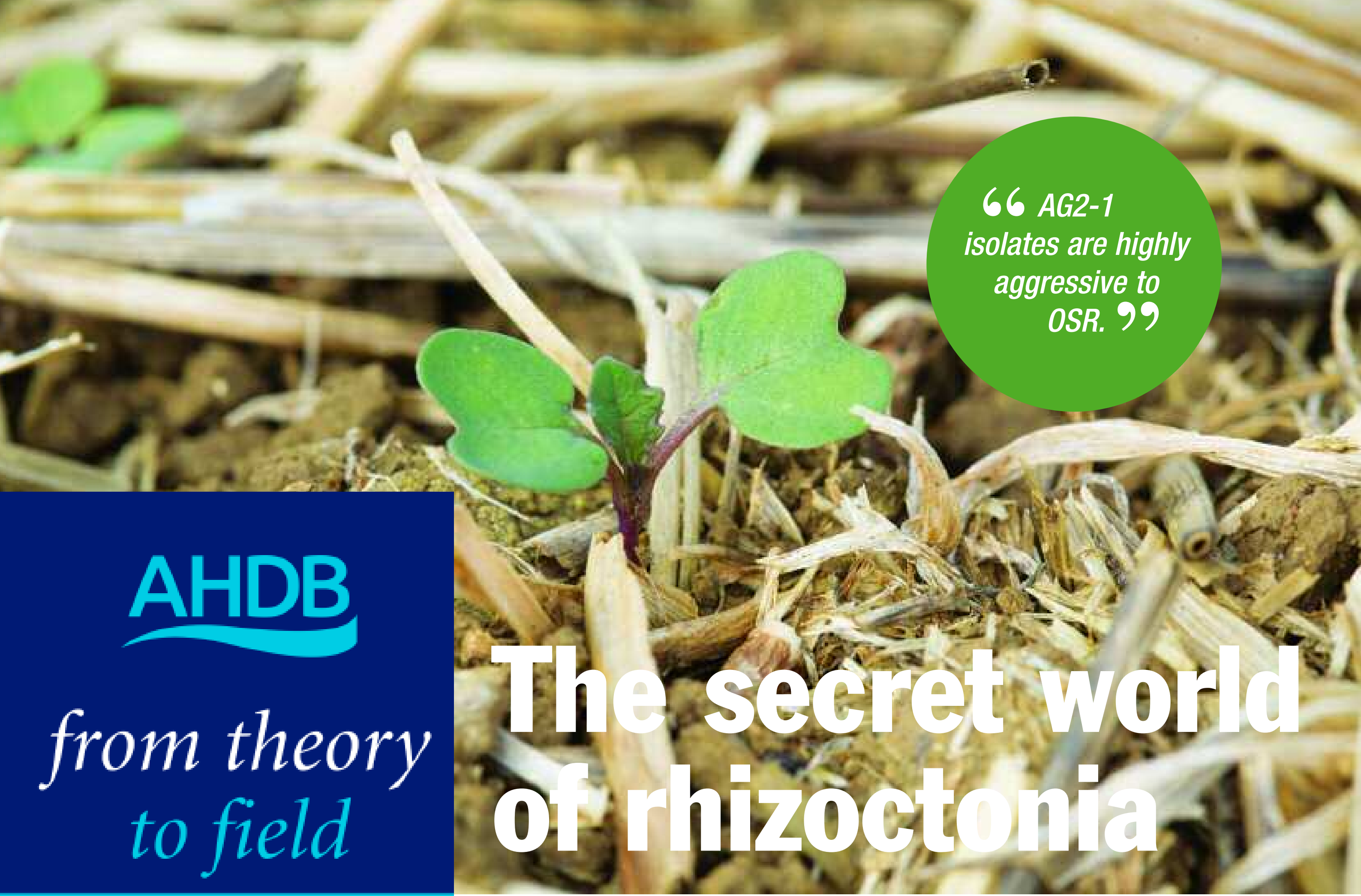

> AG2-1 isolates are highly aggressive to OSR.

AHDB

from theory to field

The secret world of rhizoctonia

New research is shedding light on the rhizoctonia pathogen which will lead to new guidelines to help growers manage the disease in OSR. *CPM* finds out more.

By Lucy de la Pasture

Soil-borne pathogens such as *Rhizoctonia solani* may attract less attention than their foliar counterparts but can have a profound effect on crop emergence and root architecture. In order to manage these diseases, it's necessary to first understand the pathogens that cause them, says AHDB's Dr Amanda Bennett.

"We need to learn more about rhizoctonia, how the pathogen interacts with other soil biology and how it's influenced by the environment. Then we can use this information to develop a more holistic approach, looking at soil health as a whole, to manage the soil environment as part of an integrated approach to managing soil-borne disease," she comments.

R. solani is a multinucleate fungus that infects roots and stems of many economically important crops including cereals, brassicas, sugar beet and potatoes.

Important pathogen

Charged with conducting research into this important pathogen is plant pathologist Dr Rumiana Ray of University of Nottingham. She's leading a three-year project, ICAROS, which has been investigating genetic traits associated with resistance to *R. solani* in oilseed rape. The aims of the research are far-reaching and will increase the knowledge of the pathogen's epidemiology and associated yield loss, as well as investigate the potential of low-dose seed treatments to control it.

"The output from the project will help produce the first guidelines for integrated control of rhizoctonia in OSR and these are expected towards the end of this year," adds Amanda.

The research is of fundamental importance because currently there are no disease resistant OSR varieties and management of this disease is often dependent on the use of fungicides. It's also ground breaking as less is known about the most pathogenic anastomosis group (AG) to OSR, AG2-1.

"The pathogen reproduces predominantly asexually," explains Rumiana. "*R. solani* is a species complex made up of 13 AGs, which are classified according to their vegetative compatibility or the ability of their paired isolates to fuse.

"Subgroups within the AGs of the *R. solani* complex exist based on host specificity, biology and genetics. AG2 is one of the most diverse, with seven subgroups (2-1, 2-2 IIIB, 2-2 IV, 2-2 LP, 2-3, 2-4 and 2-BI). Isolates belonging to each AG and subgroup are able to infect a diverse range of crops, for example, AG2-1 is pathogenic to peas, cabbage, radish, broccoli, OSR and others," she explains.

R. solani is associated with pre- and post-emergence damping off and root ►

Amanda Bennett highlights the need to know how rhizoctonia interacts with other soil biology and is influenced by the environment.

Rumiana Ray explains that soil conditions which favour plant growth also favour the AG2.1 pathogen.

▸ rots in many crops. At the seedling stage of plant development severe nfection results in seed decay and reduced plant survival associated with losses during emergence and establishment.

"AG2-1, 4 and 8 are pathogenic to OSR crops. However, plants are most susceptible during emergence and establishment or at their seedling stage of development. Seeds that germinate and develop faster have an advantage, so can potentially escape the infection at this stage.

"AG2-1 isolates are highly aggressive to OSR, causing infections on the hypocotyl and tap root, whilst isolates of AG4 can cause stem and root rots in mature plants," says Rumiana. "The classic early rhizoctonia symptoms include thinning and elongation known as 'wirestem' of stems and 'spear heading', where roots are severed at the point of infection."

Symptoms on mature plants include brown, necrotic lesions, which may girdle the root or stem circumference. These are often poorly distinguished from symptoms caused by co-occurring pathogens in complex with *R. solani*.

The rhizoctonia pathogen is ubiquitous in agricultural soils and capable of surviving in the form of resting structures, called sclerotia (made of compacted mycelia), in the soil or as vegetative hyphae on crop debris or seeds, she explains.

"Due to its saprophytic nature, the pathogen can remain viable on crop debris in soil for long periods in the absence of the host. Infections may arise from hyphae from germinated sclerotia or overwintering mycelia once the host crop has been planted. Most likely, root exudates released by the actively growing host stimulate the pathogen to produce the runner hyphae for primary infection."

One of the frustrations for UK growers of OSR is getting the crop to establish and although soil-borne disease isn't the only problem it faces at this vulnerable stage, studies indicate that losses in establishment due to rhizoctonia can range between 17% and 65% depending on the severity of the infection.

"A study took place utilising computed tomography (CT) to visualise the effect of AG2-1 on the root architecture of wheat and OSR over time. This revealed significant damage to the root system of both crops.

"The pathogen reduced the number of primary roots, root volume and root

Key points

- Min-till favours rhizoctonia
- Well-aerated, medium moisture soils favour rhizoctonia progression
- Very wet and dry soils limit rhizoctonia development
- Sandy soils favour rhizoctonia more than clays
- Close rotations, trashy crops, volunteers and weeds all increase risk
- Early rhizoctonia infection affects evenness of OSR flowering later in the season

Seed treatment for OSR in approval process

Michael Tait, Syngenta technical manager, has been involved with the research into rhizoctonia since the very beginning and Syngenta is the commercial partner in the ICAROS project.

"A previous Syngenta-funded PhD was carried out at the University of Nottingham and surveyed 100 arable crops, finding rhizoctonia was ubiquitous in English soils. It found AG2-1 was associated with close rotations of cereals and OSR, and as a result is commonplace in fields."

The results were backed up by a further AHDB-funded PhD carried out at Harper Adams University, which found AG2-1 was the most prevalent in OSR and was present at 60% of the sites surveyed.

"That raises the question whether the damage caused by the pathogen is being underestimated. Is the effect it has on establishment more of a problem than growers and agronomists are noticing?" he asks.

There are currently no seed treatments registered in the UK for use against *R. solani* in OSR, highlighting the lack of information on yield loss and contribution of the disease to current establishment losses — estimated at £30M in the worst years.

As part of the ICAROS project, various active ingredients have been screened for their effectiveness at preventing rhizoctonia in OSR. A commonly used seed treatment is fludioxonil, which is known to have good activity to a range of multinucleate and binucleate *Rhizoctonia* spp. Fungicides of the succinate dehydrogenase inhibitors (SDHI) class are also effective.

"Sedaxane is a new SDHI with very good activity and we've found that multinucleate and binucleate isolates representing 16 AG's from soils across Europe were all sensitive to sedaxane."

Syngenta have an approval for a sedaxane seed treatment for use in OSR in the pipeline, with approval hoped for in 2020. "It will help growers establish OSR and we've seen a positive yield benefit where there's disease and the environmental factors favour expression of the disease."

Michael highlights the effects of rhizoctonia infection later in the season discovered in the project as being particularly interesting.

"The effect rhizoctonia has on OSR flowering and maturation later in the season means an effective seed treatment will not only help protect seedlings during establishment, it will result in more-even flowering and maturation of the crop," he points out.

"By this autumn we'll have data from three years of work which will help give an overall picture from which we can develop strategies to mitigate the effects of rhizoctonia. We're working towards providing tools that will help growers but we're not quite there yet," he comments.

Syngenta have a sedaxane-based seed treatment going through approvals which is effective against the AGs pathogenic to OSR, says Michael Tait.

Of the three AGs that effect OSR, AG2.1 is the most pathogenic.

surface area. Furthermore, inoculated trials demonstrated that R. solani AG2-1 is capable of reducing final yield of OSR by up to 50%. The pathogen also affected crop development, with surviving infected plants having delayed maturation and uneven flowering across the field," she explains.

The research has also found that soil characteristics play a role in the ability of the fungus to spread and reach the host. "Previous work has shown that high bulk density and smaller soil aggregates reduce soil colonisation efficiency of AG4 of *R. solani*. But considerably less is known about how the soil environment and the proximity of the host affect the spread and development of AG2-1," says Rumiana.

Preliminary results from the ICAROS project agree that soil porosity (determined by soil texture and structure) is one of the most important parameters determining disease progression. Under different moisture regimes, the ratio of air and water in the space between soil particles changes, affecting both the host and the pathogen.

"Inadequate or excessive water has a profound effect on the root system development of the host, even in the absence of the pathogen, and also modifies the interaction between the pathogen and host below ground," explains Rumiana.

Rhizoctonia is one of the factors that can cause patchy emergence in OSR.

"We've shown that disease severity is greater in sandy loam soils compared to clay soils under low moisture conditions. Under high moisture conditions, air in soil spaces is displaced by water and disease severity decreases as pathogen spread is impaired.

Severe symptoms

Soil temperature also has an effect on *R. solani*, which differs according to AG. "AG 2-1 and 8 are favoured by lower soil temperatures (< 20°C), in contrast, AG4 causes more severe symptoms on adult plants in higher temperatures," she says.

One of the fascinating facts about soil-borne disease pathogens is that they often occur in complexes and are influenced by the soil community they co-exist with.

"The presence of antagonistic organisms, such as *Pseudomonas* spp. and *Trichoderma* spp., or hypovirulent binucleate *Rhizoctonia* isolates can reduce disease severity or act to protect the host against pathogenic *Rhizoctonia* isolates," she comments.

Known agronomy factors that increase the risk of disease include frequent rotations with host crops; high availability of crop residues, weeds or volunteers which can harbour the pathogen; and deep sowing below 6cm.

The project team investigated the effect of seed rate on disease in OSR and found that higher sowing rates of 80 seeds/m^2 can partially compensate for plant losses due to AG2-1 at establishment.

"The impact of tillage on disease by different AGs isn't completely clear, but rhizoctonia root rot caused by AG8 (low incidence in English soils) is favoured by direct drilling systems where no cultivation is performed. Ploughing or cultivation to 8-10cm depth can disturb hyphal networks and reduce incidence of disease," she adds.

Rhizoctonia infection affects the evenness of flowering and pod maturity later in the season.

The destruction of volunteer plants and weeds carrying inoculum into the next crop is also an effective strategy to reduce primary inoculum, she says, although there is some evidence that damage by glyphosate can lead to the crop becoming more vulnerable to disease.

"Diverse rotations can alter the microbiota composition and reduce *Rhizoctonia* spp. in soil and the severity of the disease. For OSR rotations, longer than one in four years will be most effective, but many of the UK crops in typical rotations are susceptible to AG2-1, 4 and 8 to some extent, for example wheat or peas/beans," she says.

While the application of fertiliser can help reduce rhizoctonia root rot in wheat, there's limited information available for OSR.

Plant breeders haven't focused on resistance to rhizoctonia in the past, but the project has now identified a number of genes for breeders to work with.

"There's not a lot of difference between commercial varieties but there is one conventional variety, Campus, which does seem to be more tolerant to rhizoctonia. We're now working to better understand the molecular basis of this trait," she concludes. ■

Research roundup

AHDB Project No. 21140008 – 'Integrating Control strategies against soil-borne Rhizoctonia solani in oilseed rape (ICAROS)', runs from July 2016 to November 2019. ICAROS is funded by Innovate UK, BBSRC and AHDB, in partnership with University of Nottingham and Syngenta, at a cost to AHDB of £80,000 (total funding £619,000). The project aims to discover novel traits for resistance to *R. solani* in OSR; increase the knowledge of disease epidemiology and yield loss; improve exploitation of targeted crop protection through the use of low dose seed treatment against soil-borne pathogens for crop establishment and understand trait/treatment interactions in relation to root health and yield of OSR.

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