Managing pythium root disease for better crop rotations

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Recent CSIRO Entomology research has led us to new weapons in the battle against pythium. The work has resulted in a considerable increase in knowledge on pythium itself, the conditions under which it is a problem and its epidemiology (disease incidence) on crops and pastures.

Over four years a total of 80 fungicide, crop rotation and disease bio-control trials were conducted at eight sites throughout the Western and South Australian, Victorian and New South Wales winter rainfall grain cropping zone. On average, the pythium -selective fungicide used significantly decreased both soil inoculum and root infection levels by 25 per cent.

Despite the chemical only achieving partial disease control, average grain yields increased in cereals (4 per cent), canola (12 per cent) and grain legumes (11–26 per cent).

Where will we find pythium?

Root pathogenic pythium species were found to be widely distributed throughout cropping soils in the mid to higher rainfall (greater than 350 mm) cropping zone. Eight pythium species were identified from canola-cereal-legume trial sites, with *P. irregulare* being the dominant pathogen, representing more than 90 per cent of all pythium strains isolated.

The trials showed that the major disease caused by pythium is root rot, not seedling 'damping-off', and confirmed that disease incidence tends to be greater in minimum tillage systems, particularly in higher fertility acidic, rather than alkaline, soils.

AT A GLANCE

Pythium root rot is a common plant disease caused by the soil-borne root pathogen, *Pythium* which attacks germinating seeds and seedlings of all major grain crops and pastures in Australia. Damage to these can potentially run into millions of dollars each year through lost production.

Dr Paul Harvey of CSIRO Entomology recently completed a four year project, funded by GRDC, to study and better manage pythium root disease complexes. The aim was to raise awareness of the disease and in doing so, develop strategies to improve the sustainability and productivity of crop rotations.

In-furrow application of a Trichoderma inoculant for pythium disease bio-control (left) to Yitpi wheat, reduced rhizosphere inoculum by around 10 per cent and root infection by about 50 per cent. The subsequent grain yield increased by six per cent. The disease levels were assessed at eight weeks post-emergence. (Photo CSIRO)

One interesting finding, in contrast to general opinion, was that high rainfall or cold waterlogged soils are not a pre-requisite for pythium disease development. In 2002, 2005 and 2006, there were high incidences of root rot in periods of severe drought, conditions not previously considered conducive to pythium diseases. When pythium was partially controlled with a selective fungicide (metalaxyl-M) during the drought, there were significant grain yield benefits.

There has recently been increased industry awareness of the widespread distribution and economic importance of pythium and it is now recognised as an important primary root rot pathogen. People in the industry are much more aware that pythium has significant detrimental impacts on crop and pasture productivity and that it can readily form root rot complexes with other diseases such as rhizoctonia, take-all and fusarium, thus increasing their severity.

Rotations reduce pythium

Crop species and cultivars showed significant differences in their susceptibilities to infection by pythium and, consequently, their capacities to restrict the build up of soil-borne inoculum. Reducing the levels of pythium inoculum available to infect the following crop indicates that, contrary to the generally accepted view, targeted crop rotations and selection of disease tolerant varieties can be used to manage pythium root rot in southern Australia.

Disease incidence was found to be significantly greater after long-term pastures (legume or mixed) and in less diverse rotations such as two-year wheat-canola, compared with more diverse three to four year rotation cycles which included a grain legume. Rotations that included two non-consecutive cereals, for example wheat and barley, had lower disease incidence and levels of soil-borne inoculum.

In addition to total levels of pythium changing in response to crop rotation, the genetic and pathogenic compositions of pathogen populations were also shown to shift as a result of different selection pressures from the different hosts. Pythium populations appear to consist of a complex of crop-adapted genotypes that vary in abundance depending on the rotation sequence.

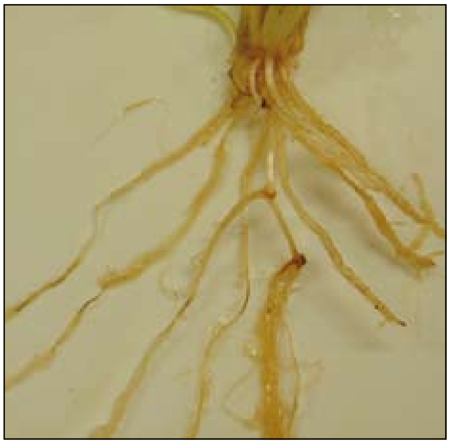
Once fully developed, integrated pythium disease management strategies are likely to be effective for extended periods because the pathogen only undergoes infrequent sexual recombination. This means there are limited opportunities for it to inherit pathogenicity (its ability to cause disease) or fungicide resistance characteristics from other pythium strains. The genetic data also indicates limited dispersal of pythium genotypes between locations. This restricts the opportunities for introducing new diverse strains with different pathogenicity characteristics into fields.

Biological control trials

From 2004 to 2006, out research team conducted a field trial to study the potential of a novel Trichoderma (a parasitic fungus) inoculant as a biological control agent for pythium.

The results showed that the inoculant was as effective as the pathogen-selective fungicide and that integration of the biological and chemical treatments further reduced disease incidence and increased wheat yields. There was also some evidence that the inoculant had a plant growth-promoting effect.

Strains of the bacterium, *Pseudomonas brassicacearum*, were also shown to have significant potential as biocontrol agents against pythium in canola and cereal take-all in acid and alkaline soils, possibly by protecting the roots against pythium infection.



Janz wheat infected with pythium. Symptoms of infection include root discolouration (browning), loss of fine feeder roots and rotting of the outer layers to expose the vascular tissues. When severe, symptoms are often confused with those caused by rhizoctonia. (Photo CSIRO)

Collectively, these inoculant strains have the potential to manage root disease complexes throughout wheat-canola rotations, across a range of soil types.

POTENTIAL NEW PRODUCTS

In early 2004, the CSIRO research team provided independent information to assist with an 'Australia-first' release of two metalaxyl-based pythium selective fungicides for broadacre cereals and canola.

Results from these rotation and fungicide trials provided data on pythium distributions, disease incidence and fungicide efficacy (that is, impacts on inoculum and root infection levels) for the agri-chemical and grains industries.

It is important for growers to know which pythium species occur in their cropping soils and the overall levels of inoculum that they have to deal with in order to decide when to use these fungicides for maximum impact. To facilitate this, CSIRO continues to participate in the on-going development of commercial pythium molecular diagnostics with the South Australian Research and Development Institute (SARDI).

Field trials conducted from 2004–06 on the fungus Trichoderma as a biocontrol agent for pythium, have lead to further independent field assessments of cereal root disease biocontrol efficacy of this inoculant against pythium, rhizoctonia and fusarium in Australia and North America in a GRDC-Philom Bios Joint Venture.

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Metalaxyl-treated canola grown in annual rotation with wheat (left, 45 per cent pythium root infection) compared with an untreated third successive canola crop (right, 90 per cent pythium root infection). (Photo CSIRO)

◁5…MANAGING PYTHIUM

In addition, strains of the recently described bacterium *Ps. brassicacearum* that were shown to provide significant bio-control of pythium damping-off in canola and wheat take-all disease have potential to be developed as products that target these root disease complexes in wheat-canola rotations.

POTENTIAL NEW PRACTICES FOR GROWERS

The research showed that even partial pythium disease control will provide significant benefits and increasing grower awareness of this will assist adoption of disease management strategies, especially given that they can be readily incorporated into current systems.

Integrated in-crop (that is, post-emergent) fungicide treatments improved grain yields of all crops compared with pythium selective seed dressings alone. This practice may be especially beneficial when targeted at susceptible minimum tillage crops and legume pastures under inoculum pressure in higher fertility, acidic to neutral soils, as these are more at risk of pythium root rot than lower rainfall regions with alkaline soils.

Environmental benefits such as reduced soil erosion and stubble burning and improved soil fertility are also likely to flow from improved pythium disease control, as this will continue to encourage the use of minimum tillage and stubble retention as sustainable cropping practices.

Based on evidence that crops and pastures experiencing chronic reductions in early vigour and yield declines are likely to be suffering pythium root rot, growers need to be aware of the ongoing need to determine if the pathogen is present and to apply pythium disease management options (for example, selective fungicides) if it is. The development of pythium molecular diagnostics and their integration in SARDI root disease testing service will assist with making these crop management decisions.

Targeted rotation strategies to minimise pythium root rot are being developed. These are based on an improved understanding of the population dynamics and genetics of the pathogen across the various phases of the rotations. Accurate diagnosis, quantification of inoculum and better knowledge of factors controlling disease development will enable more efficient selection of crops and varieties with differential disease tolerance to pythium genotypes and integration of pre- and post-emergent pythium selective fungicides.

Growers also need to routinely use more diverse crop rotations to manage pythium root rot. Low diversity rotations (for example, repetitive wheat-canola) have significantly higher disease risks than more diverse three to four year rotation cycles. Those with a four-year cycle that included two cereal phases had the lowest incidence of pythium root rot in wheat.

Variety-based pythium disease control was more apparent in the higher diversity rotations, as was the effectiveness of selective fungicides at decreasing soil-borne inoculum and root infection. This improved pythium control is probably related to differences in expression of disease tolerance by varieties under the lower overall inoculum and disease pressures in the more diverse rotations.

Even though cereals are less susceptible to pythium than canola and grain legumes, continuous wheat or barley cropping should be considered with caution, as pythium contributes to the yield declines reported in repetitive cereal crops (that is, wheat-on-wheat effect).

This was also the case with non-cereals, with pythium root rot significantly increasing when the same crop was grown consecutively, compared with when grown in annual rotations.

THE FUTURE

Although this project has made a significant contribution to knowledge of pythium and its management, further research is needed to more effectively integrate fungicides, bio-control strains, crop variety selection and diversification of rotations in a management package that will help growers avoid severe pythium root rot.

Work has commenced on providing the crucial information needed to register and ultimately commercialise the novel biological control agents as inoculants for managing root disease complexes in rotations (that is, targeting multiple crops and pathogens). In GRDC-Philom Bios disease management trials across southern Australia, ongoing research aims to improve root disease prediction and management frameworks, based on interpreting relationships between pathogen molecular diagnostics and root disease incidence.

Further work is also required to refine the pythium molecular diagnostics currently being developed to not only include the main target species, but also the crop-adapted pythium genotypes identified in this research. This will provide growers with information that will enable them to better target their rotation sequences to manage pythium and limit its interactions with other pathogens to avoid severe root disease complexes.

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