

Integrated disease management

Stephen Allen, Cotton Seed Distributors
Linda Scheikowski, Cherie Gambley, Murray Sharman and Susan Maas, Department of Employment, Economic Development and Innovation, Queensland

These pages are a brief version of Integrated Disease Management for Cotton published by the Australian Cotton CRC. For more details on any of the following pages please contact the Technology Resource Centre at the Australian Cotton Research Institute or see the Cotton CRC website.

Introduction

A plant disease occurs when there is an interaction between a plant host, a pathogen and the environment. When a virulent pathogen is dispersed onto a susceptible host and the environmental conditions are suitable then a plant disease develops and symptoms become evident.

Disease control strategies must therefore focus on the host, the pathogen and/or the environment. 'Integrated Disease Management' involves the selection and application of a harmonious range of control strategies that minimise losses and maximises returns. Each of the disease control strategies by itself is not able to provide adequate control. However, when several such strategies are used in combination then acceptable control is achieved.

Effective disease management must be integrated with management of the whole farm. The absence of symptoms does not indicate an absence of disease. Basic strategies should be implemented regardless of whether or not a significant disease problem is evident. These basic strategies should focus on the host, the pathogen and the environment.

The host

A particular plant may be immune, resistant or susceptible. Breeders also use the term 'tolerance' to imply good performance (yield) despite the presence of the disease. Examples of disease control strategies that focus on the host include:

The use of resistant varieties

Australian upland cotton varieties are completely resistant to Bacterial blight. Some have good resistance to Verticillium wilt and some have some resistance to Fusarium wilt. Use varieties with good seedling vigour.

When the Black root rot pathogen is present, use the more indeterminate varieties that have the capacity to catch up later in the season. Avoid growing susceptible varieties in fields that contain infected residues.

Balanced crop nutrition

A healthy crop is more able to express its natural resistance to disease. Adopt a balanced approach to crop nutrition, especially with nitrogen and potassium. Both deficiencies and excesses provide better conditions for the development of diseases such as Verticillium and Alternaria. For more information on cotton nutrition see NUTRIpak available from the Cotton CRC.

Replanting

Replanting decisions should be made on the basis of stand losses, not on the size of the seedlings.

The pathogen

A pathogen must be present in the area, capable of surviving the inter-crop period and adapted for effective dispersal between host plants if a disease is to occur. Disease control strategies that focus on the pathogen include:

Monitoring

Be aware of what diseases are present, where they are present and whether or not the incidence is increasing. Do your own disease survey in November and February of each season. Train farm staff to be observant and report back on possible disease occurrences.

Practice good farm hygiene

Minimise the movement of pathogens onto and off your farm, and between fields within your farm. Clean down machinery and vehicles of mud, crop and weed residues between fields and farms. Minimise movement of crop residues in tailwater recirculation systems. Encourage all visitors to 'COME CLEAN' and 'GO CLEAN'. For more information refer to myBMP.

Use rotation crops that are not hosts

Develop a sound crop rotation strategy. Successive crops of cotton can contribute to a rapid increase in disease incidence – especially if susceptible varieties are used. Use rotation crops that are not hosts for the pathogens present. The Verticillium wilt pathogen has a large host range and most legume crops are hosts of the Black root rot pathogen.

Control alternative hosts and volunteers

The pathogens that cause Verticillium wilt, Fusarium wilt, Black root rot, Tobacco Streak Virus and Alternaria leaf spot can also infect common weeds found in cotton growing areas. Control alternative hosts to prevent build up of inoculum and carry over of disease from one season to the next.

Cotton volunteers and cotton ratoons can significantly increase the risk of disease carry over between seasons. Ensure weed management strategies for fallows and rotation crops consider the need for volunteer control, particularly in systems where herbicide tolerant crops are grown. Manage cotton stubble to avoid the occurrence of ratoon cotton as herbicides are rarely cost effective or highly efficacious.



Boll rot. (Stephen Allen, CSD)

Crop residues

Manage crop residues to minimise carryover of pathogens into subsequent crops. The pathogens that cause Verticillium wilt, Fusarium wilt, Black root rot, boll rots, seedling disease and Alternaria leaf spot can all survive in association with crop residues. Incorporate cotton crop residues as soon as possible after harvest, except where Fusarium wilt is present. Where Fusarium is present residues should be slashed and retained on the surface for at least one month prior to incorporation.

The Fusarium wilt pathogen can also survive and multiply on the residues of non-host crops such as cereals. Currently recommendations are that residues should be buried or baled as soon as possible after harvest.

Application of fungicides

Examples include seed treatments for seedling disease control and foliar sprays for the control of Alternaria leaf spot on Pima cotton. For more details see Tables 33 and 34 on page 127.

Biofumigation

In addition to fixing substantial quantities of nitrogen, vetch has a biofumigation effect against Black root rot. As the vetch breaks down in the soil, ammonia is released in sufficient quantities to kill spores of the Black root rot pathogen. In contrast, vetch residues can increase the activity of Fusarium wilt in the following cotton crop.

The success of biofumigation depends on the growth of the biofumigant crop and good incorporation (at least 4 weeks before planting). Biofumigant crops can be grown and incorporated a year before planting the following cotton crop.

Control of insect vectors

Diseases caused by a virus or phytoplasma can often be prevented by controlling the vector that carries the pathogen. Cotton Bunchy Top (CBT) can be transmitted by aphids feeding on infected plants then migrating to healthy plants. Transmission of Tobacco Streak Virus (TSV) to plants relies on the virus from infected pollen entering plant cells through the feeding injury caused by thrips. Many species of thrips are potentially capable of transmitting TSV. For more information on these diseases, see the following section. Aphid and thrip thresholds can be found on pages 36–37.

The environment

Pathogens have optimum temperature, relative humidity, leaf wetness and/or soil moisture content requirements for infection to occur and for the disease to spread and multiply in the host

plant. When environmental conditions are not optimal then the rate of disease development is reduced.

It may appear difficult to manipulate the environment but it can be achieved by altering row or plant spacing, irrigation method or frequency or by changing the sowing date. Possible disease control strategies that focus on the environment include:

Good bed preparation

Plant into well prepared, firm, high beds to optimise stand establishment and seedling vigour. Carefully position fertiliser and herbicides in the bed to prevent damage to the roots. Fields should have good drainage and not allow water to back-up and inundate plants.

Irrigation scheduling

Applying water prior to planting provides better conditions for seedling emergence than watering after planting.

Watch for signs of water stress early in the season if the root system has been weakened by disease (eg. Black root rot) and irrigate accordingly. Avoid waterlogging at all times, but especially late in the season when temperatures have cooled. Irrigations late in the season can result in a higher incidence of Verticillium wilt.

Agronomic management

High planting rates can compensate for seedling mortality however a dense canopy favours development of bacterial blight, Alternaria leaf spot and boll rots. Avoid rank growth and a dense canopy with the use of growth regulators. Manage irrigations, nutrition and insects for early maturity as many pathogens are favoured by cool conditions at the end of the season.

In fields where Fusarium wilt is present avoid inter row cultivations after seedling stage as mechanical damage to the roots provide a site for infection by the pathogen.

Sowing date

Delay sowing as late as possible within the planting window to avoid cool, wet conditions that favour disease. Sowing when the soil temperature is above 20°C would be best for reducing cotton's susceptibility to disease, but generally this is not practical. Time planting to coincide with soil temperatures of at least 16°C and rising.

Soil health

Fields where soil borne pathogens cause chronic disease in cotton are not 'unhealthy' as healthy cereal crops could be grown in the same field. These diseases are not present because the soil has been mistreated, the presence of the pathogen creates a problem with the health of the plants but not a problem with the health of the soil.



Aerial photo of fusarium damage.

Common diseases of cotton

Stephen Allen, Cotton Seed Distributors
Linda Scheikowski, Cherie Gambley, Murray Sharman
and Susan Maas, Department of Employment, Economic
Development and Innovation, Queensland

Seedling diseases

There have been over 30 species of fungi isolated from dying cotton seedlings. Death of seedlings is often referred to as 'damping off' but is mainly caused by

Rhizoctonia solani

Pythium spp.

Fusarium spp. (not Fusarium wilt)

Symptoms

Pre-emergent seed rots. Post emergent wilting, collapse and death (damping off). Slow early season growth, small cotyledons and reddened hypocotyls, lesions on roots.

Favoured by

Anything that slows down germination and seedling growth favours infection by seedling disease. This includes cool and/or wet weather, poorly formed beds, compaction, waterlogging, incorrect planting depth, fertiliser under the plant line, excessive rates of planting herbicide, movement of herbicide into root zone (ie by rain) and infection by other pathogens.

Host range

These pathogens have wide host ranges and can survive on residues of many crops and weeds.

IDM tactics

- Use a variety with good seedling vigour.
- Use effective seed treatment fungicides.
- Avoid freshly incorporated rotation crop residues.
- Plant into well prepared, high, firm beds.
- Carefully position fertiliser away from the plant line.
- Plant into moisture.
- Delay planting until temperatures are optimum.
- Take care with use of herbicides at planting.



Rhizoctonia seedling disease. (Alison Seyb, I&I NSW)

Black root rot

Thielaviopsis basicola

Symptoms

Affected crops appear to be slow growing or stunted, especially during the early part of the season. The disease causes destruction of the root cortex (outer layer), seen as blackening of the roots. Some roots may die but *T. basicola* does not kill seedlings by itself. Severe black root rot opens the root up for infection by *Pythium* or *Rhizoctonia*. Plants that are badly 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.

Host range

The host range of *T. basicola* includes all varieties of cotton, most legumes including faba bean, soybean, cowpea, field pea, chickpea, mung bean, lablab and lucerne. *Datura* weeds (thornapple, castor oil) are also hosts, but little is known about other weeds.

Non hosts include all the cereal crops, sunflower, canola and vetch.

IDM tactics

- Choose varieties that can 'catch up'.
- Use Bion seed treatment.
- Prepare beds well ('high and firm' not 'low and loose')!
- Pre-irrigate and/or plant into moisture.
- Delay planting if possible.
- Rotate with non-hosts for up to 3 years.
- Avoid legumes and control weeds.
- Effective biofumigation with vetch or mustard.
- Minimize your tailwater.
- Always practice good farm hygiene.
- Summer flooding if possible.



Black root rot. (Stephen Allen, CSD)

Verticillium wilt*Verticillium dahliae***Symptoms**

Leaf mottle – yellowing between the veins and around the leaf margins, vascular discolouration or browning extending throughout the stem and into the petioles, root system otherwise healthy, some defoliation may occur if cool.

Internal symptoms can be checked by cutting the stem. The vascular tissue of an infected plant will reveal flecking brown discolouration extending throughout the stem and into the petioles. Under Australian conditions with Australian strains of the pathogen, all plants with vascular symptoms will also display foliar symptoms,

The discolouration is similar to that of Fusarium wilt but usually appears as flecking rather than continuous browning. Severe cases often need to be tested by a pathologist to determine whether the pathogen is Fusarium or Verticillium. The root system appears otherwise healthy.

Favoured by

Resistance to the disease is temperature sensitive. Varieties that are resistant at 25°–27°C are susceptible at 20°–22°C. The disease is most severe during extended wet weather and/or waterlogging and in late maturing crops. The disease is favoured by excessive use of nitrogen which results in late season growth and also by potassium deficiency.

Host range

Verticillium wilt has a large host range which includes sunflower, soybean, noogoora and bathurst burr, saffron thistle, thornapple, caustic weed, bladder ketmia, burr medic, black bindweed, pigweed, devils claw, turnip weed, mintweed, blackberry nightshade and others.

Non host crops include sorghum and cereals.

IDM tactics

- Choose varieties with V.ranks over 100.
- Manage for earliness.
- Avoid late season irrigations.
- Incorporate cotton residues soon after harvest.
- Rotate with non-hosts such as cereals or sorghum.
- Control alternative weed hosts.
- Minimize your tailwater.
- Always practice good farm hygiene.



Verticillium wilt. (Stephen Allen, CSD)

Fusarium wilt*Fusarium oxysporum var. vasinfectum (FOV)***Symptoms**

External symptoms include stunted growth and dull and wilted leaves followed by yellowing or browning of the leaves and eventual death from the top of the plant. Some affected plants may reshoot from the base of the stem. External symptoms can appear in the crop at any stage. Most commonly they become apparent in the seedling phase when plants are beginning to develop true leaves, or after flowering during boll fill. Symptoms can appear as only a few, individual plants or as a small patch, often but not always in the tail drain or low-lying areas of the field.

Internal symptoms can be checked by cutting the stem. An affected plant will reveal continuous brown discolouration of the stem tissues running from the main root up into the stem. The discolouration is similar to that of Verticillium wilt but usually appears as continuous browning rather than flecking.

Favoured by

Use of susceptible varieties. Stresses in the crop such as waterlogging, root damage through cultivation and cool, wet growing conditions. Spores surviving in soil and on crop residues can be spread by overland flows, in irrigation water and attached to people and machinery.

Host range

The FOV pathogen is specific to cotton but can live on the residues of most non host crops. Known alternative weed hosts include bladder ketmia, sesbania pea and dwarf amaranth, however there are possibly more.

IDM tactics

- Plant a high F.rank variety with Bion seed treatment.
- Delay planting to the end of October.
- Avoid cultivating with knives.
- Retain cotton residues on the surface for 60 days.
- Bare fallow rotation is best.
- If using a cereal rotation then bury, bale or burn cereal residues ASAP.
- Minimise your tailwater.
- Always practice good farm hygiene.
- Summer flooding if possible.



Fusarium wilt. (Linda Smith, DEEDI)

Alternaria leaf spot

Alternaria macrospora
Alternaria alternata



Alternaria leaf spot. (Chris Anderson, I&I NSW)

Most commercial varieties of cotton are relatively resistant to *Alternaria* and the impact of the disease on yield is insignificant, unless the crop is severely affected with premature senescence associated with potassium deficiency. Pima cotton is very susceptible.

Symptoms – *A. macrospora*

Brown, grey brown or tan lesions 3–10 mm in diameter on lower leaves, sometimes with dark or purple margins. Circular dry brown lesions on bolls.

Pima varieties can defoliate rapidly when the environment favours the disease.

Symptoms – *A. alternata*

Purple specks or small lesions with purple margins on bolls and leaves.

Favoured by

Heavy dews or extended periods of wet weather resulting in long periods of free moisture on the leaf. Suppressed by hot dry weather. Nutritional stress can favour development. Pima varieties are quite susceptible.

Host range

Cotton, bladder ketmia, sida and anoda weed.

Boll rot

Phytophthora boll rot is the most common, while *Sclerotinia* boll rot and *Fusarium* boll rot (not *Fusarium* wilt) are usually only seen in very rank crops.

Phytophthora boll rot

Phytophthora nicotianae var. *parasitica*

Symptoms

Infected bolls quickly turn brown and become blackened before opening prematurely. Symptoms most prevalent on the lower bolls.

Favoured by

Heavy rainfall on exposed soil that splashes soil up onto low bolls enables infection. Low mature bolls and lodged plants are at highest risk of infection.

Host range

Safflower, some horticultural and many ornamental plants.

Tobacco streak virus

Tobacco streak virus (TSV)

Symptoms

Symptoms included dark purple or necrotic, spreading lesions on leaves, sometimes forming numerous diffuse ring spots. On plants with numerous necrotic lesions the upper leaves sometimes also display chlorotic mottle and deformed, down-curved leaves. Symptoms in young cotton crops are generally mild and consist of single, diffuse necrotic lesions on one leaf of infected plants.

Favoured by

TSV disease is favoured by climatic conditions which enable high thrips populations to develop, and large amounts of infective pollen to be produced by host plants such as parthenium. These conditions generally occur during warmer months and is highly dependant on rainfall and weed growth patterns.

Host range

Cotton, sunflower, mung beans, chickpeas, soybean and peanuts. Weed hosts include parthenium, native jute, native rosella, milk weed, thornapple, ground cherry, rattle pods, crownbeard and Noogoora burr.



Tobacco streak virus. (Murray Sharman, DEEDI)

Cotton bunched top (CBT)

CBT is viral disease that is relatively new to Australian cotton being first observed in the 1998/99 season. The disease has since been reported from the Macquarie Valley in the south to the Emerald region in the north. CBT is spread by the cotton aphid (*Aphis gossypii*, Glover).

Symptoms

Symptoms include; reduced plant height, leaf size, petiole length, internode length and boll size. Leaf symptoms are usually an angular pattern of pale green margins and darker green centres. These darker leaves have a leathery and sometimes glossy texture when compared to leaves on healthy plants. Typically, the pale angular patches turn red as leaves age. Bolls are often less than half the size of healthy bolls. Symptoms are also evident on roots. These include the formation of small knots on the secondary root branches. The roots also appear

hairy and dark brown in comparison to the light yellow-brown colour of healthy roots.

Usually a period of 3–8 weeks lapses between when the infection occurs and when symptoms are first observed. The severity of symptoms expressed by infected plants depends on their age at the time of infection. After the plant is infected, new growth is also characterised by small leaves, short internodes and small bolls. This is usually limited to growth that occurs after infection; growth before this stage may appear normal. When plants become infected very early, as seedlings, the growth of the whole plant is affected and the crop takes on a compact, stunted, 'climbing ivy' appearance.

Infections early in the season have the greatest potential to reduce yield. However the extent to which yield is affected also depends on the proportion of plants infected. If the proportion is low, then uninfected neighbouring plants will often compensate and make up any yield loss. Often the CBT-infected plants will become obscured by their neighbours. If the proportion infected is high (>50%), yield may be reduced, but this level of infection rarely occurs.

Plants showing symptoms of the disease are often found in circular patches in association with prolonged aphid activity. These are most likely to occur;

- On field margins, where aphids carrying the disease have moved from other hosts into the cotton crop; or
- In portions of the field where there has been survival of CBT-affected cotton ratoons from the previous season.

Favoured by

Fields at highest risk of CBT are those in close proximity to ratoon cotton. When cotton plants are infected with CBT late in the season, there may not be sufficient time for symptoms to be expressed. However when such plants ratoon, the new growth will be strongly affected. Ratoons act as both a preferred host for the aphids and a reservoir for the disease, creating a source of infection in the new season.

Disease spread is favoured by climatic conditions which are suitable for aphid reproduction, feeding and spread. The risk from CBT is probably higher after wetter winters and lower after dry winters. The presence of weed hosts allow larger aphid



Cotton bunchy top. (Stephen Allen, CSD)

populations to overwinter, increasing the likelihood of aphids moving into cotton early in the season when there is sufficient time for infection to result in the development of severe symptoms.

Even when there is a source of CBT in close proximity to a cotton field, the spread of the disease is also highly dependent on the size and movement of the aphid population. CBT is more easily transmitted when plants are colonised by many infected aphids. If just one CBT-infected aphid colonizes a plant, the transmission rate is ~5% (1 in 20 plants become infected). If there are three or more infected aphids the transmission rate increases to ~40%.

There is a 'latent' period that also slows down the rate of transmission through a field. When a CBT-infected aphid feeds on a cotton plant, transmission will happen within half a hour if it is going to occur. A latent period then passes. Over the next 10–14 days young aphids produced by the infected female can feed on the newly infected plant and not pick up the disease. They move on to nearby plants to start new colonies before becoming carriers of the disease. When the young aphids do pick up CBT from the original plant before moving to the next plant there will again be a latent period in that plant. This is compounded by the low transmission rate when a single aphid colonizes a plant. Many colonization events do not result in successful transmission. This scenario is often seen in commercial fields where at the centre of an aphid hotspot a single CBT infected plant will be found, while the nearby plants are disease free.

Host range

The most critical alternative host plant is ratoon cotton. Ratoon plants are often large, with a deep tap root. They are able to survive through periods of low rainfall and often retain leaves and active growth through winter, supporting infected aphid populations from one season to the next.

Pima cotton (*Gossypium barbadense*) is a symptomless host. Even if plants become infected when they are very young disease symptoms will not be expressed. Aphids that feed on infected plants can become infected and transfer CBT to upland cotton (*G. hirsutum*) which will then express disease symptoms.

The cotton aphid has a broad host range, including many weeds common in cotton growing areas. At this stage only marshmallow has been confirmed to be an alternative host for CBT. However it is possible that other weeds are also hosts. Weed hosts may not express disease symptoms, similarly to pima cotton. For a comprehensive list of the cotton aphid's alternative hosts, refer to the Cotton CRC Information Sheet 'Managing Aphids in Cotton', available from the Cotton CRC website.

IDM tactics

- Manage cotton stubble to prevent ratoons.
- Control farm weeds that are aphid hosts, particularly marshmallow.
- Consider cotton volunteer management when making weed control decisions for fallows and rotation crops.
- Monitor cotton fields regularly from crop emergence for the presence of aphids.
- Check aphid hot spots for symptoms of CBT.
- If CBT symptoms are present early season, consider rouging infected plants or selectively controlling aphids in compliance with the IRMS.

ADVERTISEMENT

Superior insecticide seed treatment - at a lower price

The proven superior performance of imidacloprid cotton seed insecticide treatment is now available at a comparable price to other seed treatments. eChem, manufacturers of Genero 600FS, has drastically reduced prices for the 2010 planting season to allow growers access to the best seed treatment at an affordable cost.

Genero 600FS contains 600g/L imidacloprid and gives cotton seedlings tried and tested protection against thrips, aphids, brown beetles and wireworms.

Col Hibbard, General Manager of eChem, suggests that growers have a close look at the CSD seed treatment price list this year before making their product selections.

"We have been able to bring the price down because eChem is an Australian-owned, grower controlled company and lower prices are one of the reasons for our existence," says Col. "Like any company, we have to make a profit. But we also aim to supply products at the lowest possible price, and that's what we have done with Genero 600FS this year."

Independent research trials have shown that Genero 600FS has equal performance when compared with other 600g/L imidacloprid products. It has also been tested for crop safety at more than four times the current use rate and undergoes rigorous product quality assurance testing.

"The benefits of imidacloprid cotton seed dressing have been shown time and again in field trials," says Col. "The price differential has been a stumbling block, but this has now been largely removed for this season."

For more information contact Col Hibbard on 0428 658 390.



The best insecticide cotton seed treatment just got cheaper

GENERO 600

600g/L imidacloprid seed treatment

Controls thrips, aphids,
brown flea beetle and
wireworms

Available from...

eChem

eChem (Australia) Pty Ltd
(ABN 23 089 133 095)

13833 New England Highway
CAMBOOYA QLD 4358

Ph: 07 4696 1054

Fax: 07 4696 1057

Mob: 0428 658 390

Cotton Pathology Survey 2009/10

SJ Allen¹, CMT Anderson², J Lehane³, PA Lonergan², LJ Scheikowski³ and LJ Smith⁴, Cotton Catchment Communities CRC

Commercial cotton crops across NSW and Queensland were inspected in November-December 2009 and February-April 2010. The incidence and severity of those diseases present were assessed and field history, ground preparation, cotton variety, planting date and seed rate were recorded for each of the 82 and 54 fields that were surveyed in NSW and Queensland respectively. This represents the 27th consecutive season of quantitative disease surveys of cotton in NSW and the 8th consecutive season of cotton disease surveys in Queensland. Most cotton production areas experienced very dry conditions in October and November with some extreme hot weather in November. This was followed by a wet summer with some cooler temperatures and overcast conditions and very wet weather in March followed by dry weather and a good finish in April. These conditions impacted significantly on the incidence and severity of cotton diseases and on the timing of disease surveys.

Cotton industry biosecurity plan – crop surveillance for priority pests

During these surveys particular attention was given to the detection of Cotton Leaf Curl Virus, Blue disease, Phymatotrichopsis root rot, the hypervirulent strains of the bacterial blight pathogen, the defoliating strains of the Verticillium wilt pathogen and exotic strains of the Fusarium wilt pathogen. None of these diseases and/or pathogens were observed.

Volunteer cotton – carry-over from the previous season

The following information was collected at the request of the CRDC during the annual disease surveys and is based on visits to 45 farms in NSW and 28 farms in Queensland during November 2009. The number of farms with (1) mature cotton plants surviving along roadsides, fence lines, along channels and in tail water return systems or drains and (2) mature cotton plants surviving from the previous season or regrowth from stubs (Ratoon cotton?) in current cotton crops, were recorded.

	1. Channels, roads, fences	2. In the current crop	TOTAL
In NSW	17/45 (38%)	17/45 (38%)	17/45 (38%)
In Qld	11/28 (32%) 9/11 in Emerald Theodore	15/28 (54%) 11/15 in Emerald Theodore	20/28 (71%)

The presence of volunteer plants surviving over from the previous season enables pests and pathogens such as mealy bug and cotton bunchy top to overwinter and initiate new outbreaks in the spring. Wet weather during early 2010 has allowed vigorous growth of volunteer cotton in non-cropped areas. These volunteers should be controlled and not allowed to overwinter.

1 Cotton Seed Distributors, PO Box 17, Wee Waa NSW.
 2 Industry & Investment NSW, Locked Bag 1000, Narrabri NSW.
 3 Department of Employment, Economic Development and Innovation, 203 Tor Street, Toowoomba, Qld.
 4 Department of Employment, Economic Development and Innovation, 80 Meiers Road, Indooroopilly, Qld.

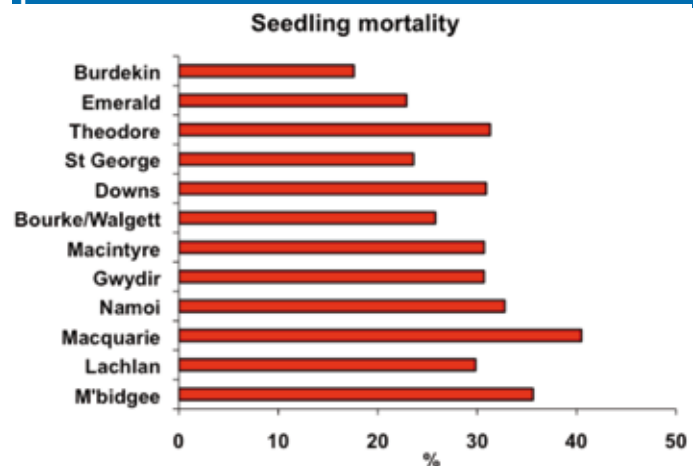
Seedling mortality

As part of the disease survey an estimate of the number of seeds planted per metre is compared to the number of plants established per metre. This comparison produces an estimate of seedling mortality which includes the impact of seedling disease (Rhizoctonia and Pythium etc.) as well as seed viability, the activity of soil insects such as wireworms, physical problems such as fertiliser or herbicide burn and the effects of adverse environmental conditions.

Mean seedling mortality (Figure 1) for the crops inspected in Queensland and NSW was 25.8% and 32.5%, respectively, (24.9% and 28.8% in 2008-09; 19.5% and 31% in 2007-08; 22.5% and 28.9% in 2006-07). Problems with crop establishment were noted in most areas. Many growers experienced the warm conditions in early September, and pre-irrigated. Temperatures dropped and planting had to be delayed. When the weather did eventually warm up the moisture had receded and some growers had to irrigate again using valuable water.

In Queensland mean seedling mortality was generally higher than that in the previous season particularly in crops on the Darling Downs, where it was 15.6% last year and 30.9% this year even though six of the 13 crops surveyed were planted in November. Seedling mortality exceeded 40% in all three fields where cotton had been planted after soybean. Mean seedling mortality exceeded 30% in all production areas in New South Wales with the exception of the Bourke and Walgett areas where it averaged 26% and the Macquarie valley where it averaged just over 40%.

FIGURE 1: Mean seedling mortality in the 2009/10 season was generally higher than in the previous season. Seedling mortality is derived from the difference between the number of seed planted and the number of plants established.

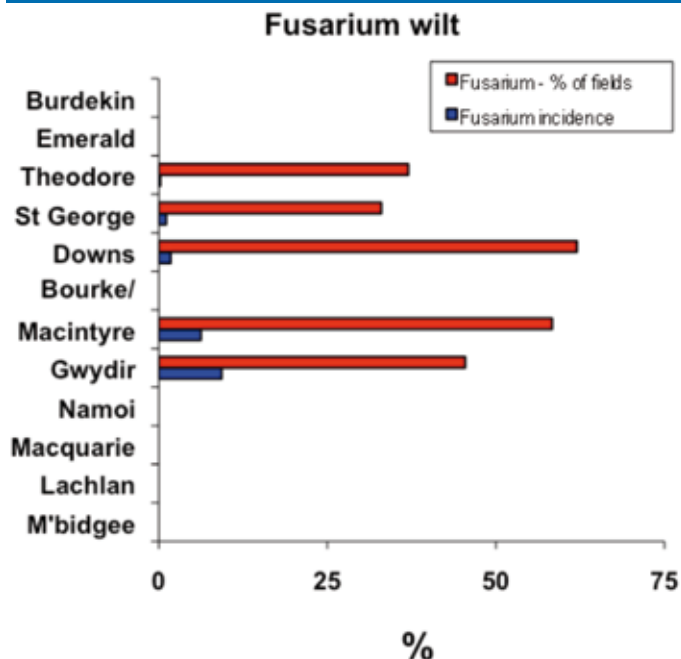


Fusarium wilt

There were no new reports of Fusarium wilt from either NSW or Queensland this season. The very dry conditions in October and November combined with the very hot weather in November were not favourable for the development of Fusarium wilt (Figure 2). The disease was observed in only 15 of the 54 crops surveyed in Queensland including eight of the 13 crops inspected on the Darling Downs. The incidence of Fusarium wilt averaged 1.8% and 1.1% respectively, for the Darling Downs and St George areas and only exceeded 5% in two fields.

Fusarium wilt was observed in only 12 of the 82 crops surveyed in NSW including seven of the 12 crops inspected in the Macintyre valley and five of the 11 crops surveyed in the Gwydir valley. The incidence of Fusarium wilt averaged 6.3% and 9.3% respectively, for these two production areas. Over 50% of plants were infected in one crop near Boggabilla and in one crop near Moree. Though Fusarium wilt is known to be present and widespread in the Macquarie valley, the upper Namoi valley and Bourke areas it was not detected in the 2009/10 disease survey.

FIGURE 2: The average distribution and incidence of Fusarium wilt of cotton in the 2009/10 season.



Transects have been established in fields near Theodore, St George and Boggabilla. The incidence of Fusarium wilt is assessed along these transects whenever cotton is grown in these fields. Assessments during the 2009/10 season show reductions in disease incidence from 6.6% in 2008/09 to 1.3% at Theodore, from 19.4% in 2007/08 to 3.5% at St George and 19% in 2007/08 down to 7% at Boggabilla.

Several factors may be contributing to this apparent decline in the incidence of Fusarium wilt. These include:

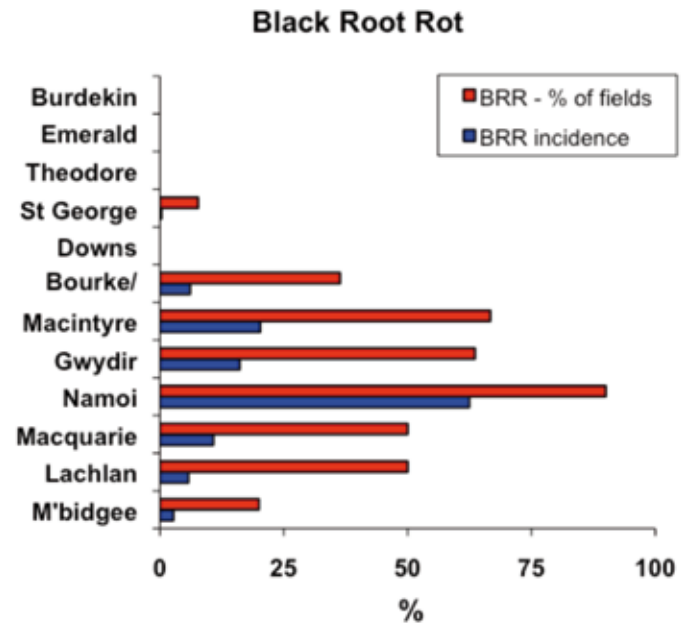
- (i) Dry spring weather and delayed planting. Six of the 13 fields surveyed on the Darling Downs were planted in November. Previous work has shown that dry spring weather and delayed sowing can significantly reduce the incidence of Fusarium wilt for the whole season.
- (ii) More resistant varieties. During the last two seasons the most popular commercial cotton varieties have been Sicot 70BRF with an F.rank=113(19) and Sicot 71BRF with an F.rank+120(15). Previously the most popular variety was Sicot 71BR with an F.rank=101(14).
- (iii) The widespread use of BION seed treatment. This product has been shown to provide some control of Fusarium wilt and black root rot through systemic induced resistance. Over 1000 tonnes of cotton planting seed treated with BION was sold for planting in the 2009/10 season.

Black root rot

Black root rot of cotton is favoured by cool weather conditions early in the season. The pathogen colonises the root surface, suppresses the development of secondary roots and stunts

seedling growth. When temperatures rise the tap root expands and the blackened root surface is sloughed off and disappears. The dry and hot weather in November 2009 enabled cotton seedlings with adequate moisture to grow away from the disease with less stunting than usual.

FIGURE 3: The distribution and incidence of black root rot in cotton in the 2009/10 season.



Black root rot was observed on 93% of farms visited and in 58% of the fields surveyed in NSW (Figure 3). The average incidence within fields was 23% and mean disease severity was 0.97 (9.7% of each tap root blackened). The disease was most common in crops in the Namoi valley where it was observed in 18 of the 20 fields surveyed. The average incidence within fields was 62% and the incidence exceeded 90% (of plants infected) in eight of the fields. The mean disease severity was 2.83 (28.3% of each tap root blackened).

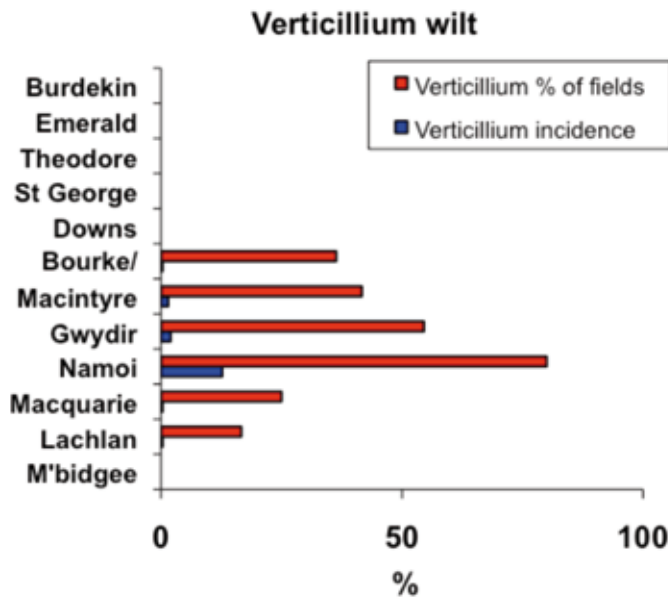
Black root rot has previously been observed in all Queensland cotton production areas except the Burdekin. Surveys were completed in Emerald and Theodore in early November and in St George and the Darling Downs in late November and early December. Six of the 13 fields surveyed on the Downs were planted in November and two were planted in late October. The late planting and the dry, hot start to the season resulted in very few records of the disease in this survey. Generally the warmer climate of Queensland does not favour black root rot. The mean minimum and maximum temperatures for October, 2009 were 15.5°C/32.4°C for Emerald and 11.1°C/28.0°C for Narrabri.

Verticillium wilt

Verticillium wilt is also favoured by cooler weather and is rarely observed in Queensland production areas. The disease was observed in 36% of fields surveyed in NSW. However, the average incidence was only 3.7% of plants infected (Figure 4). This represents the lowest average incidence of Verticillium wilt in NSW for several years.

Verticillium wilt was observed in 80% of fields surveyed in the Namoi valley where the average incidence of the disease was 12.7% of plants infected. The three worst affected fields had 42%, 52% and 85% of plants with symptoms. It is interesting to note that the fields that had 85% and 52% of plants with Verticillium wilt at the end of the season had 95% and 100% of plants with black root rot at the beginning of the season. The

FIGURE 4: The distribution and incidence of Verticillium wilt of cotton in the 2009/10 season. The disease was present in many areas but the incidence was generally low.



interactions between the pathogens that cause black root rot and Verticillium wilt and the effect of that interaction on cotton needs to be investigated.

Significant yield reductions are most likely when cool wet overcast weather occurs mid-season and symptoms of Verticillium wilt become apparent. The 123mm and 192mm rainfall recorded in Moree and Wee Waa in December 2009 may have been important. Symptoms of Verticillium wilt usually become most obvious late in the season as temperatures become lower. Past research has shown that late season disease development results in minimal losses because fruit load has already been set.

Boll rots

The incidence of boll rots was higher than previously recorded in all cotton production areas (Figure 5). In some areas the wet and overcast weather continued for several weeks after the surveys were finished and the final incidence would have been substantially higher than that recorded. Late season rainfall also interfered with the timing of some surveys and consequently some surveys were completed later than usual. The average incidence of boll rots was recorded as 9.7% for NSW and 7.3% for Queensland (2.7% and 1.9% in 2008/09).

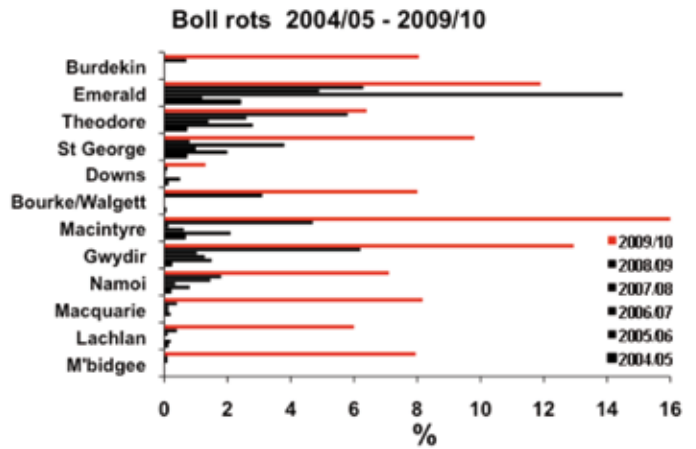
In Queensland production areas the weather conditions resulted in low boll set mid-season and many crops became tall and rank. Rainfall at Emerald in January (117mm) and February (216mm), at St George in February (124mm) and March (249mm) and in the Burdekin in March (189.6mm) caused the development of high humidity within the canopy and newly opened bolls quickly succumbed to the common boll rotting fungi.

In NSW Phytophthora boll rot was common. The pathogen survives in the soil and is splashed up onto low bolls that are about to open. Heavy rainfall events in February and March, and low-set bolls favour disease development.

Other diseases and disorders

Alternaria leaf spot and premature senescence. Alternaria leaf spot was present at low levels in almost all crops and was generally of minor significance. Some defoliation may

FIGURE 5: The average incidence of boll rots in each of the cotton production areas for the 2009/10 season (red) and the previous five seasons (black). These figures may underestimate the final incidence as assessments are usually completed after the final irrigation and several weeks before harvest.



occur late in the season especially when plants are exposed to extended periods of wet weather when they are beginning to show signs of 'cut-out', low Potassium or premature senescence. Defoliation caused by Alternaria leaf spot was reported from the Emerald area as a result of the extended wet weather in February that occurred after surveys were completed. Rain and consequent flooding in the St George and Dirranbandi areas delayed surveys and prevented assessment of Alternaria leaf spot and premature senescence.

Above average rain in March, rank growth, high humidity and heavy dews favoured some premature senescence (2.8% of plants), boll rots (8.05% of bolls) and leaf spots causing defoliation of lower leaves in crops in the Burdekin valley of Queensland.

Cotton bunchy top. Bunchy top was commonly observed on volunteer cotton plants surviving over from the previous season. A large area of severely affected plants was observed in a field near Theodore.

Tobacco Streak Virus (TSV). The very dry and hot start to the season with negligible thrip activity resulted in virtually no movement of the virus from parthenium weed into young cotton crops. TSV has only been recorded on cotton in central Queensland.

Seed rot. Symptoms of seed rot include a soft brown rot of developing seed within the bolls that may not become apparent until the bolls either drop or open prematurely. Only one or two locks, or sometimes the whole boll, can be affected. Seed rot appears to be caused by either bacteria or fungi that are introduced into the young developing boll by sucking insects such as the green vegetable bug. The average incidence of seed rot in cotton crops in the Burdekin valley was estimated to be 5.6%.

Acknowledgments:

These surveys were made possible with the financial support of the Cotton Research & Development Corporation, the Cotton Catchment Communities CRC, Cotton Seed Distributors Ltd., Industry and Investment, NSW and the Queensland Department of Education, Economic Development and Innovation. The assistance of Dr Murray Sharman, Dr Cherie Gambley, Dr Alison Seyb and Bethany Cooper is gratefully acknowledged.

SENDING A SAMPLE FOR DIAGNOSIS BY A PATHOLOGIST – ATTACH A COMPLETED FORM TO EACH SAMPLE

Collected/Submitted by: (e.g. Cotton Extension Officer)

Address/Email/Fax/Telephone:

Property name and field number:

Date collected:

Grower/Agronomist

Grower's address or area/locality:

Mark (X) as appropriate

SYMPTOMS	DISTRIBUTION	INCIDENCE/SEVERITY	CROP GROWTH STAGE
<input type="checkbox"/> Poor emergence or seedling depth	<input type="checkbox"/> One field only	<input type="checkbox"/> All plants	<input type="checkbox"/> Irrigated
<input type="checkbox"/> Leaves: spots or dead areas	<input type="checkbox"/> In several fields	<input type="checkbox"/> Scattered single plants	<input type="checkbox"/> Dryland/rain-grown
<input type="checkbox"/> Leaves: discoloured	<input type="checkbox"/> In all fields	<input type="checkbox"/> Scattered patches of plants	<input type="checkbox"/> Seedling stage
<input type="checkbox"/> Leaves: mottled	<input type="checkbox"/> One variety only	<input type="checkbox"/> In a large patch (>5 m)	<input type="checkbox"/> Setting squares
<input type="checkbox"/> Leaves or shoots: distorted or curled	<input type="checkbox"/> Several varieties affected	<input type="checkbox"/> In a small patch (1–5 m)	<input type="checkbox"/> Early flowering
<input type="checkbox"/> Plants stunted	<input type="checkbox"/> Some rows more affected	<input type="checkbox"/> In a small patch (<1 m)	<input type="checkbox"/> Peak flowering
<input type="checkbox"/> Plants wilting	<input type="checkbox"/> On lighter soil types	<input type="checkbox"/> Plants dead	<input type="checkbox"/> First bolls open
<input type="checkbox"/> Premature plant death	<input type="checkbox"/> On heavier soil types	<input type="checkbox"/> Plants defoliating	<input type="checkbox"/> Defoliated
<input type="checkbox"/> Bolls: spots or dead areas	<input type="checkbox"/> In poorly drained area(s)	<input type="checkbox"/> One to a few plants only	<input type="checkbox"/> Ready to pick
<input type="checkbox"/> Roots: discoloured, bent, pruned, etc.	<input type="checkbox"/> Other: (please specify)		

OTHER INFORMATION

- Cultivar
- Paddock History
- Nearby crops
- Rainfall in last 10 days
- Average temperature range over the last 10 years
- Date of last irrigation
- Date of last cultivation

Please contact your Cotton Industry Development Officer or District Agronomist to determine the appropriate Pathologist and address for submitting sample

ALL SAMPLES WHERE FUSARIUM WILT IS SUSPECTED MUST BE SENT TO INDOOROPILLY

When sending samples:

- Send multiple samples (e.g. more than 1 leaf, stem or plant).
- If possible include a healthy plant as well as the diseased plant material.
- It is better to despatch samples early in the week rather than just before the weekend.
- Never wrap samples in plastic. Dry or slightly dampened newspaper is better.
- When collecting seedlings – dig them up rather than pull them out. Include some soil.
- Several sections of stem (10–15 cm long) are usually adequate for wilt diseases.
- Keep the sample cool and send as soon as possible.

Cotton Disease Control Guide

Tracey Leven, CRDC.

Registration of a pesticide is not a recommendation for the use of a specific pesticide in a particular situation. Growers must satisfy themselves that the pesticide they choose is the best one for the crop and disease. Growers and users must also carefully study the container label before using any pesticide, so that specific instructions relating to the rate, timing, application and safety are noted. This publication is presented as a guide to assist growers in planning their pesticide programs.

If there is any omission from the list of chemicals, please notify the authors.

IMPORTANT – avoid spray drift

Take every precaution to minimise the risk of causing or suffering spray drift damage by:

- Planning your crop layout to avoid sensitive areas, including homes, school bus stops, waterways, grazing land and non-target crops.
- Ensuring that all spray contractors have details of any sensitive areas near spray targets.

- Carefully following all label directions.
- Consulting with neighbours to minimise risks from spraying near property boundaries. Keep neighbours informed of your spraying intentions

Spray Log Books

To assist in record keeping for pesticide applications, Spray Log Books can be purchased from:

DEEDI, cost \$6.60 each plus postage and handling. Contact DEEDI in Toowoomba – 07 4688 1415 or in Dalby – 07 4669 0800 to place an order.

I&I NSW, cost \$12.00 each plus postage and handling. Contact I&I NSW, Yanco – 1800 138 351.

ABBREVIATIONS USED IN TABLES 33–34

EC = Emulsifiable concentrate
FC = Flowable concentrate
SC = Suspension concentrate

WDG = Water dispersible granule
WP = Wettable powder

Insecticide & Bt Resistance Testing

In-season testing of field populations of



Helicoverpa

Sharon Downes
02 6799 1500



Mites

Grant Herron
02 4640 6471



Aphids



Whitefly

Richard Lloyd
07 4688 1315

to monitor changes in resistance across the industry

Providing information critical to pest management

Learn about resistance, species composition and parasitism levels on your farm.

Arrange delivery of collections by contacting the people above.



TABLE 33: Control of Cotton Diseases

Active ingredient	Fungicide chemical group	Concentration and formulation	Application rate of product	Comments
Alternaria leaf spot				
mancozeb	Y	750 g/kg WG	2.5 kg/ha	Pima varieties only. Do not apply before flowering. Begin applications as soon as disease symptoms appear and before each infection period. DO NOT apply more than 4 sprays per season.
Rhizoctonia solani (Damping off)				
tolclofos-methyl	X	500 g/L SC	0.12 L/ha or 0.12 L/10km row	QLD and NSW only. Apply as an in-furrow spray or by water injection at time of planting.
		100g/L	40g/kg of seed	Put with seed immediately before planting
Pythium spp. and Phytophthora spp. (Damping off)				
metalaxyl-m	D	350 g/L EC	0.1 L/100 kg seed	Commercial application recommended.
Rhizoctonia solani and Pythium spp.				
azoxystrobin + metalaxyl-m + fludioxonil	K D L	75 g/L SL 37.5 g/L SL 12.5 g/L SL	0.2 L/100 kg seed	Commercial application recommended. This seed treatment should be used as part of an integrated strategy to control seedling disease.
Fusarium Wilt				
acibenzolar-s-methyl		500 g/L FC	1.2 mL/100 kg seed	Seed treatment for suppression of Fusarium wilt and Black root rot.
metalaxyl-m	D	350 g/L	0.043 L/100 kg seed	For Fusarium wilt disinfection. Commercial application recommended.

TABLE 34: Fungicide trade names and marketers

Active ingredient	Concentration and formulation	Trade name	Marketed by
acibenzolar-s-methyl	500 g/L FC	Bion Plant Activator	Syngenta
azoxystrobin + metalaxyl-m + fludioxonil	12.5 g/L SL	Dynasty	Syngenta
	37.5 g/L SL		
	75 g/L SL		
mancozeb	750 g/kg DF	Innova Mancozeb 750	Syngenta
	750 g/kg DF	Mancozeb	Forward
	750 g/kg DF	Mancozeb 750	Imtrade
	750 g/kg DF	Mancozeb 750 DF	Farmoz
	750 g/kg DF	Mancozeb 750 DF	Sabero
	750 g/kg DF	Mancozeb 750 DF	Titan Ag
	750 g/kg DF	Manzate DF	Dupont
	750 g/kg DF	Penncozeb 750 DF	Arkema
	750 g/kg DF	Unizeb	United Phosphorus Limited
	750 g/kg WG	Dithane Rainshield Neo Tec	Dow AgroSciences
	750 g/kg WG	Manzeb	Farmalinx
	750 g/kg WG	Mancozeb 750 WG	Ospray
	750 g/kg WG	Manfil	Runge Agrichems
metalaxyl-m	350 g/L ES	ApronXL 350	Syngenta
tolclofos-methyl	500 g/kg WP	Rizolex	Sumitomo Chemicals
	500 g/L SL	Rizolex liquid	Sumitomo Chemicals
	500 g/L SL	Tolex	Genfarm