fact sheet

October 2016

Black root rot:

The research roundup.

Author: Sharna Holman (CottonInfo, Queensland Department of Agriculture and Fisheries (DAF)).
Acknowlegments: Karen Kirkby (NSW DPI), Linda Smith (DAF), Lily Pereg (UNE), Christopher Anderson (Biosecurity Queensland)

Black root rot remains an issue for many growers, especially those in the expanding southern regions of NSW. The shorter and sometimes cooler climatic conditions can favour the disease resulting in the young seedlings' inability to compensate for the delays in plant growth and maturity.

Unless managed effectively, the disease has the potential to cause chronic yield losses, which can threaten the sustainability of cotton production. The best approach for managing Black root rot is integrated disease management, using a range of strategies to reduce its distribution, incidence and severity, as well as avoiding the introduction of the pathogen onto farms by practicing strict farm hygiene practices such as Come Clean. Go Clean.

The pathogen

Black root rot is caused by the fungus *Thielaviopsis basicola*, which can be dispersed in soil adhering to vehicles, machinery and trash floating in tail water. The pathogen is capable of surviving for years in the soil, producing two types of reproductive spores – thick-walled chlamydospores and thin-walled endospores. Inoculum builds up in the soil from previous host roots. *T. basicola* is an obligate soil pathogen so cannot grow on dead organic matter. Crop rotations can be a major contributing factor for *T. basicola* inoculum levels in soil.

Symptoms

Affected crops may be slow growing or stunted, especially during the early part of the season. The pathogen causes destruction to the root cortex (outer layer) seen as blackening of the roots. This damage reduces the capacity of the plant to absorb nutrients. Some roots may die but the fungus itself does not kill seedlings. Severe Black root rot weakens the root making them more susceptible to infection by *Pythium, Rhizotonia* and *Fusarium spp*.

Plants that are severely affected early in the season may not continue to show symptoms later in the season as the dead cells of the root cortex are sloughed off when growth resumes in warmer weather.

Economic impact

Black root rot delays development of the crop and in effect 'steals time' from the crop. If conditions later in the season are warm then the crop may not compensate and yield well. Severe Black root rot can lead to delays in maturity of up to four weeks and yield reductions as high as 40 per cent.

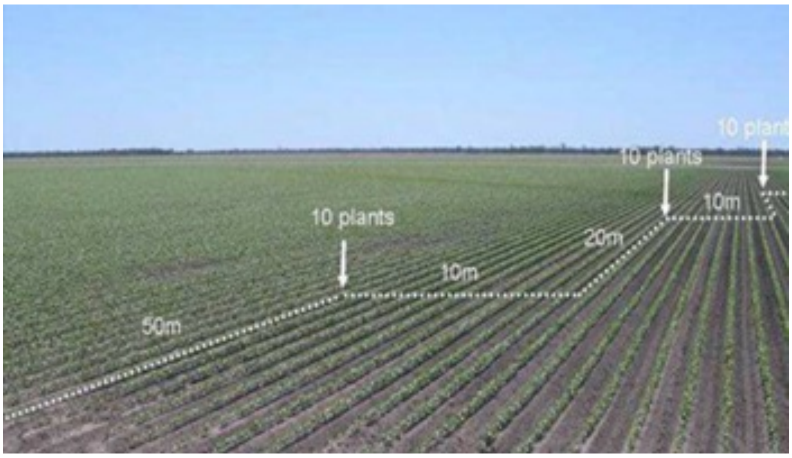
The growth difference between healthy plants (right) vs plants infected with Black root rot (left). The plants on the left are also expressing symptoms of Black root rot through the black tap and lateral roots. (Photo: Stephen Allen)

Best Practice

CottonInfo

fact sheet

How can I assess fields that may be affected by Black root rot?
Look for patches or large areas of slow-growing, stunted cotton (with or without reduced stand). If symptoms are present, then it may be possible to estimate the area of the field affected.



The incidence and severity of Black root rot in the crop can be assessed by a step point transect four weeks after planting. At approximately 50 meters from the tail drain, dig (not pull) up ten seedlings. Record the number of seedlings with blackened roots. Rate the severity of each seedling tap root on a scale of 0 to 10, where 0 = no blackening and 10 = 100 per cent of the tap root is blackened. Walk up 20 meters and across ten rows and assess another ten plants. Continue this until you have assessed a total of 100 plants. Repeat the line transect at the other end of the field. Express the incidence of disease as a percentage of plants infected and severity rated 1 to 10.

What is the research telling us?
Research conducted by NSW DPI and DAF (through support from CRDC) has shed light on methods of managing and controlling Black root rot. Below are some of the frequently asked questions regarding the pathogen, its interaction with other diseases and pathogens, and suggested management tactics.

The pathogen	
Are there prominent regions T. basicola are present?	*Thielaviopsis basicola* was first detected in cotton in 1989 in north-western NSW (Allen 1990) and since then the pathogen has quickly spread to all cotton growing areas of NSW. **By 2004, *T. basicola* reached all cotton growing regions in NSW and Queensland**, and the disease was declared an Australian pandemic (Nehl et al. 2004). The 2015–2016 cotton pathology surveys showed that in NSW, 46.8 per cent of the farms and 76.8 per cent of the fields surveyed had plants infected with Black root rot, while in Queensland 50 per cent of the farms and 30 per cent of the fields survey had plants infected with Black root rot. In Queensland, traditionally Black root rot prevalence is relatively low however over the past few seasons the disease has become a lot more prevalent being recorded during the annual industry cotton pathology surveys. Since 2004–2005, Black root rot has not been detected in Theodore and Emerald. However in the 2015–2016 surveys, Black root rot was observed on roots of cotton from one field in Moura. **The lower prevalence of the disease in some cotton growing regions is most likely due to the higher temperatures at the start of the growing season.** This climatic advantage as well as contributions from other aspects of the farming system such as use of cropping rotations assists with *T. basicola* not progressing as a major pathogen.

Best Practice

fact sheet

The pathogen	
What affects the spread and severity of Black root rot?	**An understanding of the *T. basicola* lifecycle is a key factor in explaining the increasing spread and severity of Black root rot.** *T. basicola* is a soil borne fungus that produces two types of reproductive spores—thick-walled chlamydospores and thin-walled endospores. Both spore types can cause disease. During periods when no susceptible host plants are available the fungus must survive as dormant spores. The thin-walled endospores are relatively short lived (up to seven months in soil). In contrast, the thick-walled chlamydospores survive for many years in the soil and start the disease cycle once a host is available. *T. basicola* is able to produce enormous quantities of spores on the roots of cotton and in the adjacent soil. Nehl (2000) observed three weeks after cotton was sown into soil with a low population of *T. basicola* (40 chlamydospores/g soil), almost 800 000 chlamydospores were produced for every gram of cotton root. The spores are easily spread on machinery wheels, trash floating in water and foot wear. **This makes farm hygiene practices such as Come Clean. Go Clean very important to avoid further spread**, as once the spores have reached a farm, it is very challenging to eradicate them.
How does T. basicola interact with plants?	Studies have found that *T. basicola* exhibits three modes of interactions with plants (Pereg 2011): isolates of *T. basicola* may (1) infect the roots and cause disease (**susceptible hosts**), (2) infect the roots and not cause disease (**non-susceptible hosts**) (3) not infect the roots (**non-hosts to *T. basicola***). Non-susceptible hosts are those in which chlamydospores of *T. basicola* were detected on healthy looking roots of plants. It is unclear whether such infected hosts would remain unaffected by the disease under any given condition.
What is the host range of T. basicola?	One of the other reasons for the difficulty in managing Black root rot is the wide host range of *T. basicola*. All varieties of cotton are susceptible to Black root rot. Many legumes are susceptible including faba bean, soybean, cowpea, field pea, chickpea, mung bean, pigeon pea, lablab and lucerne. Many common weeds including Bellvine and datura weeds (thornapple, castor oil) are also hosts. **The wide host range of *T. basicola* makes crop rotation choice important in preventing the build-up of the fungal load in the soil.** Non-hosts include most cereals, sunflower, brassicas such as canola and broccoli, onions and woolly pod vetch. It was previously mentioned that plants can also be non-susceptible hosts, that is, a plant that has infected roots but does not have disease or express symptoms. Pereg (2011) found that **wheat is a non-susceptible host to several isolates of *T. basicola***, including cotton isolates when tested in soil under controlled conditions. Wheat was previously not considered a host and therefore was planted in rotation with cotton in *T. basicola* infested fields. The finding that wheat is a non-susceptible host can explain the observations that Black root rot severity on cotton was similar in rotation with and without a wheat rotation in long term trials (Nehl 2004).
Is T. Basicola able to adapt to a host over time?	The different strains of *T. basicola* have different capacities to colonise a range of host. Once a strain enters a particular cropping system, it will increase in pathogenicity towards the crops in that cropping system, but only if it already has the innate capacity to colonise them.

interaction with other diseases and pathogens	
What is the interaction between Black root rot and Verticillium	NSW DPI has recently investigated whether there is a link between the incidence (percentage) of Black root rot early in the season and incidence of Verticillium wilt late in the season. Statistical analysis of the long term data collected for each NSW cotton valley showed a slight trend in the Namoi valley however the correlation was very weak. For all other valleys there was no trend or correlation. In a separate study looking at disease severity, a growth room pot trial examined the effect of dual infection on the severity of Black root rot (rated on a scale of 0-10). Cotton seedlings that were grown in soil containing both *T. basicola* and *V. dahliae* had a higher severity of Black root rot (6.2) compared to seedlings grown in soil with only *T. basicola* (4.6). As Black root rot delays early development of the crop and in effect 'steals time' slowing maturity of the crop at the end of the season. **Pushing the last irrigation to add further yield can delay boll maturity and expose the crop to cooler weather, which is ideal for the development of Verticillium wilt caused by *Verticillium dahliae*.**

Crop rotation	
What crop rotations would help reduce Black root rot?	**Crop rotations are very important for reducing the risks and severity of Black root rot.** One of the recommended strategies for reducing the risks associated with Black root rot is to rotate with a non-host for up to three years, avoiding legumes and controlling weeds. Growing non-hosts will prevent the build-up of the fungal load in the soil, as the fungal spores may germinate. However, in the absence of a host, the pathogen is unable to complete the life cycle or produce new spores. Management strategies include implementing crop rotations of non-host cereals, sunflowers, brassicas such as canola, broccoli, onions and woolly pod vetch.
Are fallows effective in controlling Black root rot?	**Fallows are not recommended for controlling Black root rot as the fungal spore load remains persistent in the soil.** Furthermore, many grasses and weeds are hosts of *T. basicola* and if present will act as a host for the pathogen.
What biofumigation crops are effective for controlling Black root rot?	**A biofumigation crop (eg. vetch or mustard) between consecutive cotton crops or after a wheat fallow has been successfully used to reduce the effects of Black root rot.** Biofumigation crops provide a self-generating method of distributing a natural fumigant throughout the soil profile, as well as the added benefit of providing nitrogen to the following cotton crop. The success of a biofumigation crop rotation depends upon the growth of the biofumigation crop and timely incorporation (at least four weeks before planting cotton).

Other suggested management tactics	
What are the seed treatment selection options?	One of the recommended management controls for Black root rot is using the Bion Activator seed treatment, which is now applied to seeds as part of the Dynasty Complete seed treatment. Bion (acibenzolar-S-methyl) induces host systemic resistance against Black root rot and other pathogens. Bion tests gave mixed results in Australia, with disease suppression of 33 per cent observed (Mondal et al. 2005). While it cannot control Black root rot on its own, **the seed treatment is recommended as part of an integrated disease management strategy.**

fact sheet

Other suggested management tactics	
Good ground preparation and irrigation	**Ensure the time for good bed preparation ('high and firm, not 'low and loose') to optimise stand establishment and seedling vigour.** Pre-irrigate and plant into moisture in preference to 'watering up' as it provides better conditions for seedling emergence. Monitoring for signs of water stress, especially if the root system has been weakened by disease early in the season, would allow for appropriate irrigation planning.
Delay planting (if possible)	**The peak activity of the Black root rot pathogen, *T. basicola*, is limited to a window of favourable environmental conditions early in the season.** The severity of symptoms on the tap root begins to decline, coinciding with the onset of warm conditions that favour plant growth, not infection by the pathogen. As seedlings mature, the tap roots expand and infected outer tissues are sloughed off leaving few visible symptoms 6 to 8 weeks after sowing. **Time sowing to avoid cool temperatures. Where possible, delay planting until soil temperatures are at least 16°C and rising.**
Summer flooding (if possible)	**Flooding for 30–60 days before planting seems to reduce disease in the next crop.** It has been demonstrated that flooding can decrease the severity of Black root rot by up to 98 per cent, especially when applied before planting (Jhorar 2004). Summer flooding is recommended for disease management in Australia however is constrained due to the high costs, availability of water, terrain and the risk of disease spread through run-off.

Current Black root rot research

CRDC-supported research:
A predictive diagnostic test for Black root rot in cotton soils
Black Root rot is increasing in southern regions and has a greater impact on southern regions due to the shorter season resulting in an inability to compensate for the delays the disease causes. This project has been developed in partnership with consultants from the southern cotton region and will conduct a comprehensive review of worldwide scientific literature related to detection and quantification of Black root rot of cotton *(Thielaviopsis basicola)* and develop a quantitative method with predictive potential based on worldwide best practice up to trial test stage.

On successful completion of this project, Microbiology Labs Australia will offer fee-for-service analysis that will allow growers and consultants to monitor their *Thielaviopsis basicola* levels over time.

CSIRO-supported research:
CSIRO has been investigating the potential for developing varieties with resistance to Black root rot for the last few years. There is currently no resistance available in the cultivated cotton germplasm pool, so this is long-term research. For more information contact Dr Warwick Stiller: warwick.stiller@csiro.au

Remember: Come Clean. Go Clean

T. basicola spores are easily spread on machinery tyres and foot wear. If your farm is free of Black root rot, it is important to keep it this way. Practice good farm hygiene such as cleaning machines and equipment with anti-fungal substances (eg. FarmCleanse) to reduce spore spread. Preventing the pathogen from spreading onto your farm is easier than attempts to eradicate *T. basicola*.

For more information, contact:
Sharna Holman, CottonInfo Technical Specialist for disease, volunteer and ratoon management
P: 07 3404 6999
E: sharna.holman@daf.qld.gov.au

Best Practice