

MANAGEMENT OF BLACK ROOT ROT OF COTTON: CURRENT STATUS AND FUTURE STRATEGIES

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Black root rot of cotton has been observed in 98 per cent of the farms regularly surveyed by NSW Agriculture in the Macquarie, Namoi, Gwydir and Macintyre valleys. The disease has potential to cause up to 40 per cent yield loss. The disease develops over time when the fungus *T. basicola* is present in adequate numbers within the vicinity of cotton roots when the environment is favorable for infection. The management strategy for this disease, therefore, could be based on four important components of the disease pyramid host, pathogen, environment and their interaction over the time.

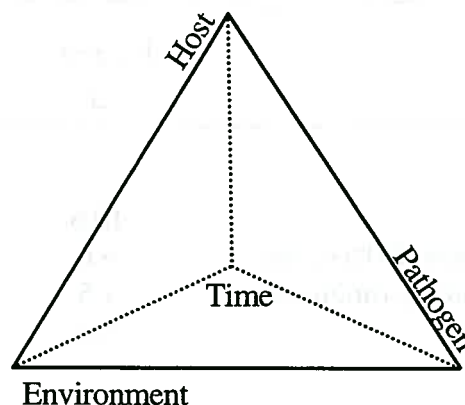


Figure 1. The disease pyramid (viewed from above). Severe development of a disease requires a susceptible host, encountering a virulent pathogen under favorable environmental conditions. Time is the fourth factor in the progress of disease

Managing the host

There are more than 137 plant species that are hosts for *T. basicola* including cotton, a large number of legumes and some weeds. Such a large host range makes it difficult to eradicate this pathogen once established in the soil. Cereals are non-hosts for the black root rot fungus and will not increase its population in soil. Host management options that may reduce the severity of the disease are now discussed.

Host resistance: This is the best option to manage plant diseases. However, a source of resistance to black root rot is not yet known and hence no resistant varieties are available. All cotton cultivars available in Australia are equally susceptible to *T. basicola*. There are some efforts being made elsewhere to look for resistant genes in wild cotton but success is still awaited.

Induced Resistance: All plants possess in-built defense to resist infection by pathogen. While these defenses may not be active against all pathogens all the time, it is possible to use chemical or biological agents to activate this resistance at a heightened level. Use of acibenzolar-S-methyl seed treatment in cotton to enhance resistance against black root rot disease is a promising development in this area. An in-furrow spray at the time of sowing reduced disease severity and advanced the development of bolls, although no increase in seed yield was observed (Table 1). However, more field

Table 1. Reduced severity of black root rot in cotton following treatment with acibenzolar-S-methyl as an in-furrow spray at planting, in a field near Moree

	Untreated	Treated	Probability ^a
8 November 2001			
Stand (plants/m)	10.6	11.6	Not significant
Disease severity on tap roots (0-10 scale)	9.6	7.4	$p < 0.001$
Relatively healthy lateral roots (no./plant)	1.5	6.8	$p < 0.001$
Shoot dry mass (g/plant)	0.6	0.7	Not significant
30 January 2002			
Fruit development (bolls/m)	20	27	$p = 0.004$
5 April 2002			
Yield (bales/ha)	8.0	8.3	Not significant

^aValues in rows are significantly different at the stated probability level.

trials are required to validate the method and test efficacy of the chemical at different locations before it can be recommended for control of black root rot. Acibenzolar-S-methyl only induced resistance in cotton at the seedling stage and does not work as a fungicide and, therefore, does not give complete control and it would need to be part of integrated disease management strategies.

Stage of the host: Infection of cotton by *T. basicola* occurs at seedling stage because this coincides with cool conditions. However, as the season progresses and plants grow, the infection process is slowed down. Cold shocks at early stage of cotton are known to favor infection but we still do not know the extent to which the pathogen continues to infect new cotton roots after seedling stage and late in the season when temperature starts declining. Looking into this aspect may help devise new strategies to manage host to reduce spore population in cotton fields.

Alternating hosts: Most legumes are hosts for *T. basicola* and may increase the population of its spores in soil, worsening the disease problem. Some weeds such as *Datura stramonium* and *Abutilon theophrasti*, are also good hosts for the pathogen. However, the potential of more weeds to host *T. basicola* has not been determined in the field. Detailed investigations are still needed.

Host vigor: In general a weak plant is more susceptible to diseases. The role of seedling vigor and crop nutrients in reducing or enhancing black root rot severity is not yet known. These aspects of the disease need to be investigated.

Crop rotation with non-hosts: Most cereals are non-hosts for the black root rot fungus and, in rotation with cotton will not increase the severity of the disease. However, rotation with cereal for a single season will not decrease the pathogen population enough to reduce disease severity in the following cotton crop. In preliminary research the population of *T. basicola* in a severely infested field was reduced dramatically by three consecutive years of wheat. However, it is not yet known in how many seasons the pathogen will buildup back to economic threshold.

Managing the pathogen

T. basicola, the causal organism of black root rot is wide spread in established cotton grown areas in Australia. The pathogen is capable of surviving for several years as thick walled spores (chlamydospores) in soil. Once a susceptible host is available in the presence of suitable environment, the chlamydospores germinate, infect the roots and multiply in large numbers. Management options for the pathogen include minimising dispersal, reducing its survival, and slowing its growth and reproduction. Practical applications of these strategies are discussed below.

Fungicides: It is relatively easy to apply fungicides for foliar diseases but more difficult for root diseases. The potential for control of black root rot with fungicides applied as cottonseed coatings and in-furrow sprays have been investigated for several years. So far no fungicides have proved to be effective. New formulations will be tested against this pathogen as they become available.

Biofumigation: Biofumigation involves growing crops that release substances that are toxic to the pathogen. These crops are incorporated into soil and produce volatile substances that either kill or suppress the fungus. Canola, vetch or mustard can be used as biofumigants for *T. basicola*. Mustard and canola release isothiocyanates that in sufficient quantity may decrease the population of soilborne pathogens (Sarwar & Kirkegaard, 1998). When vetch is incorporated into soil its breakdown can release ammonia levels sufficient to kill *T. basicola* while it also provides nitrogen to the subsequent cotton crop (Candole & Rothrock, 1996). Growing rotation crops that also have biofumigation effect would additionally increase the time that the remaining spores of *T. basicola* would have to survive until the next cotton crop.

Suppressive soil: Certain soils appear to be suppressive to black root rot and this is currently the subject of post-graduate research project (CRC 18C). These properties need to be analyzed. Once the nature of the suppression is known, it may be possible to exploit it in some way to reduce the pathogen population.

Exclusion and dispersal management of the pathogen: Although a large number of farms are already infested with this pathogen, many farms and fields within farms are free of black root rot. Farm hygiene practice can minimise the spread of *T. basicola* in soil and mud. All participants in the cotton industry should adhere to the “come clean go clean” strategy that has been promoted in recent years. Rain and irrigation can erode infested soil, thus spreading the pathogen. Cover crops have potential to reduce erosion in irrigated cotton fields and would therefore, reduce the spread of infested soil to some degree. Farm machinery can spread *T. basicola* from an infested field to uninfested fields and farm hygiene practice would minimise the spread.

Survival of the pathogen: The pathogen survives in soil for several years in the form of resting spores (chlamydospores) and germinates when a suitable host is available. Summer flooding (30 days) will drastically reduce survival of *T. basicola* in soil. However this

control method has limited application due to the availability of water and the topography of fields. Solarization using polyethylene sheets can also reduce the spore population by raising the soil temperature. This technique, however, needs to be tested for its feasibility and affordability to control *T. basicola* in Australian conditions.

Managing the environment

The environment is one of the four basic components of disease pyramid that play a vital role in influencing the interaction between pathogen and host. Disease severity will be very high when environmental conditions favor the pathogen more than the host, giving an advantage to the pathogen over the plant. There are various components of the environment that can influence plant diseases but in this paper, the main focus is on temperature and soil moisture.

Temperature: Temperatures ranging from 16 to 20 °C are optimum for the development of black root rot (Rothrock, 1992). However, the infection of cotton root will still occur at temperatures below 16 °C and above 20 °C. For a given population of *T. basicola* in the soil, severity of the disease is largely influenced by prevailing temperature. As the season advances the temperature rises and pathogen activity is retarded although it is still not known what temperature would completely stop infection of cotton roots. Such information is required for developing strategies to manipulate the soil environment for reduced disease severity. The crop microenvironment, when modified by trapping additional energy with reduced dissipation, can rise the seed bed temperature. This in turn would not only help to reduce pathogen multiplication but also supply additional heat to enhance seedling vigor. Current research is investigating the use of winter cover crops to raise the soil temperature and reduce wind-chill during the seedling stage of cotton with minimum hindrance to incoming solar radiation.

Moisture: Moisture is vital for black root rot development. Studies in United States have proved that disease incidence is reduced from 85 to 58 per cent with reduced soil moisture from -10 to -30 matric potential respectively, while disease severity remained unaffected (Rothrock, 1992). However, such information is not available for Australian conditions. Preliminary observations in a current pot experiment indicated a reduction in the severity of black root rot with reduced soil moisture although shoot growth was also reduced. It may be possible to reduce disease pressure by manipulating seedbed moisture without compromising plant growth. Winter covers crops can maintain seedbed structure and their potential to improve soil drainage and reduce severity of seedling diseases is currently being examined.

Conclusion

Black root rot has already increased to an alarming level. It is now time to look into holistic approaches to manage this disease using environmentally friendly principles. This will only be possible with active participation and feed back of growers in cotton growing regions.

Acknowledgement

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Reference

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