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Grower crop root health workshops

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PROJECT REPORT

Executive Summary

- Eight root health workshops were delivered to 126 growers and advisors. Five were delivered in person at Keith, Coomandook, Blyth, Maitland and Waite and three were delivered via live video link at Lock, Kimba and Gladstone. These were very well received, with key highlights including the hands-on sessions where participants assessed the health of their plant roots and others in their district.
- When surveyed 12 months later 82% indicated they had made an on-farm practice change as a result of attending the workshop. Prior to the workshops 70% of participants said they did not check crop root health.
- Root health scores were consistently moderately unhealthy across all locations. All of the samples (258), were DNA tested to identify the primary pathogens. The results show *Rhizoctonia*, *Pratylenchus neglectus* and *Pythium* had the highest incidence and levels in cereals and pulses.
- One key message was that above ground growth is not necessarily a good indicator of root health; a feature of early sown crops where root disease often develops later in the season. This was confirmed by many samples assessed at the workshops.
- A back pocket grower manual was developed to assist growers and advisers in the identification and management cereal root diseases; 81% of participants reported they had referred to the manual, post workshop and found it a valuable resource.

Project Objectives

1. Develop and deliver crop root health workshops to SA growers and agronomists to:
 - Encourage growers to monitor crop root systems;
 - Provide hands-on experience scoring root health using cereal and pulse plants from their crops;
 - Train growers to recognise characteristic symptoms of the main soilborne diseases and score nodulation;
 - Demonstrate the value of PREDICTA® B to identify primary pathogens in diseased roots.
2. Survey participants one year after completing the workshop and to get feedback on how to improve workshop format, identify and develop useful supporting material and monitor uptake by growers.
3. Develop skills in SARDI young researchers to communicate effectively with grower groups, including seeking and responding to feedback.
4. Capture intelligence on disease trends and issues.

Overall Performance

Eight root health workshops were delivered to 126 growers and advisors across the major SA cropping regions.

The success of these workshops was driven by the hands-on sessions where participants assessed the health of their own plant roots and of those in their district. The 20 participants limit ensured growers had the opportunity for one-on-one discussions with SARDI pathologists; rated as 'invaluable' in participant feedback.

Prior to the workshops 70% of participants said they did not check root health of crops and 30% of participants were not confident in recognising root diseases. Post workshops 100% said that they were confident in assessing crop root health, with 50% knowing now when roots are not healthy and where to seek advice and the other 50% being able to recognise the main root diseases.

When surveyed 12 months after the workshops, participants still reported greater confidence in identifying root health issues and recognised root diseases are more common than they thought. 82% indicated they made an on-farm practice change as a result of attending the workshop. This indicates the hands-on learning approach is achieving the desired result of encouraging growers to be more active in their diagnosis and management of root diseases, which in turn improves the productivity and profitability.

85% of participants said that they would attend the workshop again to receive updated information, particularly on emerging pulse diseases, and 73% said they would recommend the workshop to colleagues.

258 root samples were examined at the workshops and following DNA testing of the samples, participants received a report summarising the visual symptoms of the and the DNA levels for the pathogens tested. PREDICTA® B analysis showed disease diagnosis is difficult based on visual symptoms alone; it is a useful tool to identify paddocks with levels of pathogens that require disease management implementation.

Root health at each workshop was assessed as moderately unhealthy. The roots selected from better performing areas often had significant root disease highlighting one of the key workshop messages that above ground growth is not always a good reflection of root health.

The workshops revealed more than 80% of cereal and pulse samples contained three or more soilborne pathogens. DNA testing confirmed *Rhizoctonia*, *Pratylenchus neglectus* and *Pythium* had the highest incidence and levels in cereals and pulses. Pulses were also commonly infected with *Phoma pinodella*.

Based on the feedback of participants in 2018, we developed a back pocket grower manual: 'A practical guide to identifying and managing cereal root diseases in South Australia'. The manual provides identification and management information to assist growers and advisers to manage cereal root diseases. When surveyed 12 months post workshop 81% of participants had referred to the guide and found it a valuable resource.

The courses were delivered by early and mid-career researchers Katherine Linsell, Blake Gontar, Tara Garrard and Liz Farquharson and were supported by Ross Ballard, Marg Evans and Alan McKay. AgCommunicators organised logistics and marketing, with Belinda Cay facilitating each workshop.

COVID-19 restrictions in 2020 meant workshops had to be moved online. This format had a one-hour group session, followed by individual 45-minute consultations where photographs of washed root samples were analysed by the SARDI Pathologists. The one-on-one consultations were well received and generated great discussions.

Key Performance Indicators (KPI)		
<i>KPI</i>	<i>Achieved (Y/N)</i>	<i>If not achieved, please state reason.</i>
<p>Contract signed with SAGIT, staff appointed to project and contract developed with AgCommunicators Completed – refer to 2019 Progress Report.</p>	Y	
<p>Develop and deliver two root health workshops in SA in September/October 2018, one in the Mallee and one in the South East.</p> <p>Survey participants to determine initial impressions of the value of the course, proposed changes to format and need to improve supporting materials.</p> <p>Report PREDICTA® B results of root samples to workshop participants in follow-up meeting with growers or if not practical by circulating written report.</p> <p>Completed – refer to 2019 Progress Report.</p> <p>Two workshops were delivered in 2018 at Keith and Coomandook, with a total of 35 growers and advisors attending and 72 samples inspected. Reports sent to participants summarising root health analyses.</p>	Y	
<p>Progress report accepted by SAGIT, including stop/go recommendations based on grower feedback.</p> <p>The 2019 Progress Report was accepted.</p>	Y	
<p>Support material revised, based on feedback from growers attending 2018 workshops, and AgCommunicators organised locations and venues to deliver 3 more workshops to grower groups in SA during 2019.</p> <p>Completed – refer to 2020 Progress Report.</p> <p>A back pocket grower manual was developed: ‘A practical guide to identifying and managing cereal root diseases in South Australia’.</p>	Y	
<p>Three more root health workshops delivered to grower groups in SA between late August and early October 2019. Grower feedback collated including suggestions on changes to improve format and supporting material. PREDICTA® B results collated with visual diagnosis and sample images presented to growers at follow-up meeting.</p> <p>Growers attending the 2018 workshop surveyed to determine how many had adopted practices from the workshop and impacts on management decisions.</p> <p>Completed – refer to 2020 Progress Report.</p>	Y	

<p>Three workshops were delivered in 2019 at Blyth, Maitland and Waite, with a total of 48 growers and advisors attending and 119 samples inspected. Reports sent to participants summarising root health analyses.</p> <p>AgCommunicators completed survey of 2018 participants.</p>		
<p>Progress report submitted.</p> <p>The 2020 Progress Report was accepted.</p>	Y	
<p>Support material revised based on feedback from growers attending 2019 workshops, and AgCommunicators organised locations and venues to deliver 3 more workshops to grower groups in SA during 2020.</p> <p>Completed – refer to 2021 Progress Report.</p> <p>The online webinar was recorded, and a link was emailed to each participant. The ‘Grower Manual: A practical guide to identifying and managing cereal root diseases in South Australia’ was updated and a new section included.</p>	Y	
<p>Three more root health workshops delivered to grower groups in SA between late August and early October 2020. Grower feedback collated including suggestions on changes to improve format and supporting material. PREDICTA® B results collated with visual diagnosis and sample images presented to growers at follow-up meeting.</p> <p>Growers attending the 2019 workshop surveyed to determine how many had adopted practices from the workshop and impacts on management decisions.</p> <p>Completed – refer to 2021 Progress Report.</p> <p>Three online workshops were delivered in 2020 for 43 participants from Lock, Kimba and Gladstone. The format included a webinar followed by 45 minute consultations, often with advisors attending; 67 crop samples were inspected and reports sent to participants.</p> <p>AgCommunicators completed survey of 2019 participants.</p>	Y	
<p>Progress report submitted.</p> <p>The 2021 Progress Report was accepted.</p>	Y	
<p>Final report submitted.</p> <p>The Final Report has been submitted.</p>	Y	

Technical Information

SARDI and AgCommunicators delivered eight Root Health Workshops for South Australian growers and advisers between 2018 and 2020. Locations included Keith, Coomandook, Blyth, Maitland, Waite, Lock, Kimba and Gladstone.

Total participants included 86 growers and 40 advisors from seven farming systems groups (Coomandook agricultural bureau, Malle Sustainable Farming, Mackillop Farm Management Group, Hart Field Site Group, YP Ag, AIR EP, Upper North Farming Systems).

Workshop Format

These interactive workshops explored the main soil-borne root diseases in each region, providing an insight into symptoms and management. The interactive sessions where participants could assess the health of their own plant roots (cereal and pulse crops) gave them hands on learning in diagnosing root health issues. The participant numbers within workshops were kept to a maximum of 20 to ensure growers have the opportunity for one-on-one discussions with SARDI pathologists.

The key workshop take home messages were:

- Soilborne disease is often not diagnosed because above ground growth doesn't always reflect root health or the symptoms are attributed to other causes.
- Regular root health checks can help identify root health issues.
- The main objective of doing root health checks is to recognise when a root is not healthy by looking for signs of disease, not to identify specific diseases.
- PREDICTA®B can be used to make better informed variety, crop sequence and paddock management decisions.

Participants brought plant samples (cereal and pulse) to the workshop from their own or their client's paddocks. Each participant collected one sample from a well performing or average area and one from an underperforming area, within one paddock or two different paddocks. Plants were collected in labelled bags distributed prior to the event and individual plants were labelled during the workshop. At the 2018 and 2019 workshops, participant roots were washed by SARDI staff whilst participants attended an introduction session, which was followed by a number of interactive sessions where participants:

- Assessed root health of all workshop samples.
- Observed pathogens (fungal and nematode) samples under the microscope.
- Assessed nodulation on pulses.
- Observed how to collect plant samples and wash roots.

The workshop concluded with an overview of diseases observed and a Q&A panel session with researchers. Based on feedback from the 2018 workshops, a session on disease management was also included at the 2019 and 2020 workshops.

Each plant sample was photographed and assessed by PREDICTA®B to confirm diagnosis. Following DNA testing, participants received a report which summarised the visual symptoms, pathogen DNA levels and root health comments (see example in Appendix 2).

Due to COVID-19 restrictions the 2020 workshops were delivered online. The online format included a one-hour group session, followed by individual 45-minute consultations. The participants washed and photographed their own samples and sent the sample to SARDI for DNA testing by following simple illustrated instructions. Each participant joined their individual consult via zoom; photographs of their washed roots samples were viewed via the share screen tool and analysed by SARDI pathologists. Two consultations were run simultaneously by two teams of SARDI pathologists to ensure the workshops were conducted over the scheduled three days.

Participant feedback formed the basis for reviewing the workshop format and support materials. Participants scored each workstation and provided recommendations for improvements. A year later, participants were surveyed to gauge the lasting impact of the workshop and whether this translated to practice change.

Participants were provided with several useful take home resources encouraging them to diagnose and manage soilborne diseases. All participants received a clip-on phone microscope to encourage them to dig up, inspect roots and take photos of symptoms to seek ID advice.

Based on feedback from participants in 2018 we developed a new cereal root health manual for growers, which was delivered at the 2019 workshops (Appendix 3). This back-pocket type guide provides identification and management information to assist growers and advisers in managing cereal root diseases. It is based on the successful PREDICTA® B manual, however, information was modified for growers. All participants also received the GRDC 'Disease Tips and Tactics' factsheets for key diseases and the current SARDI cereal and pulse variety disease guides. When surveyed 12 months post workshop 81% of participants had referred back to these resources, with some saying that they distributed it to others in their business.

Workshop feedback

All workshop sessions were highly rated scoring 4.5/5 each year. Many participants indicated the interactive hands-on learning and ability to talk one-on-one with so many 'experts' as invaluable. Many said they had an improved enthusiasm to dig up plants and would recommend these workshops to a colleague.

Participants were also surveyed to gauge their knowledge of root health at the start and end of the workshop. The results indicated that 90% of participants had crops with unexplained yield loss and nearly 70% were not performing regular root health checks.

Prior to the workshop:

- 30% of participants were not confident in recognising root diseases.

After the workshop:

- All participants said that they were confident in assessing crop root health
- 50% know where to seek advice
- 50% were able to recognise the main root diseases.
- 82% intended to increase the crop root health assessments on farm.

One year after the workshop, participants reported:

- Greater confidence in identifying root diseases
- Greater appreciation that root disease can affect yield
- Understanding the value of assessing root disease risk prior to making plans
- Understanding the range of management options
- 82 % had made an on-farm practice change.

The main practice changes included:

- Rotation changes
- Use and consideration of seed and fertiliser treatments
- Change of nutrition plans
- Making a management plan for grower clients
- PREDICTA® B soil tests
- Examining roots in different zones and taking more care to wash roots
- Checking the roots of pulse as well as cereal crops.

Participants that did not make a practice change, stated that the workshop had reinforced what they were doing.

85 % of participants said they would go to another workshop. Most people stated they wanted to be informed of any changes to disease pressure or management. Being informed about new pulse diseases was an interest point.

Soil borne pathogen results

From the eight workshops, 258 root samples were DNA tested; 205 from cereals crops and 43 from pulse crops.

Common visual symptoms indicated *Rhizoctonia solani* AG8 (Rhizoctonia) and root lesion nematode were important pathogens in cereal roots. DNA testing revealed *Pratylenchus neglectus* was present in 93% of samples and Rhizoctonia in 63% of samples, and both were at high levels in 30% of samples. Pythium was detected in 73% of samples. Take-all, while not observed in the visual assessments was detected in 66% of cereal samples and crown rot in 38% (Appendix 1.4, Table 4).

Cereal roots from good, average and poor performing areas were rated 1.9, 2.1 and 2.9, respectively. Root samples from poor performing areas often had higher *Rhizoctonia* levels. However, the root samples from good areas often had high levels of root lesion nematodes and *Pythium* (Appendix 1.4, Table 5).

In pulse crops, the most common visual symptoms were dark lesions on roots and lower stems; these symptoms can be caused by many pathogens. DNA testing revealed *Pythium* clade F (89% of samples), *P. neglectus* (83% of samples), *Didymella pinodes/Phoma pinodella* (78% of samples) and *Rhizoctonia* (28% of samples). Each of these pathogens except for Rhizoctonia, were present at high levels in 20% of samples (Appendix 1.4 Table 6).

Pulse root health scores for samples from good, average and poor performing areas of crops averaged 1.7, 2.1 and 2.8, respectively. Pathogens present at high levels in the poor and average samples included *Didymella pinodes/Phoma pinodella* and *Pythium*. By contrast, 30% of root samples from the better performing areas had high levels of *Pythium* and *P. neglectus* (Appendix 1.4 Table 7).

Pathogen complexes were common, with 81% of cereal samples and 87% of pulse samples containing 3 or more soilborne pathogens (Appendix 1 Fig. 11).

These results show that root pathogens often occur together and difficult to diagnose based on symptoms alone. Use of PREDICTA® B to test roots during the growing season can be a useful tool.

Conclusions Reached &/or Discoveries Made

- 85% of participants rated the workshops as 5/5.
- Highlights included the hands-on sessions where participants assessed their crop samples, viewed samples from across their district, and one-on-one discussions with SARDI pathologists. Feedback examples included:
 - ‘Improved enthusiasm to dig up plants’
 - ‘Very impressed. Might be a thing of the future (online webinars)’
 - ‘Would recommend. All farmers would benefit from the course’
 - ‘Don’t often get the chance to talk to so many experts’
- The online format (due to COVID-19) was less popular (34%) than face-to-face (66%).
- Prior to the workshop 30% of participants were not confident in recognising root diseases. After the workshop all said that they were confident, with 50% confident they could recognise when roots are not healthy and where to seek advice, and the other 50% felt they could recognise the main root diseases.
- 73% of participants said that they would recommend these workshops to a colleague.
- 82% of participants left the workshop with the intention of increasing the amount of crop root health assessments on farm.
- Twelve months after the workshops:
 - 82% had reported making an on-farm practice change.
 - 81% kept and referred to grower manual and other resources provided for disease ID and management decisions.
 - 85% said they would go to another workshop.
 - Participants wanted more information on root disease in pulses.
- Moderately unhealthy roots were common when scored visually.
- The roots sampled from good performing areas often had significant root disease, a clear message that above ground growth is not a reliable indicator of root health.
- DNA testing can be a useful tool to identify pathogens in diseased roots.
 - In cereal samples, *Rhizoctonia*, *Pratylenchus neglectus* and Pythium clade F were detected in most samples. *Rhizoctonia* and *P. neglectus* were both detected at high levels in 30% of samples.
 - In pulse samples, DNA results revealed the most commonly detected pathogens were Pythium clade f (89%), *P. neglectus* (83%), *Didymella pinodes/Phoma pinodella* (78%). These three were present in high levels in 20% of samples; *Rhizoctonia* was also detected in 28% of samples.

Intellectual Property

New grower cereal root health manual ‘A practical guide to identifying and managing cereal root diseases in South Australia’.

Application / Communication of Results

- Participants preferred hands-on workshop formats where participants assessed the health of their own plant roots and viewed others from across their district.
- The one-on-one discussions with SARDI pathologists was rated as 'invaluable'. Many said they had an improved enthusiasm to dig up plants and 73% of participants said that they would recommend these workshops to a colleague.
- Twelve months after the workshops, 82% of participants stated they had made an on-farm practice changes, indicating the workshops had a lasting impact.

Participants received a report summarising the pathogen DNA levels detected in their samples, the visual symptoms, a photograph and a root health score (Appendix 2).

The online webinars were recorded, and a link was emailed to each participant.

A podcast was created with Drew Radford (Events on air) discussing the importance of checking root health, the main diseases and symptoms, and what to do if a root disease issue was observed. The podcast is available from the PIRSA YouTube channel. (Appendix 1.1).

A summary of the disease results from the workshops was presented at the PREDICTA® B training courses.

The AgCommunicators team have written a range of media releases promoting the workshops which were distributed to media outlets in relevant regional centres, farming system groups, GRDC calendars and local events bulletins.

A feature story was published in the Stock Journal after the 2019 workshops (see Appendix 1.5).

POSSIBLE FUTURE WORK

A further nine grower root health workshops will be delivered in a new project supported by SAGIT in 2021 and 2022, The workshops will be delivered in regions not covered by this project using the latest workshop format.

SARDI is considering adapting the workshop format developed in this project to assist growers in evaluating new practices e.g., soil amelioration.

APPENDIX 1

SARDI, with support from AgCommunicators delivered eight interactive Root Health Workshops for South Australian growers and advisers between 2018 and 2020 across the major cropping regions at Keith, Coomandook, Blyth, Maitland, Waite, Lock, Kimba and Gladstone (Fig. 1).

The eight root health workshops were delivered to 126 participants (86 growers and 40 advisors) across the major SA cropping regions and engaged support from seven farming systems groups (Coomandook agricultural bureau, Malle Sustainable Farming, Mackillop Farm Management Group, Hart Field Site Group, YP Ag, AIR EP, Upper North Farming Systems).

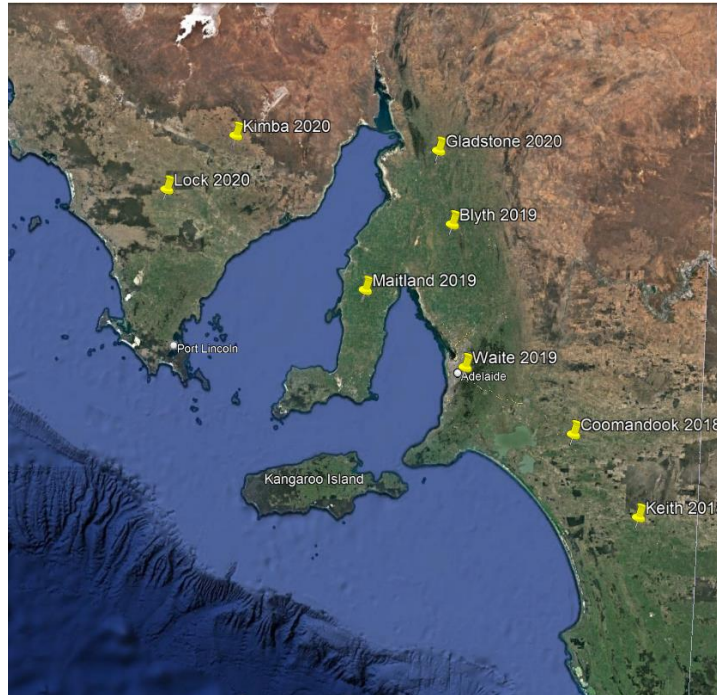


Figure 1: Map of workshop locations.

1.0 Workshop Format

These interactive workshops explored the main soil-borne root diseases in each region, providing an insight into symptoms and management. The interactive sessions where participants could assess the health of their own plant roots (cereal and pulse crops) gave them hands on learning in diagnosing root health issues. The participant numbers within workshops were kept to a maximum of 20 to ensure growers have the opportunity for one-on-one discussions with SARDI pathologists. Feedback from past participants has rated the ability to talk one on one with so many ‘experts’ as invaluable.

The key workshop take home messages were:

- Soilborne disease is often not diagnosed because above ground growth doesn’t always reflect root health.
- Performing root health checks regularly can help identify root health issues
- The main objective of doing root health checks is not to identify specific diseases but to simply recognise when a root is not healthy by looking for signs of disease
- Demonstrated how PREDICTA® B can be used to make better informed variety, rotation and paddock management decisions.

Participants brought plant samples (cereal and pulse) to the workshop from their own or their client's paddocks. Samples were collected from a well performing or average area and one from an underperforming area, from within one or two different paddocks. Plants were collected in labelled bags distributed prior to the event (Fig 2A) and individual plants were labelled during the workshop.

At the 2018 and 2019 participant roots were washed by SARDI staff (Fig 2B) whilst participants attended an introduction session, which was followed by a number of interactive sessions (Figs. 3-5) where participants

- Assessed root health of all workshop samples
- Observed root disease pathogens (fungal and nematode) samples under the microscope
- Assessed nodulation on pulses
- Observed how to collect and wash roots for root health checks

The workshop concluded with an overview of diseases observed and a Q&A panel session with researchers. Based on feedback from the 2018 workshops a session on disease management was also included at the 2019 and 2020 workshops.

Each workshop sample was photographed (Fig. 3A and B) and assessed by PREDICTA®B to confirm diagnosis. Following DNA testing of the samples the participants received a report summarising the visual symptoms of the sample, the DNA levels for the pathogens tested and comments on DNA levels which exceeded a threshold. An example of the report can be found in Appendix 2.

Due to COVID-19 restrictions the 2020 workshops were forced to move from face to face to online. The online format included a one-hour group session, followed by individual 45-minute consultations. The participants washed and photographed their own samples and sent the pictures before the workshop. They were sent simple illustrated instructions and a barcoded sample bag to send the sample to SARDI for DNA testing. The one-hour online session was held on the original day of their chosen workshop covering root health, diseases, and pulse nodulation. These one-hour sessions were then followed with individual 45-minute consultations with each participant where they were able to have their photographed root samples analysed by SARDI Pathologists. Two consults were run simultaneously with two teams of SARDI pathologists to ensure the workshops were conducted over the scheduled three days. Photographs of the participants washed roots samples were uploaded prior to their consult and were viewed via the share screen tool in zoom.

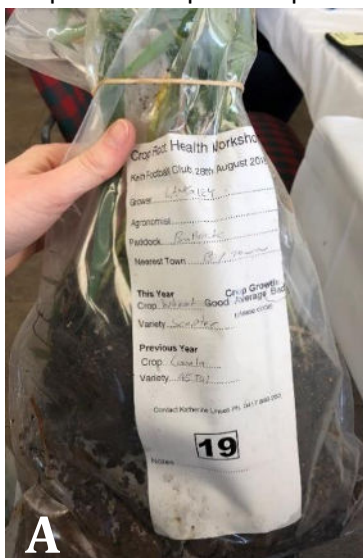


Figure 2: A: Example of participant samples collected. **B:** SARDI staff washing out participant samples at the workshop.



Figure 3: A: Example of photo of diseased cereals root included in report. **B:** Example of disease pulse roots included in report. **C:** Presentations on disease symptoms in crop and on roots **D:** Participants washed our root samples **E:** Participants doing root health checks on workshop samples.



Figure 4: Photos from the workshops. **A:** Example of root health rating scale **B:** Rhizobiologist Ross Ballard discussing pulse nodulation **C:** Participants looking at fungi and nematodes under the microscope **D:** Participants looking at root disease symptoms **E:** The SARDI pathologists at the 2019 workshops.



Figure 5: Photos from the workshops. **A:** Examples of soilborne disease symptoms on cereal and pulse. **B:** Examples of how to wash roots for health assessments in the field.

1.1 Resources

All participants received a clip-on phone microscope at the workshop to encourage them to dig up, inspect roots and take photos of symptoms for further ID advice (Fig 6).

Based on the feedback of participants in 2019 we developed a new cereal root health manual for growers (Fig 6). This back-pocket type guide provides identification and management information to assist growers and advisers identify and manage cereal root diseases (See Appendix 3). It is based on the successful PREDICTA® B manual, however, information was modified for growers. This received extremely positive feedback and was be updated again for the 2020 workshop series.

All participants received the GRDC Disease Tips and Tactics factsheets for key diseases and the current years SARDI cereal and pulse variety disease guides.



Figure 6: **A:** The grower manual developed in 2019 to assist growers and advisers identify and manage cereal root diseases. **B:** Clip-on phone microscope received by participants.

The online webinars presented in 2020 were recorded, and a link was emailed to each participant.

In 2020 a podcast was created with Drew Radford (Events on air) discussing the importance of checking root health, the main diseases and symptoms, and what to do if you do have a root disease issue. The podcast is available from the PIRSA YouTube channel. [SAGIT Root Disease - Tara And Katherine - COMPLETE by Events On Air \(soundcloud.com\)](#)

1.2 Feedback – Post Workshop

Participants completed a feedback form upon completion of the workshop, scoring each workstation on a scale of 1-5 with 5 being excellent, providing recommendations for workshop improvement and ideas on further supporting written material.

All workshop sessions were highly rated with the overall workshop scoring more than 4.5 each year (Table 1). The participant feedback was very positive, with the majority of comments contributing the success to the interactive hands on learning and rated the ability to talk one on one with so many ‘experts’ as invaluable (Table 2). Many said they had an improved enthusiasm to dig up plants. 73% of participants said that they would recommend these workshops to a colleague.

Table 1: Summary of participant workshop assessment scores for all 3 years.

	Year		
	2018	2019	2020
Introduction and presentations	4.57	4.85	
Root health check	4.48	4.85	
Under the microscope	4.09	4.20	
Nodulation	4.26	4.75	
Overall day	4.56	4.92	4.67

Table 2: Summary of participant workshop feedback for each year.

2018

Excellent to see real life examples, not just textbook cases.
Best part of the day. Was very relevant to assess own sample.
Great to get hands on first hand evidence of the diseased roots
Excellent local comparisons and brilliant way to demonstrate
Just need some results back to make management decisions with the brought in plants.
Improved enthusiasm to dig up plants

2019

Yes. Yes. Run it again. I would pay to do it and send the next generation
One of the best workshops I have attended
Hands on is very important. Getting DNA results as well is great
Plenty of people with relevant knowledge.
Great to have so many people with good knowledge
Great hands on and interactive. Will highly recommend
Would recommend. All farmers would benefit from the course
Look forward to hearing more about pulse root diseases in the future.
Glad I came along, will encourage all ag bureau members to come along next time
Very motivational and informative
Great chats with the experts
Look forward to using the manual
Nodulation was my favourite presentation
Best workshop I have been to. Great to have the practicals
Amazing to have all the SARDI team here
Amazing day. Well worth the drive

2020

It's great to be able to identify root diseases. Being able to confidently do something about it (ie rotation changes or strategies etc) would be a significant step.
Don't often get the chance to talk to so many experts
Great to have to have so many people with good knowledge
Very impressed. Might be a thing of the future (online webinars)
The ability to talk one on one is invaluable.

Participants were also surveyed with a number of questions (captured with a clicker based system) to gauge their knowledge of root health at the start and end of the workshop.

The survey highlighted that 90% of participants had crops with unexplained yield loss but nearly 70% were not performing regular root health checks (Fig. 7).

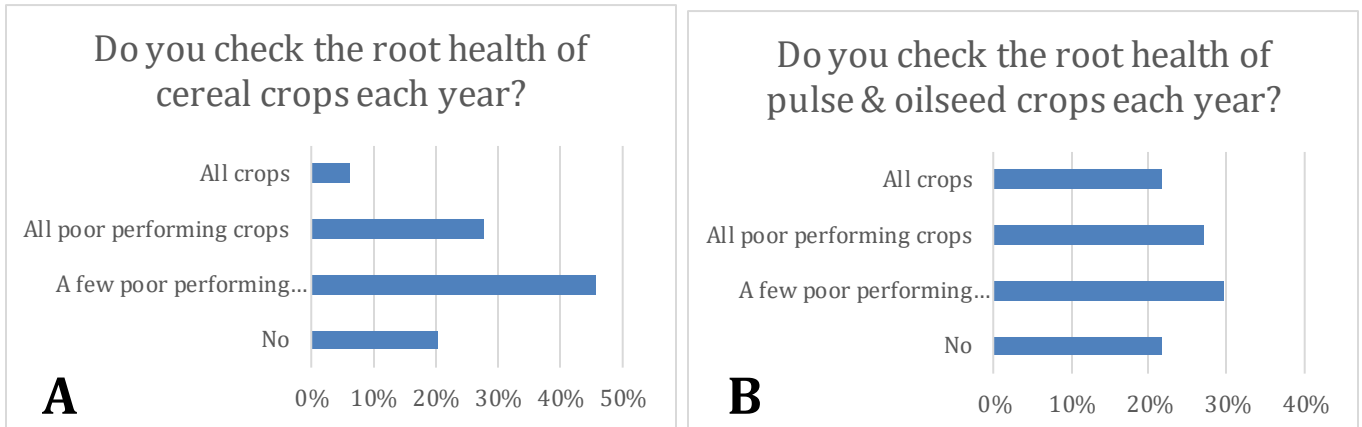


Figure 7: Participant pre workshop feedback on performing root health checks in **A:** cereals and **B:** pulses.

Prior to the workshop 30% of participants were not confident in recognising root diseases. Post workshop 100% said that they were confident in assessing crop root health, with 50% knowing when roots are not healthy and where to seek advice and the other 50% being able to recognise the main root diseases (Fig. 8). 82% of participants left the workshop with the intention of increasing the amount of crop root health assessments on farm.

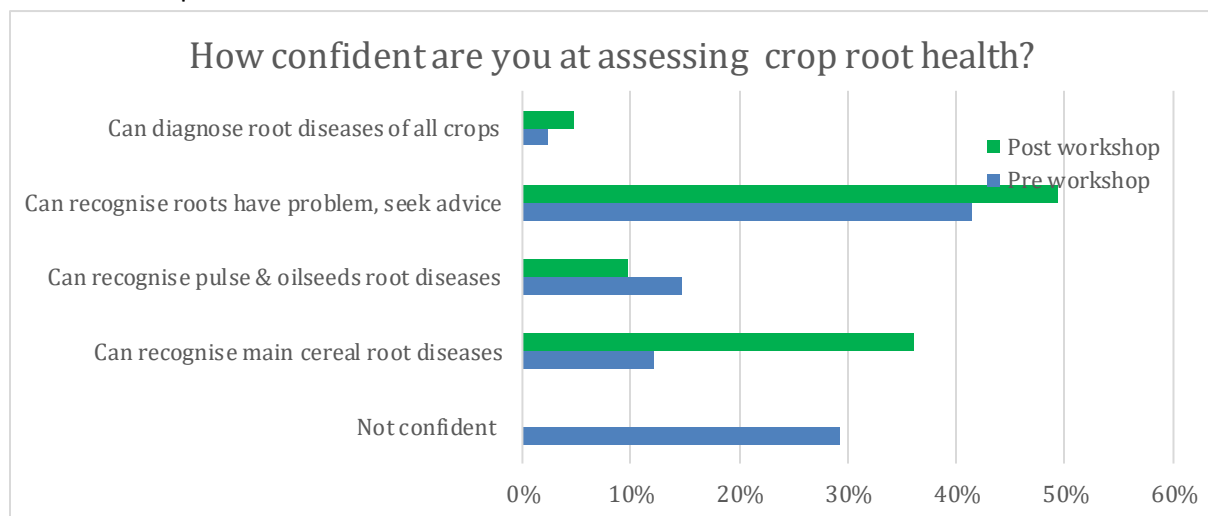


Figure 8: Participant pre and post workshop feedback on confidence in performing root health checks.

1.3 Feedback – 12 months Post Workshop

One year after attendance, participants were surveyed to gauge their knowledge, learnings and practice change.

Upon reflection, the overall workshop scored 8.7 out of 10.

The main learnings which were recalled (non promoted) included:

- Greater confidence in the ID of root diseases
- That root disease can be an issue with seeing a paddock effect
- The importance of diagnosis and assessing root disease risks prior to making plans
- Understanding the range of management options

82 % of participants stated they made an on farm practice change as a result of attending the workshops (Fig 9A). This means the hands on learning approach is achieving the desired result of encouraging growers to be more active in their diagnosis and management of root diseases, which in turn improves the productivity and profitability. The main practice change actions included

- Rotation changes
- Use and consideration of seed and fertilizer treatments
- Change of nutrition plans
- Making a management plan for grower clients
- PREDICTA® B soil tests
- Looking at roots in different zones and doing proper root washes
- Checking the roots of pulses as well as cereals
- Spending more time examining crop roots and changing management plans.

Those who said they did not make a practice change stated it reinforced what they were doing.

85 % of participants said they would attend another workshop (Fig 9B). Most people stated they wanted to be informed of any changes to disease pressure or management. Being informed about new pulse diseases was an interest point.

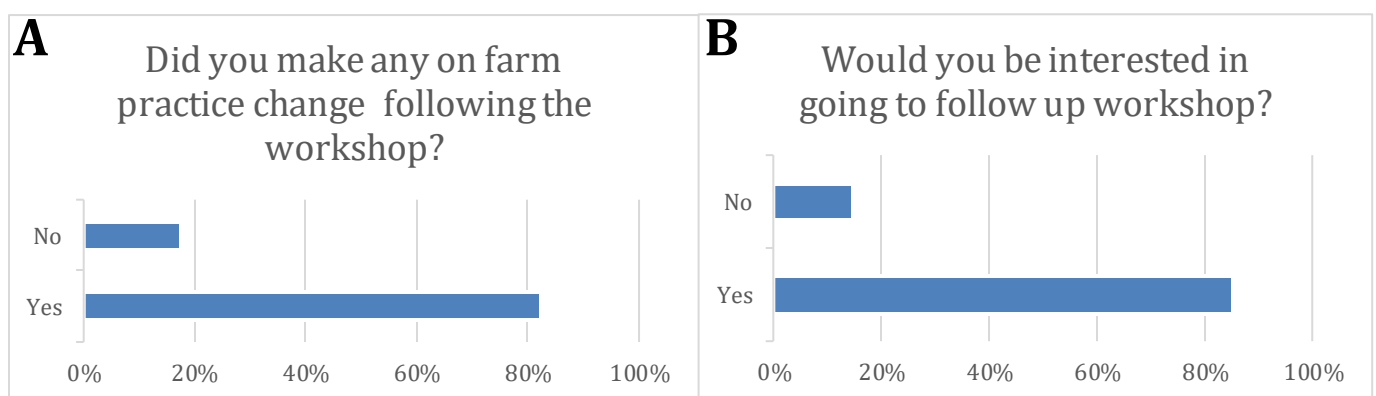


Figure 9: Participant 12 month post workshop feedback on **A:** On farm practice changes and **B:** follow up workshops.

67% said that the online format in 2020 provided all the information that they were hoping to gain. When asked about the preferred delivery mode 66% said they preferred face to face delivery and 34% preferred an online webinar with individual consults.

81% of participants referred back to the hard copy resource material which were provided to them in the workshops (Fig. 10). This demonstrates there is still value in hard copy, with some saying that they distributed it to others in their business. However, 30% of participants said they would much prefer an online e version of the manual or an app they could use in field for both disease identification and management information.

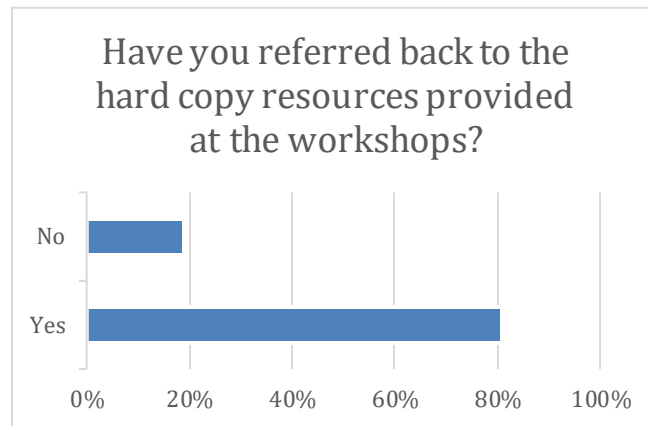


Figure 10: Participant 12 month post workshop feedback on workshop resources.

Overall, post feedback was extremely positive with participants able to recall specific information regarding soil born disease management. The design and delivery of the workshop is driving practice change and empowering growers / advisers to make new decisions around the ways they manage soil borne diseases. This research gives us confidence that the workshop style, content and delivery mode is achieving the goals and delivering back to SAGIT.

1.4 Soil borne pathogen results

Over the eight workshops a total of 258 root samples were analysed, 205 cereal samples and 43 pulse samples.

Common visual symptoms suggested rhizoctonia and root lesion nematode were the most important pathogens in cereal root samples. Testing confirmed *P. neglectus* was in 93% of samples and rhizoctonia in 63% of samples, and most concerning both were at high levels in more than 30% of samples. *pythium*, as expected was present frequently in 73% of samples. Although no visual symptoms were observed, take-all and crown rot were present in 66% and 38% of samples respectively (Table 4).

The roots sampled from average and bad performing areas were reflected in their visual root health assessments with good, average and bad rated 1.9, 2.1 and 2.9 respectively (Table 3). The roots from 'bad' performing areas often showed higher rhizoctonia levels. However, the 'healthy roots' selected from well performing areas often had the highest levels of root lesion nematodes and *pythium* (Table 5).

Table 3: Average root health scores for participants samples collected from good, average and poor performing areas of paddocks each year in cereals and pulses.

	Average cereal root health scores	Average pulse root health scores
Good	1.9	1.7
Average	2.1	2.1
Bad	2.9	2.8
	2.3	2.2

The most common visual symptom on the pulse root samples were lesions on roots and lower stems making it difficult to diagnose pathogens present as these symptoms are common to many diseases. DNA testing showed the most common pathogens present to be Pythium clade f (89% of samples) *P. neglectus* (83% of samples), *Didymella pinodes/ Phoma pinodella* (78% of samples) and *Rhizoctonia solani* AG8 (28% of samples). All of these pathogens, except Rhizoctonia, were present in high levels in 20% of samples (Table 6).

The roots sampled from average and bad performing areas were reflected in their visual root health assessments with good, average and bad rated 1.7, 2.1 and 2.8 respectively (Table 3). The ‘healthy roots’ selected from well performing areas still had high levels of pathogens with 30% of samples having high levels of Pythium and *P. neglectus* (Table 7).

In both the cereal and pulse samples collected from well performing areas there were significant levels of soil borne pathogens. This highlights one of the key workshop messages that above ground growth is not always a good reflection of root health.

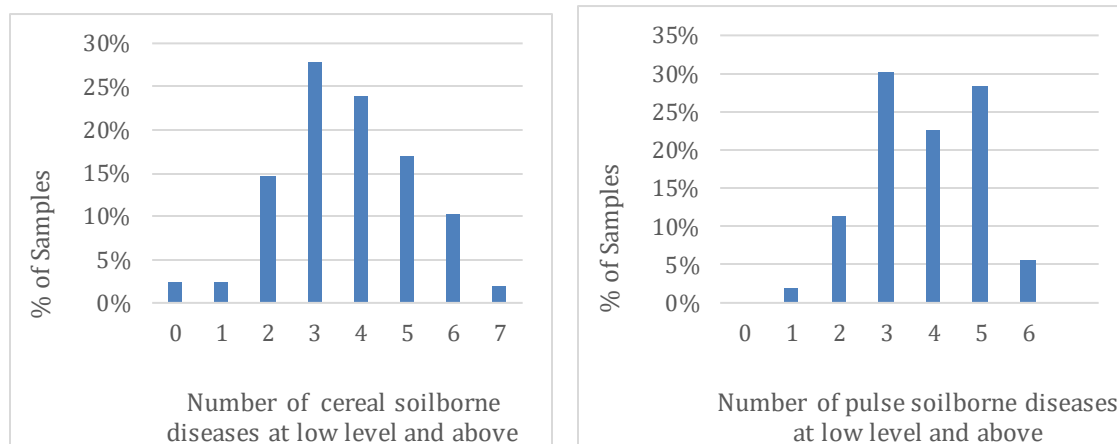


Figure 11: The percentage of samples with multiple soilborne diseases in **A:** cereals and **B:** pulses.

81% of cereal samples had 3 or more soilborne pathogens and 53% had 4 or more soilborne pathogens. Similarly, in 87% of pulse samples had 3 or more soilborne pathogens and 57% had 4 or more soilborne pathogens (Fig 11). This highlights one of the key workshop messages that soilborne pathogens often occur together and as symptoms are not clearly distinguishable between diseases PREDICTA® B of roots in season can be a useful ID tool.

In the 12 month post workshop survey 82% of people stated they would be interested in SARDI providing an in season root disease testing and monitoring service, saying this service would be valuable. They did stress that turn around time of information must be timely and relevant with clear management recommendations provided.

Table 4: DNA testing results of soilborne pathogens in workshop cereal samples from all 3 years. The number of samples with low, medium and high levels is reflected for each pathogen. Numbers in brackets is the percentage of samples with that level of disease.

Disease Level	Take-all -										
	CCN	Stem nematode	Take-all	Oat Strain	Rhizoctonia	Crown rot	Bipolaris	Pratylenchus neglectus	Pratylenchus thornei	Pythium clade f	Eradu
Total	22 (12%)	0	116 (66%)	1 (1%)	111 (63%)	67 (38%)	31 (18%)	164 (93%)	35 (20%)	129 (73%)	19 (16%)
Low	20 (11%)	0	105 (59%)	0	19 (11%)	38 (21%)	8 (5%)	37 (21%)	27 (15%)	42 (24%)	3 (2%)
Medium	1 (1%)	0	6 (3%)	1 (1%)	30 (17%)	25 (14%)	23 (13%)	79 (45%)	8 (5%)	83 (47%)	7 (6%)
High	1 (1%)	0	5 (3%)	0	62 (35%)	4 (2%)	0	48 (27%)	0	4 (2%)	9 (7%)

Table 5: DNA testing results of soilborne pathogens in workshop cereal samples from all 3 years. The number of samples with low, medium and high levels is reflected for each pathogen for plants collected from good, average and bad paddock areas. Numbers in brackets is the percentage of samples with that level of disease.

Status	Disease Level	Take-all -										
		CCN	Stem nematode	Take-all	Oat Strain	Rhizoctonia	Crown rot	Bipolaris	Pratylenchus neglectus	Pratylenchus thornei	Pythium clade f	Eradu
Good	Low	8 (11%)	0	46 (62%)	0	11 (15%)	19 (26%)	5 (7%)	20 (27%)	13 (18%)	17 (23%)	2 (4%)
Good	Medium	0	0	1 (1%)	0	15 (20%)	7 (9%)	5 (7%)	28 (38%)	3 (4%)	41 (55%)	3 (6%)
Good	High	0	0	3 (4%)	0	13 (18%)	1 (1%)	0	19 (26%)	0	1 (1%)	3 (6%)
Good	Total	8 (11%)	0	50 (68%)	0	39 (53%)	27 (36%)	10 (14%)	67 (91%)	16 (22%)	59 (80%)	8 (15%)
Average	Low	7 (19%)	0	19 (53%)	0	5 (14%)	6 (17%)	3 (8%)	4 (11%)	4 (11%)	11 (31%)	0
Average	Medium	0	0	1 (3%)	0	8 (22%)	3 (8%)	5 (14%)	18 (50%)	1 (3%)	8 (22%)	1 (4%)
Average	High	0	0	0	0	7 (19%)	0	0	10 (28%)	0	2 (6%)	2 (8%)
Average	Total	7 (19%)	0	20 (56%)	0	20 (56%)	9 (25%)	8 (22%)	32 (89%)	5 (14%)	21 (58%)	3 (12%)
Bad	Low	5 (7%)	0	40 (60%)	0	3 (4%)	13 (19%)	0	13 (19%)	10 (15%)	14 (21%)	1 (2%)
Bad	Medium	1 (1%)	0	4 (6%)	1 (1%)	7 (10%)	15 (22%)	13 (19%)	33 (49%)	4 (6%)	34 (51%)	3 (7%)
Bad	High	1 (1%)	0	2 (3%)	0	42 (63%)	3 (4%)	0	19 (28%)	0	1 (1%)	4 (9%)
Bad	Total	7 (10%)	0	46 (69%)	1 (1%)	52 (78%)	31 (46%)	13 (19%)	65 (97%)	14 (21%)	49 (73%)	8 (18%)

Table 6: DNA testing results of soilborne pathogens in workshop pulse samples from all 3 years. The number of samples with low, medium and high levels is reflected for each pathogen. Numbers in brackets is the percentage of samples with that level of disease.

Disease Level	R. solani	R. solani	R. solani	R. solani	Aphanomyces spp.	Phoma rabiei	Blackleg	Black root rot	Didymella pinodes/ Phoma pinodella	Macrophomina phaseolina	Phytophthora spp.	Pratylenchus neglectus	Pratylenchus thornei	Pratylenchus Penetrans	Pythium clade f	Pythium clade I	Stem nematode	S. sclerotiorum
	AG2.1	AG2.2	AG4	AG8														
Total	6 (13%)	0	0	13 (28%)	0	0	1 (2%)	2 (4%)	36 (78%)	11 (24%)	0	38 (83%)	9 (20%)	0	41 (89%)	14 (30%)	0	1 (2%)
Low	1 (2%)	0	0	6 (13%)	0	0	1 (2%)	0	7 (15%)	10 (22%)	0	11 (24%)	7 (15%)	0	7 (15%)	13 (28%)	0	1 (2%)
Medium	3 (7%)	0	0	5 (11%)	0	0	0	0	19 (41%)	1 (2%)	0	18 (39%)	2 (4%)	0	20 (43%)	1 (2%)	0	0
High	2 (4%)	0	0	2 (4%)	0	0	0	2 (4%)	10 (22%)	0	0	9 (20%)	0	0	14 (30%)	0	0	0

Table 7: DNA testing results of soilborne pathogens in workshop pulse samples from all 3 years. The number of samples with low, medium and high levels is reflected for each pathogen for plants collected from good, average and bad paddock areas. Numbers in brackets is the percent age of samples with that level of disease.

Status	Disease Level	R. solani	R. solani	R. solani	R. solani	Aphanomyces spp.	Phoma rabiei	Blackleg	Black root rot	Didymella pinodes/ Phoma pinodella	Macrophomina phaseolina	Phytophthora spp.	Pratylenchus neglectus	Pratylenchus thornei	Pratylenchus Penetrans	Pythium clade f	Pythium clade I	Stem nematode	S. sclerotiorum
		AG2.1	AG2.2	AG4	AG8														
Good	Low	1 (5%)	0	0	3 (15%)	0	0	1 (5%)	0	3 (15%)	3 (15%)	0	1 (5%)	3 (15%)	0	3 (15%)	6 (30%)	0	0
Good	Medium	1 (5%)	0	0	2 (10%)	0	0	0	0	9 (45%)	0	0	7 (35%)	1 (5%)	0	10 (50%)	1 (5%)	0	0
Good	High	0	0	0	0	0	0	0	1 (5%)	3 (15%)	0	0	7 (35%)	0	0	6 (30%)	0	0	0
Good	Total	2 (10%)	0	0	5 (25%)	0	0	1 (5%)	1 (5%)	15 (75%)	3 (15%)	0	15 (75%)	4 (20%)	0	19 (95%)	7 (35%)	0	0
Average	Low	0	0	0	0	0	0	0	0	5 (63%)	0	0	3 (68%)	1 (13%)	0	0	3 (38%)	0	0
Average	Medium	0	0	0	2 (25%)	0	0	0	0	5 (63%)	0	0	3 (38%)	0	0	6 (75%)	0	0	0
Average	High	0	0	0	0	0	0	0	0	1 (13%)	0	0	1 (13%)	0	0	2 (25%)	0	0	0
Average	Total	0	0	0	2 (25%)	0	0	0	0	6 (75%)	5 (63%)	0	7 (88%)	1 (13%)	0	8 (100%)	3 (38%)	0	0
Bad	Low	0	0	0	3 (17%)	0	0	0	0	4 (22%)	2 (11%)	0	7 (39%)	3 (17%)	0	4 (22%)	4 (22%)	0	1 (6%)
Bad	Medium	2 (11%)	0	0	1 (6%)	0	0	0	0	5 (28%)	1 (6%)	0	8 (44%)	1 (6%)	0	4 (22%)	0	0	0
Bad	High	2 (11%)	0	0	2 (11%)	0	0	0	1 (6%)	6 (33%)	0	0	1 (6%)	0	0	6 (33%)	0	0	0
Bad	Total	4 (22%)	0	0	6 (33%)	0	0	0	1 (6%)	15 (83%)	3 (17%)	0	16 (89%)	4 (22%)	0	14 (78%)	4 (22%)	0	1 (6%)

1.5 Publications

A feature story was published in the Stock Journal after the 2019 workshops.

20 STOCK JOURNAL Thursday November 21, 2019

CROPPING

SA workshops offer root disease insights

SAGIT

ABOUT 60 growers and advisers gained practical experience in identifying and managing soil-borne root diseases through workshops held in Adelaide, Maitland and Blyth recently.

Cereal root diseases cost growers more than \$200 million annually in lost production, but with the right management these losses can be reduced.

SARDI Soil Biology and Molecular Diagnostics leader Alan McKay said the workshops were designed to be informative and interactive and raise awareness of crop root health in cereals and pulses, especially in early-sown crops where strong early growth can mask a root health issue later in the season.

The workshops, funded by the SA Grain Industry Trust, demonstrated the importance of assessing root health to growers and advisers, as well as how they can identify the symptoms of main root diseases, while highlighting the importance of soil testing prior to sowing.

"Pre-sowing management decisions such as variety selection, use of fungicides and crop rotations are the best line of defence for many soil-borne diseases, so it is important to understand the risks to make the best decisions," Dr McKay said.

"When root diseases affect crops during establishment, areas of poor growth often develop and these are a good indication there is a problem.

"When crops are sown early and seedlings establish in warm moist soil, root diseases may not impact root growth until later in the season.

"In these crops, canopy growth can be a poor indicator of root health, and if



PLANT HEALTH: Root Health Workshop attendees were (front) Alan McKay, Ross Ballard, Liz Farquharson, Marg Evans, Tara Garrard and Jade Rose, (back) Sara Blake, Ioane Vakaci, Blake Gontar and Greg Naglis.

the crop is stressed in spring, yield can be reduced. This can cause growers to observe that the crop looked good, but it didn't finish well."

While options to reduce the impact of soil-borne diseases in-crop are limited, knowing there is a problem is useful for making late-season decisions, such as further nitrogen application and whether to cut for hay.

It is also important for planning future crops and identifying which paddocks need to be tested using the Predicta B soil pathogen testing service to confirm the diagnosis.

Growers brought their own samples to the workshops and were shown how to assess the roots.

To back up the observations, the root samples were tested using Predicta B to identify specific pathogens involved in symptoms.

Dr McKay said the workshop samples show root diseases were still prevalent in today's farming systems, which are characterised by earlier sowing times.

They also highlighted that traditional methods of visual diagnosis based on symptoms, while useful for identifying crops with poor

root systems, were not necessarily reliable to diagnose the cause.

Feedback from the three events showed attendees appreciated Dr McKay bringing the 'lab to the land' to assist with on-farm decisions.

Post-workshop survey results found all participants were more likely to complete soil testing once they understood root disease could occur despite the crop looking healthy.

"To support growers to monitor root health, we are investigating new versions of Predicta B to test cereal, pulse and oilseed root samples," Dr McKay said.

A national survey is under way, coordinated through SARDI and funded in collaboration with SAGIT and the GRDC, aiming to assist in better diagnosis and management of pulse root diseases.

The survey uses visual assessment and Predicta B testing to identify which of the known pathogens are most commonly associated with poor performing pulses and help develop new DNA sequencing methods to check for new or emerging pathogens.

† Details: sagit.com.au