Living with Fusarium Wilt

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What is fusarium wilt?

Fusarium wilt is a destructive disease of cotton which occurs in many cotton growing areas of the world, including; south-eastern USA, Egypt, Tanzania and China. It is caused by the soil-inhabiting fungus *Fusarium oxysporum* f.sp *vasinfectum (Fov)* (Hillocks, 1992).

The first confirmed record of the disease in Australia was from wilted cotton collected from the Brookstead/Cecil Plains area in the Darling Downs of Queensland, in March 1993 (Kochman, 1995). Fusarium wilt has since been recorded in many commercial cotton crops on the Downs and in isolated locations at Mungindi, Boggabilla, Goondiwindi and Moree. More recently, the disease was confirmed in wilting plants in the Theodore and Miles areas of Queensland. To date, fusarium wilt has not been recorded in the Emerald or St George areas of Queensland or cotton production areas in the Namoi and Macquarie Valleys of New South Wales.

The fungus

The fungus *Fusarium oxysporum* lives in the soil and the species is very diverse, containing a large number of saprophytic and pathogenic forms. The pathogenic forms are grouped into *formae speciales* (f.sp.) or special forms, based on their ability to attack particular host plants. The f.sp. *vasinfectum* is able to cause a vascular wilt disease of cotton and is further sub-divided into races. Worldwide, up to eight races of *Fov* have been identified. Some are confined to acid sandy soils and associated with nematodes while others are prevalent in alkaline, heavy clay soils. Some races of *Fov* can also infect and survive on alternative hosts that include both weeds and other crops.

Our studies of the Australian isolates of *Fov* from cotton indicate that there are two strains of the fungus which have developed locally and have not been introduced from overseas (Davis *et al.*, 1996). The first strain was identified from the Darling Downs and the second from the Boggabilla area. The two strains differ in their ability to attack different varieties, are in different Vegetative Compatibility Groups (VCG) and, have different DNA fingerprints. Both strains are dissimilar to all the overseas isolates of *Fov* tested to date. The two strains do occur together in a number of fields in NSW but only one strain has been identified in Queensland to date.

The fungus has two spore types, called macroconidia and microconidia, which are thin-walled and thick-walled resting bodies called chlamydospores. These chlamydospores play an important role in the longer-term survival of the fungus in the field and appear to be the primary infection units. They are stimulated to germinate by root exudates from developing plants. They produce germ-tubes that grow through the soil until they come into contact with the root system of the cotton plant. They then infect directly behind the growing point of the root-tip. Infection through the hypocotyl has also been reported (Rao and Rao, 1966 cited by Hillocks, 1992). After the fungus has entered the root system it grows into the vascular system where the conidia are formed and distributed rapidly throughout the plant. It is the damage caused within the vascular system that leads to the symptoms seen in the field, particularly the wilting phase that gives the disease its name.

Symptoms

Symptoms of the disease can appear at any stage of crop development, from seedling to adult plants. In seedlings the cotyledons start to wilt and then rapidly die. If the stem is cut along its length the vascular system will be brown. Symptoms in older plants include: stunted plants; wilting; extensive dark-brown discolouration of the vascular system and; leaf and stem death, often from the top of the plant down. Some infected plants may re-shoot from the base giving the appearance that these plants have revived but the regrowth is usually killed as well.

Key factors in fusarium wilt incidence

There are a number of factors that influence the development of fusarium wilt in cotton fields. These include, the presence of the pathogenic strain of the fungus in the soil, the susceptibility of cotton varieties to the disease, climatic conditions, soil type, interaction with other soil-borne micro-organisms, fertilisers and, alternative hosts. All of these factors interact for disease development and affect the amount of wilt in a crop.

Presence of the pathogenic strain of the fungus

The pathogenic strain of the fungus must be present in the soil before the disease can occur but the fungus may be present in the soil without any disease symptoms being evident. The disease only becomes evident in the crop when there are sufficient fungal propagules in the soil. Mr Bo Wang (pers. comm.) found, during his Ph D studies at the University of Queensland, that a very low number of fungal propagules, in contact with the roots, would not cause disease in any varieties but a very high number would kill all the varieties, even the least susceptible ones.

As the Australian isolates of *Fov* appear to have developed locally, they may have originated as a minor population in the indigenous Fusaria and existed initially without a major host. An exponential increase in this population could have resulted from the widespread and continued planting of particularly susceptible cotton varieties. Once the population was established it may have been spread in floodwaters or in contaminated soil attached to equipment, vehicles or boots. It can also be transmitted in seed, but this is unlikely to have occurred in Australia because seed production areas were carefully monitored and seed crops had not been produced in areas where the disease was first identified.

Cotton varieties

Results from field and glasshouse trials indicate that there is a range of susceptibility in current commercial varieties but to date we have not found any immunity to the disease. These are similar to results reported overseas (Hillocks, 1992). The data have been used to rank cotton varieties into three broad susceptibility groups, least susceptible, moderately susceptible and, most susceptible (in alphabetical order) (Table1). A number of other varieties require further testing.

Table 1. Varietal reaction to infection by *Fusarium oxysporum* f.sp. *vasinfectum*.

Least Susceptible	Moderately Susceptible	Most Susceptible
CS8S	Delta GEM	CS50
Delta EMERALD*	DP 5415	Delta JEWEL*
Delta OPAL*	Siokra L22	Sicala 34
Delta PEARL	Siokra L23	Siokra 1-4
Sicala V-2		Siokra V-16*
Sicot189		

*** New release in 1998**

The least susceptible varieties not only have a lower incidence of disease in the field but also require a higher number of fungal propagules in the soil to become infected. In pot trials twenty times more spores (conidia) were required to cause disease symptoms in the variety Sicot 189 (in the least susceptible group) than in variety Siokra 1-4 (most susceptible group) (Wang, pers. comm.).

Varieties also appear to play an important role in the development of fungal propagules in the soil. On a number of occasions the disease was found in crops of less susceptible varieties which had followed the growing of a very susceptible variety in the previous season. There is also some evidence that growing of the least susceptible cotton varieties may reduce the rate of fusarium wilt build-up in fields (Wang *et al.*, 1997).

Climatic conditions

Fusarium wilt is reported to be a warm weather disease. Mean temperatures above 23°C favour fungal growth and disease incidence and the wilt phase of this disease is most evident when temperatures are high. However, there was a very high disease incidence in seedlings on the Darling Downs during the last two seasons, in cold, wet soils and it seems that any form of plant stress may favour the disease. Overseas reports indicate that conditions which favour infection of the roots by the fungus may not be the same as those which favour growth of the fungus within the plant. Warm moist conditions may promote infection but the wilt symptoms are most severe in hot dry conditions (Hillocks, 1992).

Soil type

There appears to be some correlation between the race of the fungus and soil type. Races 1 and 2, first described in the USA, occur in sandy soils with a pH of 5-6.5 while races 3 and 4 (Egypt and India) are prevalent in clay soils (Hillocks, 1992). In Australia the disease usually occurs in heavy black clay soils, although there have been some small outbreaks in lighter soils.

Interaction with other soil-borne micro-organisms

There have been many reports from overseas that soil microorganisms interact with *Fov* to increase or decrease the incidence of wilt (Hillocks, 1992). Nematodes interacting with races 1 and 2 increase the severity of wilt in the USA. The presence of *Rhizoctonia solani* together with *Fov* also increased the incidence of wilt in susceptible varieties.

On the Darling Downs last season black root rot (caused by the fungus *Thielaviopsis basicola*) was found in many of the roots of seedlings that had been infected with *Fov*. Seedling death was severe and resulted in replanting over significant areas. Experiments are currently underway to investigate the interaction between these two fungi on root infection by *Fusarium* and the incidence of wilt.

Fertilisers

Initial trials at Boggabilla indicated that nitrogen applied as anhydrous ammonia reduced the level of *Fov* propagules in the soil when compared with the same level of nitrogen applied as urea. However, it has not been possible to repeat these results. Many of the results from overseas fertiliser trials appear to be contradictory but this could be due to some interaction with varietal tolerance and races of the fungus. This area requires further work.

Alternative hosts

Cotton is the primary host for *Fov* but the fungus can multiply on secondary hosts. Wang *et al.* (1997) reported that the level of *Fov* was higher in the soil under sorghum than in soil under soybean or maize. Therefore crops which might be grown in rotation with cotton could be an important factor in survival and development of the disease. There is information from overseas that the race of the pathogen could influence the reaction of crops in a rotation and this area needs a lot more work with the Australian isolates.

Davis (pers. comm.) found that weeds, growing in two fusarium wilt affected cotton fields on the Downs and near Boggabilla, were symptomless hosts of the fungus. Weeds from 14 families and 22 species were screened. Isolates of *Fusarium* were found in the vascular systems of *Amaranthus macrocarpus* (dwarf amaranth), *Hibiscus trionum* (bladder ketmia) and *Sesbania cannabini* (sesbania). Hence weeds should be controlled in fallows.

Grower actions to prevent the spread of fusarium wilt

Diseases such as fusarium wilt, pose potential threats to farm profit so it is important to try to prevent their introduction into new areas or to minimise their spread and build up once they occur. Growers should use *best practice* to achieve this. *Best practice* involves choosing the best option when a choice has to be made. Sometimes it is neither possible, nor practical but the practise of *best practice* will maximise ecological sustainability on farm. *Best practice* options are to:

- Keep irrigation tail-water and run-off water on farm.
- Keep machinery and vehicles that enter or leave the farm, free from mud or crop debris, which could carry the fungus to clean ground.
- Control weeds.
- Use a crop rotation strategy.
- Maintain good soil nutrition levels.
- Minimise spillage and loss when transporting modules, hulls, cotton seed or gin trash.
- Ensure seed used is from fusarium wilt free areas.

Can we live with fusarium wilt?

There is no doubt that fusarium wilt poses a serious threat to the cotton industry in Australia. The way the disease has spread, despite increased awareness of the disease through out the industry, is of real concern. However, the research data obtained to date indicate there is cause for some optimism that the industry will be able to manage the disease.

There is a range of susceptibility to the Australian isolates of the fungus in the cotton germplasm we have tested. We were fortunate that a number of the current commercial varieties were far less susceptible than other varieties. Growers have used these in fusarium wilt affected areas to grow profitable cotton crops even though there were some yield losses. There appears to be germplasm with better tolerance to fusarium wilt than that available in current varieties but it will take time to incorporate this tolerance into varieties with good agronomic traits.

A range of agronomic practices, which may slow the development or reduce the level of the fungus in the soil, are currently being investigated. These include stubble management, crop rotation, fertiliser inputs and, seed treatments.

The research results we have to date are quite positive and indicate that the disease can be managed provided we have fusarium wilt tolerant varieties. The long-term future of cotton production still depends on the development of varieties with better tolerance to the disease. Varieties take time to develop so it is important to slow the spread of fusarium wilt and, in areas where the disease already occurs, grow the least susceptible varieties available and minimise crop stress.

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