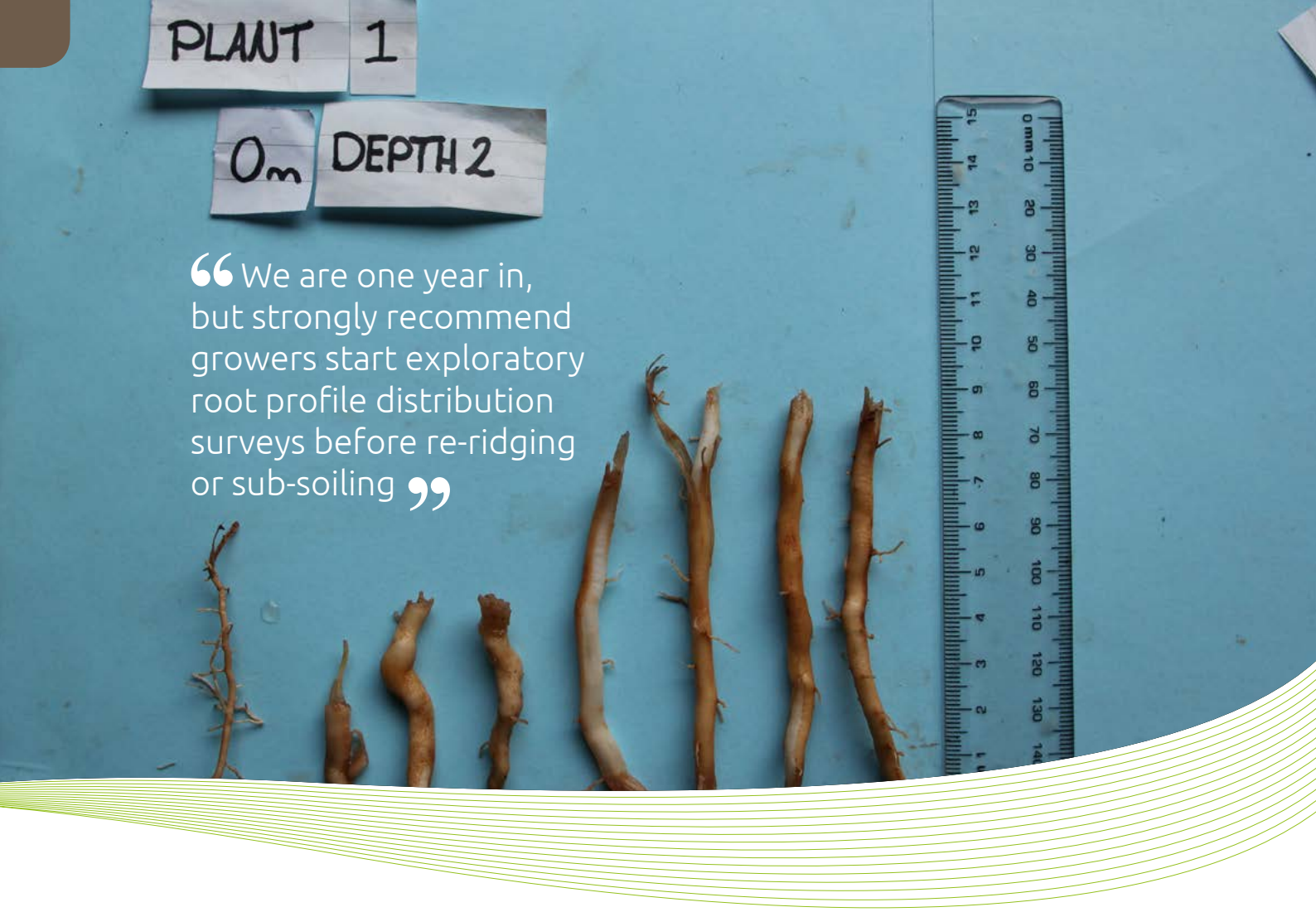
A longer term study has also been established (through funding from the AHDB Soil Health/Soil Biology Partnerships projects) in three fields – one under CTF, one under conventional tillage and one in permanent grassland – to assess the cost and benefits of a reduced tillage and controlled traffic approach. The fields were assessed this year and will be reassessed and the results compared in several years’ time.

Soil mapping, based on properties such as texture, compaction, pH, nutrient reserves and organic matter content, is key to managing crop variability caused by variation in these characteristics. A study site in Bedfordshire was chosen for its significant in-field variability in soil type.

Soil samples taken on a 25m grid pattern were analysed for pH and nutrient levels and the results used to create maps showing how relying on fewer samples could have affected the result. In fields such as this the significant variability over a small area doesn’t show up on maps based on taking one sample per hectare, which is typical commercial practice.

A comparison with results from EC sensing and electromagnetic resonance soil scanning found that both technologies were able to produce maps that compared well with results from actual soil analyses. Both correctly identified areas of lighter and heavier texture. Soil brightness maps obtained from satellite imagery were shown capable of revealing the combined effects of soil texture, organic matter content and soil moisture at the time the image was taken but the information is only reliable when taken when the soil is completely bare.

Open days for growers have been held at each site in 2016 and similar events are being staged in 2017. All event details, along with the advisory information based on the results from the programme, can be found on the GREATsoils pages of AHDB Horticulture’s website.



> “We are one year in, but strongly recommend growers start exploratory root profile distribution surveys before re-ridging or sub-soiling”

Could min-till asparagus just keep growing?

A new AHDB Horticulture project assessing root distributions of asparagus varieties Gijnlim and Guelph Millennium may hold the key to minimising root damage associated with re-ridging and sub-soiling operations.

The success of this project could have a significant impact on stand longevity and productivity of asparagus through reducing vulnerability to crown and root diseases that can result in premature yield decline.

Field operations associated with UK asparagus production, such as re-ridging, tillage and spray operations, and harvesting, can result in progressive and severe compaction of all inter-bed wheelings.

Compaction of wheelings can in turn lead to a significant reduction in rain infiltration, resulting in an increased risk of surface water ponding and on sloping land, run-off and erosion.

Surface water ponding compromises field operations, impacting on both foot and vehicular traffic, while ponding in furrows increases the risk of crown and root rot leading to yield decline.

Resource Management Scientist Dr Jim Dimmock added, “We believe that insight into the impacts of soil management practices on crop longevity from this project could be very significant and, given the very high costs of establishment of asparagus, this should be of great interest to growers.”

Key findings

Root mass density values were generally higher for Gijnlim as compared to Guelph Millennium for most soil depths and sample locations.

For both varieties, one year after planting circa 65% of the total measured plant root mass was found at the crown zero line, near the surface at 0.0–0.15m depth.

Further away from the crown zero line, roots tended to be mostly in the 0.15–0.30m and 0.3–0.45m soil layers and avoid the topsoil (0.0–0.15m).

Very few roots have explored the soil at 0.3m, 0.6m and 0.9m away from the crown zero line.

For both varieties, there were no roots detected (RD values <0.1kg m-3) in any of the root cores (0.0–0.45m depth) taken 0.9m away from the crown zero line.

Re-ridging

For both Quelph Millennium and Gijnlim there was a risk of damaging 7–9% of total root biomass if the rotating tines of the bed-former used were to till soil to 0.15–0.3m depth within 0.3m of the crown zero line.

In addition, for Guelph Millennium there was a risk of damaging two percent of total plant root biomass if the rotating tines of the bed-former till soil to 0.0–0.15m depth within 0.3m of the crown zero line.

Sub-soiling for erosion control

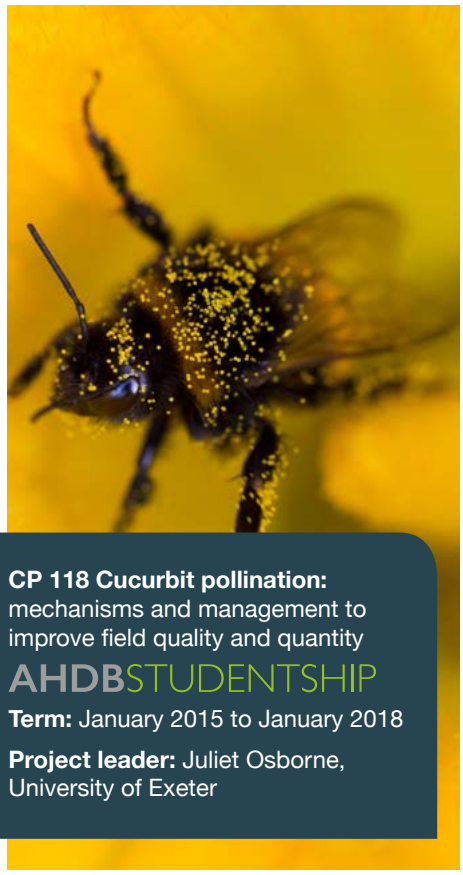
The year-one field trial results indicate that for both Gijnlim and Guelph Millennium varieties sub-soiling operations (as a mitigation measure to improve infiltration for the control runoff and erosion) could be undertaken at operating depths of 0.175–0.3m, when crowns are planted on 1.83m centres.

Dr Rob Simmons, Cranfield University, said, “Although we are one year in, we would strongly recommend growers start exploratory root profile distribution surveys before re-ridging or sub-soiling.”

FV 450 Asparagus: Sustainable soil management for stand longevity and yield optimisation

Term: May 2016 to March 2018

Project leader: Rob Simmons, Cranfield University



CP 118 Cucurbit pollination: mechanisms and management to improve field quality and quantity

AHDBSTUDENTSHIP

Term: January 2015 to January 2018

Project leader: Juliet Osborne, University of Exeter

Pollinators prove their worth to fruit set

Fruit set in most cucurbits depends on insect pollination but how effective native insects are at pollinating UK courgette crops isn't known and is a question that PhD student Jessica Knapp is looking to answer.

In collaboration with cucurbit growers, Knapp is conducting studies on field-grown courgettes to assess the effectiveness and abundance of pollinators to see whether pollination is limiting crop quality or yield and, if so, under what conditions.

Ellis Luckhurst, PE Simmons & Son, explained, "If pollinators are integral to the success of a courgette crop, there are likely to be ways that growers could boost their populations which could increase yields."

Preliminary results from field experiments in 2015 showed that while open pollination or pollination by hand increased the rate at which fruits grew, and their size and weight, many courgettes were able to reach marketable size by natural parthenocarpy. This prompted Knapp to analyse the findings from studies from around the world that had explored the effect of techniques being used either commercially or experimentally to promote parthenocarpy, such as hormone applications, or selective breeding or genetic modification.

She has since collected further data on the effect of pollination on the yield of courgettes at additional grower sites in order to gauge how dependent the UK crop is on pollinators; calculating that pollinators contribute about £2.7 million to the value of UK courgette production.

Knapp attributed the high levels of pollination observed at sites in Cornwall to the abundance, rather than diversity, of pollinators. Where pollinator numbers and crop yields vary between locations, it's likely due to differences in the landscape surrounding each study site. Despite that, the yield of open-pollinated courgettes did not fall the further the plants were from the crop margin, which Knapp concludes to be a result of the small size of the county's fields.

Pumpkin trials show smashing possibilities

With the £15 million market for pumpkins growing year-on-year alongside growers suffering annual losses of £2–3 million for decorative pumpkins alone, an AHDB Horticulture project has shown the potential benefits of utilising a programme of field treatments to improve competitiveness.

The use of fungicides for the control of Phoma and powdery mildew, combined with mineral nutrition, increased yields of marketable pumpkins with some reduction in post-harvest rots.

The project

The project helped identify Phoma and Fusarium within the crop and led to successful application of two EAMUs (Signum and Switch), giving growers chemical controls that were not available before the project.

Two sites tested a spray programme for control of Phoma and powdery mildew, combined with mineral nutrition. The programme relied on the use of Signum and Nimrod with mineral nutrition focussing on calcium, boron, manganese, copper and magnesium.

A simple cost benefit analysis for each site, assuming a cost of 80p per pumpkin, indicated that the spray costs were more than compensated for in each case; thus in Kent a spend of £232 per ha gave a gain of £560, while in Cambridgeshire a spend of £341 per ha gave a very substantial gain of £3760.

Peter Waldock, Growing Earth Consultancy, said, "The market for pumpkins is currently much stronger in the USA than in the UK, therefore horizon scanning through literature and liaising directly with American partners provided the fundamental baseline knowledge."

Debbie Rees, (NRI) project leader, said, "We recognised a strong emphasis is placed on chemical control of mildew in the US; the perception being that mildew damage of the stem increases the entry of rotting pathogens into the pumpkin. Our findings indicate that greater additional benefits can be obtained through a programme for Phoma control coupled with mineral nutrition."

FV 439 Cucurbits: Identifying pre-harvest, harvest and post-harvest management practices capable of reducing losses of pumpkins during storage

Term: October 2014 to February 2017

Project leader: Dr Debbie Rees, NRI, University of Greenwich

Holding onto the colour of freshness

Fig 1 – Celery samples – General block 1

Fig 2 – Celery samples – General block 2

Fig 3 – Celery samples – General block 3


Fig 4 – Celery samples – Butt ends block 2


Fig 5 – Celery samples – Butt ends block 3


Fig 6 – Celery samples – Cut ends block 3

With most shoppers judging the quality and freshness of edible produce by its colour, the browning that can occur on the trimmed stalks and butt ends of celery after harvest, and the discolouration of lettuce leaves which can occur in salad packs are responsible for a significant amount of wastage.

Over the course of project CP 079, PhD student Simone Rossi undertook experiments to see how agronomic factors, such as water stress or the stage at which the celery is harvested, might affect the likelihood of post-harvest browning.

Project CP 150, meanwhile, is looking for a genetic solution to discolouration of lettuce after harvest by breeding varieties with less propensity to pink or brown. To do this, researchers need to find out more about the underlying genetics and biochemistry.

Results so far

To understand the role of water stress in browning, Rossi ran a deficit irrigation trial on pot-grown celery in a polytunnel, imposing three irrigation treatments. Browning after harvest was more pronounced in plants that had been under most water stress, irrigated with 400ml every other day, and least pronounced in those watered with 800ml every other day to simulate standard practice.

In his studies on the influence of crop maturity, heads were harvested from crops in Cambridgeshire and Spain to source immature, mature and over-mature material which was then assessed for browning at intervals during storage.

The more mature the celery was at harvest the more likely it was to brown, while discolouration also increased with storage time, developing most rapidly in the first six days after harvest. Significant levels of phenolic compounds were measured in the tissues at both the cut petiole and butt ends.

Rossi also investigated the effects of ethylene and of 1-MCP, which is used during storage and transport of some fruit and vegetables to control ethylene levels. Exposing harvested heads to ethylene in store stimulated metabolic activity but did not trigger post-harvest discolouration, suggesting that browning seems to be independent of ethylene.

In CP 150, the research team has assembled a set of experimental lettuce lines derived from a cross between the varieties Saladin and Iceberg, and which are already known to show differences in the amount of pinking or browning they suffer from. The lettuces have been grown and processed in a way that mimics commercial practice and then the packed leaves assessed for the discolouration that develops. The results are being checked against each plant's DNA profile to identify groups of genes that correlate with this variation.

The same lettuces are also being analysed for compounds produced by a biochemical pathway thought to generate the pigments that cause discolouration. Scientists know from other studies which genes control the pathway and the team is now looking at how these genes behave under different growing conditions in lettuce plants that don't discolour and those that discolour badly.

Because the compounds that are produced influence other quality factors, the lettuce lines are being assessed for their taste and resistance to aphids and mildew too.

Emma Garfield, G's Growers, commented, "There has been relatively little research on the causes of browning in harvested heads of celery, and how growers could mitigate it, so this project was useful in pointing out what factors to focus on in future work."

CP 079: Understanding the underlying mechanisms and the role that pre-harvest horticultural maturity, agronomic factors and growing conditions have on post-harvest discolouration in celery

AHDB STUDENTSHIP

Term: September 2013 to March 2017

Project leader: Leon Terry, Cranfield University

CP 150: A genetic approach to improving post-harvest quality (Horticulture and Potatoes Initiative)

Term: May 2015 to May 2018

Project leader: David Pink, succeeded by Jim Monaghan, Harper Adams University

Blocking media blended by design

Research carried out by the horticulture industry to find alternative raw materials that could substitute for peat in growing media has whittled down potential candidates to just four key ingredients: bark, coir, green compost and wood fibre.

Many growers have already reduced the peat content of their growing media but each sector has its own specific requirements in terms of the physical and chemical characteristics that their crops need from the medium – and rather than rely on a straight substitute for peat, a more sustainable solution lies in having a range of materials to choose from that can be blended to do particular jobs.

The development of a model which can predict the performance of different blends will give growers confidence to use them and also help to increase the range of materials available because it will be a quick way of showing which have potential and which don't.

The project

Funded by Defra, AHDB Horticulture and the industry, this five-year project was commissioned in response to the report by the Sustainable Growing Media Task Force in 2012 that highlighted the need for research to demonstrate the viability of new substrates that would overcome barriers to their uptake.

"Predicting the performance of various raw materials will lessen the industry's dependence on peat and improve its resilience to factors outside of its control, for instance if the supply of one particular material runs short," commented Emma Garfield of G's Growers.

Results so far

The work began with analysis of the physical and chemical properties of bark, coir, green compost, peat and wood fibre from the four growing media manufacturers who are partnering the project.

In grower-hosted trials in 2016 a range of current commercial peat-reduced and peat-free growing media blends were tested on a range of ornamental and edible crops to provide baseline information about their performance that, along with the analysis results, could start to shape the model.

Five blends were trialled alongside peat alone for raising Iceberg lettuce in blocks for spring and early and late summer cropping at G's. The blends were: 80% peat with either 20% coir or 20% bark; 60% peat with either 40% coir or 40% bark; and G's own blend of 80% peat and 20% anaerobic digestate.

In terms of lettuce germination and initial growth, there was little difference between most of the blends for each of the trials.

At the point of being transplanted, the blocks were checked to see how well they held together, which is a key concern for growers. There was a very small amount of crumbling from each of the blends, but this didn't cause any issues at planting and the blocks were able to pass through the planter with ease.

For the spring and early summer crops there was little difference in yield and quality between the treatments, although heads from one of the 60:40 peat:bark blends were much smaller than from the other treatments. For the late summer crop, most of the blends yielded heads below the 450–500g specification, but this may have been due to the later planting date when shorter days meant the plants simply needed a longer growing time.

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

Term: January 2015 to December 2019

Project leader: Barry Mulholland, ADAS

More tests planned for broccoli harvester

KMS Projects have been trialling various vision-guidance systems on different crops over the last few years with the long-term aim of developing a harvester with a robotic cutting arm.

By the end of 2015, the team had manufactured a rig that could successfully identify broccoli heads, where they were not obscured by leaf cover, and send the arm to point at only those which met a pre-set size.

The project

AHDB is funding the next stage in the machine's development where KMS Projects is collaborating with the University of Lincoln on a working prototype of a module rig with cutting mechanism which could be used as the blueprint for a commercial model capable of simultaneously harvesting nine rows of broccoli. This part of the project runs from June 2016 to December 2017.

The team set themselves two objectives for the 2016 broccoli season – to improve and refine the rudimentary prototype into a rig capable of identifying and sizing broccoli heads, and to create a suitable cutting solution.

In 2017, the team expect to further improve and refine the prototype to take into account learnings from the 2016 field trials and to develop the system so that it is capable of cropping curds that are partially obscured by leaf cover.

Jim Dimmock, resource management scientist at AHDB, said, "KMS are using their technical expertise to develop robust practical machinery – we have high hopes for the future of this project."

Results so far

KMS Projects revised its initial design with upgraded robotics and imaging systems and improved the machine's physical construction.

The new prototype, complete with cutting mechanism, was trialled in the field throughout September and October 2016 at TH Clements, and then demonstrated on a commercially grown broccoli crop, where it successfully identified – and cut – heads of a specified size. The demonstration proved that the system can assess each plant in real time during a single pass, so only those heads which meet the customer's specification are selected for harvesting.

Based on the results, which revealed some aspects that needed refinement, the team has rebuilt the rig to produce its third prototype, which was tested in KMS Projects' workshop ahead of the 2017 broccoli season.

There are still challenges ahead as until now the rig has yet to be trialled on plants with leaf cover. However, the prototype's vision system has already been upgraded and coupled with new smart software and the team is confident that the new rig will be capable of identifying and cutting a crop where only a fraction of a head is visible through the leaf canopy.

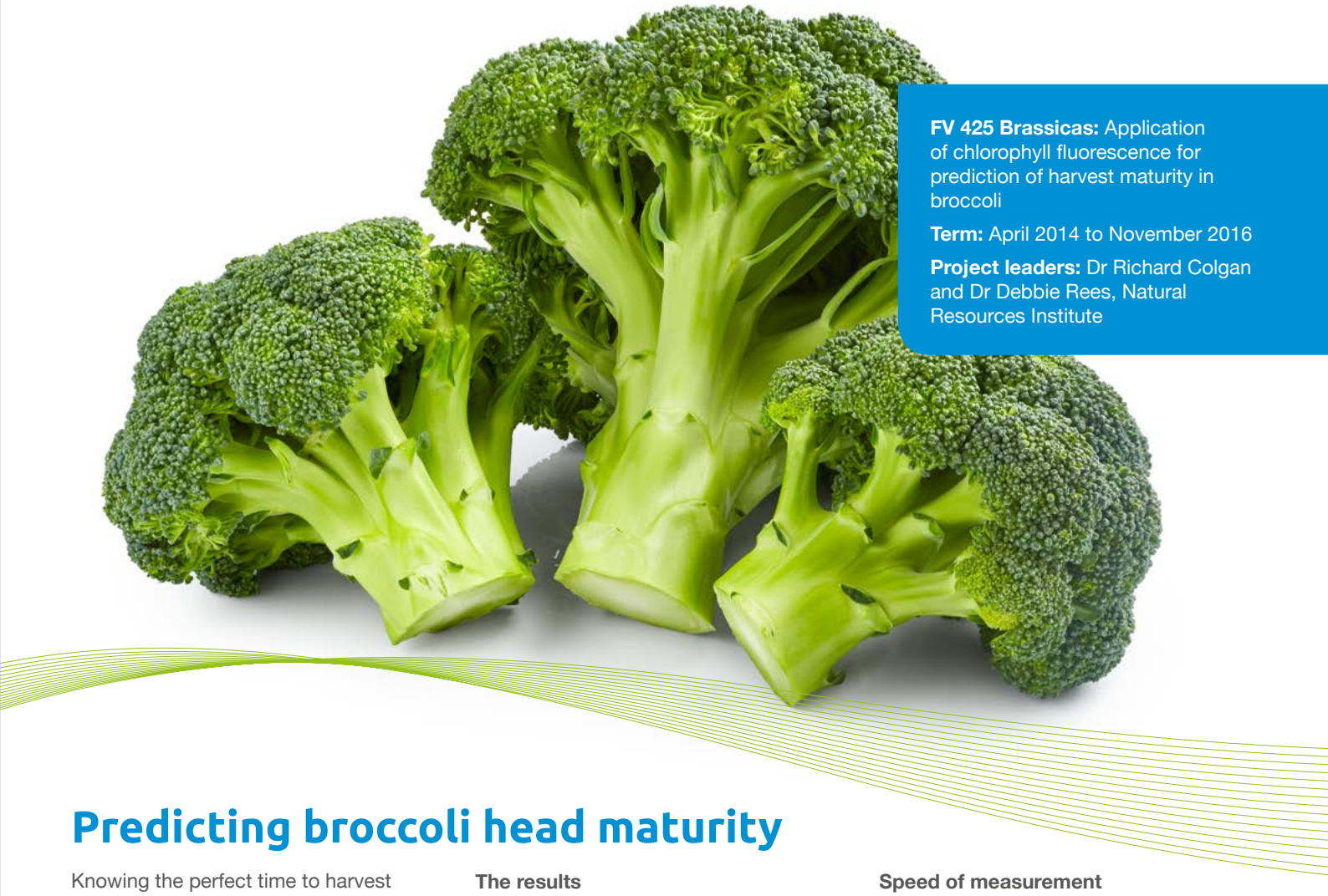
Field trials will continue throughout the summer with a 24-hour trial planned to see how the machine performs for a long period of time and whether it could be used for night-time harvesting.

Andy Blair, TH Clements, explained, "Being able to harvest broccoli selectively by machine is a priority for the Brassica Growers Association, so it's encouraging to see the progress that this project is making."

CP 153a: Development and demonstration of an automated selective broccoli harvester

Term: June 2016 to December 2017

Project leader:
Peter Keeling, KMS Projects



FV 425 Brassicas: Application of chlorophyll fluorescence for prediction of harvest maturity in broccoli

Term: April 2014 to November 2016

Project leaders: Dr Richard Colgan and Dr Debbie Rees, Natural Resources Institute

Predicting broccoli head maturity

Knowing the perfect time to harvest broccoli for optimal shelf-life and good storage behaviour has long been a tricky process for growers. Areas of a crop with seemingly identical heads, harvested at the same time, can display widely differing keeping qualities. This creates an obvious problem for scheduling a crop that, with variability in weather and consumer demand throughout the season, may need to be stored for up to three weeks to balance supply and demand.

The project

While traditionally the levels of chlorophyll in the heads was used as an indicator as to the health of the crop (with deterioration in levels of chlorophyll signifying a worsening), the project set out to ultimately discover whether chlorophyll fluorescence could provide a more accurate measure of the crop keeping quality, and if the technology can be used to inform crop management decisions in the field and after harvest.

Previously, chlorophyll fluorescence has been used to map changes in the health of broccoli during storage and shelf-life in AHDB-funded project FV 395, which revealed that a decline in the number of active chloroplasts is correlated with a reduction in head quality leading to deterioration.

The results

This project further confirmed the usefulness of chlorophyll fluorescence as a predictor of storage quality in post-harvest broccoli consignments.

Thanks to the work of Dr Richard Colgan and Dr Debbie Rees, from the Natural Resources Institute, a non-destructive measurement of harvested broccoli heads able to predict storage potential using chlorophyll fluorescence has been identified and tested. From the findings, a practical and portable instrument to use by the broccoli industry is now being developed.

“The fresh produce industry is always looking for new technologies that can be used to assess quality without damaging the produce. Technologies with the ability to predict storage quality are even more valuable. The Produce Quality Centre (Natural Resources Institute) has worked with Hansatech Instruments on a three year project, and we believe we have identified an efficient method to use chlorophyll fluorescence to predict storage quality of broccoli heads. We will be working with broccoli growers this autumn to test the commercial potential of this technology.” commented Dr Rees.

Speed of measurement

At the moment the measurement depends on four individual point measurements across a broccoli head. In order to achieve a rapid assessment, it will be necessary to design a sensor head that can carry out multiple measurements simultaneously. A prototype produced by Hansatech Instruments Ltd, was tested in the final year of this project, but will require further development.

Field or packhouse measurement

Measurements in the field have so far been difficult to interpret due to interference from sunlight, even when measurements are taken close to dawn. As a result, assessment of heads will need to be carried out after harvest, away from bright sunlight. Furthermore, the measurements are also sensitive to temperature.

Using CF to optimise field management

In practice a measurement that depends on the broccoli head is less practical as a field management tool due to the rapid development of the head near to harvest time – meaning any information provided would only be available close to the end of the growing season. However, if applied to leaves this technology might provide a valuable tool for following mineral nutrition. As such, this application will be investigated in more detail.

FV 430: Reducing wastage in stored winter cabbage and swede

Term: April 2014 to November 2016

Project leaders: Richard Colgan and Debbie Rees, Natural Resources Institute

Twin partners act on storage rots

Growers can lose up to 40% of a winter cabbage or swede crop to fungal decay or physiological breakdown during long-term storage. Post-harvest fungicide treatments currently used to manage storage rots may be restricted in future, so alternative strategies are needed.

The project

Growing season sprays of nutrient products containing calcium were tested because calcium is known to help strengthen plant cell walls, which may help to slow infections by fungal pathogens. Storage treatments such as ozone were investigated too, along with biofungicides to manage Botrytis rots in cabbage.

Three calcium treatments were trialled on cabbage in the project's first year, applied eight times between July and mid-October.

The amount of calcium present in the heads at harvest was only significantly higher in cabbages sprayed with InCa. Those treated with Brassitrel Pro or Headland Carnival were larger because of the higher nitrogen content in these products. None reduced wastage from disease after the heads had been nine months in controlled atmosphere storage.

In the second year, four applications of InCa were made later, after the heads had formed. Harvested cabbages were heavier, compared to untreated heads, which led to a softening of the outer leaves. The sprays reduced rots in heads when assessed after seven months' storage in air.

Results from first-year trials on post-harvest biofungicide dips of cabbages that had not been treated with calcium in the field suggested that Serenade ASO *(Bacillus subtilis)* could be as effective as the current fungicide regime used to control Botrytis rots.

> "InCa on its own was no more effective than water. Applied with Serenade ASO, however, losses were reduced to 9%"

Trials the following year compared post-harvest dips of InCa, either alone or together with Serenade ASO, with the standard fungicide treatment. InCa on its own was no more effective than water. Applied with Serenade ASO, however, losses from Botrytis were reduced to 9%, a level comparable to that achieved by fungicides.

To see if removing ethylene from stores holding winter cabbage would make a difference to crop quality, heads were stored in air to which the gas had been added at different rates. Their background green colour suffered at the higher rates tested but there was no effect on firmness.

Ozone treatment led to unacceptable colour changes that ultimately increased levels of wastage.

The same three calcium products tested on cabbage were also trialled on swede. All increased the calcium content of the roots but it's not known whether that was a result of the nutrient moving there from the leaves. Sugar levels at harvest were higher in treated swedes but the main impact of the enhanced calcium content in the roots was the slower rate of tissue browning observed after swedes were cut, which may offer a commercial advantage for marketing prepared vegetable packs.

The calcium treatments had no effect on controlling disease spread, which was caused by Botrytis infection of leaves and petioles, progressing to the main root only in severe cases.

Neither ozone nor hydrogen peroxide applied at harvest nor a repeat application during storage reduced the rate of Botrytis infection of swedes.

FV 202g Field vegetables: an evaluation of autumn/winter cauliflower, spring cabbage cultivars and other winter Brassica crops

Term: April 2014 to June 2017

Project leader: Bill Herring, Duchy College

FV 340b Vining peas: extension of variety evaluation trials

Term: March 2015 to February 2018

Project leader: Stephen Belcher, PGRO

FV 348d Onions: independent assessment of field and storage potential of varieties

Term: April 2015 to July 2018

Project leader: Bruce Napier, NIAB TAG

Trials get the measure of vegetable varieties

These variety trials provide independent assessment of the yield, quality and agronomic characteristics of new varieties to meet grower and end user specifications. These requirements need to be balanced and results compared over several years to eliminate seasonal variations.

Use of varieties as part of an integrated crop management strategy will become increasingly important as the number of crop protection products available to growers decreases.

The projects

In 2016, the onion trials included sets planted in Lincolnshire and Suffolk as well as seed varieties drilled in Essex and Norfolk. Storage potential of varieties was tested under both ambient and controlled environment storage.

Twenty-five pea varieties and numbered selections were trialled in a commercial crop near Holbeach in May.

Trials of new and established cauliflower and spring greens varieties, aimed at specific production periods, were conducted at the same site as in previous years, near Hayle in Cornwall.

Results: onions

Troy was the first to mature, by just a couple of days, in the early brown varieties planted in Suffolk – the earlies on the Lincolnshire site were harvested prematurely after being damaged by hail. Griffon and Jagro had the highest yields, in excess of 50 tonnes/ha.

The main issue for the drilled trials was maintaining nutrient levels on the Norfolk site due to the high amount of rainfall. Averaged across both sites, the preliminary variety Euresco was the first to mature in the brown types, and by as much as a week in Norfolk, but Hytech and Hytune continue to offer both earliness and high yields, being the only two brown varieties to yield more than 80 tonnes/ha. It's a similar picture for Red Light, which was both the earliest and the only red to yield more than 70 tonnes/ha.

The drilled bulbs stored well under ambient conditions in what was a mild winter. Some varieties were badly hit by storage rots and the results are being analysed to see whether there's a link to the incidence of mildew during the growing season. The high downy mildew levels in 2016 revealed any resistance weaknesses in newer varieties, some of which had been submitted by breeders on the basis of their performance overseas. Fusarium continues to be a major concern in commercial crops and the focus of breeding programmes is to introduce known resistances into commercially viable lines.

Results: vining peas

Beverly was the earliest maturing variety in 2016, two days ahead of Avola. Oasis, the standard for yield, matured nine days later than Avola in this trial.

The yield increase between TR100 and TR120 for Oasis was 2.03 tonnes/ha. Several varieties that yielded better than Oasis at TR100 – including the highest yielders 05S52323A, which has since been withdrawn by the breeder, and 05S52738A (now known as LG Element) did not yield as well at TR120. PLS 196 was the only variety to yield more than Oasis at TR120.

The late maturing 04S51315A (now known as LG Galileo) scored best for standing ability followed by D175161.

In the downy mildew trials, several varieties showed good field tolerance in 2016 including Beverly, Cargo, D165613, D165621, D85607, D95389, Vidor and Vivando.

Results: autumn, winter, late winter cauliflowers and spring greens

The Brassica trial was open to view at open days in November 2016 and in January and March this year while results for each variety were regularly updated on the project website: **www.cornwall.ac.uk/research/herring/default.asp**

Improving resilience in Brassica seeds

Variable seed quality is often an area of frustration for growers, but a project funded by AHDB Horticulture and the BBSRC is aiming to improve our understanding of the causes of variation in seed quality, to enable seed companies to provide a more uniform product.

Seed produced for the UK market is most often produced overseas in so-called 'counter-season production', often at several sites around the world. Variation in seed performance arises among seed lots produced at different sites, or because of variable weather conditions during seed production. Selecting the best seed production sites for different crops is a constant problem for seed companies.

The project is helping seed companies understand how environmental variables, and in particular temperature, influence seed quality.

> "If we can understand how weather and climate affect seed quality we can help seed companies make better decisions"

Professor Steven Penfield of the John Innes Centre said, "If we can understand how weather and climate affect seed quality we can help seed companies make better decisions on suitable sites for seed production, and breed new varieties with increased uniformity in germination and seedling establishment for growers."

Future perspectives

The current work will not only provide links between seed production climate and seed quality but will also understand the mechanisms by which environment affects performance of seeds. In particular the effect on the development of the seed coat will be investigated. Because the colour and other qualities of the seed coat are visible during the processing of seed lots, understanding the visual appearance of the best quality seeds can help seed producers discard those that are likely to perform badly for growers. Breeding techniques are aiming to make seed coats more resilient as well as enhancing active ingredient uptake from seed coatings. In the longer term there is also the potential of increasing uniformity for plug production, or even moving to direct sowing of Brassica vegetables into the field.

CP 145: Exploiting seed coat properties to improve uniformity and resilience in brassica seed vigour

Term: April 2015 to March 2019

Project leader: Professor Steven Penfield, John Innes Centre

Fruit Logistica 2018

Your chance to showcase your business at Fruit Logistica 2018

Join AHDB once again as we host the British hub at Fruit Logistica - which takes place next year from 7-9 February in Berlin - to showcase Great Britain's horticulture and potato industries.

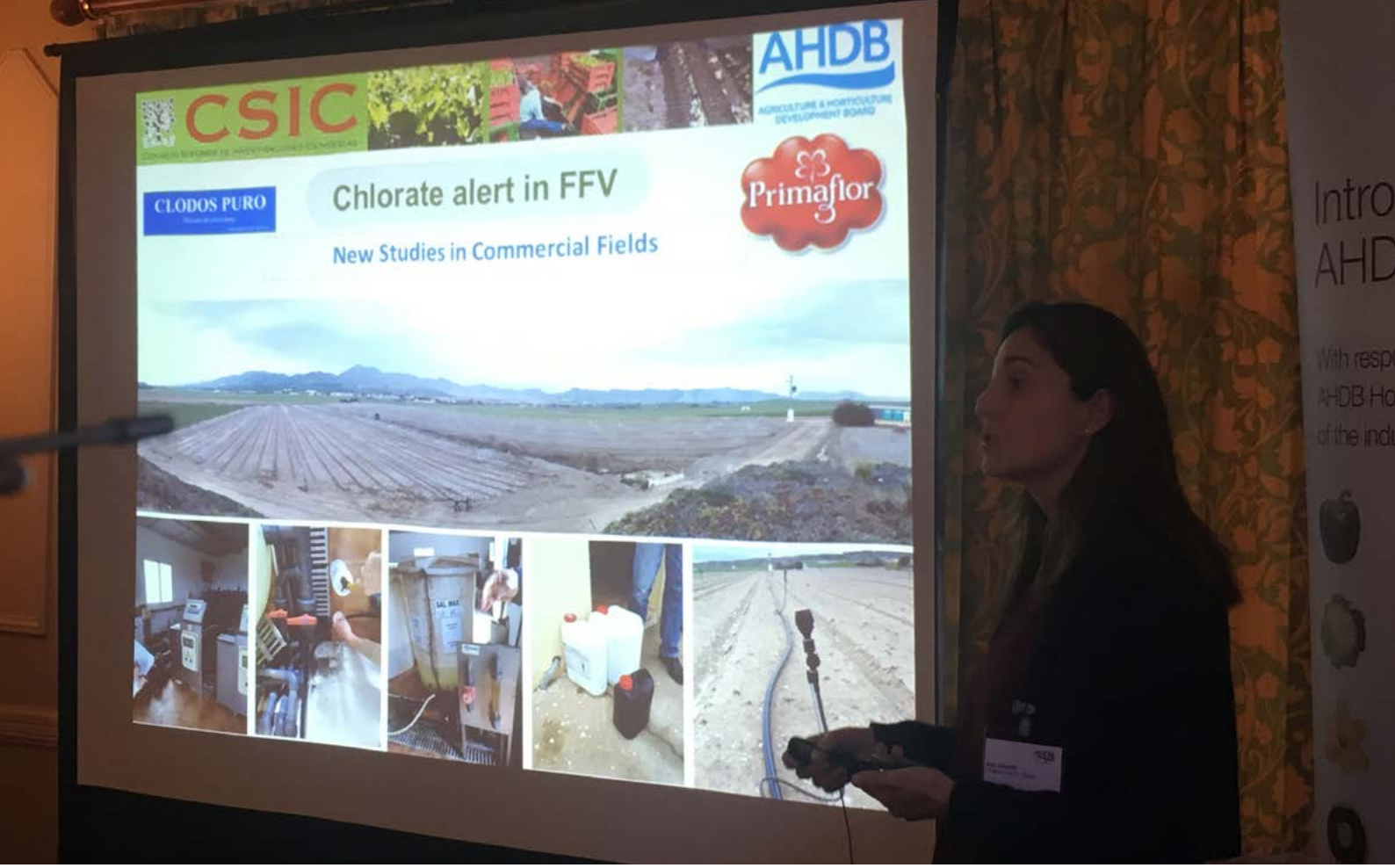
This event brings together importers and exporters, fruit and vegetable producers, wholesalers and retailers, and packaging and handling specialists, alongside transport and logistic specialists.

This is a fantastic opportunity to develop relationships with partners across Europe, to explore the possibility to export to new markets, and showcase your business and products to international trade visitors.

Places are limited and with co-exhibitors already lining up, we recommend you book your space now.

To register your interest please email hort.info@ahdb.org.uk or amanda.robins@ahdb.org.uk

FRUIT LOGISTICA



Addressing industry priorities

Tackling the diamondback moth

Diamondback moth (DBM) received considerable attention in 2016, as unprecedented damage was caused to Brassica crops and particular concerns were raised about the availability of brussels sprouts at Christmas.

Dr Dawn Teverson coordinated an industry workshop, attended by over 60 growers, agronomists and representatives of the agro-chemical industry to provide a better understanding of the pest and effective control measures.

Alongside this, resistance research at Rothamsted established new baselines for testing DBM samples, which hadn't previously existed. The study also confirmed resistance to pyrethroids in DBM.

Dr Steve Foster, Research Scientist at Rothamsted, said, "We tested a range of different chemical insecticides in bioassays for their effectiveness against the larvae of the moths that we saw in the UK last year. Some compounds were effective but the commonly used pyrethroids were not, due to strong resistance."

"If large numbers of new moths arrive in the UK in future years – a scenario which is becoming more likely due to climate change – they could carry different forms of resistance, so future outbreaks may respond differently to insecticide sprays."

AHDB was successful in securing an emergency 120-day authorisation for Benevia 10OD (cyantraniliprole) for use on brussels sprout, broccoli, cabbage and cauliflower for the 2016 season.

Further information about AHDB's work on diamondback moth can be found here: **horticulture.ahdb.org.uk/diamondback-moth**

Microbials – Keep it Clean

"The 'Keep it Clean' Microbials workshops were held in five locations of the UK starting in Fife, Scotland, and culminating in Maidstone, Kent. The workshops reminded growers of food safety risks associated with fresh produce production and provided guidelines to help ensure that produce is kept free from microbial contaminants. Novel methods to help 'Keep it Clean' were also covered.

The programme included sessions pertaining to the future of water and equipment disinfection and the current status of biocide registration and its challenges. Erika Wedgwood of ADAS covered measures to help growers to mitigate against exceeding chlorine oxide residues in edible fresh produce.

To access literature, videos and slides from the workshop please visit: **horticulture.ahdb.org.uk/microbials-keep-edible-fresh-produce-clean**

MICROBIALS WORKSHOPS

The following experts shared their insights on the day:

- Jim Monaghan, Harper Adams University – Risk assessments and standards
- Mike Hutchison, Hutchison Scientific - Listeria management and antimicrobial resistance
- Ana Allende, CEBAS, Spain - Best practice on cleaning and disinfection; current online tools, decision matrices and new research on risk management tools
- Pete Woodhead, British Association for Chemicals Specialties - Biocide Product Regulation and challenges
- Dean Burfoot, Private Consultant - Bubble technology and the potential for cleaning and disinfection

FV 391a Carrots: further development of artificial inoculation techniques for cavity spot caused by Pythium violae

Term: August 2017 to September 2018

Project leader: John Clarkson, Warwick Crop Centre

FV 432: understanding the ecology and epidemiology of Pythium violae to enable disease management in carrot crops

AHDB STUDENTSHIP

Term: October 2014 to September 2018

Project leader: John Clarkson, Warwick Crop Centre

FV 448 Carrot: an early warning system for risk of cavity spot in crops

Term: December 2015 to December 2016

Project leader: Nathalie Verhoef, NSure.

Location: Wageningen, the Netherlands.

Predictability is key to progress on cavity spot

Although our understanding of cavity spot in carrots has advanced over the last 20 years or so, there is still more we need to know; for instance about the dynamics of the main pathogen responsible, *Pythium violae*, its relationship with the host plant, and about the role of environmental factors in disease development, in order to find new and innovative strategies for its control.

Further progress has been hampered, however, by the lack of effective procedures for detecting *P. violae* and quantifying levels in soil. It's also difficult to produce high levels of the disease against which treatments can be tested in research experiments. This would be resolved by being able to artificially infect carrots, which would allow scientists to study the early stages of infections; for instance how the pathogen colonises carrot seedlings and the subsequent development of cavities on maturing roots.

The projects

In her studies on the biology, ecology and epidemiology of the pathogen, in project FV 432, Kathryn Hales is looking to improve the accuracy of the molecular detection test, recently developed with AHDB funding. In work which links in with project FV 391a, she is also exploring ways of inoculating carrots with *P. violae* oospores – the long-lived spores in soil which germinate to initiate infections – which would result in consistent and reproducible levels of the disease for trials.

Meanwhile, in project FV 448, Dutch biotech company NSure have been working on a practical genetic test that depends on carrot genes that change when roots are infected by the pathogen. Such a test could give growers an early warning of the presence of the disease in fields to help them decide on which crops to market first and which it's worthwhile going to the expense of strawing for winter.

> "Such a test could give growers an early warning of the presence of the disease"

Ian Holmes, company agronomist at Strawsons, said, "The new techniques being explored in these projects will help us learn more about how cavity spot can be managed in the long term."

Results so far

Hales has continued to collect samples of pythium from cavity spot infected carrots sourced from different locations. *P. violae* was identified from DNA sequencing as the predominant organism associated with disease lesions, but several other Pythium species were also isolated.

New 'primers' – the short lengths of DNA that a 'genetic fingerprint' test depends on – have been tested and shown to be much more specific and sensitive to *P. violae* than those previously used.

In initial experiments inoculating carrots with the pathogen, Hales had pinned down the minimum concentration of oospores needed to cause damping-off symptoms and high mortality of seedlings. In the second year of her project, she tested different concentrations on seedlings in controlled environment conditions. Damping-off developed to varying degrees but there was no clear relationship between the concentration of inoculum and disease level.

Alongside Hales's work, project FV 391a started to look at how best to produce inoculum in liquid or solid form and the Pythium concentrations that would produce symptoms in carrots. In two long-term glasshouse experiments, carrots were grown to maturity in pots of soil artificially inoculated at five different rates. The highest rate was chosen based on Hales' seedling tests whereby it would induce some damping-off but allow most plants to survive. Carrots from all treatments failed to form properly. The severity of cavity spot was low in both experiments but *P. violae* was consistently isolated from the tap roots and disease lesions. The research continues under project FV 391b.

In the first step towards a test that can predict which crops are at high risk from the disease, a set of potential indicator genes was identified in project FV 448 using samples of the variety Nairobi collected from UK growers' crops. The results are being validated in a second year of work, as project FV 448a. The aim is to develop a simple kit that would enable carrot samples lifted from a field to be processed by a laboratory and an indication of the disease risk returned to growers within 48 hours.

FV 398b Carrots: practical evaluation of field storage alternatives

Term: August 2015 to September 2017

Project leader: Steve Roberts, Plant Health Solutions

Straw substitutes can keep carrots safe

The straw that growers use to protect carrots in the ground from frost damage over the winter is becoming more of a challenge to obtain. Its cost is obviously a concern, while its potential as a source of Black-grass and the nitrogen locked up in the soil as it breaks down are issues for the crops that follow.

The project

The most promising alternative materials from an earlier review are being tested to measure their insulation values in the field and to see how they may affect crop quality and how practical they would be.

Results so far

There were no significant differences in yields from crops under any of the coverings – straw over polythene; less straw but sandwiched between two sheets of black polythene; cellulose fibre sandwiched between white polythene over the top and black polythene below; and closed-cell polyethylene foam laid directly over the top of the crop with a top layer of white polythene to anchor it – compared with straw alone or uncovered carrots over the 2015/16 season.

The materials were trialled again in what turned out to be a much colder winter, in 2016/17, when some of the practical issues identified from that first year, including how to anchor the polythene layers, were addressed.

All of the coverings were effective in preventing frost damage – even the polyethylene foam from the previous year which was reused, because this is the only way its economics will stack up.

The 'reduced straw' treatment was modified by using only one layer of polythene, over the top of the straw. The polythene was anchored by straw dropped into the wheelings, which generally kept it in place.

This time, the cellulose fibre was tested in two ways: either covered with polythene or left uncovered after applying directly to the crop using a blower. The aim of the cover is to keep it as dry as possible and so maximise the material's insulation value. On the other hand, leaving it uncovered allows it to get wet and so protect against frost via the effect of thermal mass and latent heat.

Using a blower to apply the fibre worked well and concerns about it not staying in place proved unfounded. It also seemed to leave the carrot crown much cleaner and healthier than any of the other treatments.

New AHDB Crop Walkers' Guides

Your handy crop monitoring guides

- Accurately identify pests, diseases, nutrient deficiencies and disorders in crops
- Features images of key stages in lifecycles of pests and diseases
- Concise and easy to use

Coming soon

Reducing variations in lettuce harvests

Fig 7 - Transplants field placement treatments: 1) Normal, 2) On the side, 3) Above soil surface, 4) Tilted or 50% of the peat block with soil, 5) Buried (2cm of green shoot underneath soil)

Transplant placement and positioning of lettuce at planting has a direct impact on yields and marketable quality, latest research finds.

Trials have been helping to understand why growers may find variations in their lettuce harvests and to find ways to address this to help increase marketable yields - and the first step starts with achieving uniformity in trays of transplants.

Researchers found considerable variation between transplants within a batch even though they were grown from uniform seeds in uniform conditions. Transplants that varied in height within the same tray also varied in fresh weight – and the variability not only persisted but actually increased after transplanting.

Growers are therefore recommended to exclude significantly small transplants from planting. More attention should also be given to growing media, light and moisture during propagation to encourage uniform trays of transplants.

However, the trials also showed that even with uniform transplants, growers may still find variations in size and weight of mature heads if the final planting positions vary in orientation and depth.

Yara Boubou, project researcher, said, "If transplants are planted too deep or too high in the soil, or left tilted in the soil without adjustment, growers will see reduced yields due to increased pest damage, moisture damage from the soil, as well as misshaping."

Variation in lettuce head size and weight can affect the efficiency of a single-pass lettuce harvest and oversized and under-developed heads can result in crop wastage.

CP 121: Towards precision inputs through improved understanding of the underlying causes of in-field variation in lettuce crop maturity and yield

Term: April 2014 to March 2017

Project leader: Dr Jim Monaghan, Harper Adams University

Key staff: Yara Boubou, researcher, PhD student

Dr Ivan Grove, co-supervisor, Harper Adams University

FV 440 Lettuce and baby leaf salads: investigation into control measures for silver Y moth and caterpillars

Term: April 2015 to March 2017

Project leader: Rosemary Collier, Warwick Crop Centre

Industry representatives: Phillip Effingham, Thane Goodrich, Andrew Rutherford

Novel caterpillar strategies in the picture

Feeding by caterpillars of the silver Y moth and other moth species can result in unacceptable leaf damage to, and contamination of, outdoor baby leaf and lettuce crops. Control suffers from the limited number of insecticides that growers can draw on and the fact that they have long harvest intervals.

The project

Field trials looked at how monitoring, including the use of a pheromone trap to lure male moths, can detect the pests' arrival and help growers decide on when to spray crops, while novel treatments, some of which had been identified in the SCEPTRE programme, were tested for their effectiveness.

Results

A network of Trapview traps was established in commercial salad and Brassica crops to monitor both silver Y and diamondback moths as well as turnip moth, a sporadic pest of lettuce. Each trap was equipped with a pheromone lure and a camera which photographed the sticky base on which the moths were caught each day. The images were downloaded onto a website which the participating growers could view. Standard pheromone traps were run in parallel.

All of the traps indicated when moths were more numerous but there was considerable variation within a region in the numbers captured.

While infestations of silver Y moth caterpillars usually followed periods when the moths were relatively abundant, there seems to be little scope to develop a treatment threshold based on the numbers caught in traps – so catches can only be used to highlight when significant egg-laying is likely to occur.

Male diamondback moths were detected in the pheromone traps soon after the marked influx at the end of May 2016. It seems likely that the females are able to lay eggs as soon as they arrive.

The University of Warwick was further funded to host a webpage summarising sightings of silver Y moths and diamondback moths in northern Europe in 2017 to alert growers to potential problems in case migrations reach similar levels to those of 2016.

Four bioinsecticides and a novel chemical insecticide were applied as foliar sprays on whole-head lettuce in a field trial deliberately infested with silver Y moth caterpillars and eggs at Warwick Crop Centre, Wellesbourne. The chemical insecticide was the most effective treatment; none of the bioinsecticides gave significant levels of control. In a second trial, a pre-planting drench killed all the larvae present and reduced the number of feeding holes on leaves.

At Stockbridge Technology Centre, four chemical insecticides and two novel products were tested against silver Y moth on baby-leaf lettuce; all bar one gave significant control.

Seven products, including three bioinsecticides, were compared against diamondback moth in laboratory tests at Wellesbourne, of which Tracer (spinosad), cyazypyr, a novel insecticide and Lepinox Plus gave the best levels of control. The same products, as well as the bioinsecticide azadirachtin, reduced the percentage of live larvae, compared with nil treatment, in a glasshouse trial the following year, where Brussels sprout plants had been infested with caterpillars from moths collected following the summer's large migration. Cyazypyr, as Benevia 10OD, was approved for use on Brassicas as a result of an emergency 120-day authorisation in 2016.

The results from the second trial also confirmed that some of these moths were resistant to the pyrethroid insecticide lambda-cyhalothrin, as had been suspected.

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