

## BLACK ROOT ROT: AN AUSTRALIAN PERSPECTIVE

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### Introduction

Black root rot is caused by the fungus *Thielaviopsis basicola* (Berk. & Broome) Ferraris. It infects over 137 species of plants from a wide range of families including cotton (*Gossypium hirsutum* Linn.), tobacco (*Nicotiana tabacum* Linn.) and many legumes (Otani, 1962; cited in Meyer, Shew and Shoemaker, 1989). Infected plants are usually stunted during the seedling stages, leading to delayed maturity and loss of production (Young and Allen, 1991). Seedlings and older plants pulled from the soil often have shrivelled and blackened root tissues. Survival in the soil is by thick-walled resting spores (called chlamydospores) which may remain viable in the soil for many years (Hillocks, 1992).

### History and Distribution

Black root rot of cotton was first reported in Arizona in 1922 where crops of American-Egyptian cotton were observed to be badly affected by the disease (King and Presley, 1942). In general, this fungus is widely distributed throughout the world and is known to affect cotton crops in the USA, the former Soviet Union, Peru, Spain, India and Egypt (Lindsey, 1981; Hillocks, 1992). The fungus has recently been discovered on cotton in Australia (Allen, 1990), but has been previously isolated from other plants throughout Australia. These include native plants such as Sturt's desert pea (*Swainsona formosa* (G. Don) J. Thompson), ornamentals and other crop plants in Australia such as tobacco. Overseas reports

indicate that *T. basicola* is also a pathogen of soy bean (*Glycine max* (L.) Merr.), peanut (*Arachis hypogea* Linn.) and chickpea (*Cicer arietinum* Linn.). There have been no reports of this pathogen on these crops in Australia.

The known distribution of this pathogen on cotton in Australia has expanded minimally since it was first discovered in the Namoi valley during the 1988/89 season. Currently, black root rot has been recorded in isolated areas in the Namoi, McIntyre, and Macquarie valleys as well as areas of southern Queensland (Young and Allen, 1991).

### Symptoms

Infection normally occurs at the seedling stage when soil temperatures are below 20°C (Hillocks, 1992). Seedlings may show general lack of vigour and stunting as above ground symptoms. These seedlings are easily pulled from the soil and have fragile, poorly developed root systems, showing blackened areas which may cover the entire root surface (King and Presley, 1942; Hillocks, 1992). Usually only the outer root tissue is affected while the inner stele may remain healthy and functional (Garber, DeVay and Wakeman, 1985).

Seedling death may occur when infection is severe. When mean soil temperatures rise above 20°C root growth usually resumes and infected root tissue is sloughed off, often leaving no sign that infection has occurred (Garber *et al.*, 1985). Infected plants however are often stunted in comparison to unaffected plants due to loss of early growth. These plants are also weakened and less productive than unaffected plants, and are more susceptible to attack by other pathogens (Minton and Garber, 1983).

Late infection may occur when soil temperatures fall again towards the end of the season. When mature plants are infected, swelling of the stem directly above the soil surface is often evident. This swelling relates to an internal rot of the stem caused by the production of chlamydospores in the stele (Mauk and Hine, 1988).

This may lead to death of the host plant by restricting the flow of water and nutrients. Infection by secondary plant pathogens may also occur, further decreasing the productivity of the host.

### **Factors Affecting Infection**

Factors affecting infection primarily include soil temperature, soil characteristics and inoculum levels in the soil. Low temperatures (around 10°C) enable maximum survival of propagules in the soil, while temperatures of 20-33°C result in maximum germination of these propagules (Hillocks, 1992). Maximum infection of hosts however is at temperatures below 20°C since this is when vegetative growth of the host is slower and results in lowering the resistance of the plant to infection (Mauk and Hine, 1988).

Infection is known to be more severe in those crops grown on clay than on sandy soils. This may be related to the requirement of high soil moisture for germination of the long term propagules. The disease often occurs after irrigation, particularly in slow draining soils (Hillocks, 1992).

Inoculum levels in the soil vary widely and are thought to influence the severity of infection. Studies on *T. basicola* on chickpeas showed that levels of infection increased in response to increases in inoculum levels, particularly when temperatures were lower than optimum for the growth of the host (Bhatti and Kraft, 1992). Similarly, Mathre, Ravenscroft and Garber (1966) found that levels of inoculum required to cause significant damage to host plants were often much higher than those found naturally in the field.

### **Control**

The fungicide seed treatment Triadimenol (Baytan®) has recently been registered for the control of black root rot of cotton in the USA and is currently being evaluated in Australia. Various cultural methods should be used as an adjunct

to chemical control in those areas that are worst affected by black root rot. Since the disease is favoured by cool temperatures planting should be delayed until minimum soil temperatures rise consistently above 20°C. As soil moisture is also a factor which affects disease severity, care should be taken to avoid over-irrigating on heavy soils (Hillocks, 1992).

Rotation with non-host crops is an option that can be implemented in areas severely affected by this disease. Monocotyledonous crops in particular show potential in decreasing inoculum levels in the soil. Research has shown that soil populations of the fungus after planting with crops such as barley and sorghum are significantly lower than after planting crops such as cotton and alfalfa (Lindsey, 1974). Rothrock and Kirkpatrick (1990) found that the incorporation of a hairy vetch (*Vicia villosa* Roth) cover crop could significantly reduce soil populations of *T. basicola*.

It is important to employ simple hygiene measures where the disease is present so that further spread of the pathogen is avoided or restricted. These measures include ensuring machinery travelling from diseased areas to those with 'clean' soil is free of infective soil. The possibility that the disease was originally introduced to Australia via the importation of infested second-hand ginning equipment from California is one which signifies the importance of ensuring that equipment used from farm to farm is disease free.

### **Status In Australia**

Current research by the authors includes the continuation of surveys of the cotton growing areas of eastern Australia to fully determine the distribution of this disease. These surveys are semi-quantitative in nature so as to give some indication of the inoculum levels in the soil and thus some indication of disease potential of soils in various areas. Other studies currently being conducted include:

- refinement of the quantitative soil assay techniques;

- investigations into factors (eg temperature and pH) affecting growth of various isolates of *T. basicola*;
- the susceptibility of different hosts to the fungus, particularly various legume hosts which are being considered for use as rotation crops with cotton;
- the resistance/susceptibility of current Australian and US cultivars to the disease;
- the infectivity of various isolates of the fungus on cotton (eg does an isolate from tobacco infect cotton plants? If infection does occur, and is quite severe, this could present major implications for cotton growers in that quarantine measures for ensuring these isolates do not become established in areas sown to cotton may need to be implemented);
- the effectiveness of several fungicide seed treatments (including Triadimenol), hairy vetch cover crops and various cultural practices are being evaluated.

The potential of the black root rot fungus to dramatically affect the yield of cotton crops has been recognised in many of the cotton growing areas of the USA over the past ten years (Garber and DeVay, 1985; Hake, Chrisco, DeVay, Garber and Kerby, 1985). However, the potential for yield loss in Australian cotton remains unclear due to a lack of experimental data and knowledge of how widespread the disease is. As yet, preliminary disease surveys indicate that its distribution throughout the cotton growing areas of Australia is limited. The potential of the disease to become widespread and cause serious losses in production must be assessed. In light of the losses observed in the USA, research into this disease is of great importance to the Australian cotton industry.

## References

- Allen, S. J. (1990).** *Thielaviopsis basicola*: a new record on cotton in Australia. *Australasian Plant Pathology* **19**, 24-25.
- Bhatti, M. A. & Kraft, J. M. (1992).** Effects of inoculum density and temperature on root rot and wilt of chick peas. *Plant Disease* **76**, 50-54.
- Garber, R. H., DeVay, J. E. & Wakeman, R. J. (1985).** *Thielaviopsis* the black root rot - a serious new threat to California cotton production. In *Proceedings of the Beltwide Cotton Production Research Conferences, 1985*, p25. National Cotton Council of America.
- Hake, K., Chrisco, L., DeVay, J. H., Garber, R. H. & Kerby, T. A. (1985).** *California cotton progress report: cotton black root rot - Thielaviopsis basicola*. University of California, Cooperative Extension Agricultural Experiment Station, U.S. Department of Agriculture.
- Hillocks, R. J. (1992).** Seedling Diseases. pp. 1-38. In: R. J. Hillocks (Ed), *Cotton Diseases*, Wallingford : CAB International. 415 pp.
- King, C. J. & Presley, J. T. (1942).** A root rot of cotton caused by *Thielaviopsis basicola*. *Phytopathology* **32**, 752-761.
- Lindsey, D. L. (1974).** Influence of certain plants on populations of *Thielaviopsis basicola* in soil. In *Proceedings of the Beltwide Cotton Production Research Conferences, 1974* p19. National Cotton Council of America.

- Lindsey, D. L. (1981).** Black Root Rot. pp. 47-48. In: G. M. Watkins (Ed), *Compendium of Cotton Diseases*, St Paul, Minnesota : American Phytopathological Society. 87 pp.
- Mathre, D. E., Ravenscroft, A. V. & Garber, R. H. (1966).** The role of *Thielaviopsis basicola* as a primary cause of yield reduction in cotton in California. *Phytopathology* **56**, 1213-1216.
- Mauk, P. A. & Hine, R. B. (1988).** Infection, colonization of *Gossypium hirsutum* and *G. barbadense*, and development of black root rot caused by *Thielaviopsis basicola*. *Phytopathology* **78**, 1662-1667.
- Meyer, J., Shew, H. D. & Shoemaker, P. B. (1989).** Populations of *Thielaviopsis basicola* and the occurrence of black root rot on burley tobacco in Western North Carolina. *Plant Disease* **73**, 239-242.
- Otani, Y. (1962).** Studies on the black root rot of tobacco caused by *Thielaviopsis basicola* (Berk and Br.) Ferr. *Okayama Tob. Exp. Stn.* **23**, 118.
- Rothrock, C. S. & Kirkpatrick, T. L. (1990).** Impact of legume cover crops on soilborne plant pathogens of cotton. In *Proceedings of the Beltwide Cotton Production Research Conferences, 1990*, pp. 30-31. National Cotton Council of America.
- Young, S. P. & Allen, S. J. (1991).** *Thielaviopsis basicola* :A potentially important pathogen of cotton in Australia. pp 51-55. In: J. F. Brown & C.

J. Ponter (Ed.), *Second Graduate Seminar In Plant Pathology and Mycology*. Department of Botany, UNE, Armidale, NSW, Australia.