Technology in broadacre cropping: monitoring airborne fungal spores

Background:

Fungal diseases affect crops grown for grain production, including cereals, legumes and oilseeds, costing hundreds of millions of dollars in losses, treatment and prevention each year. Common fungal diseases are rusts, like stem and leaf rust, powdery mildew and blackleg. Fungal spores are spread by the wind and can infect host plants when the conditions are suitable.

Image source: stem-rust-of-wheat.pdf.pdf (grdc.com.au)

The Hart field site is trialling technology for collecting and identifying airborne fungal spores.
There are three networks across Australia being used to monitor and report the abundance of important disease spores detected in the environment. In SA, there are two networks – one in the Mid North and one in the South East, that are trialling two systems, the **Bioscout SporeScouts** and the South Australian Research and Development Institute (SARDI) **Plant Health Surveillance Sentinels.**

Key terms:

- fungal spore
- pathogen
- airborne
- sensor
- threshold
- DNA
- image analysis
- machine learning
- surveillance
- fungicide
- resistance
- abundance

A traditional spore trap system

Traditionally, a 'sticky trap' is used to collect spores from the air. The tape with captured spores would be inspected by experts in a laboratory using a microscope to identify which disease spores are present.

Image source: https://burkard.co.uk/product/7-day-recording-volumetric-spore-trap/

How the Bioscout SporeScout works:

The Bioscout unit uses traditional and modern technology. As air passes through the unit, spores are captured onto sticky-tape, scanned by a digital microscope, then spores are identified by their size and shape using machine learning. The trial at Hart is providing data on 5 different pathogens detected each day and is shared to an online dashboard.
Register for free access to the dashboard: [BioScout]

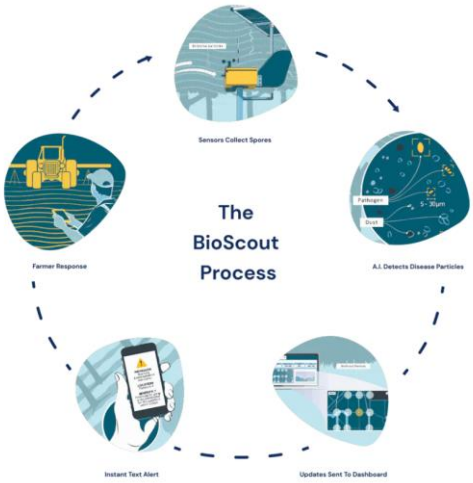
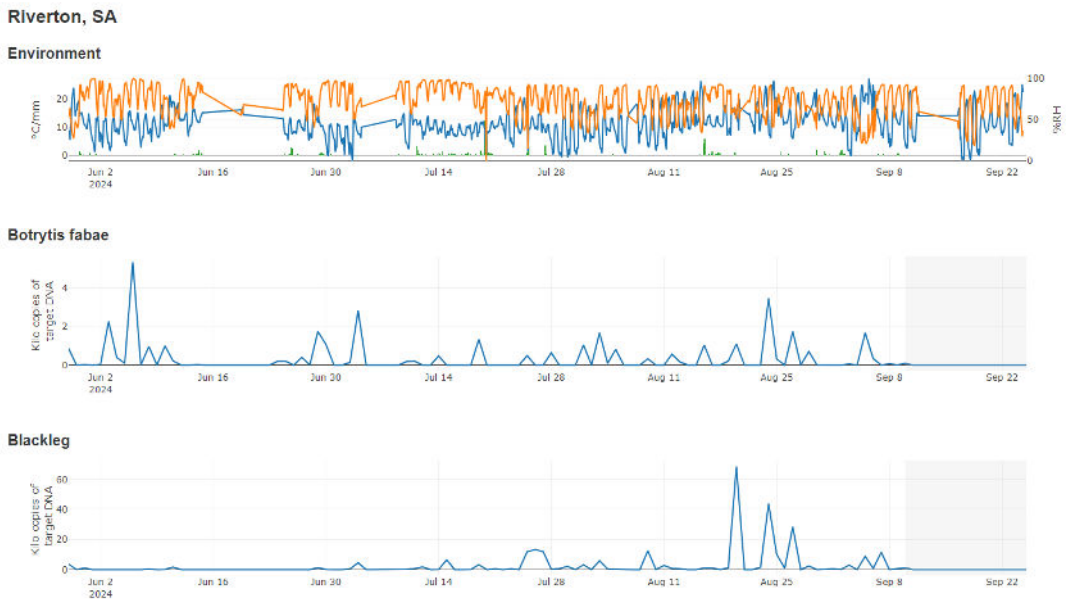


Image source: https://www.bioscout.com.au/

How the SARDI Sentinel works:

SARDI's Plant Health Surveillance Sentinel units collect daily samples using cyclone sampling and analysed using DNA by a molecular diagnostics laboratory. In the Hart trial, this system reports the data of 10 different pathogens which is shared fortnightly to an online dashboard.
Plant Health Surveillance (dtfx.com.au)

Image source https://phs.dtfx.com.au/dashboard#



Discussion points

Before exploring the SporeScout and Sentinel dashboards:

1. How do fungal diseases impact crops?
2. How are fungal diseases spread from season to season, crop to crop?
3. How are fungal diseases controlled during the season?
4. Are all crop pathogens fungi?

After exploring the Bioscout and Sentinel dashboards:

5. What is the value in monitoring spore types and numbers?
6. Who would benefit from this information?
7. Compare the method applied to detect airborne pathogen data by the SporeScout and Sentinel units. What are the benefits or limitations of each system?
8. What factors might affect the number of fungal spores in the air?
9. How does the term “threshold” relate to fungal spore monitoring?
10. How does weather impact fungal disease risk?
11. 2024 has been a very dry season across SA. How would this impact the use of data collected in 2024?
12. What is the value in connecting the two data sets for weather and disease numbers?
13. Check out the “Our Partners” section of the Bioscout website and discuss why these industry organisations have collaborated in the development of Bioscout.

Suggested responses

Key terms:

- fungal spore – *single celled reproductive unit for a fungus*
- pathogen – *disease causing organism*
- airborne – *something carried and distributed through the air*
- sensor – *a device which detects and measures a known factor*
- threshold – *the level above which a disease becomes a significant risk to a crop, requiring action by the producer*
- DNA – *deoxyribonucleic acid; the carrier of genetic information for living things; unique to each species*
- image analysis – *processing an image to gain information and data from it*
- machine learning – *a type of AI where data and algorithms are used to train a machine to learn from experience and perform tasks*
- surveillance – *close observation or monitoring*
- fungicide – *a chemical used to control fungal diseases*
- resistance – *the inherited reduction in susceptibility to a chemical that fungi can develop when the chemicals are over-used or used inappropriately*
- abundance – *the amount of spores; usually means a situation where there is more than enough*

1. How do fungal diseases impact crops?
   Fungi kill cells and cause plant stress by reducing the area available for photosynthesis or interfering with key plant functions like seed set. This could mean reduced yield and quality of the grain, fodder or fruit. Some weaken structures like stems which mean plants snap or collapse. Others contaminate the grain or fruit, making it unsafe for use by humans or livestock.

2. How are fungal diseases prevented?
   Seed treatments, bred plant resistance (different varieties), crop rotations, hygiene of machinery and equipment, quarantine and biosecurity measures.

3. How are fungal diseases controlled during the season?
   Fungicides, usually applied as a foliar spray (on leaves and stems) to protect new growth.

4. Are all crop pathogens fungi?
   No, there are also disease-causing bacteria and viruses. The SporeScout & Sentinel systems do not currently monitor bacteria and viruses.

5. What is the value in monitoring spore types and numbers?
   Can assess which diseases are present and if they are relevant for the crop types and crop growth stage in the district. Can identify new or unusual diseases, if machines are trained (Bioscout) or different DNA signatures are monitored (Sentinel).

6. Who would benefit from this information?
   Farmers, agronomists and other advisors, agribusiness retailers who provide fungicides to producers, chemical companies, researchers, trial site managers.

7. Compare the value and purpose of the data provided by SporeScout and Sentinel units.
   If fungal spores have unique size and shape to identify them from other airborne particles then digital identification by SporeScout provides a quick data set for daily info on 5 fungal diseases. DNA analysis used

by the Sentinel units will be more accurate and sensitive, with 10 types monitored, but takes longer to receive and analyse, so decision making opportunities are delayed. DNA analysis also allows additional information to be explored, like the amounts of the pathogen population that are resistant or susceptible to fungicides, identified within its DNA makeup. The SARDI sentinel also collects across a full 24 hours whereas the BioScout collects at a set time each day to allow digital scanning which may miss some fluctuations in spore numbers.

8. What factors might affect the number of fungal spores in the air?
   Weather, especially wind, humidity, rainfall and temperature. The amount of spores carried over from previous crops & seasons, or from other regions. Crop type. Number of host plants like weeds.

9. How does the term "threshold" relate to fungal spore monitoring?
   The threshold is the number of fungal spores in the air above which a farmer might need to treat the fungus. If numbers are below the threshold, there isn't a threat to the crop that needs to be acted on. This requires a lot of research to match threat with risk, so when spores in the air cross a threshold to become a high risk of disease in crops.

10. How does weather impact fungal disease risk?
    Fungi can flourish in warm, humid conditions and can be spread more easily when it is windy.

11. 2024 has been a very dry season across SA. How would this impact the use of data collected in 2024?
    The 2024 data presented on both dashboards show low levels of pathogens, which is representative of a below average season in SA due to dry conditions. The data may not provide a compelling requirement for farmers to respond in managing diseases, as their focus is turning to drought management of their crops but is useful to researchers examining the effects of climate on disease development. Data collected across several seasons will be more reliable and provide more guidance.

12. What is the value in connecting the two data sets for weather and disease numbers?
    Stakeholders could learn more about the weather conditions that result in high spore numbers which would help them as they make management decisions. If they used weather records and forecasts together with spore data, it could help them decide when to treat or not, which would save money and improve effectiveness of treatments.

13. Check out the "Our Partners" section of the homepage of the Bioscout website and discuss why these industry organisations have collaborated in the development of Bioscout.
    The partners are all involved in primary production directly or in supporting producers. They are "stakeholders" which means they have a direct connection to crop production and could potentially benefit from improved disease management. They are producers, research organisations, Government bodies and chemical companies.

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Further reading:

New technologies for regional surveillance of airborne diseases - GRDC