PATHOGENS – It's all in their DNA

As the sun sets later each day and the soil starts to warm, now is the time to be planning for the coming season, and a key part of that is testing soil and seed for the presence of pathogens.

By Ryan Hall and Jenny Ekman

Healthy soil bristles with activity. Like an endless external gut, it hums with scavenging, predation, parasitism and digestion by its inhabitants, all searching for moisture, nutrients and safe sanctuary from the thrum of life.

Bacteria and fungi dominate life in the soil. Many benefit from the growth of potato plants, or are at least neutral. However, a few are clearly harmful. Such soil-borne pathogens wage war against their host. They impact rotations, reduce yield and quality and, if left unchecked, can destroy the very plants they depend upon.

Figure 1. The risk of powdery scab increases if there is a high level of inoculum in the soil at planting, especially if environmental conditions are otherwise not favourable to the disease.

KNOWING THE ENEMY

Enter PREDICTA Pt. Developed by SARDI (South Australian Research and Development Institute) this commercial DNA testing service can identify which pathogens are in the soil, or in the skin of seed tubers. In effect, this puts power back into the farmer's hands when managing soil-borne diseases.

PREDICTA Pt testing detects specific areas of pathogen DNA. It provides not just a "detected or not", but also a quantitative result. That is, how much of that DNA is present in the original sample.

For some diseases, the amount of pathogen DNA present can be linked directly to the degree of risk from that specific disease (Figure 1). In other words, a large amount of inoculum in the soil = high risk of disease.

In this way, PREDICTA Pt can provide a risk assessment for powdery scab (*Spongospora subterranea*), black dot (*Colletotrichum coccodes*), root-knot nematodes (*Meloidogyne* spp.) and verticillium wilt (*Verticillium dahliae*) in soils.

The test can also be used to test the skins of seed potatoes and, in certain circumstances, potato plants themselves. The degree of risk of common scab (*Streptomyces scabies*), silver scurf (*Helminthosporium solani*), and rhizoctonia (*Rhizoctonia solani*) on seed potatoes can all be linked to detection and quantification of pathogen DNA in potato peel.

Expression of disease is not just due to presence of the pathogen, but also environmental and plant factors; the familiar "disease triangle" (Figure 2). It's a bit like catching a cold; whether there have been twenty people sneezing around you or just one won't necessarily change how sick you feel!

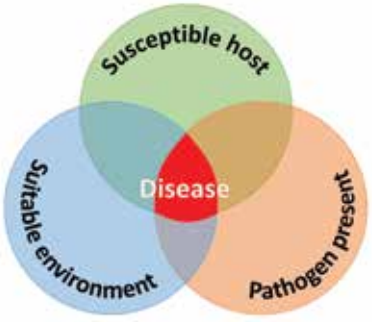


Figure 2. The disease triangle

Although the PREDICTA Pt test reports the relative amount of DNA present in soil of pathogens that cause soil-borne diseases such as rhizoctonia, pink rot and sclerotinia, in this case there isn't a clear relationship between population density and occurrence of disease. Other environmental factors, as well as the susceptibility of the plants themselves, is likely to play a major role in whether disease will be expressed or not.

It is also important to understand that getting a negative test doesn't mean the pathogen is not there. Pathogens are not evenly distributed around a paddock, or even within soil. This means that sampling is critical. Testing is a numbers game; the more samples you take, the better the chance of detection.

If only low populations are present, it can be a bit like finding a needle in a haystack. For some pathogens, levels of inoculum (spores or hyphae) that are below the level of detection can still result in high levels of disease if conditions are right.

There are also some serious pathogens – such as Fusarium dry rot (*Fusarium oxysporum*) for which no test has been developed.

WHEN SHOULD PREDICTA PT TESTING BE DONE?

According to SARDI Research Scientist Michael Rettke "PREDICTA Pt testing needs to be done well before planting. Samples should be sent to the lab one to three months prior to planting. Although turnaround of samples at SARDI lab is four to 14 days, you also need time to interpret the results, and decide what actions to take next."

Testing seed tubers before planting can be particularly valuable. Using only high quality, tested seed is the best way to maximise the chance of growing a healthy, high yielding crop.

HOW SHOULD IT BE DONE?

Sampling is conducted using a network of accredited providers. These providers have been trained in soil (and peel) sampling techniques, understand key details regarding the different pathogens tested, and can help growers interpret the test results.

A list of accredited providers is available on the SARDI website, simply search for PREDICTA Pt.

The recommended number of PREDICTA Pt soil tests varies according to paddock size. Where one or two tests may be sufficient for paddocks up to five hectares, four or more tests may be advised for paddocks over 10 hectares. The number of tests conducted might also vary depending on variations in previous incidences of disease, soil type and drainage.

Each tested sample consists of 30 combined soil cores collected in a "W" pattern over a one hectare area.

In the case of peel, samples of up to 250g fresh weight can be submitted. A single piece of peel is taken from each of 100 tubers and tested in a single sample. Using correct sampling strategies to obtain representative samples is critical when testing to assess the risk of disease.

USING THE RESULTS

There are many ways that the results can be used to take informed management decisions. "For example, you might identify that a particular paddock, or part of a paddock, is at increased risk from disease, then take actions to reduce risk" explains Michael.

This could mean improving drainage, targeted fumigation, selecting a resistant variety or choosing to plant a different crop in paddocks where risk is unmanageable. For example, if there is a high risk of black dot, then selecting a less susceptible variety, optimising nutrition, irrigation, haulm and harvest management and pro-actively managing disease risk with fungicides can help reduce risk.

As another example, use of expensive nematicides may be justified if high levels of root knot nematodes are present. Similarly, using a soil treatment where high levels of verticillium wilt are present has been demonstrated to improve crop health.

In the case of seed potato production, growers are using the tests to avoid planting in paddocks where a high risk of disease, particularly of powdery scab, is identified.

"In the longer term, using the PREDICTA Pt test to monitor paddocks provides valuable information to improve soil management and crop rotation, reducing risk for future potato crops".

"Knowledge gained from these tests can be instrumental in developing new approaches to manage potato diseases" commented Michael.

CASE STUDY – USING PREDICTA PT TO MONITOR THE EFFECT OF CROP ROTATIONS ON SOIL-BORNE DISEASE

This Tasmanian case study describes the use of PREDICTA Pt to monitor powdery scab and rhizoctonia on a commercial farm over a five-year period.

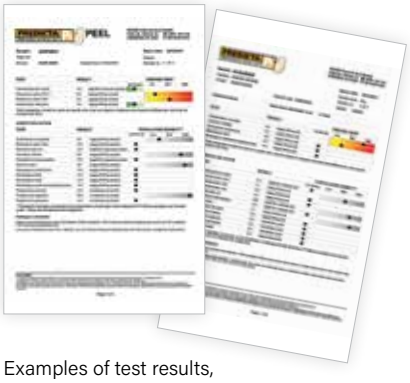
Over the winter of 2015, the paddock was divided into quarters and sown with:

1. Left fallow (commercial practice)
2. Saia oats
3. Caliente + Nemat (brassica biofumigant mix)
4. Caliente (nematode suppression)

In preparation for planting in October 2015, the cover crops were terminated, and samples analysed with PREDICTA Pt. These points were mapped using GPS, allowing sampling from the same points over time.

Each location was resampled:

- January 2016, mid potato crop
- April 2016, after the potatoes had been harvested
- March 2017, following a crop of poppies
- May 2018, after a year under clover-dominated pasture
- April 2019, after two years under pasture
- May 2020, after three years under pasture



Examples of test results, from the SARDI PREDICTA Pt website

Corer used to extract soil samples for testing. Image from SARDI

POWDERY SCAB *(Spongospora subterranea)*

Interestingly, poppies increased soil populations of powdery scab (Figure 3). Following the poppy crop, powdery scab was higher in the areas previously planted with a cover crop or biofumigant, compared to the area left fallow.

Although levels of pathogen DNA declined under pasture, they once again increased following a wetter than usual autumn in 2020.

It has not been confirmed whether or not infected poppy supports the production of *Spongospora subterranea* long-term resting spores.

RHIZOCTONIA *(Rhizoctonia solani AG2.1)*

Detections of Rhizoctonia DNA increased in areas planted to caliente or caliente + nemat (Figure 4). Levels declined during cropping with poppies and fell below detectable levels after a year or more under pasture.

Black dot was also tested. However, levels of DNA remained relatively low and constant over the entire testing period, regardless of cover crop used.

CONCLUSIONS

The results demonstrate how populations of soil-borne diseases fluctuate over time. In this case, planting a cover crop tended to increase levels of certain diseases compared to simply leaving the area fallow.

Of course, there are many benefits of cover crops in terms of improving soil health and structure, increasing soil organic matter, and preventing erosion.

However, the results suggest that brassica biofumigants should not be used if Rhizoctonia is known to be an issue. They also indicate that poppies are an alternate host to powdery scab, so are likely to increase levels of this pathogen within the soil.

Disclaimer: These results are observational only and have not been evaluated in a replicated scientific study.

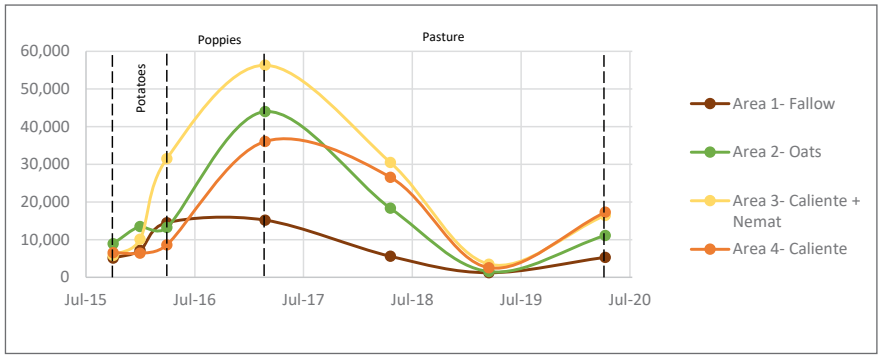


Figure 3. Relative amounts of powdery scab DNA in areas of a paddock initially planted with a cover crop or left fallow, then used to grow potatoes, poppies and finally pasture.

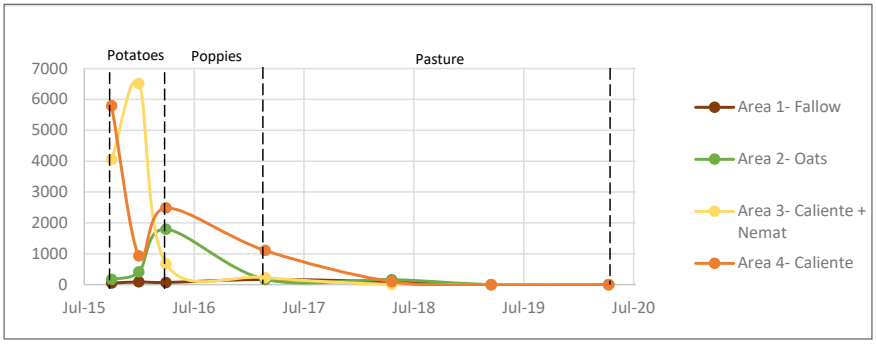
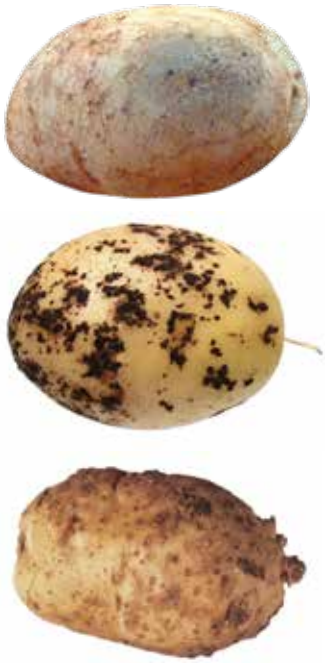


Figure 4. Relative amounts of rhizoctonia DNA in areas of a paddock initially planted with a cover crop or left fallow, then used to grow potatoes, poppies and finally pasture.



From top: PREDICTA Pt can provide an estimate of risk from black dot (*C. Hutchinson*), Rhizoctonia (*A. Hussein)* and root knot nematodes (*G. Holmes, Bugwood.org*)