NSW GOVERNMENT

Phytophthora root rot management in chickpeas

Key points

- Phytophthora root rot (PRR) is a soil- and water-borne disease of chickpea.
- There are no in-crop options for controlling PRR. Minimising yield loss is based on variety choice and avoiding at-risk paddocks.
- The disease can survive in the soil for up to 10 years.
- Waterlogging increases chickpea susceptibility to PRR.
- Avoid paddocks prone to waterlogging, with poorly drained areas or a history of lucerne, medics, or previous chickpea crops that have had PRR.
- Paddocks prone to waterlogging or flooding should be avoided if a high rainfall season is predicted.
- Use the most PRR-resistant varieties where there is a disease risk.
- All kabuli varieties are susceptible to PRR.
- Substantial yield losses (up to 70%) can still occur for chickpea varieties with the highest PRR resistance ratings when conditions are highly favourable for disease development.
- Phytophthora root rot can travel in soil and crop debris in floodwater, which can change the PRR risk status of previously clean paddocks.

Why PRR is a problem

Phytophthora root rot causes significant yield losses in chickpea grown in the northern grain region of NSW losses are estimated to cost $8.2 million per year in wetter than normal seasons or following periods of soil saturation in normal seasons (Murray and Brennan, 2012). Chickpea grown on vertisol soils, common in north-eastern Australia, have the largest issue with PRR, indicating environmental factors, such as soil type, contribute to this regionally important disease.

Biology

Phytophthora root rot is a soil- and water-borne disease caused by the pathogen *Phytophthora medicaginis*. The pathogen inoculum survives between host crops as oospores and chlamydospores. If a susceptible host is present and conditions are conducive, oospores germinate to produce mycelium and zoospores. In saturated soils the pathogen can rapidly multiply and release large numbers of zoospores. The movement of zoospores can occur through the capillary action of water between soil pores; zoospores can also swim short distances. Zoospores and mycelium often infect host roots, resulting in multiple infection points that can cause severe disease. When frequent, late winter and spring rainfall occur, the pathogen can multiply quickly on chickpea roots. By the time foliage symptoms are visible, the population on the roots will have already peaked. The pathogen only infects living plant cells.

Oospores can survive in the soil for at least 5 years. An inoculum survey of chickpea paddocks in northern NSW and southern Queensland in 2013 and 2014 indicated that the pathogen is widespread, with 33% of chickpea paddocks in this region testing positive for the pathogen.

Figure 1a PBA HatTrick$^{\Phi}$ plants showing areas of severe yellowing caused by PRR versus plants with no symptoms.
Image: Edward Britton

Symptoms and ideal climatic conditions

Infection can occur at any growth stage, causing pre- and post-emergence damping off, loss of lower leaves, chlorosis/yellowing, wilting and plant death. The first above ground symptoms are areas of chlorosis where foliage loses chlorophyll and leaves and stems turn yellow (Figure 1a). As the disease progresses, dark brown/black lesions are visible on the tap and secondary roots and these roots can die. On young plants, the lesions can extend up the stem for 10 mm or more above ground level, forming a characteristic stem constriction, which is termed a canker or girdling (Figure 1b and Figure 2b). Plants with significant PRR symptoms can be easily pulled from the soil as the rotted roots break away and offer little mechanical resistance.

The phytophthora pathogen requires high soil moisture content to multiply, therefore symptoms are often first observed in low lying (e.g. upper sides of contour banks) or compacted areas of the paddocks where water can pool after heavy rainfall (Figure 2a and Figure 2b). The amount of rainfall over the rest of the season will determine the level of inoculum spread in surface water from the infected to uninfected areas. Root-to-root spread of the disease can also occur between neighbouring plants, where PRR-infected roots are in contact with healthy plant roots.

The presence of above ground symptoms of PRR can be delayed, but if plants with PRR-infected roots become stressed, foliage symptoms can rapidly appear. A change in climatic conditions from mild, to hot and dry can also lead to foliage symptoms appearing quickly, as damaged, infected roots cannot provide sufficient water to the plant when evaporative demand is high (Figure 3a and Figure 3b).

Figure 1b A severely infected plant showing a stem canker with shrinkage of the infected stem.
Image: Edward Britton

Figure 2a PBA HatTrick$^{\phi}$ damaged by PRR in a low-lying area at the upper side of a contour bank.

Figure 2b Severely infected PBA HatTrick$^{\phi}$ seedlings showing stem canker symptoms. These were collected from the upper side of the contour bank earlier in the season.

Figure 3a The very susceptible (VS) variety Sonali responding to different PRR concentrations on 12 September.

Figure 3b The same plots as Figure 3b on 11 October after hot, dry windy conditions. Surviving plots (green plants) are control plots treated with metalaxyl.

Symptom distribution in a paddock can be uneven, with areas of both dead and apparently uninfected plants (Figure 4a and Figure 4b, top). If the infection is not severe, wet conditions are not prolonged and environmental conditions do not stress plants, affected plants might partially recover by producing new lateral roots from the upper part of the tap root (Figure 4ab, bottom). The absence of foliage symptoms does not mean the plants are not infected. Digging up and washing the roots is required to assess the level of infection where there are no obvious PRR foliage symptoms (Figure 4a and Figure 4b, bottom).

Substantial yield losses (up to 70%) can occur in chickpea varieties with the highest PRR resistance ratings when conditions are highly favourable for disease development (high inoculum loads, poorly drained soils and high rainfall). Yield loss is greatest in seasons with above average rainfall, however, only one saturating rainfall is needed for infection.

Figure 4a PBA HatTrick$^{\phi}$ plants 150 days after sowing into an area of naturally occurring PRR. Dead plants after chlorosis (top) with severely affected roots (bottom).

Figure 4b PBA HatTrick$^{\phi}$ plants 150 days after sowing into an area of naturally occurring PRR. Plants where foliage symptoms (top) do not reflect the root infection status (bottom).

Paddock risk assessment

When managing the PRR risk, pre-planting preparation is the key as there are currently no methods of in-crop control.

Susceptible host management

Phytophthora is able to infect and multiply a large number of legume hosts, especially pasture legumes such as medics and lucerne. Testing of medicago, lotus, sulla, sesbania and some vicia species, such as woolly pod vetch, has shown they are all PRR disease hosts and will increase inoculum in a paddock. Medic species, such as burr medic, snail medic and barrel medic are common weeds of cropping areas. If these weeds and/or volunteer chickpea plants are present in break crops or in fallows, inoculum could rapidly multiply, increasing the risk of PRR to following chickpea crops.

Testing of other pulse crops including faba bean, albus and narrow leaf lupin and mungbean showed they were not effective hosts of PRR. Lentils were highly susceptible to PRR. Currently lentils are not widely grown in the northern region, however if production was to increase, carry-over of PRR inoculum to chickpea crops would need to be monitored.

PRR hosts	Not effective PRR hosts
Medics, lucerne, lotus, sulla, sesbania, woolly pod vetch, lentil, chickpea	Faba bean, albus lupin, narrow leaf lupin, mungbean

Paddock history, geography and soil type

Any paddocks where chickpeas have shown PRR symptoms in the previous 5 years would be considered high risk of developing the disease in a favourable season. Paddocks that have not grown chickpeas or other PRR susceptible crops or pasture legumes would be considered low risk.

The topography or paddock aspect, along with soil type, influences the risk of PRR. Paddocks with heavy clay soils (vertisols) that have low lying areas, are poorly draining, or prone to waterlogging and/or surface flooding would be considered high risk if inoculum is present and conditions favour PRR. High risk areas include the high side of contour banks, compacted soils or soils with shallow hard pans.

Paddocks with free draining soils are at a lower risk of severe PRR as the pathogen requires periods of soil saturation to multiply and for the infection to spread.

Under very wet conditions, entire paddocks can be affected (Figure 2a). Floodwaters can carry and deposit PRR inoculum in water, silt and crop debris from infected paddocks to previously clean paddocks, changing the PRR risk level of that paddock.

Waterlogging and PRR

Waterlogging causes the greatest damage during late vegetative and reproductive growth stages.

Waterlogging favours rapid PRR pathogen multiplication, while compromising the ability of chickpea plants to maintain its PRR resistance due to physiological damage to root tissue and metabolic constraints. The ability of the plant to recover is also reduced.

Symptoms of waterlogging are similar to those of PRR but differ in that:

- symptoms develop within 2 days of flooding compared to at least 7 days for PRR.
- if assessments are made within a week of waterlogging, the roots of waterlogged plants are not rotted and are not easily pulled from the soil, whereas PRR infected roots are rotted and break off easily and stems may have cankers.
- waterlogged plants often die too quickly for the lower leaves to drop off.

PBA HatTrickϕ

Waterlogging alone: 26% yield loss from early waterlogging, 83% following late waterlogging.

Waterlogging in combination with PRR: rapid onset of disease and plant death, resulting in up to 98% yield loss.

Inoculum measurement

The PREDICTA® B test can measure PRR inoculum levels in the soil only in some circumstances, with results requiring careful interpretation.

Survey results have shown that the most reliable time to detect PRR is in the chickpea crop, rather than in the following break crop. In-crop experiments and surveys showed that even at harvest, the populations were lower than 3 months earlier when PRR foliage symptoms were evident. This is because most of the inoculum produced by the infected plants breaks down quickly, leaving only low concentrations of widely and unevenly dispersed oospores. This dispersed inoculum is difficult to reliably sample and detect. An experiment comparing PRR presence at chickpea harvest compared with a post-harvest sample showed that detection was unreliable within 4 months of harvest.

The implications of inoculum decay and a dispersed distribution for disease risk predication can be summarised as:

1. a positive detection for soil samples collected from a chickpea crop means that PRR is present and in future seasons, if conditions are conducive, chickpeas in this paddock will have a high risk of developing PRR
2. if the test is based on break crop paddock samples, results need to be interpreted with some caution as reliable detection of PRR in these crops is difficult, as outlined above. A nil detection of PRR does not mean the risk is low. Any level of PRR detection in samples from a paddock makes it high risk of developing PRR if conditions are conducive.

For more information: PREDICTA® B - PIRSA

Table 1 Paddock risk identification summary.

Paddock risk	Description
Low	• PRR disease symptoms have not been observed in previous chickpea crops. • No PREDICTA® B soil samples from chickpea crop in this paddock have tested positive. • No PRR susceptible hosts were present in break crops i.e. clean break crops. • No recent floodwater over the paddock.
High	• Where PRR symptoms have been observed in previous chickpea crops. • PREDICTA® B soil samples from a break crop, fallow or a chickpea crop tested positive in any prior season. • PRR susceptible non-crop hosts such as medics were present in break crops or fallows. Paddocks previously in pasture often have a higher medic weed burden. • Floodwater over the paddock from a neighbouring infected paddock or regions where PRR is present.

Before you sow – management options

Once growers have selected their paddocks based on the PRR risk, varietal choice should be considered. The 2 main diseases concerning NSW and Queensland growers are ascochyta blight (AB) and PRR. The recently released CBA Captainϕ has a moderately susceptible (MS) rating to AB, a susceptible (S) rating to PRR, and

currently the highest level of resistance available for both diseases. Both PBA HatTrick$^{\Phi}$ and PBA Seamer$^{\Phi}$ have an S rating for PRR, and S and MS–S rating to AB, respectively (Table 2).

Table 2 Chickpea variety resistance ratings for PRR and AB.

Variety Desi types	Resistance rating*		Variety Kabuli types	Resistance rating*	
	PRR	AB		PRR	AB
CBA Captain$^{\Phi}$	S	MS	Almaz$^{\Phi}$	n.d.	MS
Kyabra$^{\Phi}$	S–VS	VS	Genesis™ 090	n.d.	MS
Neelam$^{\Phi}$	n.d.	S	Genesis™ 836	n.d.	S
PBA Boundary$^{\Phi}$	VS	S	Genesis™ Kalkee	n.d.	S
PBA Drummond$^{\Phi}$	VS	VS	PBA Magnus$^{\Phi}$	n.d.	MS
PBA HatTrick$^{\Phi}$	S	S	PBA Monarch$^{\Phi}$	n.d.	MS
PBA Maiden$^{\Phi}$	n.d.	S	PBA Pistol$^{\Phi}$	n.d.	VS
PBA Seamer$^{\Phi}$	S	MS	PBA Royal$^{\Phi}$	n.d.	MS
PBA Slasher$^{\Phi}$	n.d.	S			
PBA Striker$^{\Phi}$	n.d.	S			

* Source: NVT chickpea national disease ratings based on 2021 data. Resistance measures the plant's ability to resist disease.
n.d. – No data; MS – moderately susceptible; S – susceptible; VS – very susceptible

For the most up to date disease ratings, head to: https://nvt.grdc.com.au/nvt-disease-ratings?crop=17&state=NSW

For high-risk paddocks, do not plant VS or S–VS varieties, such as Kyabra$^{\Phi}$, PBA Boundary$^{\Phi}$ or PBA Drummond$^{\Phi}$. All kabuli varieties are very susceptible.

Metalaxyl seed dressing, which is registered for *Phytophthora megasperma* not *Phytophthora medicaginis*, can be applied after the application of other seed dressings such as thiram. All seed dressings need to be applied before rhizobia inoculation. Metalaxyl provides protection for approximately 8 weeks from sowing, after that chickpea crops can still become infected with PRR if infection occurs once this protection has worn off. However in 2021, 3 out of 4 experiments with metalaxyl reduced PRR yield loss of chickpea. At 3 sites with low–moderate PRR disease pressure, the minimum yield benefit of a metalaxyl was ~1 t/ha (Table 3). At the fourth site, which had high disease pressure and was both flooded and waterlogged, the metalaxyl did not protect against yield loss from PRR (data not shown).

Table 3 Grain yields (t/ha) at 3 experimental sites for the interaction of PRR applied (+PRR) or no PRR applied (control) (-PRR) plus metalaxyl seed treatment, (+MET) or no metalaxyl (control) (-MET).

	Chickpea yield (t/ha)					
Site: soil type	Trangie: grey clay		Trangie: red clay		Narrabri: brown clay	
PRR/MET treatment	–PRR	+PRR	–PRR	+PRR	–PRR	+PRR
No metalaxyl	4.03	1.33	3.60	2.68	2.37	1.38
Metalaxyl	3.85	2.84*	3.58	3.66*	2.26	2.29*

*Indicates the +Met +PRR yield value is significantly higher than –Met +PRR yield value (P<0.05).

In-crop management considerations

Once a crop is infected with PRR there are currently no effective in-crop management options, such as there are for AB. Experiments in 2019 and 2020 evaluated the foliar fungicide phosphonate (fosetyl-aluminium) to potentially reduce PRR yield loss. Yield loss was not reduced by using this fungicide.

The reproduction and spread of PRR is highly dependent on soil moisture and seasonal rainfall. These factors are strongly related to the extent of yield loss from PRR (Figure 5). This information has been used to develop a tool to estimate PRR yield losses in crop from rainfall.

Chickpea can be an expensive crop to grow, especially in wet years where multiple fungicide applications are needed to manage diseases such as AB. The 'tool' estimates the proportional yield and income losses due to PRR when compared with the cost of continued crop inputs. This can assist with critical in-season decision making in wet years, when yield losses are expected to be severe and a decision is required to either continue to manage or abandon the crop. Alternatively, it can be used to reduce late season crop inputs where appropriate.

The **PRR yield loss spreadsheet tool** can be accessed at Phytophthora root rot yield loss tool (nsw.gov.au)

The tool can also be used for a number of target yields, indicative of various rainfall zones or anticipated rainfall within a region. For example, for PRR-inoculated PBA Seamer[ф] on a black vertisol, yield ranges of 1.5, 2.0 and 2.5 t/ha were predicted from rainfall totals of 200, 170 and 130 mm, respectively.

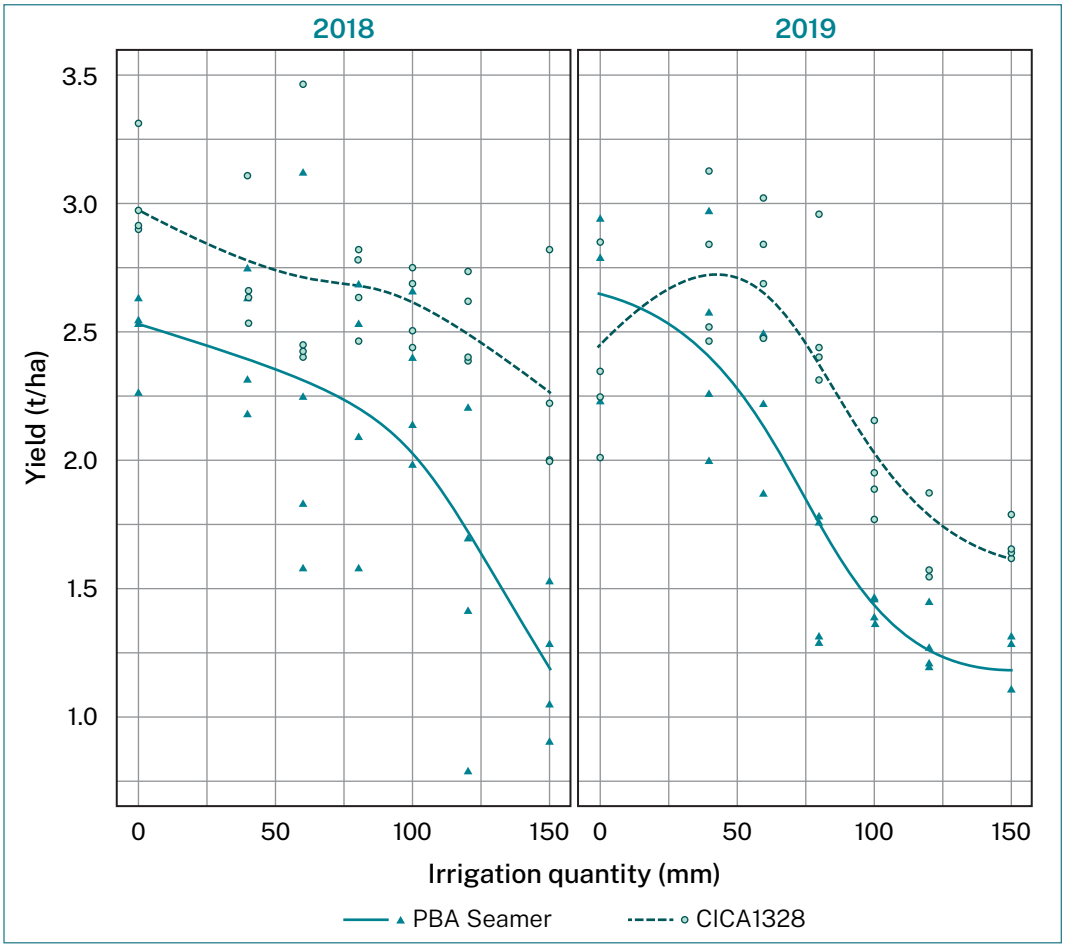

Figure 5 Yield response of PBA Seamer[ф] and CICA1328 to increasing irrigation volume for PRR inoculated treatments in experiments in 2018 and 2019 in Warwick, Qld.

Latest research

Exploring new screening methods and sources of resistance to PRR is ongoing. From this work Chickpea Breeding Australia (CBA) have successfully implemented a new rapid hydroponic phenotyping system derived from the information from these projects (Figure 6). CBA now have the capacity to screen up to 1,300 breeding lines in just 4 weeks. Along with pre-breeding efforts, new sources of resistance have been identified.

This research identified waterlogging as a major factor limiting resistance performance in chickpea. Further research will hopefully be continued into improving resistance of chickpea to both waterlogging tolerance and PRR resistance as research demonstrated close interactions in performance and mechanisms.

Further reading

GRDC Update paper Phytophthora root rot and waterlogging in chickpeas – minimising risk and management options - GRDC

Phytophthora root rot–reduced yield losses in crosses with wild Cicer relatives, Warwick 2018 https://www.dpi.nsw.gov.au/?a=1141758

The impact of waterlogging on phytophthora root rot resistance in chickpea https://www.dpi.nsw.gov.au/?a=1140516

Murray GM, Brennan JP (2012) The current and potential costs from diseases of pulse crops in Australia. Grains Research and Development Corporation. 92

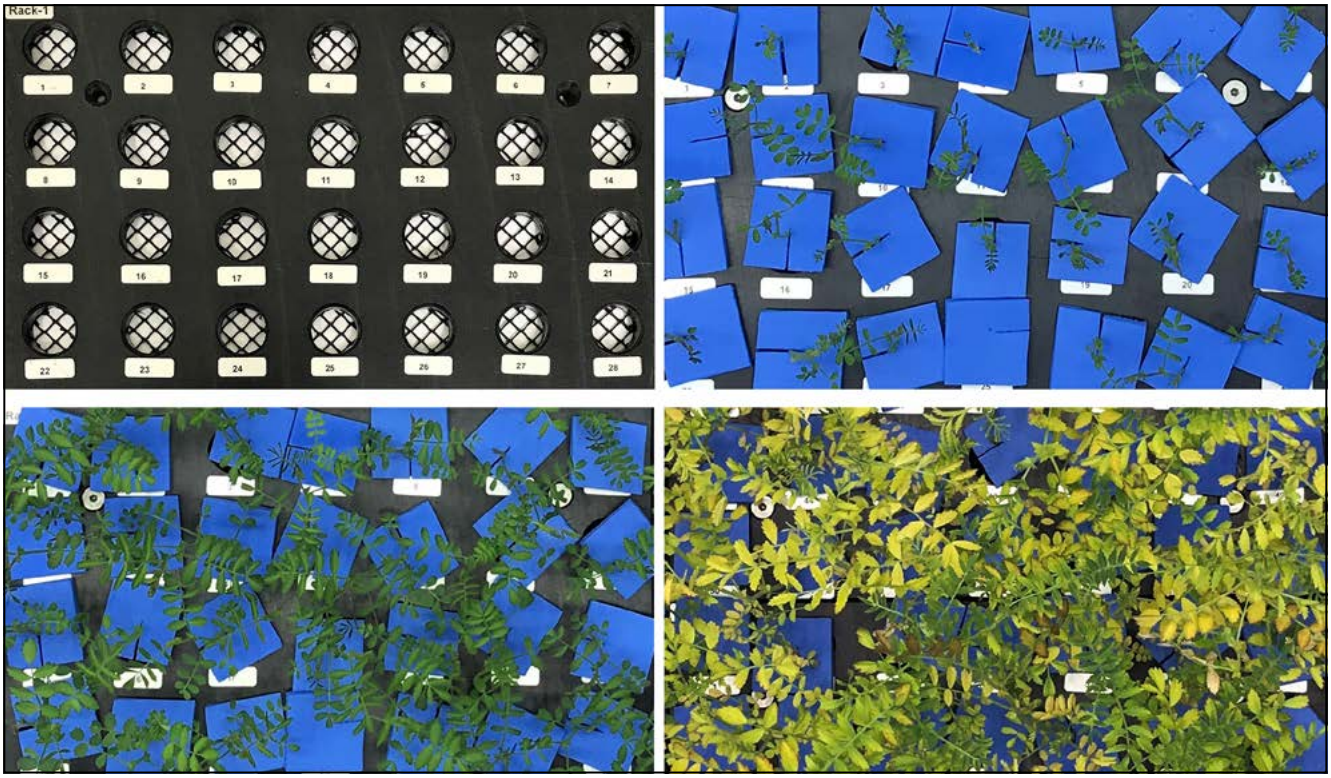

Figure 6 Different growth stages of PRR disease screening hydroponics experiment (clockwise from top left): top view of rack with seeds inside a tank; seedlings thinned to single plant per hole; plant phenotype before inoculation; plant phenotype at 12 days after *P. medicaginis* inoculation.

Contact us:

Sean Bithell
Research officer (Pulse Pathology)
NSW DPI
4 Marsden Park Rd
Tamworth NSW 2340
M: 0429 201 863
E: sean.bithell@dpi.nsw.gov.au