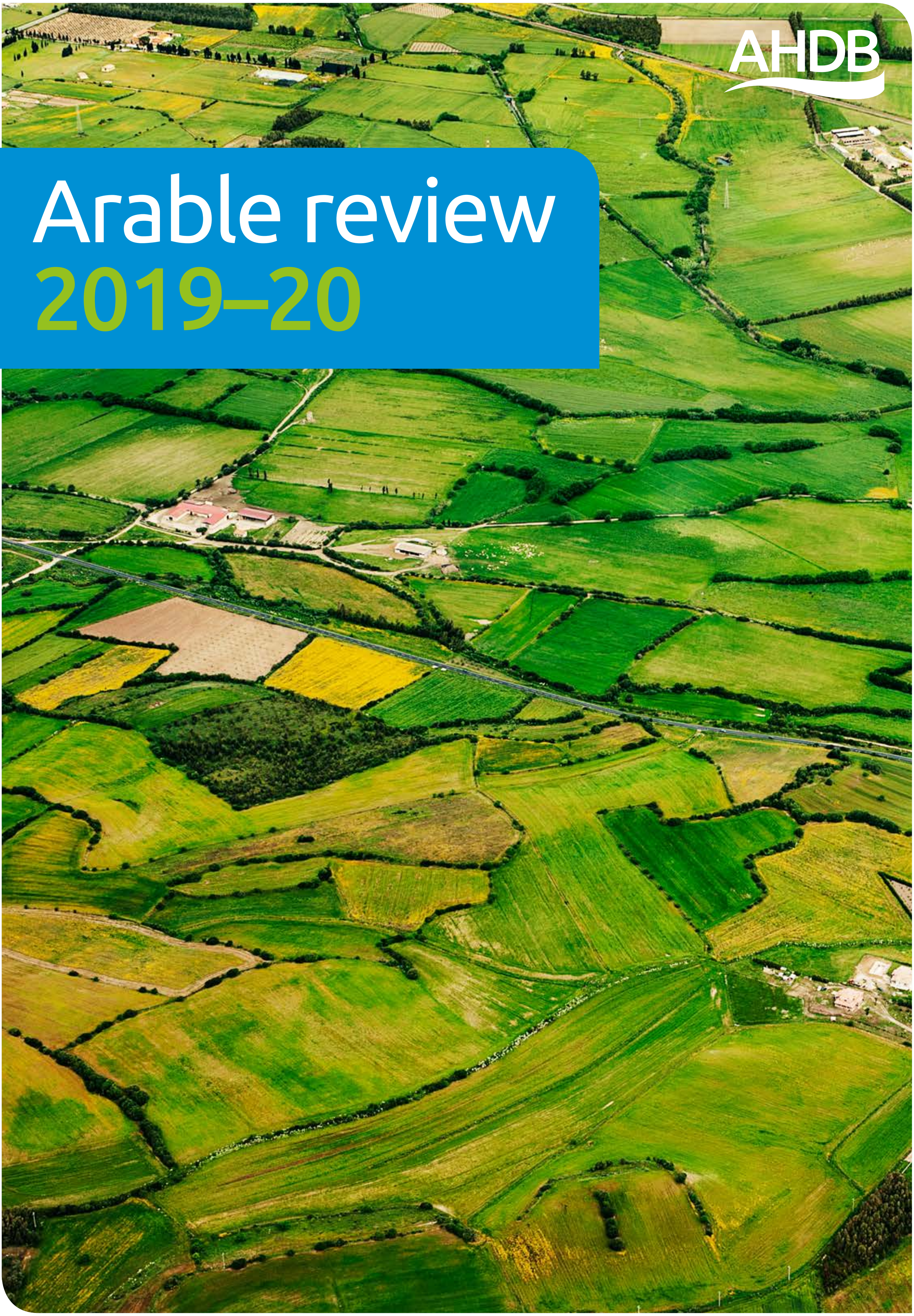
Arable review 2019–20



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Foreword

Welcome to our arable research review for 2019/20.

As a summary of research projects for both AHDB Cereals & Oilseeds and AHDB Potatoes, I hope you find it a valuable reference. Not every project is showcased, but you will find a list of current projects on pages 26–30, together with information on our wider technical activity, demonstrating the full breadth and depth of the research we commission for the arable sector.

Further information on both our current and completed programmes can be found on our website by searching the topic or project number (provided in brackets), together with details of the PhD studentships and Nuffield Scholarships that we support.

The original ambition for the first edition of this publication remains: to help provide a clearer, stronger and more united resource across the arable sector. We can deliver much better value for money by joining up similar areas of research and knowledge exchange, while still ensuring that the levy raised from the individual sectors remains ring-fenced. Some topics will always be sector-specific and these are reflected in the more specialist projects, whereas our work on soils, rotations and so on, is of relevance to all those involved in the arable industry.

You should also pick up a common theme throughout of Integrated Pest Management (IPM). It's been a key part of our work in the crop sectors for many years, but in light of the many challenges the industry is facing and the heightened need for a coordinated approach, you will increasingly find IPM front and centre of our arable activity.

While our research reports provide an extremely valuable resource in their own right, there are also many opportunities to see them brought to life through our Farm Excellence Platform, which includes Strategic Farms, Monitor Farms, Arable Business Groups, technical events and webinars. I encourage you to get involved with these, wherever you are in the country.

It's also important to mention that we work in collaboration with a long list of industry partners, meaning that levy payers see the added value of combined funding and expertise, and less duplication. Common problems require common solutions and we need to move quickly to address new challenges, so you will also see our partnership approach highlighted in this review.

If you would like more information on the full range of our activity, including the many online tools and resources produced from our research, please take a look at the AHDB website. All publications can be found at **ahdb.org.uk/knowledge-library** and reports; meeting dates and results from the on-farm demonstrations at our Monitor and Strategic Farms can be found at **ahdb.org.uk/farm-excellence**

Tim Isaac
Head of Knowledge Exchange – Arable

GREATsoils

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Resource Management
Scientist – Soils

Arable farming is a soil-based business. Without this foundation, production of combinable crops, potatoes and field vegetables would not be possible. As such, soils must be maintained in the best possible condition to ensure sustainable and profitable production.

Each soil is different, not only because of the different textures and types found across the UK, but also because of the influence of the environment; the history of cropping at any one site; the current rotation and choice of crops; varied cultivations or establishment systems; the input of organic materials or the use of cover crops. These factors all influence the physical, chemical and biological make-up of the soil in different ways. As a result, there is no one-size-fits-all solution to soil management. Instead, each site must be assessed and managed in the context of its unique situation. With this in mind, AHDB research and knowledge exchange activity provides practical tools and methods for measuring and monitoring the condition and health of soils, for farmers, growers and their agronomists – whatever the production system.

Understanding soil biology

The AHDB–BBRO Soil Biology and Soil Health Partnership (91140002) is a 5-year programme of research and knowledge exchange (2017–2021). Within the Partnership, testing of soil health indicators, including measures of soil biology, will take place at long-term experimental sites. Microorganisms, nematodes and mesofauna (Figure 1) are all active in soil, carrying out diverse functions such as decomposition and nutrient cycling, direct interactions with plant roots as beneficial symbionts, or – potentially – as soil-borne pests and pathogens. Many biological measures are not yet ready for routine on-farm soil health testing; however, work is underway to improve our understanding of how to manage soils in favour of beneficial soil biology.

Crop health is intimately linked to soil health. Additional research aims to predict crop disease from DNA assessment of the distribution and quantification of soil-borne plant pathogens. Soil-borne pathogens are particularly challenging to control. Frequently, they are not detected until a certain threshold is reached, by which time considerable effects on crop yield and product quality have already been caused. A toolbox of DNA-based diagnostic methods exists for almost all soil-borne fungal pathogens and parasitic nematodes of crop plants. However, confirming the presence of pathogens in the soil does not always mean that disease will develop in the growing crop because environmental and host crop factors also come into play. Continuing work in this area aims to extend efforts to develop and demonstrate robust DNA-based diagnostics for routine monitoring of soil-borne pathogens, as well as identifying the best management practices to minimise disease risk in arable rotations.

Figure 1. Soil mesofauna (springtails and mites), as viewed down a microscope

Developing a soil health scorecard

The Soil Biology and Soil Health Partnership aims to improve on-farm understanding of soil biology and develop and validate thresholds for various physical, chemical and biological indicators of soil health. A soil health 'scorecard', will bring together these indicators which colour-codes results from soil assessments. The scorecard will highlight results in red, amber or green, depending on where the result falls within the expected range for UK soils and climatic regions. Results shown as red indicate a risk to crop production, or – in the case of some nutrients – to the environment. Such results require further investigation to determine the cause and a change in soil management practices may be necessary. Amber results are borderline and call for additional monitoring. A green result indicates that no action is currently needed.

On-farm trials of this scorecard system are being conducted across a range of sites and soil types. An example of the system from three sites with similar soil types is shown below (Table 1). The indicators used for these on-farm assessments were soil organic matter (SOM); pH; and standard nutrient analyses for phosphorus (P), potassium (K) and magnesium (Mg) – all of which can be assessed by sending soil samples to a laboratory for routine analyses. The other assessments include a visual evaluation of soil structure (VESS) and an earthworm count as simple measures of soil physical and biological properties, respectively. Farmers' knowledge of their own fields is very important for interpretation of the results and can help to inform where short- and long-term soil health improvements can be made.

Table 1. Soil health scorecard results from three fields with the same soil type and in the same rainfall region, highlighting different areas for attention in each production system

Attribute*	Field A; Farm 1	Field B; Farm 2	Field C; Farm 3
SOM (%)	3.4	2	2.2
pH	6.7	6.9	7.0
Ext. P (mg/l)	40.6	59.6	37.2
Ext. K (mg/l)	158	106	148
Ext. Mg (mg/l)	82	89	144
VESS score	2	2	2
Earthworms (Number/pit)	13	8	1

Investigate Monitor No action needed

*SOM: Soil Organic Matter – comparison to 'typical' levels for the soil type & climate; Partnership project 2 **ahdb.org.uk/greatsoils**

Ext. P, K & Mg: Extractable Phosphorus, Potassium and Magnesium; See 'The Nutrient Management Guide-RB209' for specific crop advice, **ahdb.org.uk/nutrient-management-guide-rb209**

VESS: Visual Evaluation of Soil Structure – limiting layer score; **sruc.ac.uk/info/120625/visual_evaluation_of_soil_structure**

Earthworms: total number of adults and juveniles; >8/pit = 'active' population for arable or ley/arable soils; Partnership project 2 **ahdb.org.uk/greatsoils**

The soil health scorecard is still in development; testing is underway on indicator thresholds in different soil types and production systems. The project team is working with farmer groups across the UK to obtain feedback on the usefulness of this approach and the ease of interpreting the results.

Increasing diversity in the rotation

One of the principles of managing healthy soils is to increase diversity, whether that is belowground or aboveground, and growing cover crops is one way of doing this (Figure 2). The benefits of cover crops are varied and include nutrient capture, improving soil structure and preventing soil erosion. However, questions remain on the choice of species and how best to incorporate and manage cover crops within a rotation. It is also important to be aware of rotational conflicts; for example, avoid growing brassicas ahead of oilseed rape or cereal cover crops ahead of a cash crop of cereals.

The additional benefits of certain cover crop species are the subject of a current PhD studentship (21140024). This project focuses on understanding whether cover crops can increase populations of beneficial arbuscular mycorrhizal fungi (AMF) and how these carry over into the following cash crop. Some plant species, such as brassicas, are non-mycorrhizal. The project investigates the impact of including species such as radish in a mixture, alongside mycorrhizal species, such as oats and vetch. As well as root colonisation by AMF, the project assesses the impact on crop growth and yield. Findings from this research will help inform the future choice of cover crop species to enhance populations of beneficial soil organisms throughout the crop rotation.

Figure 2. Cover crop clover nodules

Reducing risk of soil compaction

A perceived benefit of cover crops and organic amendments is improvement in soil structure, which can potentially alleviate areas of compaction. However, it is preferable to avoid soil compaction in the first place and, as part of the Rotations Partnership (91140001), an online tool that can be used to assess compaction risk caused by agricultural machinery is under development for soil types found in the UK. Currently, the tool provides information for Scottish soils, but users can also manually input their own soil type into the Terranimo® model, available at **www.terranimo.co.uk**

Figure 3. Soil compaction can be alleviated by managing ground pressures of tyres and weight of machinery loading

Long-term data to inform rotational planning

The various site-specific factors involved in growing cover crops means that individual farms must use trial and error to determine how to maximise the benefits. It is important to keep good records of what has been tried, since information collected over several seasons will help to inform and improve decision-making each year.
A cost-benefit analysis of growing cover crops should also consider the whole rotation because some benefits may be seen in following crops. The Maxi-Cover crop project (21140009), which concludes at the end of 2019, includes examples of cost-benefit analyses for growing a cover crop, taking into account the following spring crop and subsequent winter crop in the rotation. The project will also provide information on the rooting of several different species of cover crop and their impact on soil properties.

Seasonal variation means that much research on soils requires several years of repeated trials in different locations and rainfall regions. The Rotations Partnership (2016–2021) is gathering information from on-farm trials on the effects of different cover crops and the use of organic amendments, particularly for rotations that include potatoes. Results to date highlight the importance of looking at these effects over several seasons, with greater yield benefits occurring in some years compared with others. Continuing analysis of soil physical properties in samples taken in different seasons may indicate the mechanisms influencing these effects. The use of organic amendments and cover crops has so far been associated with small improvements in bulk density, porosity and aggregate stability. In addition, parallel work is investigating the interaction between soil conditions, root distribution and length to determine water use efficiency and yield.

In time, data collected from the research and on-farm trials will help to inform what makes an effective rotation. It will also help us to understand how management approaches, such as including cover crops or applying organic materials, can improve the long-term resilience of soils. A long-term rotational experiment at Broom's Barn (Suffolk) was reinstated in 2016. This site had a history of organic amendments up to 2011 when the last farmyard manure (FYM) treatment was applied. To date, results indicate benefits from the residual effect of FYM on cereal yields.

Running concurrently with the experimental trials is the collection of grower survey data on past cropping, land use and management practices. This encompasses a wide range of soils, climatic conditions and rotation types. Analysis will provide insight to corroborate findings from the trials. Analysis on the economic performance of rotations will also complement this work.

Precision farming technologies to enhance rotations

Precision farming technologies and imaging systems can provide growers, agronomists and land managers with a 'toolbox' to help them manage soil resources more effectively. The Rotations Partnership uses techniques such as electromagnetic conductance (EMI) scans of soil, maps of variation in potato yield and plough draft to improve our understanding of some of the causes of variation in crop yield and quality. Novel spectroscopic techniques will be explored to establish the chemical composition and quality of organic matter, as well as the spatial distribution of soil porosity.

Shared knowledge and experience

Within AHDB's GREATsoils programme, farmers and growers are working together with research scientists and industry stakeholders to share their knowledge and experience, providing insight and feedback on what is practical and useful, as well as hosting on-farm trials for several projects. To find out more about the GREATsoils programme, visit our website: **ahdb.org.uk/greatsoils**

Integrated pest management

Charlotte Rowley
Crop Protection
Scientist – Pests

This year, arable insect pests have presented some challenges that demonstrate exactly why an integrated approach to pest management is urgently needed. Many oilseed rape growers have again dealt with severe damage from cabbage stem flea beetle, cereal growers are facing a future with only foliar sprays for aphid control and dramatic changes in molluscicide restrictions once again raised questions over the future of slug management. The latest pest research from AHDB helps growers to reduce their need for chemical inputs and adopt integrated pest management (IPM) practices with confidence.

Monitoring is key

One of the main components of IPM, upon which all control decisions should be based, is pest monitoring. This is why improvements in monitoring are the focus of many wider IPM research programmes – every year, the development of new techniques and technologies improves the accuracy and ease of evaluating insect pest numbers or activity.

AHDB currently provides various pest monitoring services to help growers keep track of insect pests. Probably the most popular among cereals growers is the aphid monitoring service, also known as Aphid News. Subscribers receive weekly updates of aphid numbers caught in the network of suction traps run by Rothamsted Research. The data are emailed out to subscribers on a weekly basis to update growers and agronomists on aphid migration progress. The email also shows how numbers compare to those in previous years. This year, for the first time, AHDB has funded virus testing from samples caught in five of the suction traps each week (Figure 4). Trials of this method will take place this autumn to determine whether testing for virus levels at a national scale can help inform spray decisions.

Grain aphid *(Sitobion avenae)*

With an increasing reliance on pyrethroids for aphid control in cereals, AHDB is continuing to invest in its insecticide resistance monitoring programme (21510015) to keep informed of changes in pest sensitivity to these chemicals. The latest results show that moderate rates of pyrethroid resistance are already widespread in grain aphid, so full label rates should be used to ensure effective control. The AHDB Barley yellow dwarf virus (BYDV) management tool can be used to help reduce the number of sprays by timing applications to coincide with the appearance of the secondary (wingless) generation of aphids. Monitoring aphids in crops remains necessary to determine whether or not sprays are needed.

An improved method for in-field aphid and virus monitoring has been piloted this year as part of our 1-year project on BYDV (21120077). Researchers on this project, led by the Game and Wildlife Conservation Trust in collaboration with Agrii, are conducting trials on the use of yellow sticky

(IV) Inverness. (D) Dundee. (G) Gogarbank. (Ay) Ayr.
(N) Newcastle. (Y) York. (P) Preston. **(KII) Kirton.**
(BB) Broom's Barn. (We) Wellesbourne. (H) Hereford.
(RT) Rothamsted Tower. **(Wr) Writtle.** (SP) Silwood Park.
(EM) East Malling. **(SX) Starcross.**

Figure 4. Position of suction traps. Those in green are undergoing virus testing

traps for local aphid monitoring. Field experiments using the sticky traps last season highlighted large differences in aphid numbers between and within fields, with most aphids caught in the headlands. An MSc student from Harper Adams University determined the potential for testing these trapped aphids for virus infection, with assistance from researchers at Rothamsted Research.

The results showed how variable virus levels can be in aphid populations – even across short distances. This work demonstrates the potential for more localised aphid and virus level monitoring, which could help farmers to improve their assessments of what is going on in their fields. Over the next three years, AHDB will be investing a further £190,000 into BYDV research. This comes on the back of the recent review of novel approaches to virus management across all UK crops (FV 461), which was jointly funded by the three AHDB crop sectors, alongside a 3-year programme of work on virus management in pea and carrot crops, funded by AHDB Horticulture (FV 459, FV 460). It is hoped that this work will support growers to make informed, risk-based decisions on the need to spray for aphids in the future and reduce dependency on insecticides for aphid management.

Figure 5. Yellow sticky pest trap in cereal crop

Pest monitoring doesn't stop with aphids though. As well as knowing how many insects there are and when they are active, it is also useful to know where pests are so that controls can be properly targeted. This is the thinking behind AHDB's latest slug research, which builds on a former PhD project (2140009118) that used radio frequency identification (RFID) technology to track slugs and determine the behaviour behind slug patch formation (Figure 6). PhD student Emily Forbes demonstrated that slugs kept to a defined 'home range' and patches could form in much smaller areas than originally thought. The use of mathematical models also found that patches were relatively stable over time, opening up the potential for targeted treatment. The next phase of work (21120078) will investigate whether soil characteristics and soil mapping can be used to sufficiently predict areas of slug activity to enable precision application of molluscicides. Targeted application of plant protection products, either in terms of area covered or the timing of applications, is one of the principles of IPM to keep pesticide use to a minimum.

Figure 6. Tagged slugs tracked with RFID scanner

The future of pest control

Another way to reduce pesticide use is through alternative control methods, whether these are biological or cultural interventions. Insecticides face regulatory challenges and the constant threat of insecticide resistance means that alternative control methods are becoming increasingly important.

A classic example of this is cabbage stem flea beetle, which has developed widespread resistance to pyrethroids and may become harder to control as populations and resistance spread. This is why, in AHDB's latest cabbage stem flea beetle research (21120049), scientists at ADAS are conducting trials of two alternative methods of control: using volunteer oilseed rape as a trap crop for adults and winter defoliation to control larvae. In trials, both of these techniques are showing promising reductions in adult and larval numbers. A recent field lab, in collaboration with Innovative Farmers, saw the defoliation method taken out onto farm, with farmers employing several techniques to top their crops, including grazing with sheep. While neither method will solve the flea beetle problem in one stroke, a holistic approach that combines these strategies with good crop management will hopefully ensure oilseed rape remains a profitable break crop.

Cabbage stem flea beetle is also the subject of an ongoing PhD project at the John Innes Centre (JIC; 21120064), which aims to find the genetic basis for flea beetle resistance in oilseed rape. Utilising material from the JIC brassica genetic diversity set, early results from the project indicate significant differences in adult feeding preferences between different breeding lines. The next stage will be to find out if there is a genetic basis to these differences, which would be invaluable information for future breeding programmes.

Figure 7. Cabbage stem flea beetle larval damage on oilseed rape

Biopesticides are an attractive alternative pest control option because of their minimal impact on the environment, specificity to the target pest and their role in resistance management. Already reasonably well recognised in the horticultural industry, interest in these products is now growing in the arable sector. As with any new type of product, there are important questions to answer about how to get the most from biopesticides. Some of these questions will be addressed in a new PhD project at Harper Adams University (21510042), which is investigating the use of biopesticides in the fight against flea beetle. As well as testing the efficacy of different products, both on their own and in combination with conventional insecticides, the project will explore the effects of applications at different times of day and test products in field situations.

The use of nematodes for slug control is an area of growing interest in the arable sector. Nematodes are the specialist research area of our current Nuffield scholar, Jenna Ross, who has been travelling the world to learn about methods of slug management used in other countries – biologically based or otherwise. Her findings demonstrate the need to be vigilant when it comes to invasive slug species because they may present new challenges for control in the future.

Alternative controls are the theme of two further PhD projects targetting the multi-insecticide resistant peach-potato aphid. The first is led by researchers at Rothamsted Research and explores the possibility of using RNAi technology to manage this problematic pest (21120079). This project builds on previous work showing that this novel control option holds promise for aphid pest management. The second, funded by AHDB Horticulture and led by the University of Exeter, is investigating the use of entomopathogenic fungi to control peach-potato aphid, using artificial selection experiments to attempt to improve the biocontrol characteristics of pathogenic fungi (CP 176). Both of these projects are still in the early stages, but may pave the way for various alternative control options in the future.

Stepping up IPM

Most growers and agronomists are already practicing some form of IPM on their farms. AHDB's pest research aims to help levy payers and their agronomists take that a step further: finding ways to reduce reliance on insecticides so they are used as a last resort. The pest research currently underway reflects the requirement for IPM to adopt a more flexible approach to crop protection.

Peach-potato aphids *(M. persicae)*

Ramularia leaf spot on barley

Disease decision support

Catherine Harries
Crop Protection
Scientist – Diseases

AHDB-funded work develops practical disease decision support tools as part of an IPM strategy. Growing a disease-resistant variety is an important component of IPM. Research into the genetics of varieties and pathogens is vital to understand how resistant varieties are to current diseases.

Disease forecasting is supported by the AHDB WeatherHub, which includes information on air temperatures; rainfall; relative humidity; sunshine duration; wind speed; soil moisture at 10, 30 and 60 cm depths; soil temperature and solar radiation. Pulling together information from the AHDB WeatherHub, as well as research on disease life cycles, decision support tools have been developed to highlight risk. The tools allow growers to make more informed decisions about the need for – and timing of – appropriate spray applications. Understanding the risk allows a control management strategy to be developed, saving both time and money.

Ramularia leaf spot

Ramularia leaf spot is becoming increasingly difficult to control across the UK. The causative fungus is resistant to azole, succinate dehydrogenase inhibitor (SDHI) and strobilurin fungicides. Chlorothalonil is the only remaining effective fungicide, but is due to be withdrawn in 2020.

From 2013, the Recommended List produced resistance ratings for ramularia, but these were suspended in 2018 because of difficulties in identifying consistent differences between varieties. This means that using resistant varieties to help manage this disease is now more problematic for growers.

In October 2018, AHDB held a ramularia workshop, which brought together researchers, plant breeders, agrochemical company representatives, agronomists and other experts to share their experiences and ideas to help find a way forward for ramularia leaf spot control. Investigations are currently looking at nutrition to

Figure 8. Ramularia leaf spot on barley

minimise crop stress and cover crops that either improve soil and fertility or suppress any spore release from straw. Read more at **cereals-blog.ahdb.org.uk/ramularia-resistance-and-ratings**

A series of special trials is being carried out in areas known to be hotspots for this disease, with the aim of putting ramularia ratings back onto the Recommended Lists.

Yellow rust

Yellow rust is an important disease of wheat, but is usually effectively controlled through varietal resistance and fungicides. For many varieties on the Recommended List, a single major gene controls yellow rust resistance. This means that although these varieties have very high resistance ratings, the resistance can easily be overcome if the yellow rust pathogen population changes.

The United Kingdom Cereal Pathogen Virulence Survey (UKCPVS) monitors the UK populations of wheat yellow rust, brown rust, powdery mildew and barley powdery mildew. Each season, it collects samples from the field, which are tested to determine whether a new race of yellow rust has emerged. Recommended List varieties are infected with these races to see if they are a threat to the yellow rust resistance of current varieties, so determining the risk to growers of these new races.

The UKCPVS relies on growers, agronomists and trial operators to send in their infected leaf samples. Sampling instructions are available at **www.niab.com**

Yellow rust on wheat leaf

Sclerotinia

The sclerotinia forecast (**ahdb.org.uk/sclerotinia**) runs from March to June during the main oilseed rape flowering period. It enables growers to see the forecast risk of Sclerotinia infection in their region, informing the need for protectant fungicide applications.
The forecast considers:

- Airborne Sclerotinia spores from a network of spore traps across the country. If spores are not present, Sclerotinia infection will not occur
- Flowering, which growers can determine by themselves. If the crop is not in flower, Sclerotinia infection will not take place
- Weather, as shown by a tool powered by the AHDB WeatherHub. If the necessary weather criteria are not met, infection by Sclerotinia spores is unlikely to occur

Along with these criteria, growers should consider risk factors including rotation, history of Sclerotinia and local factors that may elevate spore levels, or that alter weather conditions compared with those displayed in the forecast. If risk is low, application of protective fungicides is not needed.

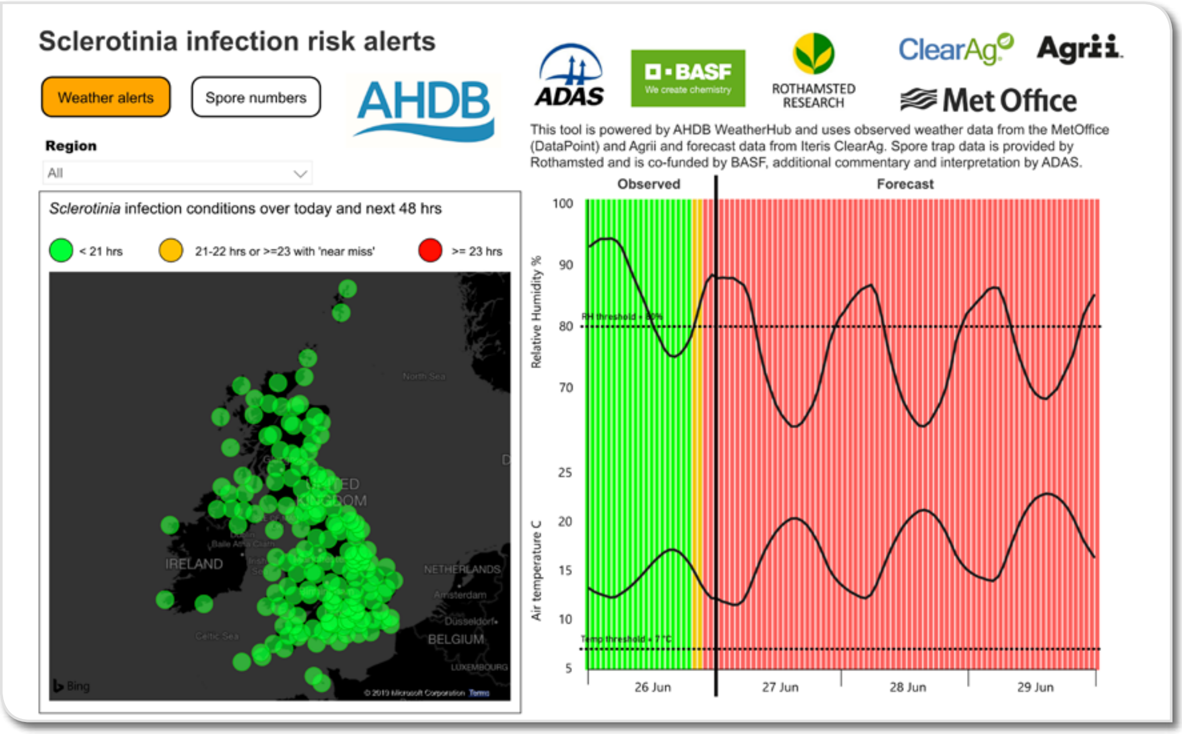

Figure 9. The weather-based Sclerotinia forecast

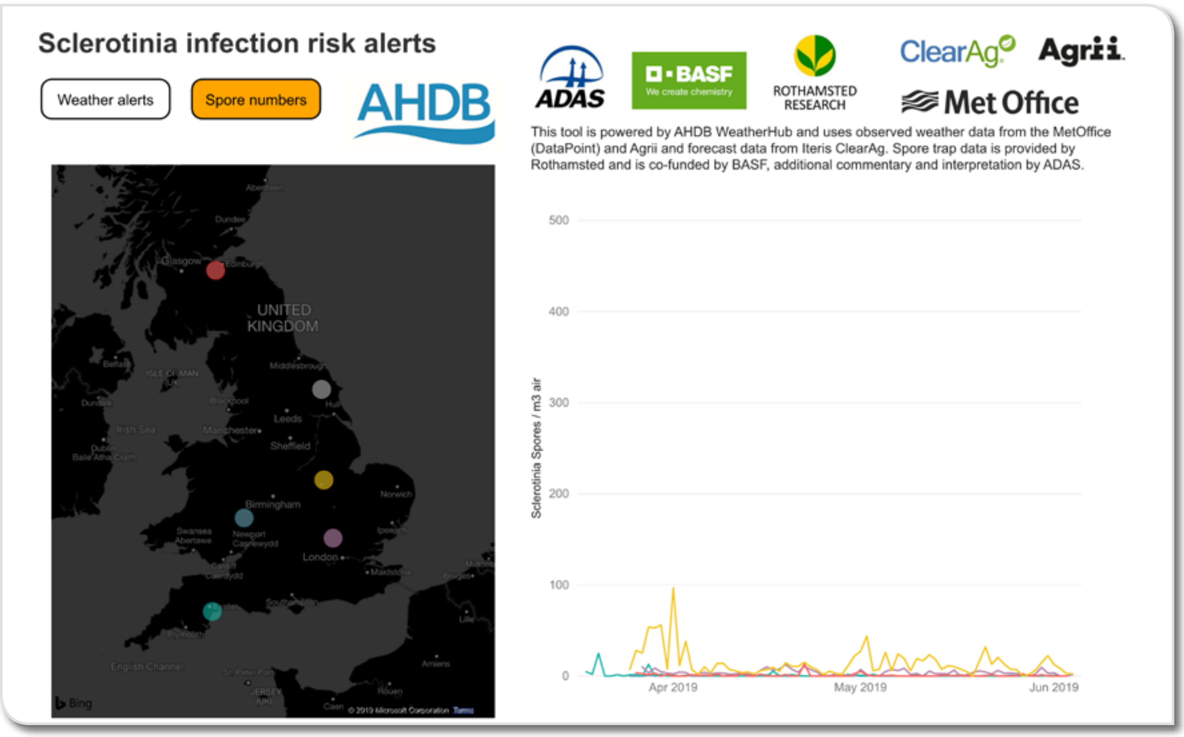

Figure 10. Airborne Sclerotinia spore data, as displayed on the AHDB Sclerotinia forecast. In 2019, levels were generally below those considered to be high risk

Blight

Late blight management involves heavy reliance on chemical fungicides, the cost of which is increasing year on year. Managing blight is challenging because of the threat of the loss of fungicides and the changing genetic make-up of the disease. This makes it important to study blight populations in Britain.

Fight Against Blight (FAB) is AHDB's blight monitoring service, reporting national outbreaks of blight since 2008. New in-season genotyping means growers can use the genotyping data to inform blight management decisions. Key findings this year show that a large number of samples, particularly in the East, have been genotyped as 36_A2 – a new, highly aggressive strain. We are also continuing the fungicide sensitivity testing that was started in 2017 for some of the key blight genotypes.

Using statistics and new geographic information system (GIS) analysis tools, current AHDB research examines the epidemiology of late blight using spatiotemporal analysis. The work includes analysis of the relationship between an outbreak during one season and an early outbreak the following season. Tracking instances of the strain 37_A2, which is insensitive to fluazinam, is also part of the research. The next step for this project is to produce key visual aids to help growers' decision-making for early blight outbreaks.

Late blight on potato leaf

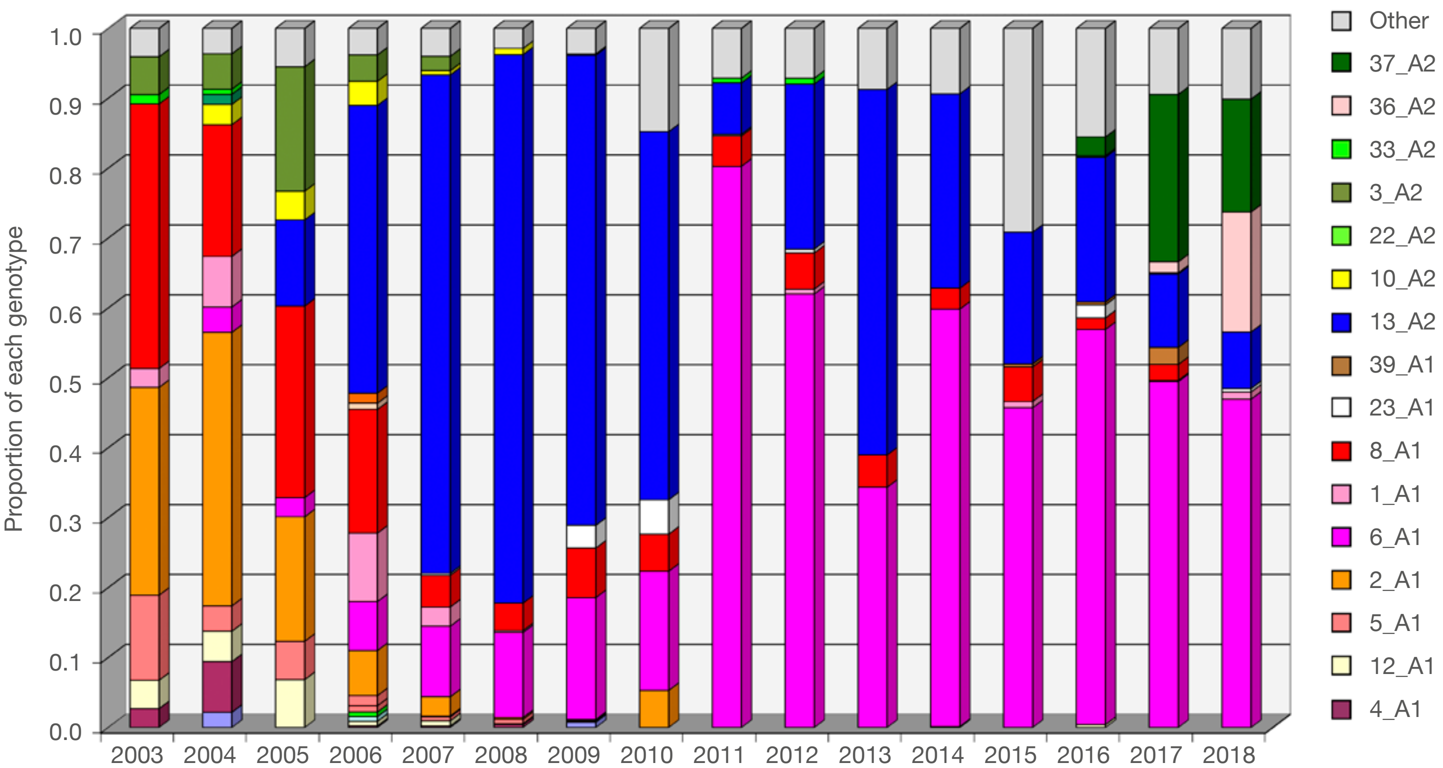

Figure 11. *Phytophthora infestans* genotypes recorded in GB potato crops via AHDB Potatoes Fight Against Blight campaign (David Cooke, James Hutton Institute)

Reviewing weed control options and opportunities in the UK

Joe Martin
Crop Protection Senior Scientist – Weeds

Currently, herbicides are the main method of weed control across cropping sectors. However, the use of these products is under increasing pressure from legislation, climate change and market requirements, such as reduced pesticide inputs and maximum residue levels. These pressures, combined with herbicide resistance, have a considerable impact on arable and horticultural sectors. Legislative changes have reduced the number of key herbicides available, exacerbating the problem of resistance to actives used on grass and broad-leaved weeds. Although resistance in black-grass dominates thinking, UK populations of wild oats, ryegrass, poppy, chickweed and mayweed are all locally resistant to a range of herbicides. Resistance issues are also emerging in bromes (*Anisantha* spp. and *Bromus* spp.) – although not nationally important, all are increasing in frequency and can present serious problems, with associated business costs. The cost of weeds to cereal and oilseeds production is substantial, with an average of £89–125/ha in winter wheat.

In the absence of any weed control, yield losses in potatoes can vary from 14–80% and financial losses could be up to £228 million per year. The loss of linuron has limited the weed control options for potatoes and changes to the Water Framework Directive could result in further losses for growers. Cultivation will become more important, but is considerably more expensive than herbicide treatment. The seed sector is at particular risk because of the loss of post-emergence actives.

Reviewing future options

The future of weed control will probably require a more holistic approach – tackling weeds across the whole system rather than within individual crops. AHDB and BBRO commissioned a review of weed management in cereals, oilseeds, potatoes, sugar beet, legumes, horticulture and grassland systems

The review provided the comprehensive information needed to coordinate investment through a targeted programme of research and knowledge exchange (KE). AHDB has recently committed to support a coordinated programme of activity on the integrated management of weeds over the next five years.

For cereals and oilseeds, quantification of the benefit of alternative weed control approaches is a priority. More robust information on the ability of varieties to compete with weeds is in particular demand. The efficacy and value of all main alternative weed control approaches is required, from simple hand rogueing, to harvest weed seed control opportunities.

Resistance issues are emerging in bromes

In potatoes, the loss of key herbicides means mechanical weeding approaches must be fast-tracked. Improved information on canopy development and guidance technology is also urgently required. Herbicide evaluations need to be improved and should include assessments of variety sensitivity.

Effective weed control generally involves the use of more than one method, which is at the heart of integrated pest management. Whole system approaches will see a greater dependence on the use of cover crops, minimum cultivation systems, inter-row management, inter-cropping, drone technology and weed maps.

As chemistry will continue to play a role in weed control, good stewardship of current active substances is vital and requires companies, regulators and users to work together to retain them. Accurate identification of weed species, understanding the life cycle and detecting herbicide resistance are vital to planning herbicide use. Improved targeting of herbicides was also cited as a key knowledge gap, including the development of weed thresholds for patch spraying.

Investment in weed monitoring also needs to be sustained to allow growers to react to population changes. This includes funding basic research to investigate – for example – how weeds spread (e.g., via organic materials) and how herbicide-resistant populations can be tracked and managed.

A review of global weed management tactics culminated in one of the most comprehensive assessments of non-chemical control methods to date. The review found that mechanical, electrical and thermal weeding techniques have great potential. Genomic approaches to disrupting weeds and developing herbicide-tolerant crops were earmarked as avenues for exploration. Alternative chemistry, including biopesticides, was also considered to have strong potential.

Weed control solutions on Strategic Potato Farms

This year, at four of the Strategic Potato Farms (SPot), several trials were conducted to investigate and demonstrate weed control solutions for potato growers.

At SPot West and SPot North, two replicated trials were conducted to study the efficacy of aclonifen in combination with various other available residual herbicides, as well as to assess phytotoxicity effects. Earlier this year, Emerger (aclonifen) was approved for potatoes at the rate of 1.75 l/ha. These trials were used to generate information on the product for growers and agronomists.

Two varieties, Maris Piper and Sunita, were used to gain more crop safety data.

At the SPot North site, some weed control was provided by Emerger applied alone. Discussions at the demonstration day concluded that it would be best to mix Emerger with other herbicides, such as Praxim and Defy. Full results will be available later in the year. In terms of efficacy, the best treatments at Spot North were Shotput + Praxim and Emerger + Shotput.

Two other trials established and carried out in 2019 explored the use of carfentrazone-ethyl as an alternative contact herbicide to diquat. Trials were demonstrated at SPot South and Elevedon.

This year's herbicide demonstration at SPot South investigated how the contact herbicide diquat can be replaced with a contact herbicide such as Shark (carfentrazone-ethyl). It also explored the differences in application timings. Two varieties, Lanorma and Georgina, were planted on 2 and 3 May. A pre-emergence application of four herbicides was applied to all treated plots. For each variety, a control and a hand-weeded control plot was left untreated (the hand-weeded control for direct comparison with treated plots) and either diquat (Retro) or carfentrazone-ethyl (Shark) was applied to the remaining plots at one of three timings (pre-emergence, 10% emergence, 50% emergence). At the field walk in June, visitors saw the effect, in terms of phytotoxicity, that the timing of application of the contact herbicides had on the different varieties, with some clear differences seen particularly at the 10% and 50% emergence timings.

This time, two plants from each plot were dug up to see if there were differences in the number or size of tubers.

At the demonstration day in August, differences were observed in tuber formation. Growers felt that 50% emergence was too late and could be damaging to the crop and yield quality.

Full results from all the trials will be available later in the year. The cost of the product is important when growers are choosing products, along with efficacy and crop safety. Indicative costs will be included in the final report.

Figure 12. Residual and contact herbicide demonstration at Strategic Potato Farm North

Nutrition

Sajjad Awan
Resource Management
Scientist – Nutrition

AHDB has an extensive nutrient management research programme for arable crops, comprising work to improve and optimise nutrient applications that are both environmentally and economically sustainable. The programme also considers local growing conditions and crop physiology to meet key target yield and product quality requirements.

With industry support, £2 million has been invested in the programme for the next 3–5 years, with approximately £750K being provided by AHDB. Key results from the trials will continue to develop the basis of new nutrient recommendations for future revisions of the Nutrient Management Guide (RB209), which AHDB updates in collaboration with industry and government partners.

Changes in phosphorus management for 2020

Bringing changes from research into practice was the subject of a recent review of research on phosphorus management (21140005). The review brings together evidence from three AHDB co-funded projects spanning 10 years. The results have prompted proposals for changes in phosphorus recommendations for arable agriculture. The changes include greater emphasis on soil, as well as crop material sampling (e.g., tissue and grain), plus accompanying analysis to monitor, assess and improve nutrient use efficiency. The target yield for the nitrogen (N), phosphorus (P) and potassium (K) recommendations has been aligned for all cereals. There is also evidence for reducing phosphorus offtake in some cereals, such as in winter wheat, from 7.8 kg/t of fresh weight (FW) to 6.5 kg/t FW. Adjustments to fertiliser recommendations will take account of these factors. The aim is for the next revision of the Nutrient Management Guide to include these changes when published in early 2020, with updates available at **ahdb.org.uk/RB209**

High yield and grain protein in milling wheat: are the two mutually exclusive?

Research on milling wheat (21140040) runs parallel with the spring barley trials (21140038) and explores the effect of N and sulphur (S) rates and timings required to achieve optimum grain quality and milling specifications. The key factors known to affect protein content and milling quality in wheat are variety, nitrogen rate and timing, nitrogen product, application of sulphur and where the crop is grown within the rotation. Lower protein content is also associated with increasing starch production.

Tests on modern high yielding Recommended List (RL) varieties will measure grain quality (grain protein and specific weight) in response to N fertiliser application rate and timing. These tests will take various soil types and growing environments into account. Three milling wheat varieties were sown during autumn 2018: KWS Zyatt (Group 1), KWS Siskin (Group 2) and Skyfall (Group 1). Furthermore, the project will evaluate the grain quality (primarily grain protein and specific weight) of these

Norfolk experimental site 2018 (spring barley)

varieties under varying N and S timings and rates, as well as their effects on elasticity and baking performance relating to protein quality and the effect of S on the production of asparagine, a precursor of acrylamide.

Could we improve malt specifications in spring barley?

The area of spring barley grown in Britain ranged between 647,000 ha and 768,000 ha in 2015–2019. It is likely to increase further to aid the control of black-grass and other weeds and as a replacement for oilseed rape – especially in regions where cabbage stem flea beetle pressure is high. The increased demand for spring cropping includes farmers new to growing spring barley who may find it challenging to reliably achieve the grain quality targets.

Spring barley was traditionally grown on light land, but is now expanding to heavy land too. This is likely to affect the optimum N strategy to achieve various grain N% targets. Malting premiums can be substantial and achieving them is often the difference between profit and loss. Growers are often over-cautious with their fertiliser rates to avoid exceeding thresholds and, as a result, may miss out on yield benefits because of suboptimal N rates. On top of this, some modern varieties yield 12% more than some traditional varieties. More recent varieties may require more N to achieve potential yield.

In 2018, research began to address these issues (project 21140038), and aims to quantify the effect of the rate and timing of soil-applied N and S fertiliser on grain N%, with a view to developing guidelines for achieving grain N% targets without yield penalty. These trials involve the testing of modern, high yielding spring barley varieties: Concerto, Laureate, Planet and KSW Irina.

The first year of trials, covering Nottinghamshire, Norfolk, East Lothian and North Yorkshire, found preliminary economic optimum N rates of between 104 kg N/ha (Nottinghamshire) and 219 kg N/ha (North Yorkshire). However, the response of grain N% to increasing N rate was the same for each variety. ***AHDB Nutrient Management Guide*** recommendations overestimated N requirement by >70 kg N/ha in Nottinghamshire, but was within 30 kg N/ha at the other three sites. Future tests will determine the sustainability of these results.

Are oats being fed enough nutrients?

Currently, guidance about when to apply N to oats is consistent with that of wheat. However, this may not be optimum for oats because the industry quality specifications for milling oats are very different. For example, there is no target for grain protein content. It is also not known whether oats really do achieve better yields and quality if they are fertilised like wheat. Therefore, with the participation of industry players including plant breeders and millers, research is seeking to determine the most appropriate N rates and timings. Trials are taking place in England, Scotland and Ireland (21140039). With S deposition from the atmosphere decreasing in recent years, the other part of this project is to optimise sulphur applications for yield and milling quality of winter and spring oats.

What is the risk of sulphur deficiency in potato crops?

The risk of sulphur (S) deficiency is also being investigated for potato crops. In this case, the research seeks to specify the conditions under which applications of S to the potato crop can be economically justified. Currently, about one-quarter of the GB potato crop

Sulphur deficiency in potato

receives an S application. However, in the recent review and revision of the potato section of RB209, a lack of experimental data was found relating to S nutrition of the UK potato crop. The most recent UK data, which were published in Scotland in the mid-1980s, were used to formulate the recommendation for 25 kg SO_3/ha (10 kg S/ha) when S deficiency was 'expected'.

Previous UK field studies have investigated the effects of N and S application on tuber sugar and amino acid concentrations and on acrylamide-forming potential. Trial data were inconclusive, but suggested that S applications might help to reduce acrylamide formation in crops given excessive N. This current project (11140048) aims to establish an appropriate S application rate in S-deficient circumstances, as well as the effect of S application on the accumulation of acrylamide precursors in cooked potato products.

Improving nitrogen recommendations in potatoes

Understanding the determinacy group of potato varieties is essential to understanding the appropriate N application rate for a given season length and soil N supply. Current N recommendations in AHDB's ***Nutrient Management Guide (RB209)*** are based on determinacy groupings of varieties, although only a few varieties are grouped based on multiple N response trials.

What is determinacy and how can it help?

Determinate varieties stop leaf production after they have initiated the first flower, while indeterminate varieties continue to produce leaves and flowers. Typically, determinate varieties need twice the amount of N as indeterminate ones, but calculating the determinacy group of a variety currently requires years of time-consuming and expensive field-testing. This can mean that during the initial commercialisation of new varieties, the recommended N rate is estimated incorrectly, leading to increased production costs, yield loss, poor crop quality and increased wastage.

Research led by the National Institute of Agricultural Botany at Cambridge University Farm (NIAB CUF; 11140044), which started in 2017, aims to produce simple objective measurements to reliably allocate varieties to determinacy groups without extensive field experimentation. These measurements include integrated ground cover, main-axis aboveground nodes and harvest index at around 55 days after emergence.

From the first year of experiments, the number of main-axis aboveground nodes seems the best indicator of determinacy. In well-replicated experiments, there was good correlation between the measurements and they are likely to produce reliable estimates of N grouping. Repeat experiments will be conducted to assess whether these measurements continue to be good indicators of determinacy. A draft protocol has been developed and will be further tested in 2019–2020.

Further information

Further research updates and resources from the AHDB Crop Nutrient Management R&D and KE programme can be found at **ahdb.org.uk/RB209**. The ***Nutrient Management Guide (RB209)*** is also available as an app for Android and iOS.

Potato storage research

Laura Bouvet
Knowledge & Innovation Facilitator – Agri-Tech East and AHDB

AHDB invests around £800,000 annually into potato storage and knowledge exchange (KE). In recent years, the portfolio of research projects has focused on four key areas of storage: sprout control, quality, diseases and defects and storage systems. With the forthcoming non-renewal of chlorpropham (CIPC), a further £800,000 has been ringfenced in preparation for this outcome, which will go towards further research and KE initiatives over a two year period to spring 2021. Further research aims to improve industry knowledge of alternative sprout suppressants, varietal dormancy characteristics and CIPC contamination. Pathology work also continues.

Sprout control post-CIPC

Sprouting in stores has largely been controlled by chlorpropham (CIPC) application, a chemical that provides effective and long term sprout control, particularly at higher temperatures (6–13°C). Under review from the European Union since 2015, its non-renewal was announced on 18 June 2019. The chemical will officially lose its approval for use as a sprout suppressant on 8 January 2020.

In preparation for this important change for the industry, Sutton Bridge Crop Storage Research (SBCSR) is undertaking three research projects to investigate the efficacy of alternative sprout suppressants for the fresh (11140057) and processing markets (11140043), building on a previous body of work on ethylene and spearmint oil as alternative treatments. In parallel, other projects are specifically exploring the effect of maleic hydrazide application timing and dose in the field on sprout control (11140056). SBCSR is also gathering varietal data on natural dormancy, since this will become more important in future sprout control strategies (11910058).

Integrating CIPC alternative sprout suppressants for the processing sector

The non-renewal of CIPC is a particular hit to the processing sector. Crisping and frying potatoes are usually stored at warm temperatures (6–12°C) to meet commercial fry colour standards. However, as these temperatures are conducive to sprouting, efficient sprout suppression is crucial to this sector.

The efficacy of alternative sprout suppressants in stand-alone and combination treatments is being explored (11140043), as shown in Table 2.

Table 2. Processing storage trials summary

Varieties to be tested	Innovator, VR808, Royal, Perfomer, Maris Piper
Sprout suppressants to be tested (stand-alone and combination)	Maleic hydrazide (MH), spearmint oil, ethylene, 1-4 dimethylnaphthalene (DMN), chlorpropham (CIPC)
Storage conditions and sampling regime	9°C stores; sampling at 3, 6 and 9 month intervals
Assessments	Sprouting and frying colour

In the first year of storage trials, CIPC and DMN were the most effective in controlling sprouting, followed by ethylene and spearmint oil. When used in combination, treatments were more effective than either treatment alone. A single dose of CIPC increased the efficacy of other treatments. This was also the case with DMN, which was a highly effective sprout suppressant on its own, but gave a statistically significant improvement when used in combination. Sprouting in all varieties was

significantly controlled with MH treatment, although the use of different stocks in the trial did not permit valid comparison across treatments.

Integrating CIPC alternative suppressants for the fresh market

An effective sprout control strategy for short-to-mid-term storage for the fresh market is to store at lower temperatures using refrigeration. However, this strategy is not always adequate, particularly in underperforming 'overhead throw' stores, where there has often been a reliance on CIPC. The integrating alternative suppressants for the fresh market project (11140057) mirrors research efforts on alternative sprout suppressants for the processing markets. Similarly, actives are being evaluated as stand-alone or combination treatments (Table 3).

Table 3. Fresh market storage trials summary

Varieties to be tested	King Edward, Maris Piper, Melody, Nectar
Sprout suppressants to be tested (stand-alone and combination)	Maleic hydrazide (MH), spearmint oil, orange oil, ethylene, 1-4 dimethylnaphthalene (DMN), chlorpropham (CIPC)
Storage conditions and sampling regime	4.5°C stores; sampling at 3, 6 and 9 month intervals
Assessments	Sprouting

Results from the first set of trials are being analysed and will be summarised in a report to be made available on the AHDB Potatoes website in Autumn 2019.

Optimisation of maleic hydrazide as a sprout suppressant

Maleic hydrazide (MH) is a plant growth regulator that has been shown to provide good levels of sprout suppression. Relatively little is known about environmental and canopy or crop factors at the time of field application and their effect on sprout control efficacy. SBCSR is addressing some of these gaps by 1) carrying out a research review and industry consultation on current practices and 2) optimising the use of MH in the field for effective sprout suppression.

The latest research suggests that timing of application, as well as crop condition, have considerable effects on efficacy, in particular because of suboptimal intake. The UK survey revealed that MH is primarily applied for sprout suppression (78% of interviewees) and secondary growth (72%) and to a lesser extent for volunteer control (66%). The survey reached growers, agronomists and advisors, representing 51 responses in total. The review 'Maleic hydrazide as a potato sprout suppressant' (11140056), which includes the survey results, can be accessed online via the AHDB Knowledge Library.

Sprouting potato in store

Following the outcomes of the review, field trials have been set up at two Strategic Potato (SPot) Farms to specifically investigate the impact of timing of in-field applications on MH performance as a sprout suppressant and to determine minimum effective dose. Two varieties are being tested.

Understanding dormancy in potatoes

Growers can tackle sprout growth using dormancy, the period before sprout growth begins. However, there is lack of knowledge about the dormancy of different potato varieties. Research aims to gather varietal information covering the different end markets and to identify a standardised methodology for assessing dormancy (11140058). Trials are taking place at two Strategic Potato Farms. In this first year, the trial is examining the dormancy of 27 varieties grown and stored under the same conditions (Table 4).

Table 4. Variety dormancy rankings following storage at 15°C (SBCSR preliminary data, 2018/19)

Market	Days to 50% sprouting >3 mm at 15°C		
	<90 days (short/medium)		≥90 days (long)
French fries	Challenger Forza Innovator	Maris Piper Royal Sagitta	Markies* Performer Russet Burbank
Crisps	Alcander Brooke	Triple 7 VR808	Markies* Taurus
Fresh	Estima Georgina Laura Maris Peer Maris Piper	Melody Nectar Panther Sensation Sunita	Lanorma Mozart

*Variety suitable for both markets.

Preliminary results are now available from the trial and are shown below. Some results are inconsistent with industry knowledge and further work is being carried out. Following years will examine how different growing environments affect dormancy in common seed stocks in similar varieties.

CIPC contamination of stores

CIPC was the sprout suppressant of choice in Great Britain for the past 50 years. Withdrawal of its approval will take place in 2020. Due to the persistence of CIPC, a large number of potato stores with a history of CIPC use are expected to contain residual levels of the sprout suppressant in store fabrics and flooring many years after the final application. These stores carry the risk of cross contamination of crops using the stores in future.

CIPC's non-renewal means that the maximum residue level (MRL), currently at 10 ppm, would normally default to the limit of quantification (around 0.01 ppm) following the withdrawal period but, in this case, would lead to some stores exceeding the MRL. Research will determine these likely levels of CIPC contamination from stores with previous CIPC use (11140059). Data from the project will form part of an industry-wide European submission to inform regulators in order to secure a higher, transitional MRL for the period following CIPC's withdrawal. This will mean that buildings can remain in use for long-term storage of potatoes.

CIPC being applied to potato stores

Mechanism of cell cycle repression in tubers

CIPC irreversibly suppresses sprouting by disrupting cell division in the cell cycle. However, little is understood about how it actually does this. By identifying the biological mode of action of CIPC, research (11140039) will provide fundamental insights into the plant cell cycle and, as a result, characterise parts of the plant cell division pathway that could provide potential targets for new sprout suppressants.

Tackling diseases in stores

Diseases in potato stores can cause substantial losses if not managed carefully. Researchers are examining diseases in the wider context of seed and ware management, as well as various environmental factors. The bacteria causing blackleg and soft rots (e.g., *Pectobacterium* spp.) are a particular threat to potato production. Blackleg control is currently difficult to achieve because the processes underlying the establishment and spread of blackleg remain largely unknown.

Research using machine learning for blackleg prediction (11120048) will utilise various datasets including those from soil, weather, geographic information systems (GIS) and epidemiology to build a predictive model and identify the principal drivers of potato blackleg development. The model and experimental results will form part of a decision support tool to guide growers and inform government to develop disease intervention strategies.

Monitoring the various stages of seed production, including storage, will take place to identify any blackleg contamination risks and bottlenecks. Novel soft rot control methods, including bacteriophage and UV treatment, will also be tested (11120031).

Integrated agronomy and storage

Presently, there is limited understanding of how different environmental factors affect seed performance and, ultimately, ware production, both during multiplication and storage. Monitoring multiple stocks of Maris Piper and Royal varieties will take place through several generation cycles in commercial and experimental systems (11140032), with stocks representing relevant agronomic and storage practices, including different storage conditions.

Results so far indicate that, on average, the incidence and severity of several diseases, notably gangrene and skin spot, were greater following commercial storage than more closely controlled experimental storage. There were correlations between high incidences of gangrene and skin spot and incomplete emergence and low ground cover, respectively.

Latent infection of tubers during storage and transit

Determining the importance of latent infection in seed lots destined for export will identify those that are at risk of quality deterioration prior to dispatch. The effects of storage and the transit journey on the maintenance of seed tuber quality are being quantified (11120028). The resulting data will provide valuable insights into disease development and tuber quality during export transit, which will help formulate effective management strategies for growers and exporters. Developing practical guidance requires additional work since the project is still in its early stages.

Figure 13. Symptoms of bacterial soft rot. Potato slice on the right has been washed of symptoms, leaving a hard edge

Looking on the horizon

Jon Knight
Head of Crop Health
& Protection

Looking on the horizon

In an industry where the only certainty is uncertainty, it's essential to have access to knowledge and data to make informed decisions. A core activity within AHDB is to generate knowledge through evidence-based research and deliver that information to growers and their advisers. As well as providing information on common issues, AHDB recognises the need to lead on understanding future challenges facing the industry to provide the right support going forward.

What do we need to know?

Some things are clear because they address current issues, so they are well-defined areas for research. It is more difficult to identify and deliver solutions that convince people to make changes in response to future challenges that are less easy to define. While AHDB can help stimulate the thinking about these challenges, we also need to plan research and knowledge exchange to enable levy payers to remain environmentally and economically sustainable.

How do we identify what areas to focus on?

Many of the staff in the AHDB technical team have specialist knowledge from years of working in their specific area. This allows them to assess the changes that are taking place and make predictions as to the likely direction of travel for the future. However, AHDB does not work in isolation; we engage with a variety of different organisations and individuals to build an overall picture of current and future concerns.

AHDB has strong engagement with levy payers through the wide range of events that we run, which provides intelligence on the immediate and medium-term issues that growers are facing. Understanding broader, long-term issues is perhaps more difficult and we work with various organisations, committees and Government departments in the UK to better understand the possible scenarios. Since farmers in other countries face many of the same issues, AHDB also communicates with many overseas organisations, such as the Foundation for Arable Research in New Zealand and the USDA in the USA, to gather as much intelligence as possible.

What are the issues?

The industry is already aware to a greater or lesser extent of the big issues it will face over the coming years. Changing weather, crop protection options, political uncertainty and trade all come into play.

Ever-increasing public and political pressure for reduced pesticide use, increasing resistance and fewer crop protection products are strong drivers for rethinking the way in which we manage pests. Integrated Pest Management (IPM) is a theme that runs through a lot of AHDB research, focusing on a holistic approach to pest, weed and disease management, to mitigate risk. This is especially important as changes in weather, a likely outcome of climate change, could lead to existing pests, weeds and diseases becoming more problematic, as well as new ones appearing in the UK through changing weather, or increased trade.

Political change means that the current system of support payments is also likely to move on from an area-based system to one of 'public money for public goods'. Farmers will need to appraise their business using support tools like Farmbench to see which areas of the business are performing well and which areas may be better suited to a different crop or enterprise. Having an understanding of costs will put farmers on a better footing as changing markets will undoubtedly put pressure on farmers to maintain or increase margins through improving productivity or reducing costs in some way.

Concerns on the sustainability of soils and other environmental impacts such as greenhouse gases leading to climate change and habitat loss may well determine how we farm in the future. Longer-term work through the GREATsoils programme will provide practical information to allow farmers to understand their soil and make informed decisions. Again, the theme of IPM will inform some areas of environmental protection by looking at the rotation as a whole, rather than each enterprise in isolation.

The other sections in this review detail much of the current activity within AHDB aimed at delivering solutions to address current problems, but they also reveal what we are planning today to better support farmers and advisers in the future. Hopefully, by starting the thinking, discussion and some of the research ahead of time, levy payers will be better equipped to face the future when it arrives.

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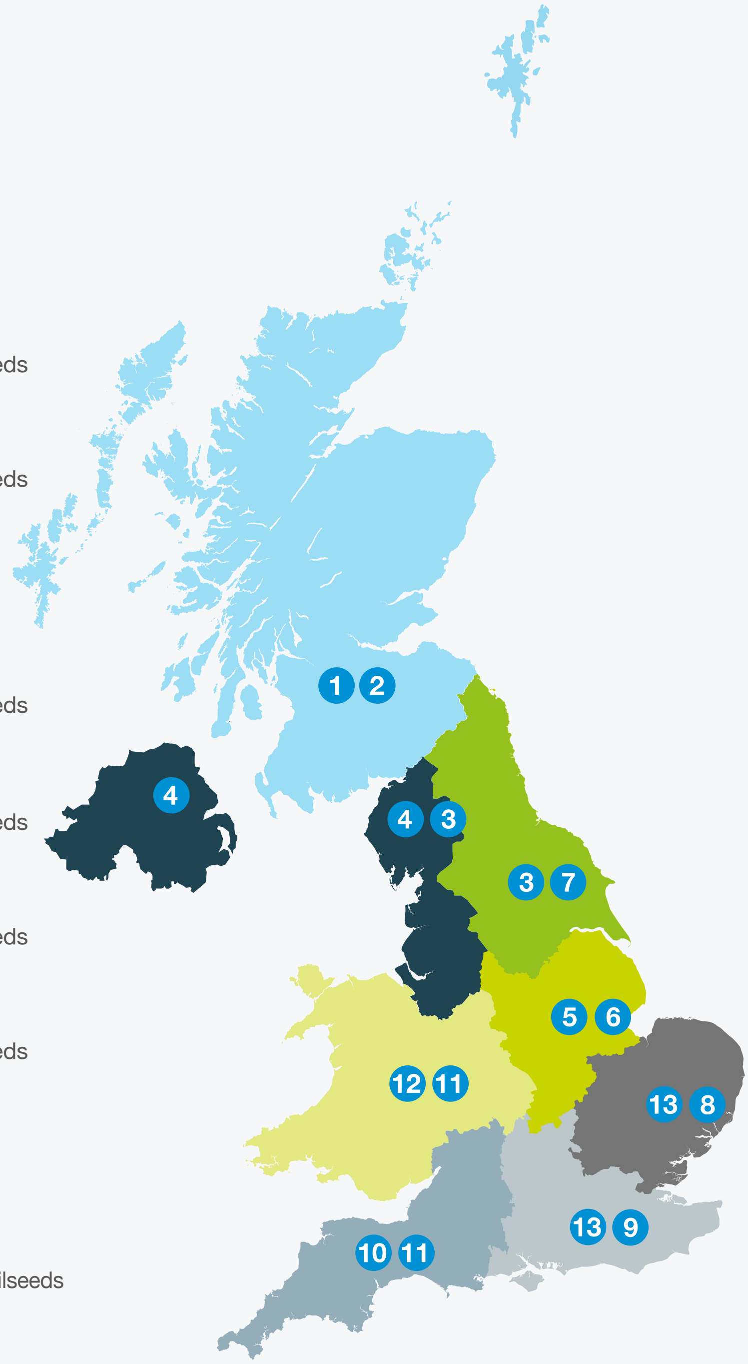

AHDB-funded research

Project number	Full title	Lead contractor	End date	AHDB funding	Cereals & Oilseeds	Potatoes
Soil						
21140029	Predicting crop disease from molecular assessment of the distribution and quantification of soil-borne pathogens (PhD)	Fera, University of Newcastle	December 2021	£25,000	✓	
91140002	Soil Biology and Soil Health	National Institute of Agricultural Botany (NIAB)	December 2021	£999,803 (Joint with BBRO)	✓	✓
91140001	Soils and Water Research Partnership: Rotations	NIAB CUF (Cambridge University Farm)	March 2021	£1,203,152	✓	✓
21140024	Fostering populations of arbuscular mycorrhizal fungi through cover crop choices and soil management (PhD)	University of Cambridge	January 2021	£35,250	✓	
21140009	Maximising the benefits from cover crops through species selection and crop management (Maxi-Cover crop)	ADAS	October 2019	£230,000	✓	
21140008	Integrating control strategies against soil-borne *Rhizoctonia solani* in oilseed rape (ICAROS)	University of Nottingham	November 2019	£80,000	✓	
Pests						
21510042	Novel approaches to CSFB control (PhD)	Harper Adams University	September 2022	£36,150	✓	
21120079	RNAi in aphids (PhD)	Rothamsted Research	September 2022	£72,300	✓	
P1907308	Management of aphid and BYDV risk in winter cereals	ADAS	August 2022	£190,000	✓	
21510022	Autumn survey of wheat bulb fly incidence	ADAS	July 2022	£32,000	✓	
21120078	Development of an environmentally sustainable and commercially viable approach to the control of the grey field slug, *Deroceras reticulatum*	Harper Adams University	April 2021	£120,000	✓	✓
11120009	Assessing the impact of root lesion nematode (*Pratylenchus* spp) infestations on the production of potatoes (PhD)	Harper Adams University	April 2021	£69,327		✓
21510012a	Aphid News 2019–2021	Rothamsted Research	March 2021	£151,960	✓	
21120064	Genetic basis of winter oilseed rape resistance to the cabbage stem flea beetle	John Innes Centre (JIC)	September 2021	£70,500	✓	
21510015	Monitoring and managing insecticide resistance in UK pests	Rothamsted Research	March 2020	£40,000	✓	✓
21120049	Integrated pest management of cabbage stem flea beetle in oilseed rape	RSK ADAS Ltd	December 2019	£150,000	✓	
11120001	Establishing biofumigation as a sustainable replacement to pesticides for control of soil-borne pests and pathogens of potato and horticultural crops	University of Leeds	February 2019	£90,747		✓
21120077	Field monitoring of BYDV risk in winter cereals	Game and Wildlife Conservation Trust	September 2019	£60,000	✓	

Project number	Full title	Lead contractor	End date	AHDB funding	Cereals & Oilseeds	Potatoes
Diseases						
21120013	Fungicide performance in wheat, barley and oilseed rape	Harper Adams University, NIAB, Scotland's Rural College (SRUC)	March 2022	£732,234	✓	
11120034	Population monitoring and fungicide sensitivity testing of late blight in Great Britain	James Hutton Institute	March 2022	£254,866		✓
21120015	Maximising the effective life of fungicides to control oilseed rape diseases, through improved resistance management	Rothamsted Research	June 2021	£160,966	✓	
21120058	Managing resistance evolving concurrently against two or more modes of action, to extend the effective life of new fungicides	RSK ADAS Ltd	March 2021	£196,500	✓	
21120018a	Monitoring and understanding fungicide resistance development in cereal pathogens to inform disease management strategies	Rothamsted Research	March 2022	£90,000	✓	
21130048	Barley resistance to Rhynchosporium: new sources and closely linked markers (PhD)	James Hutton Institute	March 2021	£70,500	✓	
21120062	Developing guidance for fungicide resistance management: a case study for SDHIs and generalisations for the future mode of actions (PhD)	Rothamsted Research	September 2020	£35,250	✓	
21120007	Combining agronomy, variety and chemistry to maintain control of Septoria in wheat	RSK ADAS Ltd	March 2020	£155,404	✓	
11120048	Application of machine learning to blackleg prediction (PhD)	James Hutton Institute	March 2020	£71,400		✓
11120032	Spatiotemporal analyses of potato late blight in Great Britain (Fellowship)	James Hutton Institute	March 2020	£100,000		✓
21140006	Developing targeted management methods for clubroot through pathotyping and field mapping to establish the impact and spread of the disease in oilseed rape	SAC Commercial Ltd	February 2019	£176,832	✓	
2140020105	Sclerotinia risk live-reporting system for oilseed rape	RSK ADAS Ltd	March 2019	£161,400	✓	
21120036	Understanding risks of severe phoma stem canker caused by *Leptosphaeria biglobosa* on winter oilseed rape in the UK	University of Hertfordshire	March 2019	£120,000	✓	
21120045	Investigating a potential new variant of *Zymoseptoria tritici*, causal agent of Septoria leaf blotch, and implications for UK winter wheat varieties	NIAB	April 2019	£69,207	✓	
Weeds						
21120059	Investigating the distribution and presence, and potential for herbicide resistance of UK brome species in arable farming	RSK ADAS Ltd	February 2021	£218,000	✓	
21120059	Investigating the distribution and presence, and potential for herbicide resistance of UK brome species in arable farming	RSK ADAS Ltd	February 2021	£218,000	✓	
21120023	Managing the resistance risk to retain long-term effectiveness of glyphosate for grass-weed control in UK crop rotations	RSK ADAS Ltd	September 2020	£250,000	✓	

Project number	Full title	Lead contractor	End date	AHDB funding	Cereals & Oilseeds	Potatoes
Weeds (continued)						
2140012101	Variable rate application of plant protection products - investigations to establish the feasibility and potential cost benefits (PhD)	Cranfield University	July 2020	£54,000	✓	
11120038	Potato desiccation trial	NIAB CUF	March 2020	£54,229		✓
11120045	Potato herbicide trial	Eurofins Agroscience Service Ltd	August 2019	£23,000		✓
21120035	Understanding interactions between *Ramularia collo-cygni* and barley leaf physiology to target improvements in host resistance and disease control (PhD)	SAC Commercial Ltd	January 2019	£54,000	✓	
Nutrition						
21140039	Nitrogen and sulphur fertiliser management for yield and quality in winter and spring oats	ADAS	May 2022	£120,000	✓	
21140040	Nitrogen and sulphur fertiliser management to achieve grain protein quality targets of high-yielding winter milling wheat	NIAB	March 2022	£179,548	✓	
21140038	Updating N and S fertiliser recommendations for spring malting barley	SRUC	April 2021	£139,980	✓	
11140048	Sulphur recommendations and acrylamide potential (PhD)	NIAB CUF	March 2021	£83,093		✓
11140044	Estimation of determinacy: Improving nitrogen recommendations for potatoes through estimation of determinacy of varieties	NIAB	January 2020	£80,815		✓
21140023	PhD: Screening and performance of phosphorous-efficient cereals cultivars for future food security	Bangor University	December 2019	£54,000	✓	
21130004	Developing enhanced breeding methodologies for oats for human health and nutrition	Aberystwyth University	August 2019	£157,841	✓	
Storage						
11140032	Quantifying effects of potato seed multiplication systems and storage practices on ware production	NIAB CUF, Sutton Bridge Crop Storage Research (SBCSR)	March 2022	£115,000		✓
11140059	CIPC contamination of stores	SBCSR	September 2021	£63,580		✓
11140039	Mechanism of cell cycle repression in tubers (PhD)	University of Sheffield	September 2021	£8,600		✓
11140058	Understanding dormancy in potato	SBCSR	September 2021	£75,000		✓
11140057	Integrating alternative suppressants for the fresh market	SBCSR	June 2021	£264,000		✓
11140056	Maleic hydrazide: optimisation as a sprout suppressant	SBCSR	June 2021	£100,000		✓
11120031	Improved seed management to minimise losses due to *Pectobacterium* species	James Hutton Institute	August 2020	£204,884		✓
11120028	Latent infection of tubers during storage and transit	SASA, SBCSR, University of Warwick	June 2020	£63,423		✓
11140043	Integrating CIPC alternative sprout suppressants for the processing sector	SBCSR	June 2020	£199,950		✓

Project number	Full title	Lead contractor	End date	AHDB funding	Cereals & Oilseeds	Potatoes
Storage (continued)						
11120028	Latent infection of tubers during storage and transit	SASA, SBCSR, University of Warwick	June 2020	£63,423		✓
11140024	Mechanisms of senescent sweetening – elucidating the mechanisms of senescent sweetening in stored potato tubers to improve storage regimes and identify candidate genes (PhD)	James Hutton Institute	September 2019	£69,327		✓
Quality						
21130058	Environmental effect of grain protein (PhD)	Rothamsted Research	September 2022	£72,300	✓	
21130047	Understanding components of specific weight in barley grains – opportunities for improving grain quality and processing efficiency (PhD)	SRUC	March 2020	£69,327	✓	
21130024	Developing systems to control male fertility in wheat for hybrid breeding, enhanced pollen production and increased yield	University of Nottingham	September 2020	£896,624	✓	
21130040	Monitoring of contaminants in UK cereals used for processing food and animal feed	Fera Science Ltd	July 2021	£871,600	✓	
21130012	Identification of Fusarium resistance within UK oat breeding lines (PhD)	Harper Adams University	September 2021	£20,000	✓	
21130005	Developing new types of wheat with good bread-making quality at low protein content	Rothamsted Research	December 2019	£80,000	✓	
21130018	Maximising the potential for Pch1 eyespot resistance and increased grain protein content in commercial wheat	John Innes Centre	June 2019	£62,000	✓	
21130025	Defining the basis for variation in water absorption of UK wheat flours	Rothamsted Research	March 2019	£180,000	✓	
21130013	Improving winter malting barley quality and developing an understanding of the interactions of introgressions with genetic background	James Hutton Institute	March 2019	£106,040	✓	
21130055	Investigation of high levels of erucic acid in consignments of double zero oilseed rape varieties	NIAB	February 2019	£45,938	✓	
21130017	Rapid development and dissemination of genetic markers for yield improvement in elite UK winter wheat (MAGIC map)	NIAB	February 2019	£99,544	✓	
21130053	Understanding the transmission or movement of ergot alkaloids in cereals grains	NIAB	January 2019	£49,792	✓	
Varieties, genetics and production						
11140054	Investigation of the potential for precision soil and crop growth mapping to improve tuber size distribution at harvest	Harper Adams University	September 2021	£71,400		✓
212000110	AHDB Recommended Lists for cereals and oilseeds 2016–2021	AHDB, BSPB, MAGB, nabim	March 2021	£7,953,359	✓	
21130024	Developing systems to control male fertility in wheat for hybrid breeding, enhanced pollen production and increased yield	University of Nottingham	September 2020	£141,312	✓	
11140035	Soil management and irrigation interactions affecting root-to-shoot signalling and yield of potato	Lancaster University	September 2020	£70,500		✓

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Varieties, genetics and production (continued)						
21130048	Barley resistance to *Rhynchosporium*: new sources and closely linked markers (PhD)	James Hutton Institute	March 2021	£70,500	✓	
21130016	Introgressing resilience and resource use efficiency traits from Scots Bere to elite barley lines	James Hutton Institute	August 2019	£54,000	✓	
11120013	Independent variety trials	SASA	July 2019	£136, 797		✓
21130018	Maximising the potential for Pch1 eyespot resistance and increased grain protein content in commercial wheat.	John Innes Centre	June 2019	£62,000	✓	
11140031	Alternative approaches for the production of healthy mini-tubers	SASA	October 2019	£77,902		✓

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