

# Cotton Symptoms Guide

**The guide to symptoms of diseases and disorders in Australian cotton**

Introduction & symptoms key

Diseases

Biosecurity threats

Herbicides

Insect damage

Soil constraints & planting management

Environmental & other symptoms

Nutrition deficiency/toxicity

**A production of**  
**The Australian Cotton Industry**  
**Development & Delivery Team**

EDITORS: Susan Maas, Stephen Allen and Duncan Weir

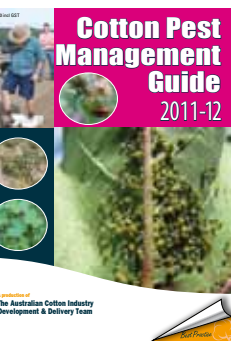
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*Best Practice*





# You never stop learning



Delivery of timely information resources that support best practice cotton farming is a goal of the Australian Cotton Industry Development and Delivery Team (Cotton D&D).

Cotton D&D is the new name for industry's renowned extension service.

Cotton D&D is all about keeping access to your trusted cotton specialists and world-leading cotton scientists while increasing the flow of information which targets both seasonal and long term needs of best practice cotton farming.

Under the banner of 'Best Practice', Cotton D&D provides specialist advice services based on research that is developed for everyday use.

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**The Australian Cotton Industry**  
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**F**ARMERS, consultants and fellow researchers have been challenging me to identify the causes of diseases and disorders of cotton for nearly 30 years and I am still forced to admit "I don't know!" on a fairly regular basis.

I suspect that there are other 'experts' with similar experiences!

A disease can be defined as any deviation from normal growth and development. Such deviations can be caused by pathogens, pests, other plants, the environment, herbicides or problems with plant nutrition. Observations made from a seat in a vehicle parked near the tail drain or the application of sophisticated molecular diagnostics probably won't distinguish between bean root aphid, Fusarium wilt, allelopathy or a lightning strike. It is hoped that the use of this field guide for symptoms, and a closer look at the problem, will enable most causes to be identified. Only when a cause is identified can appropriate control strategies be recommended and implemented.

This publication provides an updated and expanded guide to the symptoms of most of the diseases and disorders that may be observed in Australian cotton crops. It also provides descriptions of those diseases identified as 'priority pests' or 'biosecurity threats' in our Farm Biosecurity Manual for the cotton industry. These are diseases we don't have and don't want in Australia! Quarantine is vital! It is very important that farmers, consultants, agronomists, tractor drivers and anyone else that enters the crop should keep their eyes open to the unusual and keep asking the questions and challenging the 'experts'!



**Stephen Allen**  
**Senior Plant Pathologist**  
**CSD Ltd, ACRI, Narrabri**

**T**HIS publication aims to bring to your field and farm, the vast wealth of industry experience that we call on when faced with diagnosing a problem. This guide builds on the original "Symptoms of diseases and disorders of cotton in Australia" by David Nehl and Stephen Allen and includes updates for the disease sections as well as expanded sections in nutrition, herbicide damage, insect and other problems.

The symptoms key is a great place to begin. Find your symptom, and look at each of the options. Be aware that many symptoms are similar, so make use of the "looks like" section on each page. While a photo speaks a thousand words, don't forget to read the text about the symptom description and environmental factors, as these can help differentiate between similar looking symptoms.

Think you know what you have but want to send a sample away for confirmation? Use the form on page 9 to ensure you supply all the right information.

Want to take your farm to the next level? Best practice tips for conducting farm surveys can be found on page 8.

We would like to thank Australian cotton industry researchers in disease, weeds, insect, soil and nutrition and the Cotton Delivery and Development Team for assistance with this guide.

This symptoms guide isn't aimed at providing solutions to problems; it is merely the guidepost so you can begin to know where to look for the solutions to: "What's wrong with my crop?"

**Susan Maas & Duncan Weir**  
**Cotton Development and Delivery Team**



## What's wrong with my cotton crop?

### Seedlings not emerging

	Go to section	Go to page
Seedling disease	Diseases	20
Group C herbicides	Herbicide damage	32
Group D herbicides	Herbicide damage	33
Group K herbicides	Herbicide damage	36
Wireworm/cutworm	Insect damage	41
Fertiliser burn	Soil constraints & planting management	48
Planting problems	Soil constraints & planting management	50
Salinity/sodicity	Soil constraints & planting management	51
Soil compaction	Soil constraints & planting management	52

### Seedlings stunted, dead or dying – no root symptoms

Group B herbicides	Herbicide damage	31
Group C herbicides	Herbicide damage	32
Group I herbicides	Herbicide damage	35
Group K herbicides	Herbicide damage	36
Aphids	Insect damage	40
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Mycorrhiza	Soil constraints & planting management	49
Planting problems	Soil constraints & planting management	50
Salinity/sodicity	Soil constraints & planting management	51
Wind damage	Environmental & other symptoms	60
Sulfur	Nutrition deficiency/toxicity	72
Zinc	Nutrition deficiency/toxicity	74

### Seedlings stunted, dead or dying – with root symptoms

Bacterial stunt	Diseases	12
Black root rot	Diseases	13
Fusarium wilt	Diseases	17
Seedling disease	Diseases	20
Fusarium wilt – exotic strains	Biosecurity threats	28
Texas/Cotton root rot	Biosecurity threats	29
Group D herbicides	Herbicide damage	33
Symphylla	Insect damage	46
Wireworm/Cutworm	Insect damage	41
Fertiliser burn	Soil constraints & planting management	48
Salinity/Sodicity	Soil constraints & planting management	51
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Allelopathy	Environmental & other symptoms	53
Phosphorus	Nutrition deficiency/toxicity	66

**Leaves with spots/lesions or dead areas**

	<b>Go to section</b>	<b>Go to page</b>
Alternaria leaf spot	<b>Diseases</b>	10
Bacterial blight	<b>Diseases</b>	11
Tobacco streak virus	<b>Diseases</b>	22
Tropical rust	<b>Diseases</b>	23
Bacterial blight (hypervirulent strains)	<b>Biosecurity threats</b>	25
Group B herbicides	<b>Herbicide damage</b>	31
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Sun spot	<b>Environmental &amp; other symptoms</b>	57
Sunscald	<b>Environmental &amp; other symptoms</b>	58
Boron	<b>Nutrition deficiency/toxicity</b>	61
Manganese	<b>Nutrition deficiency/toxicity</b>	63
Potassium	<b>Nutrition deficiency/toxicity</b>	68
Premature senescence	<b>Nutrition deficiency/toxicity</b>	70
Zinc	<b>Nutrition deficiency/toxicity</b>	74

**Leaf discoloured – interveinal or mottled**

Cotton bunchy top	<b>Diseases</b>	16
Fusarium wilt	<b>Diseases</b>	17
Tobacco streak virus	<b>Diseases</b>	22
Verticillium wilt	<b>Diseases</b>	24
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Group B herbicides	<b>Herbicide damage</b>	31
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Group N herbicides	<b>Herbicide damage</b>	39
Aphids	<b>Insect damage</b>	40
Mites	<b>Insect damage</b>	44
Chimera	<b>Environmental &amp; other symptoms</b>	55
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Manganese	<b>Nutrition deficiency/toxicity</b>	63
Phosphorus	<b>Nutrition deficiency/toxicity</b>	66
Potassium	<b>Nutrition deficiency/toxicity</b>	68
Premature senescence	<b>Nutrition deficiency/toxicity</b>	70
Zinc	<b>Nutrition deficiency/toxicity</b>	74

## Leaf discolouration over whole leaf

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Group M herbicides	Herbicide damage	38
Mycorrhiza	Soil constraints & planting management	49
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Sudden wilt	Diseases	21
Verticillium wilt	Diseases	24
Fusarium wilt (exotic strains)	Biosecurity threats	28
Texas/Cotton root rot	Biosecurity threats	29
Verticillium wilt (defoliating strains)	Biosecurity threats	30
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**Bolls with spots or dead areas, or completely dead**

Alternaria leaf spot	Diseases	10
Bacterial blight	Diseases	11
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Sulfur (S)	72
Zinc (Zn)	74

It is important to be aware of what diseases and crop constraints are present, where they are present and whether or not the incidence is increasing. Accepted best practice is an early season and late season inspection. Do not confine your observations to the tail drain only – walk into the field or across the field or along a diagonal!

### Early season

- Count and record the number of plants established/metre and compare to seeds planted/metre.
- Where there are dying or stunted plants try to establish the cause by examining roots, foliage and soil. Digging up plants is better than pulling up plants!
- Regular monitoring of crop nutrition can detect a problem before symptoms become obvious.

### Late season

- Look for leaf discolouration, wilts, stunted plants, and/or other unusual symptoms.
- In season leaf testing can detect some late deficiencies; otherwise record the location of the problem areas so that post crop soil testing can be conducted.
- Pathogen identification services are offered by the industry. See page 9.

### General tips

- Train farm staff to be observant and report back on unusual plant symptoms.
- Make a note of problem areas on farm maps. This can help compare problems season to season.
- Quantitative observations are more valuable than general comments. For example, at each stop, make a note of how many plants in a metre have symptoms.

### When an unidentified symptom is observed:

- Do not automatically remove the plant from the field as this may impact on the opportunity to correctly diagnose the problem. It may also spread a pathogen or pest that has yet to be identified.
- Ideally you should photograph symptoms and GPS the location immediately. If this is not possible, record the location of the plant/s from the edge of the field by either flagging the position or counting the number of steps from a landmark.
- Observe best practice farm hygiene to reduce risk of spreading pathogens and pests.

### Make a note of:

- Symptoms – in addition to obvious symptoms, look for other symptoms on the plant.
- Distribution – is it only in one field, or several fields, are some rows more affected, does it vary with soil types, or topography?
- Incidence/severity – is it one plant or one patch, scattered single plants or patches? How severe are the symptoms?
- General crop information such as crop growth stage, variety, irrigated (furrow or overhead) or dryland, variety, paddock history, nearby crops, rainfall, temperature and other notable weather over the last 10 days, date of last irrigation, cultivation and any recent spray applications.
- Send photos (and plant material once advised) to relevant expertise to confirm symptoms.
- For disease enquiries contact the cotton pathologist in your state:  
Qld DEEDI Cotton Pathologist  
07 3255 4356,  
NSW DPI Cotton Pathologist  
02 6799 2454.

## SENDING A SAMPLE FOR DIAGNOSIS – ATTACH A COMPLETED FORM TO EACH SAMPLE

Collected/Submitted by: .....

Address/Email/Fax/Telephone: .....

Property name and field number: .....

Date collected: .....

Grower/Agronomist: .....

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 or mottled	<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 days: .....

Date of last irrigation: .....

Date of last cultivation: .....

Other comments: .....

### DO NOT DROP OFF OR SEND SAMPLES WITHOUT FIRST CONTACTING LABORATORY OR EXPERT AND GETTING ADVICE ON WHERE AND HOW TO SEND A SAMPLE

**Samples need to be handled and transported in very specific ways depending on what is being tested**

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 affected plant material.
- It is better to despatch samples early in the week rather than just before the weekend.
- 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
- Wear gloves when collecting soil or plant samples to be tested for nutrition, so as not to contaminate the sample (eg. sunscreen)

**DO NOT SEND ANY PLANT OR SOIL MATERIALS TO THE AUSTRALIAN COTTON RESEARCH INSTITUTE UNLESS INSTRUCTED TO DO SO AND ENSURE PLANT/SOIL IS PACKAGED AS REQUESTED – PESTS AND DISEASES ARE A RISK TO THE RESEARCH BEING CONDUCTED AT THIS SITE**

**Please contact CRDC on 02 6792 4088 for an Australian Cotton Industry Development and Delivery team member or district agronomist to determine the appropriate pathologist and address for submitting samples**

**A**LTERNARIA leaf spot is caused by a fungal pathogen that can be carried over on infected cotton residues from the previous season.

## Symptoms

Brown, grey brown or tan lesions (spots) on cotyledons, leaves, bracts and bolls varying from 1 to 10mm in diameter.

Rapid defoliation can occur when a susceptible crop (eg. Pima varieties) is exposed to favourable conditions. Affected leaves develop an abscission layer, senesce and drop to the ground.

Symptoms generally more severe on lower leaves. Plants are most susceptible at the seedling stage

and late in the season when the crop begins to 'cut out', especially following premature senescence.

Lesions can have dark brown or purple margins and sometimes have obvious concentric zones.

## Environmental factors

Favoured by either repeated heavy dews or extended periods of wet weather.

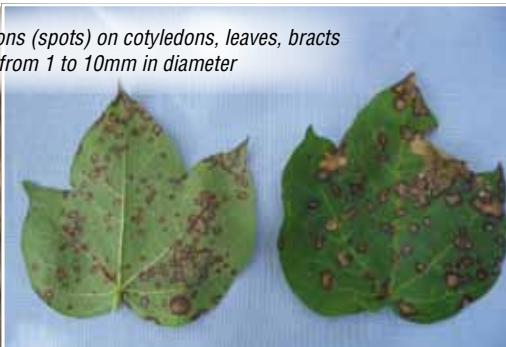
Favoured by physiological or nutritional stress (eg. heavy fruit load or low potassium).

## Looks like

See pages: 11, 23, 25, 33, 36, 37, 66, 68, 70.



*Brown, grey brown or tan lesions (spots) on cotyledons, leaves, bracts and bolls varying from 1 to 10mm in diameter*



*Affected leaves develop an abscission layer, senesce and drop to the ground.*

**B**ACTERIAL blight was a problem. Most Australian cotton varieties are resistant and only some of the older Pima varieties are susceptible.

## Symptoms

Dark green, watersoaked, angular lesions, 1 to 5mm across on cotyledons, leaves and bracts. Spots are more obvious on the lower leaf surface. Lesions darken and become black with age. Leaves can shed prematurely resulting in extensive defoliation.

Large dark green watersoaked lesions may develop along leaf veins and on stems and branches ('black-arm').

Symptoms are usually more prevalent on lower leaves than on upper leaves.

Dark green, watersoaked, greasy, circular lesions, 2 to 10mm across can occur on bolls, especially at the base of the boll under the calyx crown. As the boll matures the lesions dry out and prevent normal boll opening.

## Environmental Factors

Wind driven rain, hail and sand-blasting increase disease severity.

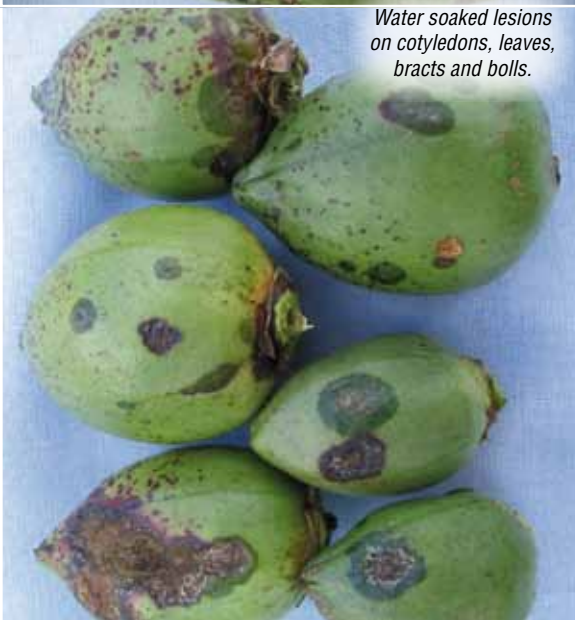
Can survive on plant residues.

## Looks like

See pages: 10, 23, 25.



*Water soaked lesions on cotyledons, leaves, bracts and bolls.*



*'Blackarm'.*





**B**ACTERIAL stunt occurs when soilborne bacteria infect cotton roots.

### Symptoms

Uniformly stunted, slow growing plants. Growth will generally improve later in the season. Severity varies from season to season, but the distribution in fields does not vary.

Look for rapid development of root browning in seedling plants.

When infected roots are cut into a drop of water, bacteria can be seen flowing out (bacterial streaming).

### Environmental factors

Bacterial stunt is most severe on heavy grey clays and is easier to identify when soil type varies within one field.

### Looks like

See pages: 13, 31, 33, 49, 50, 51, 52, 59, 66.



**B**LACK root rot delays development of the crop.

## Symptoms

Seedlings are stunted and slow growing early in the season compared with healthy plants from the same field. Roots appear black and there are generally few lateral roots. The black layer can be removed by thumb and forefinger exposing a white centre. As the season gets warmer the black layer sloughs off and normal growth resumes.

Usually first observed as patches of stunted, slow growing cotton seedlings apparent only early in the growing season. In subsequent seasons

the patches may no longer be obvious as the pathogen spreads throughout the field.

Fungus can infect the centre of the tap root causing a 'black heart'.

## Environmental factors

Favoured by cool wet conditions.

Symptoms will be more severe in medium to heavy clay soils.

Favoured by cotton following susceptible crops, including most legumes and cotton.

## Looks like

See pages: 12, 20, 31, 33, 49, 50, 51, 52, 59.



*Fungus can infect the centre of the tap root causing a 'black heart'.*





**B**OLL rots are caused by a number of pathogens, including fungi and bacteria. Tight lock refers to a type of boll rot, where the lock remains hard and fails to fluff out.

### Symptoms

*Alternaria* boll rot begin as small spots with dark margins. The spots enlarge and eventually may affect the whole boll.

Bolls infected by *Phytophthora* boll rot appear dark brown to black, sometimes with areas of white mould on the surface. Locks remain hard, don't fluff out (tight lock) and often have a brown stain. Affected bolls either don't open at all, or

open prematurely, with the compact locks easily dislodged and falling to the ground. *Phytophthora* boll rot usually occurs when soil is splashed up onto low bolls that are beginning to crack open or when low bolls are subject to inundation by tail water backing up into rows.

*Sclerotinia* boll rot characteristically has black fungal structures (2 to 10mm diameter) within and/or on the surface of the rotted bolls. A white cottony fungal growth may be present and the branch adjacent to the boll may also be affected.

Bacterial blight produces circular, dark green and greasy spots on young, green developing bolls.



*Sclerotinia* boll rot.



*Phytophthora* boll rot.



When spots develop under the calyx crown at the base of the boll then affected bolls do not open properly. Secondary fungal growth sometimes develops in old spots on mature bolls.

Several other fungi can cause secondary boll rots in cotton. These fungi usually require an injury or a wound, such as that caused by an insect pest, to allow infection to take place.

### **Environmental factors**

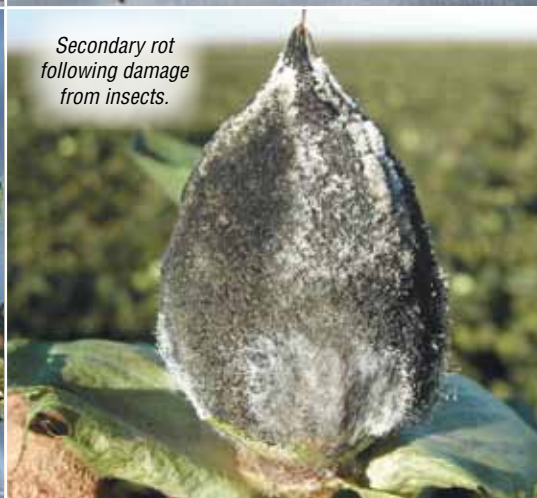
Favoured by wet weather and humidity deep in the plant canopy.

Favoured by rank growth.

Boll rots and tight locks can also develop when bolls that are opening are exposed to wet weather.

### **Looks like**

See page: 19.





**C**OTTON bunchy top is a virus spread by cotton aphids.

### Symptoms

New growth is characterised by small leaves, short internodes and small bolls.

Leaves have pale green angular patterns around the margins and darker green centres (mottle).

This leaf mottle may turn red on the upper surface of the leaf. The leaves also have a leathery texture.

Early infection results in the crop taking on a compact, stunted, 'climbing ivy' appearance.

Roots appear hairy and dark brown and form small knots on the secondary root branches.

### Environmental factors

Favoured by wet winter/spring as this favours the build up of hosts for the disease and the aphid vector, such as cotton volunteers/ratoons or marshmallow.

There is a 3-5 week delay from infection to obvious symptoms.

Symptoms can be difficult to distinguish in perennial volunteer cotton and late crops (post cut out) where there has been insufficient new growth to show symptoms.

### Looks like

See pages: 17, 24, 26, 28, 30, 31, 40, 44, 45, 70.



*Leaves have pale green angular patterns around the margins and darker green centres (mottle).*



*New growth is characterised by small leaves, short internodes and small bolls*



*Leaves are small and have a leathery appearance. Leaf mottle may turn red.*

**F**USARIUM wilt is a disease of cotton caused by the soil inhabiting fungus *Fusarium oxysporum* f.sp. *vasinfectum* (Fov).

## Symptoms

External symptoms, including stunting, yellowing, wilting and plant death, occur at any time during the season. This often results in a 'gappy' stand.

Movement of the pathogen in irrigation water may result in 'tear shaped' patches or strips. Fusarium wilt is often first observed as dead plants at the tail drain.

A feature of Fusarium wilt is solid the brown discolouration throughout the woody part of the

stem and tap root. Browning may fill the whole stem. Some leaves develop a yellow mottle.

Plants die back from the top and may re-grow from the base later in the season.

## Environmental factors

Favoured by wet and cool conditions in spring.

In the more resistant varieties, symptoms may include stunting, a 'gappy' stand, or uneven plant height, but not necessarily wilting and death.

Stem discolouration is always present.

## Looks like

See pages: 21, 24, 28, 29, 30, 41, 53, 56.



*Brown discolouration in the woody part of the stem and tap root.*



*Often first observed as dead plants at the tail drain.*



**P**OST harvest rot occurs when rain delays harvest or water gets into modules and micro-organisms (bacteria and fungi) attack the cellulose in the cotton fibres. This can significantly affect fibre quality.

Microscopic inspection of the fibres when mounted in 18% sodium hydroxide reveals the presence of microbes in and on the fibres. Unaffected fibres are smooth and cylindrical while the breakdown of cellulose is indicated by bumps and swellings.

### Symptoms

Post harvest rot of seed cotton develops when water enters the module through a hole in the module tarp or along the ropes holding the module tarp in place. An 'inky cap' fungus (*Coprinus species*) is often present in these areas of rotted seed cotton.

### Environmental factors

Favoured by high moisture from picking too wet, too much trash, from poor storage of modules/bales or damage to plastic/tarps.



'Inky cap' fungus.



No microbial damage

Immature fibre

Fungi on outside

Fungi on inside

Fungi all over!

Cellulolysis of cellulose by cellulases produced by cellulolytic bacteria



**S**EED rot refers to boll rot that begins in the seed. Recent overseas research indicates that pathogens spread by sucking pests such as green vegetable bug and pale cotton stainers may be responsible.

### Symptoms

Small black spots 1-2mm diameter on the surface of the bolls indicate the feeding of sucking insects on developing seed within the boll.

Seeds within the maturing green bolls are swollen and discoloured yellow or brown.

When affected bolls open the locks with infected seed fail to 'fluff out' and remain compact and discoloured.

Seed rots do not necessarily affect the whole boll and may be limited to one or two locks.

### Environmental factors

High numbers of sucking pests such as green vegetable bug and pale cotton stainers soon after flowering can increase the likelihood of seed rots.

### Looks like

See pages: 14.



**S**EEDLING diseases may be caused by numerous pathogens acting alone or in combination that commonly cause reduced plant stand.

### Symptoms

Seedlings die off before or after emergence, as single plants or in patches. Roots may be damaged resulting in poor growth. Patterns of seedling death can occur across rows.

*Pythium* spp. usually causes a soft rot and stem collapse leading to death of seedlings.

*Rhizoctonia* sp. causes sunken red/brown lesions on the lower stem and roots often leading to girdling (sore shin).



*Pythium.*



*Rhizoctonia.*

A collar rot caused by *Sclerotium rolfsii* affects a large range of different crops. Distinctive white to brown sclerotia (balls 0.5-2.0mm) form on a white cottony collar at or just below ground level.

Anthrachnose (*Colletotrichum gossypii*) is rarely seen in Australia but has been reported in Northern Australia and Queensland. All parts of the plant may be attacked. Typical symptoms include a girdling of the stem at or near ground level.

### Environmental factors

Favoured by weather conditions and soil characteristics that delay germination and emergence.

Incidence can be higher where other factors have stressed plants (poorly drained areas, fertiliser placement, herbicide application, planting depth etc).

High stubble load (cotton or rotation crops especially legumes) can contribute to disease development.

### Looks like

See pages: 13, 17, 28, 31, 33, 34, 35, 36, 37, 39, 41, 48, 50, 51, 52, 53, 56, 60.



*Sclerotium rolfsii.*





**S**UDDEN wilt is caused by a weakly pathogenic species of *Fusarium* (NOT the species that causes Fusarium wilt).

## Symptoms

Plants wilt suddenly and defoliate, usually in hot weather after irrigation or rainfall.

Plants die or occasionally re-grow.

Affects single plants or small patches.

Does not re-occur in the same place.

Brown discolouration is confined to the woody parts of the roots and lower stem only.

## Environmental factors

Symptoms almost always appear in hot weather after irrigation or rainfall.

Root damage from late cultivation can contribute.

## Looks like

See pages: 17, 24, 28, 29, 30, 52, 56.



*Symptoms almost always appear in hot weather after irrigation or rainfall*

**T**OBACCO streak virus (TSV) is transmitted by infected pollen, which can be spread by wind, or carried by insects. Thrips are the only known insect vector and are required for TSV infection to occur.

### Symptoms

Dark purple, spreading lesions on leaves, occasionally forming numerous diffuse ring spots.

On plants with numerous lesions the upper leaves may also display chlorotic mottle.

Symptoms in affected cotton crops are typically mild and consist of one or more, diffuse purple lesions on one leaf of the infected plant.

### Environmental factors

Favoured by conditions which enable high thrip populations to develop, and large amounts of infective pollen to be produced by the major alternative weed host, Parthenium weed. These conditions generally occur during warmer months. This disease is currently only found in Queensland where Parthenium weed is abundant.

### Looks like

See page: 23, 47.



*Dark purple, spreading lesions on leaves, occasionally forming numerous diffuse ring spots.*





**T**ROPICAL rust is common on feral cotton and tree cotton in parts of northern Australia.

## Symptoms

Numerous small spots develop on older leaves.

Spots are purple with a red/brown centre on the upper side of the leaf and brown, powdery pustules underneath.

## Environmental factors

More severe during the dry season.

## Looks like

See pages: 11, 22, 25.



*Numerous small spots develop on older leaves.*



*Purple spots with red-brown center on upper side.*

**V**ERTICILLIUM wilt of cotton is caused by *Verticillium dahliae*, a soil borne fungus that enters the roots and grows into the vascular system of the plant.

### Symptoms

Vascular discolouration or browning extending throughout the stem and into the petioles.

Plants rarely wilt but may defoliate prematurely at the end of the season.

Leaves develop a characteristic yellow mottle, at the edges and between the veins.

Lower leaves are usually affected first.

Dead tissue develops at the leaf edges and may replace the mottled areas.

The mottle can be diffuse or angular.

### Environmental factors

Favoured by cool seasons.

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.

### Looks like

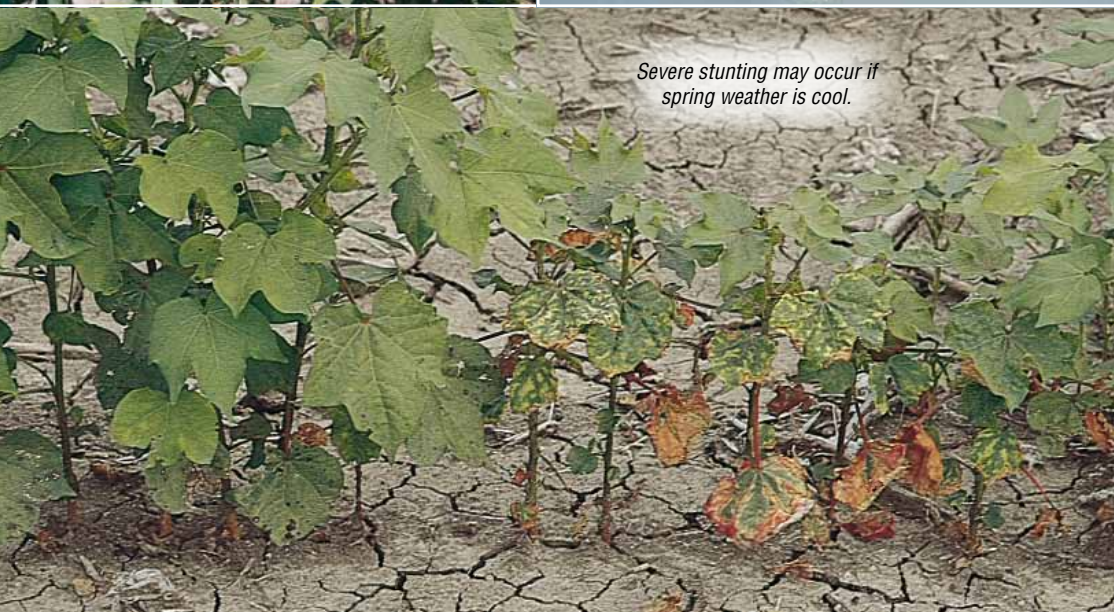
See pages: 17, 21, 28, 29, 30, 58, 60.



*Characteristic yellow mottle*



*Vascular discolouration.*



*Severe stunting may occur if spring weather is cool.*



**B**ACTERIAL blight is already present in Australia. However all current varieties are resistant to the strains that are present. Exotic strains (races) which are described as being 'hypervirulent' have developed in several African countries and have spread to the US. All current varieties would be susceptible to the hypervirulent strains if they were introduced to Australia.

## Symptoms

Dark green, watersoaked, angular lesions, 1 to 5mm across on cotyledons, leaves and bracts. Spots are more obvious on the lower leaf surface. Lesions darken and may become black with age.

Leaves may be shed prematurely resulting in extensive defoliation.

Large dark green watersoaked lesions may develop along leaf veins and on stems and branches ('black-arm').

Symptoms are usually more prevalent on lower leaves than on upper leaves.

Dark green, watersoaked, greasy, circular lesions, 2 to 10mm across can occur on bolls, especially at the base of the boll under the calyx crown. As the boll matures the lesions dry out and prevent normal boll opening.

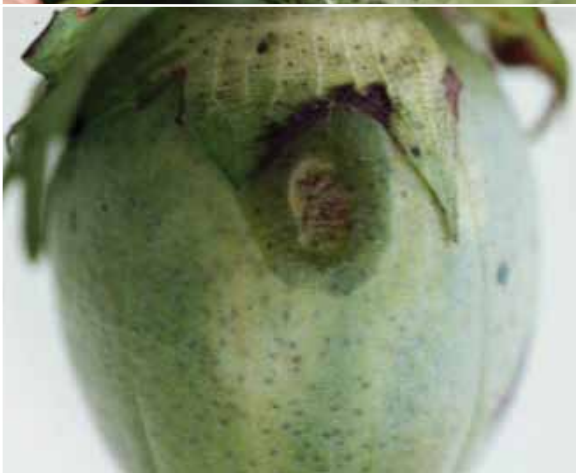
## Environmental factors

The disease is seed borne allowing easy dispersal and introduction of new races into new areas.

Bacterial blight is favoured by high temperatures, humidity and rainfall. In the absence of favourable conditions, it can survive on leaf surface with no symptoms.

## Looks like

See pages: 10, 11, 23.



**B**LUE disease is caused by cotton leaf roll dwarf virus, a cotton virus that is spread by the cotton aphid.

### Symptoms

Affected leaves tend to be smaller, thick, more brittle and leathery and have an intense green to bluish colour with yellow veins.

Reddening of stem petioles and leaf veins can occur in some infections.

Leaf edges tend to roll downwards and under.

Plants become stunted due to a shortening of the branch internodes and produce many branches, giving a bunchy zig-zag stem habit.

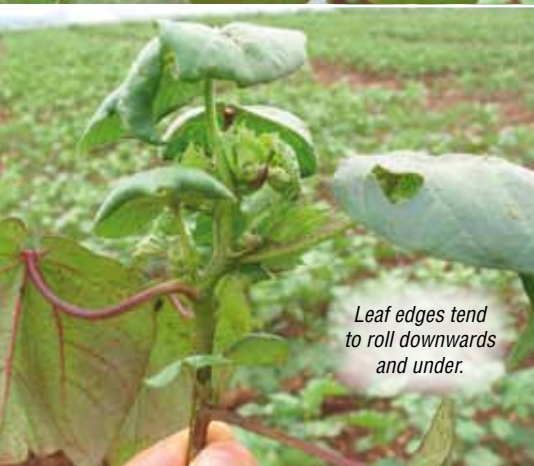
Cotton leaf roll virus is a very similar aphid vectored virus. Neither cotton leaf roll dwarf virus or cotton leaf roll virus are present in Australia.

### Environmental factors

Favoured by conditions that promote aphids.

### Looks like

See pages: 16, 40.



*Leaf edges tend to roll downwards and under.*





**C**OTTON leaf curl disease CLCuD, (Gemini virus), is spread by a whitefly vector, such as silverleaf whitefly. There are at least seven different begomoviruses and several different DNA satellite molecules associated with CLCuD. A cotton plant needs to be infected with at least one begomovirus and one satellite to develop CLCuD.

## Symptoms

Symptoms on leaves appear as a swelling and darkening of leaf veins, followed by a deep downward cupping of the youngest leaves then either an upward or downward curling of the leaf margins.

Leaf-like structures (enations) on the underside of leaves are common and vary in size from only a few millimetres in diameter to almost the size of a normal leaf.

## Environmental factors

Low levels of silver leaf whitefly vector can spread virus.

## Looks like

See pages: 44, 45.





**F**USARIUM wilt in Australia is caused by strains that have developed in Australia and are unique to Australia. New strains (races) of the pathogen have developed in the US, Egypt, India, Africa and China. Race 4, which was first reported in India, has been reported in California in recent years and is spreading very rapidly causing great concern. Some exotic strains require co-infection with a nematode to enable symptoms to develop. Some are able to infect other hosts such as soybean, tobacco and lupin.

### Symptoms

Symptoms include death of seedlings, wilting and stunting. Some plants may appear unaffected but all plants will develop a brown discoloration in the vascular tissue throughout the stem.

### Environmental factors

Australian strains are favoured by cool wet conditions. Most exotic strains prefer higher temperatures and symptoms disappear under cool temperatures.

### Looks like

See pages: 17, 21, 24, 30, 56.



**T**EXAS/COTTON root rot is an extremely damaging fungal disease with a wide host range.

## Symptoms

Sudden death of affected plants, usually during the warmer months.

Yellowing or bronzing of leaves.

Leaves wilt and die.

Dead leaves usually remain on plant.

Root surface is covered with network of tan fungal strands.

Forms survival structures (sclerotia) deep in the soil.

## Environmental factors

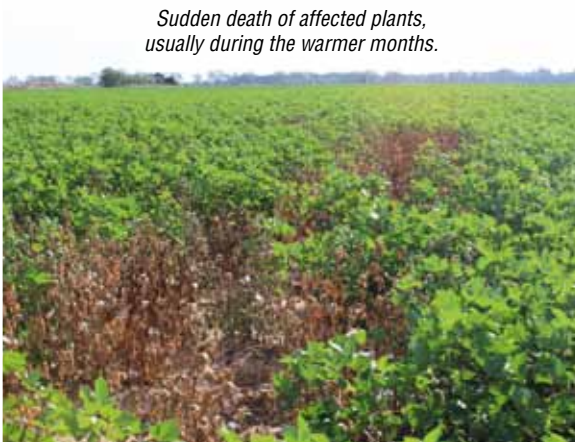
Spread by movement of infected soil or plant material.

## Looks like

See pages: 17, 21, 24, 28, 30, 56.



*Root surface is covered with network of tan fungal strands.*



*Sudden death of affected plants, usually during the warmer months.*



*Dead leaves usually remain on plant.*



**V**ERTICILLIUM wilt in Australia is caused by non-defoliating strains of the pathogen which are considerably less virulent than the 'defoliating' strains that originated in the US and have since been observed in Peru, Spain, Greece, Iran, Turkey, South Africa and China.

### Symptoms

Symptoms are initially similar, but sometimes more severe, than those caused by the Australian strains of the pathogen (see page 24). As the disease progresses there is a sudden and almost total defoliation and shedding of bolls. There is a rapid down-curling of the terminal leaves

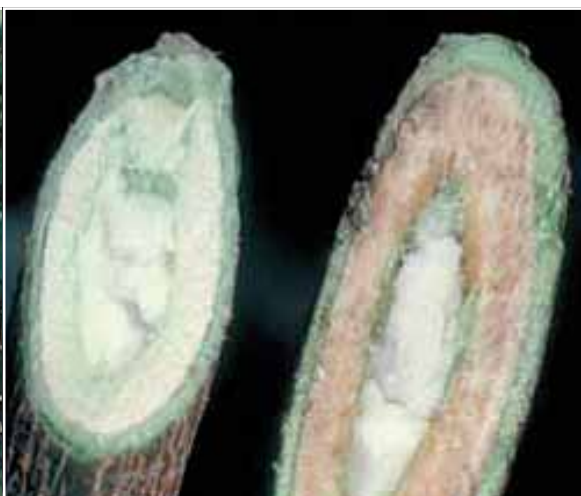
resulting in severe epinasty (downward bending leaves).

### Environmental factors

Temperature is very important. Plants become more susceptible as temperatures decrease and more resistant at higher temperatures.

### Looks like

See pages: 17, 21, 24, 28, 56.



**G**ROUP B (inhibitors of acetolactate synthase) includes azimsulfuron, bensulfuron, chlorsulfuron, ethoxysulfuron, halosulfuron, iodosulfuron, mesosulfuron, metsulfuron, rimsulfuron, sulfometuron, sulfosulfuron, thifensulfuron, triasulfuron, tribenuron, trifloxysulfuron imazamox, imazapic, imazapyr, imazethapyr, flumetsulam, florasulam, metosulam, pyroxsulam, and pyriithiobac.

## Symptoms

Residual herbicides, such as metsulfuron, used on other crops and in fallows can cause damage such as stunting of seedlings and roots, yellowing

of growing tip, leaf distortion, yellow streaks and purple veins on leaves.

## Environmental factors

Plant back period may exceed 1-2 years depending on rate applied, soil moisture, pH and temperatures.

In adverse conditions, herbicides that would not normally damage cotton can cause damage. In very cold weather pyriithiobac may cause puckering and yellowing of seedling leaves.

## Looks like

See pages: 12, 13, 16, 62.



*Seedling stunting.*





**G**ROUP C (inhibitors of photosynthesis at photosystem II) includes ametryn, atrazine, cyanazine, prometryn, propazine, simazine, terbutylazine, terbutryn, hexazinone, bromacil, terbacil, chloridazon, phenmedipham, diuron, fluometuron, linuron, methabenzthiazuron, siduron, tebuthiuron, propanil, bromoxynil, ioxynil, and bentazone.

Group C herbicides includes a number of pre/post emergent herbicides used in cotton, rotation crops and in fallows with prolonged residual periods.

### Symptoms

Group C herbicides that can be translocated in the

plant, such as triazine, triazone, uracils and ureas, will cause inter-veinal bleaching of leaves sometimes with grey crusting on surface, and yellowing of leaf margins that eventually turn brown and die.

Contact herbicides in this group, are not translocated in the plant and so symptoms such as yellow or bronze spotting, will be limited to treated tissue.

### Environmental factors

Plant back period may exceed 1-2 years depending on rate applied, soil moisture and temperatures.

### Looks like

See pages: 37, 39.



**G**ROUP D (inhibitors of microtubule assembly) includes oryzalin, pendimethalin, trifluralin, chlorthal, propyzamide, diithiopyr, and thiazopyr.

### Symptoms

High rates of trifluralin may cause swelling at the base of cotton stems and root pruning.

New roots attempting growth from the base of the stem may also burn back.

### Environmental factors

Problems are most common following wet and cold planting conditions.

### Looks like

See pages: 12, 13, 48, 49, 50.



**G**ROUP G (Inhibitors of protoporphyrinogen oxidase (PPOs)) includes acifluorfen, oxyfluorfen, flumioxazin, oxadiargyl, oxadiazon, carfentrazone, butafenacil and pyraflufen. These herbicides are pre and post-emergence contact herbicides.

### Symptoms

Group G herbicides will produce a 'bronzing' appearance or bleached speckling.

Higher rates will cause defoliation and eventually plant death, especially in seedling stage.





**G**ROUP H (Inhibitors of 4-hydroxyphenyl-pyruvate dioxygenase (HPPDs) includes diflufenican, benzofenap, pyrasulfotole and isoxaflutole. This group typically consists of residual herbicides for selective broadleaf weeds.

## Symptoms

Group H herbicide are bleachers, causing inter-veinal bleaching, and necrotic lesions on leaf and stems.

Higher rates result in complete leaf loss of contacted leaves and burning of stem tissue, and plant death.

New growth is unaffected.



*Inter-veinal bleaching, and necrotic lesions on leaf and stems.*





**G**ROUP I (Synthetic Auxins) include 2,4-D, 2,4-DB, MCPA, MCPB, mecoprop, dicamba, aminopyralid, clopyralid, fluroxypyr, picloram, triclopyr, and quinclorac. Group I herbicides are used to control broadleaf weeds in grass crops and fallow. Cotton is very susceptible.

## Symptoms

What may be considered to be 'typical 2,4-D damage' may in fact have been caused by another of the Group I herbicides.

Affected leaves are cupped, and crinkled, with points developed on leaf edges giving a 'drawstring' appearance. High doses can lead to 'strapping' or 'witches hands'.

Some cause pronounced epinastic growth (downward bending, swollen split stems and reddening of petioles).

Shedding of squares and bolls may occur.

New growth is affected the most.

## Environmental factors

Herbicides deposited in atmospheric inversion layers can be dispersed across large areas. This can result in plants randomly affected across a number of fields.



**G**ROUP K (Inhibitors of cell division and VLCFA – Very Long Chain Fatty Acids) includes napropamide, dimethenamidm, metolachlor, and propachlor. These selective pre emergence herbicides act on roots and shoots.

## Symptoms

Low soil temperatures and heavy rainfall can result in poor crop emergence and stunting.

Group K on cotton foliage can result in necrotic spotting.

## Looks like

See pages: 31, 33, 37, 39..



*Necrotic spotting.*



**G**ROUP L (inhibitors of photosynthesis at photosystem I) include diquat and paraquat.

Paraquat and diquat are contact herbicides with minimal translocation.

## Symptoms

Necrotic lesions on leaf and stem at lower rates.

New growth is unaffected.

Higher rates result in complete leaf loss of contacted leaves and burning of stem tissue, and plant death.

## Looks like

See pages: 32, 39.





**G**ROUP M (inhibitors of EPSP synthase) includes glyphosate.

Cotton that does not contain the glyphosate tolerant gene (ie not Roundup Ready Flex®), is susceptible to glyphosate.

### Symptoms

Stunting and reddening of petioles.

Cotyledons and leaves fold down.

Higher levels of exposure will cause yellowing/bronzing of leaves and will kill seedlings.

Some shedding of bolls and squares dependent on rate applied.

Severely affected plants may appear to be normal but will retain few, if any fruit.

### Looks like

See pages: 72.



**G**ROUP N (inhibitors of glutamine synthetase) include glufosinate.

Cotton that does not contain the glufosinate tolerant gene (ie not Liberty Link®), is susceptible to glufosinate.

## Symptoms

Light rate will result in burn marks with necrotic lesions on contacted leaves.

Higher rates result in defoliation of contacted leaves, and can result in plant death.

New growth is unaffected.

## Looks like

See pages: 32, 37.





**A**PHIDS can cause damage to cotton early to mid season by feeding on young growth and late season by secreting honeydew. Cotton aphids vector the cotton bunchy top virus.

### Symptoms

Severe aphid damage results in wrinkling, stunting and cupping of leaves and reduced internodes and fruit production. Younger leaves may show a yellow margin and reddened patches.

Honeydew produced by aphids covers the lint and quality can be significantly downgraded. Leaves become sticky and dark green, promoting the growth of black sooty moulds.

### Environmental factors

Close proximity to host crops or weeds can favour higher numbers in crop.

Practices that reduce beneficials allow rapid development of aphid populations.

Severe infestation can be similar to CBT. If symptoms persist in new growth or appear after aphids have gone, then CBT should be suspected.

SLW and mealybug also produce honeydew.

### Looks like

See pages: 16.

*Wrinkling, stunting and cupping of leaves.*



*Honeydew covers the lint.*



*Leaves become sticky and dark green, promoting the growth of black sooty moulds.*





**I**NSECTS such as wireworm and cut worm can reduce plant stands. Bean root aphid can also affect seedling cotton plants but is rare.

## Symptoms

Cutworm larvae attack cotton seedlings at or above soil level and may destroy seedlings by either chewing through the stem or eating entire leaves.

Wireworm and false wireworm chew holes in the stems of seedlings below the soil surface. Consecutive seedlings may be damaged.

A damp mat left on the soil overnight and checked early in the morning can encourage these insects to come to the surface, to allow identification.

Bean root aphid will leave a network of tunnels in the soil surrounding the tap root. Ants may be present as they 'farm' the aphids. Tunnels collapse and aphids and ants disappear after irrigation.

## Environmental factors

Wireworm and false wireworm will be more severe in newly developed fields, in fallow fields (with heavy trash cover) and in fields following summer crops (particularly soybeans).

Bean root aphid infestations have occurred in fields previously heavily infested with burr medic.

## Looks like

See pages: 13, 17, 20, 28, 46, 48, 49, 50, 53, 56.



*Bean root aphid.*



*Wireworm and false wireworm chew holes in the stems of seedlings below the soil surface.*

**I**NSECTS that feed on leaves and stems can cause a range of symptoms. Identification of the pest is important as feeding symptoms can be similar.

### Symptoms

Feeding action of insects will affect the symptom on the plant.

Plants that have had the growing tip damaged by insects such as *Helicoverpa*, thrips, mirids and tipworm become 'tipped out'. This means that the plant can have more than one main growing branch.

Leaf feeding insects such as cluster caterpillar,

loopers and locusts remove large sections of leaves and in severe cases may defoliate plants.

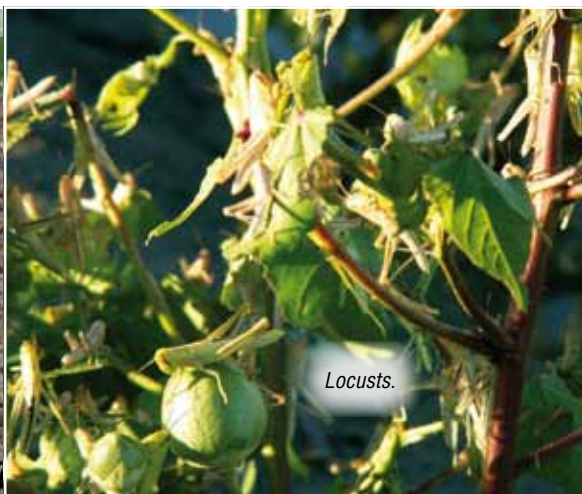
Cotton leaf perforator causes tunnels in leaves.

Shot holes or lacerations in leaves of seeding cotton can be caused by flea beetles.

Jassids cause white stipples on the leaf surface.

### Environmental factors

It is important to monitor the crop for the presence of pests as well as looking for in-crop damage.







*Flea beetles.*



*Jassids.*





**M**ITE damage symptoms will depend on the species present.

### Symptoms

Spider mites prefer younger leaves and highest populations are found on the main stem nodes 3 to 5 below the terminal.

Two spotted spider mites cause bronzing of the upper leaf surface, usually beginning near the petiole or leaf folds. These bronzed areas are matched by brown areas on the underside of the leaf. Heavy mite damage will cause leaves to desiccate and fall off.

Bean spider mite damage usually does not cause

bronzing, but the underside of leaves will show characteristic browning. Prolonged feeding and high numbers of this pest may cause leaf loss.

Strawberry spider mites cause characteristic sparsely mottled feeding damage.

Blue oat mites are only occasionally found in seedling cotton crops and can cause leaves to have a mottled whitened appearance and unthrifty growth.

Redlegged earth mites are only occasionally found in seedling cotton crops and can cause leaves to have a mottled whitened appearance and can be severe, resulting in very slow growth of young seedling or plant death.

*Two spotted spider mite damage.*



*Bronzing of the upper leaf surface.*



Brown wheat mites are only occasionally found in seedling cotton and can cause underside of leaves to have a bleached white appearance and stunting of plant growth.

Broad mites are rarely a pest in cotton and can be difficult to see even with a good hand lens. Feeding damage gives the undersides of leaves a wet appearance, as though covered by a thin layer of water. Damage results in the leaves being stunted, hard and brittle and cracks can appear in leaves. It can be mistaken for herbicide damage.

### **Environmental factors**

Close proximity to host crops or weeds can

favour higher numbers in crop. The mite species only occasionally found in cotton, are generally associated with other crops.

Use of broad spectrum sprays can reduce populations of beneficials and allow rapid development of mite populations.

Hot conditions allow rapid build up of spider mite populations.

### **Looks like**

See pages: 16, 35, 56, 66, 68, 70.

*Brown wheat mite damage.*



*Broad mite damage.*



*Two spotted spider mite damage.*





**S**YMPHYLANS are decomposers and a part of healthy soil biota, however in the Dawson Valley they have been found to feed on root tips and root hairs, and have been associated with significant reductions in plant stands and seedling growth.

### Symptoms

The symphyllans feed on the soft root tips and cause a repeated branching at the root tip giving a 'witches broom' effect and poor root development. Symphylla can be found by breaking apart clods of soil.

### Environmental factors

Symphyllans normally move throughout the soil profile but damage is worst where activity is confined and concentrated by poor soil structure.

### Looks like

See pages: 41, 52, 53.





**T**HRIPS are the most common seedling pests of cotton in most cotton growing districts. Thrips are also the vector for tobacco streak virus.

## Symptoms

Silvery damaged area on underside of leaves.

Feeding on the edges of embryonic leaves in the terminal results in mild leaf distortion (slightly malformed and crinkled), severe leaf distortion (leaves greatly reduced in size and cupped), or in the worst cases terminal death (tipping out).

Plants will usually compensate for leaf damage provided they are able to start producing normal leaves by about the 6 leaf stage.

Prolonged severe damage, particularly during cooler weather, can result in yield loss and delayed maturity.

Thrips are also predators of spider mite eggs and may be found feeding within mite colonies.

## Environmental factors

Abundant host plants in winter and spring will tend to lead to higher early populations.

## Looks like

See page: 22.



**F**ERTILISER burn occurs when fertiliser (solid and liquid) is placed too close to the planting line or directly under the plant line.

### Symptoms

Root tips are 'pinched off' and sometimes blackened.

Roots are affected at the same depth / level.

Fertiliser burn can result in very poor emergence and establishment.

### Environmental factors

Dry weather between fertiliser application and planting can exacerbate the problem.

Fertiliser burn can be a problem when timing between fertiliser application and planting is too short.

### Looks like

See pages: 12, 13, 20, 33.

*Root tips are 'pinched off' and sometimes blackened.*





**A** MYCORRHIZA is a symbiotic relationship between a fungus and a host plant. The fungus infects and colonises the roots of the plant providing efficient uptake of nutrients (mainly P and Zn) from the soil while receiving a protected environment and metabolites from the plant. Almost all plants form mycorrhizas with the exception of plants belonging to the Brassica family.

## Symptoms

Poor establishment and growth of emerging seedlings (as seen below) as well as symptoms of nutrient deficiency:



*Symptoms in commercial field following land development.*

- Top left photo shows symptoms in commercial field following land development; and,
- Bottom photo shows research plot where methyl bromide has been used to reduce mycorrhiza.

Plants can develop inter-veinal chlorosis (yellowing) and other symptoms similar to zinc deficiency.

The symptoms are transient – the crop may recover later in the season.

## Environmental factors

The population of mycorrhizal fungi in the soil is reduced by extended periods of bare fallow (especially when weeds are controlled by cultivation instead of herbicide), rotation with non-mycorrhizal crops such as canola and land leveling with cuts of more than 40cm.

## Looks like

See pages: 12, 13, 20, 41, 66, 74.



*Research plot where methyl bromide has been used to reduce mycorrhiza.*



**P**ROBLEMS with stand establishment can occur as a result of either human error or the impact of undesirable weather conditions. These problems may include seed depth, soil moisture, planting bed conditions, crusting as well as fertiliser placement, compaction, allelopathy, mycorrhizas, soil quality, soil insect activity and seedling diseases which are dealt with separately.

### Symptoms

Poor, slow, uneven or patchy emergence. Some rows can be consistently better or worse than others (look for patterns). Roots can be deformed and damaged.

### Environmental factors

If the seed bed is dry and loose then problems may include seed sinking after irrigation and relocation of herbicide into the root zone with rainfall soon after planting,

If the seed bed is too wet then the sides of the planting slot can be smeared and normal tap root growth is impaired. As the seed bed dries out the crack down the centre of the bed opens up and seedling stems have little support.

Rainfall is rarely as even as an irrigation. Crops established on rainfall may not be as even as desired. Heavy rainfall after planting can cause crusting which restricts emergence of the germinating seedling.

### Looks like

See pages: 20, 32, 33, 36, 41, 47, 48, 49, 52, 53.



*Smearing of planting slot.*



*Roots can be deformed and damaged.*



*Planting problems can occur in patterns.*

**S**ALINITY and sodicity are separate issues however sodium chloride is the predominant soluble salt in Australian soils. Saline soils are those which have concentration of soluble salts in the soil solution high enough to impact on plant growth and development. Sodicity occurs when the concentration of sodium ions in the soil cation exchange complex is high enough to impact on soil structure.

## Symptoms

After rainfall or irrigation, beds slump or tend to flatten with the soil often setting like 'concrete' when drying out.

Emergence is often slow and establishment is poor and uneven.

Roots develop very poorly and are often necrotic. Plants appear water stressed even when there is adequate soil moisture. Small plants may appear dark green with purple veins, leaves become purple.


## Environmental factors

Soils are often dispersive and develop crusting on the surface following irrigation or rain.

Salt can accumulate on the soil surface.

## Looks like


See pages: 12, 13, 20, 50, 53.



*Beds slump or flatten.*



*Necrotic, poorly developed roots.*



*Small plants may appear dark green with purple veins, leaves become purple.*



**S**OIL compaction is a physical soil condition which prevents normal root development. Repeated cultivation to a set depth under rain-grown conditions results in a compacted impervious layer in the soil profile – often referred to as a plough-pan or hard-pan. Similar compacted zones develop under the wheel tracks in row-crop farming where heavy machinery is used under wet soil conditions.

### Symptoms

Roots are unable to penetrate these hardened layers and may terminate in a swollen 'nub' or show an abrupt directional change. Root

damage occurs at a uniform depth. Further root development is often confined to the upper layers of the profile which tends to dry out more quickly. Plants can be stunted and yellower, particularly along traffic lines and may more readily abort fruit. Cotton plants in rows under the tractor may be shorter than those in the 'guess' rows.

### Environmental factors

Compacted zones may be softened by moisture and are hardest when the soil profile is dry. Flood water can contribute to soil compaction.

### Looks like

See pages: 46, 50.



*Roots may terminate in a swollen nub.*



*Root damage occurring at uniform depth.*



*Further root development is confined to upper layers of soil profile.*



**A**LLELOPATHY is the suppression of plant growth and development by the production and release of toxic metabolites from the roots or residues of another plant.

## Symptoms

Circular or irregular areas of poor stand establishment with stunted and uneven seedling growth. Roots can appear malformed and root tips may be blackened.

## Environmental factors

Planting into freshly incorporated, unweathered crop residues can lead to allelopathic effects. Damage to emerging cotton has been observed in

the field with cotton planted into sorghum, canola and medic residues.

Cotton planted into freshly incorporated rice straw established poorly and grew very slowly (below left). Seedling growth and root development of cotton planted into soil containing canola or medic residues was significantly different from the control seedlings in a pot experiment (below right).

## Looks like

See pages: 17, 20, 41, 46, 50.



*Cotton planted into freshly incorporated rice straw.*



*Fresh canola.*

*Control.*

*Fresh medic.*

**B**OLL dangle results from an abortion of a young developing boll in response to a stress which interrupts water supply (cavitation).

## Symptoms

Immature small fruit die and dry on the plant.

An elongated dead patch always develops down along the fruiting branch.

## Environmental factors

Boll dangle or cavitation occurs following heat and/or water stress in plants with a full fruit load.

## Looks like

See pages: 14.



*An elongated dead patch always develops down along the fruiting branch.*



**A**CHIMERA is a genetic fault that causes white or variegated areas on leaves. Chimeras usually develop on one branch or one side of the plant.



**F**ROST will cause dead areas on leaves and cotyledons. Cotton is very sensitive to chilling injury.

### **Looks like**

See pages: 10, 32, 37, 39.





**L**IGHTNING can cause damage at all crop stages.

### Symptoms

Circular or irregular patches of dead or damaged plants. Leaves can be completely desiccated or may be partially blackened.

All plants in a patch are affected at the same growth stage (simultaneously).

In mature crops the damage, including browning in the stem, may occur at the top of the plant, while the roots and lower stem are unaffected (top left).

### Environmental factors

Thunderstorms.

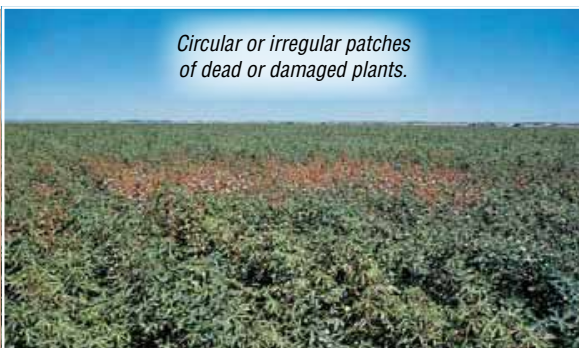
### Looks like

See pages: 17, 21, 41, 44, 45, 66, 68, 70.

*Roots and lower stem may be unaffected.*



*Circular or irregular patches of dead or damaged plants.*



*All plants in a patch are affected at the same growth stage (simultaneously).*



**S**UNSPOT only occurs during hot weather in mid summer and symptoms do not last.

## Symptoms

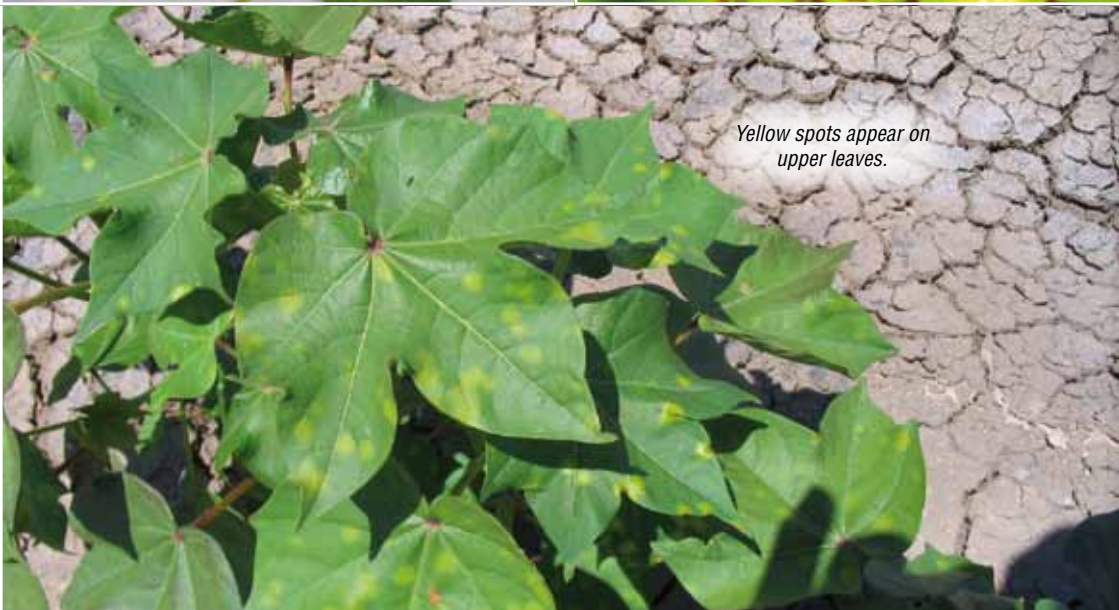
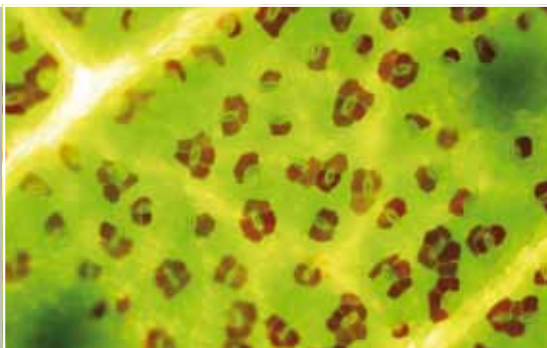
Yellow spots 5-8mm in diameter, appear on upper leaves – usually confined to a particular layer with no spots on younger or older leaves. The spots usually appear on all plants, on all varieties and in all fields at the same time and all disappear after a few days.

Microscopic inspection of the spots reveals a red discoloration of epidermal cells, especially those immediately adjacent to the guard cells. All

epidermal cells are discoloured in the centre of some spots.

## Environmental factors

Development of the yellow sunspots requires the combination of a light shower of rain, very high temperatures and high radiation.



*Yellow spots appear on upper leaves.*



**S**UNSCALD can occur in response to a rapid change in weather conditions.

### Symptoms

Brown, dry edges and spots on leaves.

Symptoms can resemble damage by chemical defoliants.

Complete defoliation can occur 10 to 14 days after the initial symptoms develop.

### Environmental factors

May occur in late summer or early autumn, when a few days of cool cloudy weather are followed by a rapid rise in temperature and light intensity.

### Looks like

See pages: 24.





**W**ATERLOGGING describes a saturated soil with little or no oxygen available to plant roots. Normal root activities are impaired, restricting the plants ability to take up nutrients and maintain photosynthesis.

## Symptoms

Leaf chlorosis or yellowing.

Reduced growth and shedding of squares and bolls.

Root growth is impaired and becomes necrotic under prolonged waterlogging.

## Environmental factors

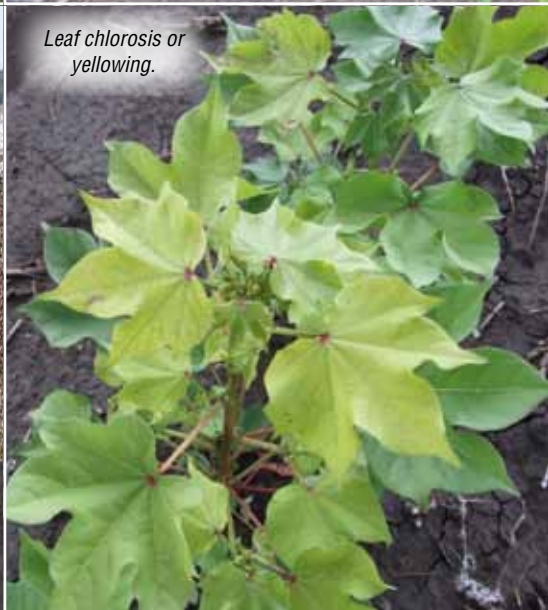
Prolonged irrigation or extended periods of rainfall can cause waterlogging conditions.

Cloudy weather and low radiation can extend waterlogging. Under low radiation conditions, plants may shed fruit even without waterlogging.

Soil compaction, bed formation and slope can contribute to waterlogging.

## Looks like

See pages: 52, 62, 64, 72.



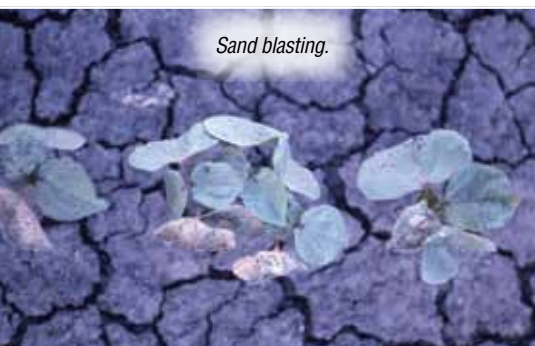
**S**ANDBLASTING (top left photo) will damage leaves and bark on the windward side of the plant only.

Excessive dry winds (bottom photo) may completely desiccate and kill plants.

Leaves rubbing (top right photo) across opening bolls can become scratched on the under-surface, resulting in burn like spots on the upper surface.

## **Looks like**

See pages: 31, 58.





**B**ORON is an essential plant nutrient required in small quantities. It is relatively immobile in plants, so is taken up throughout the season.

## Deficiency symptoms

Symptoms first appear in new growth. Young leaves become light green at their base and lose their shape (top right photo).

Older leaves become twisted and distorted.

Flowers become distorted and malformed with short petals that fold inwards.

Young petioles are irregularly thickened and darkly banded with dying pith. In severe cases petioles split and young bolls are shed.

Mild deficiency can produce rank growth and parrot beak bolls.

## Toxicity symptoms

Toxic concentrations of boron result in leaf cupping, chlorosis and death of leaf tissue in localised spots.

## Environmental factors

Deficiencies can occur through leaching so may be more common on sandy soils.

Prolonged dry periods can reduce soil boron availability.

## Looks like

See page: 63.





IRON is an essential plant nutrient required in small quantities. Although plentiful in the soil it is normally in a form unavailable to plants. Plants require a continuous supply of iron as it is very immobile within the plant.

### Deficiency symptoms

Symptoms first appear as interveinal chlorosis (yellowing) in youngest leaves.

Veins remain green unless deficiency is severe.

Older leaves remain green.

### Toxicity symptoms

Not recorded in Australian cotton.

### Environmental factors

Deficiency favoured by waterlogging in young cotton.

Most commonly associated with alkaline or calcareous soils.

Can be induced by high concentrations of other cations such as manganese, zinc or potassium.

Applications of P & Zn can reduce Fe uptake.

Recently limed soils can induce Fe deficiency.

Associated with sandy soils low in Fe.

### Looks like

See pages: 49, 59, 63, 64, 72, 74.



**N**UTRITION problems with manganese are rarely seen in cotton production. The range of concentrations within a plant defining deficiency and toxicity is narrow.

## Deficiency symptoms

First signs appear in younger leaves as interveinal chlorosis and cupping.

Yellowing of the terminal bud and possible necrotic spots.

## Toxicity symptoms

Leaves become crinkled, mottled and chlorotic.

Mn toxicity can induce iron and zinc deficiency.

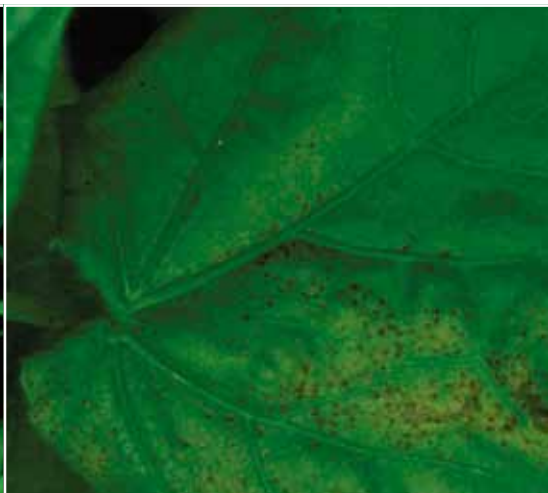
## Environmental factors

Deficiency symptoms can be induced when soil pH has been raised through the application of lime, N or P fertiliser

Toxicity can be induced by waterlogging and is more common in acid soils.

## Looks like

See pages: 61, 62, 74.





**N**ITROGEN can be a critically limiting factor in yield. It is very mobile in the plant and is taken up throughout the growing season and stored in leaves.

### Deficiency symptoms

Can appear at any stage of growth.

First signs of deficiency are seen as yellowing in the older leaves and a reduction in the size of young leaves. Yellowing of leaves works up the plant as deficiency advances.

Plants appear unthrifty, stunted and have a reduced growth rate. They tend to be spindly with

few vegetative branches, and fruiting branches are fewer and shorter.

Where deficiency is severe, older leaves turn brown and die while young leaves yellow.

Newly initiated bolls tend to shed. Bolls are smaller and production of seeds and lint is low.

Yield can be severely impacted when nitrogen is the limiting nutrient.

### Toxicity symptoms

Excessive rank vegetative growth and dark green foliage are characteristic of too much nitrogen.

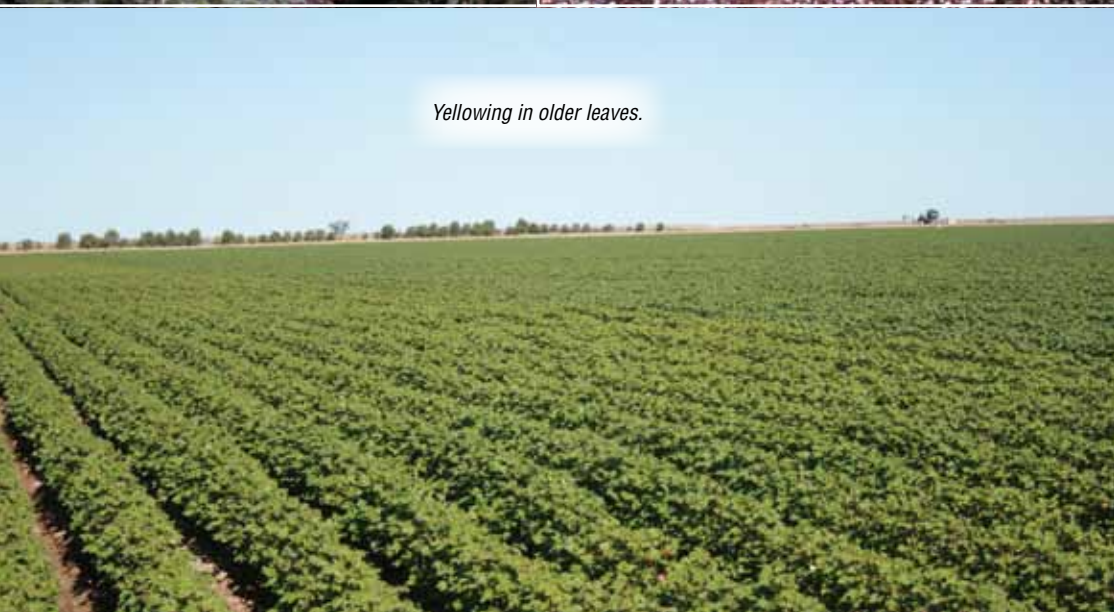
Delayed flowering and lower fruit numbers.



*Deficiency.*



*Deficiency.*



*Yellowing in older leaves.*



Bolls are smaller and fibre more immature.

### **Environmental factors**

Nitrogen is a highly mobile nutrient and can be readily lost in water movement, such as leaching and run-off.

Soil aeration constraints such as water logging and compaction can reduce plant nitrogen availability through denitrification and volatilisation.

### **Looks like**

See pages: 59, 62, 72.



**P**HOSPHORUS plays a critical role in seedling vigour, crop establishment and root development. It is an immobile element within the soil and although abundant in the soil may not be available for plant uptake.

### Deficiency symptoms

Early season symptoms include reduced seedling vigour, plant establishment and poor root development.

Plants are usually stunted with dark green foliage which later may become purplish or red. Leaves may become distorted.

Secondary branch growth can be significantly reduced.

Flowering, boll set and maturity can be delayed.

Low P levels during crop maturity can result in premature senescence, with older leaves becoming chlorotic between the veins, necrosis develops and the leaf drops.

The plants usually have reduced tolerance to cold and are more susceptible to pests and diseases.

### Toxicity symptoms

Not recorded in Australian cotton.

*P deficient.*



*Secondary branch growth can be significantly reduced.*



**Environmental factors**

P is a highly reactive nutrient in the soil, making it relatively immobile and unavailable.

Soluble P quickly becomes unavailable in the soil.

Low levels of mycorrhizal fungi (AM) can reduce the capacity of cotton to uptake P (known as long fallow disorder).

**Looks like**

See pages: 10, 12, 16, 49, 56, 68, 70.





**P**OTASSIUM is a major plant nutrient. It is very mobile, readily moving throughout the plant. Premature senescence is a potassium related disorder which can occur even when soil potassium reserves are adequate for normal growth.

### Deficiency symptoms

Before peak flower, potassium deficiency symptoms first appear in the older leaves on the leaf margins and interveinal areas as yellowish white mottling which turns to a rusty bronze colour.

Brown necrotic spots at the leaf margins and between leaf veins cause the leaf to look rusted or spotted.



*Brown necrotic spots at the leaf margins and between leaf veins.*



Finally the leaf breaks down; margins and leaf tips shrivel; and, the leaf dies and drops off.

After peak flower, potassium deficiency symptoms first appear on the younger mature leaves in the upper third of the canopy.

Premature shedding of leaves reduces or prevents boll development, resulting in small immature bolls which fail to open.

### Toxicity symptoms

Not recorded in Australian cotton.

### Environmental factors

Deficiencies are only likely to occur in highly weathered coarse-textured soils in wetter environments where available potassium is easily leached.

These soils normally have low potassium reserves and low cation exchange capacity.

Excess K can induce deficiencies in other nutrients eg Mg, Ca.

### Looks like

See pages: 10, 16, 66, 70.

*Premature senescence.*



# Put your best foot forward...



## Come Clean Go Clean





**P**REMATURE senescence is a disorder related to inadequate potassium and phosphorus nutrition. Both nutrients are normally involved. It is observed where high boll loads demand more nutrients than the roots can supply – therefore leaves become depleted in P and K in particular. Stresses such as waterlogging, cool, cloudy weather or soil compaction that reduce the crop's ability to take up nutrients enhance/hasten premature senescence.

### Deficiency symptoms

First signs appear as a slight yellowing of veins of the youngest leaf. The third or fourth leaf yellows

then rapidly becomes red or bronze, while the underside of the leaf remains green.

Bronzing then spreads down the plant while the upper leaves drop off.

As the season progresses, premature senescence can spread and defoliate the crop.

Plants in the edge row or near gaps are less effected.

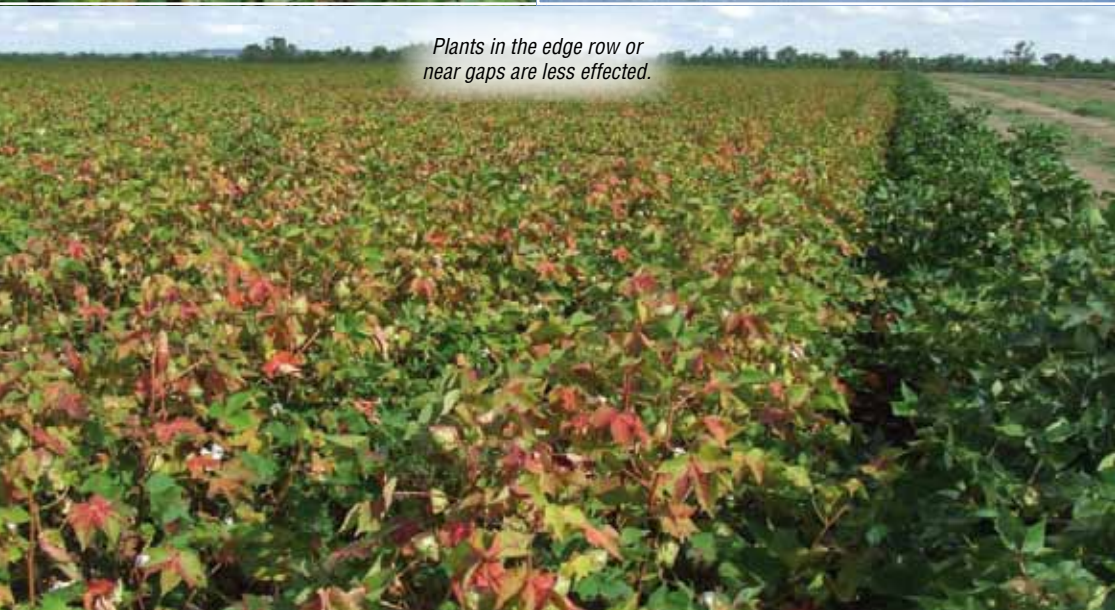
The area around leaf veins remains green and the underside of the leaf is rarely discoloured.

### Toxicity symptoms

Not recorded in Australian cotton.



*Plants in the edge row or near gaps are less effected.*





### Environmental factors

High boll load contributes to plant stress and, combined with other stresses, can induce the syndrome.

The stresses include:

Cool, cloudy weather late in the season.

Soil compaction.

Waterlogging or irrigation.

Inadequate nitrogen.

Alternaria infection can be associated.

Some cultivars are more susceptible.

### Looks like

See pages: 10, 16, 44, 45, 56, 66, 68.



*Senesced plant has more bolls and open cotton.*

**S**ULFUR is relatively immobile within the plant, so it is required throughout the crop life. It is subject to leaching, particularly in lighter soils.

### Deficiency symptoms

Pale light green or yellowing of younger leaves.

Younger leaves become chlorotic including veins.

Young leaves are smaller and can become cupped.

Severe deficiency can result in reduced branching, flowering and boll set and plants appear stunted.

### Toxicity symptoms

Not recorded in Australian cotton.

### Environmental factors

Deficiencies are becoming more common in cotton where sulfur has not been applied.

Sulfate is leached with rain and irrigation water.

### Looks like

See pages: 59, 62, 64.



# Avoidable

**Cotton bunched top is the avoidable disease caused by an aphid-vectored virus.**

**Every year, be sure to remove all cotton volunteers, ratoons and marshmallow plants on the farm, natural areas and roadsides for a higher level of protection.**





**Z**INC is an essential plant nutrient required in small quantities. It is very immobile in the soil. Long fallow disorder is often manifested as zinc deficiency.

### Deficiency symptoms

First appears shortly after first true leaves appear.

Early symptoms appear as interveinal chlorosis (yellowing).

More severe symptoms appear as bronzing.

Leaves can be cupped and smaller than normal.

Plants are shorter with thin stems, and have reduced branching, flowering and boll set.

Yields can be severely reduced, maturity delayed and fibre quality affected

### Toxicity symptoms

Not known to have occurred in Australia

### Environmental factors

Very immobile in soil and concentrates in the surface. Removal of the top soil (laser levelling) can reduce available Zn.

Soluble Zn quickly becomes unavailable in the soil.

Long fallow disorder is often manifested as Zn deficiency. Low levels of mycorrhizal fungi (AM)



can reduce cotton's capacity to uptake Zn & P. Usually grows out of deficiency, but often with a yield penalty.

Inhibition by high concentrations of other cations, such as Cu, Fe, Ca, Mg.

**Look like**

See pages: 49, 62, 63.



We would like to acknowledge the contributors to the first *Symptoms of diseases and disorders of cotton in Australia*, especially editors David Nehl and Stephen Allen.

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**Contact the local entomologist, pathologist or the Exotic Plant Pest Hotline on 1800 084 881 immediately if a biosecurity threat is suspected.**



Industry & Investment



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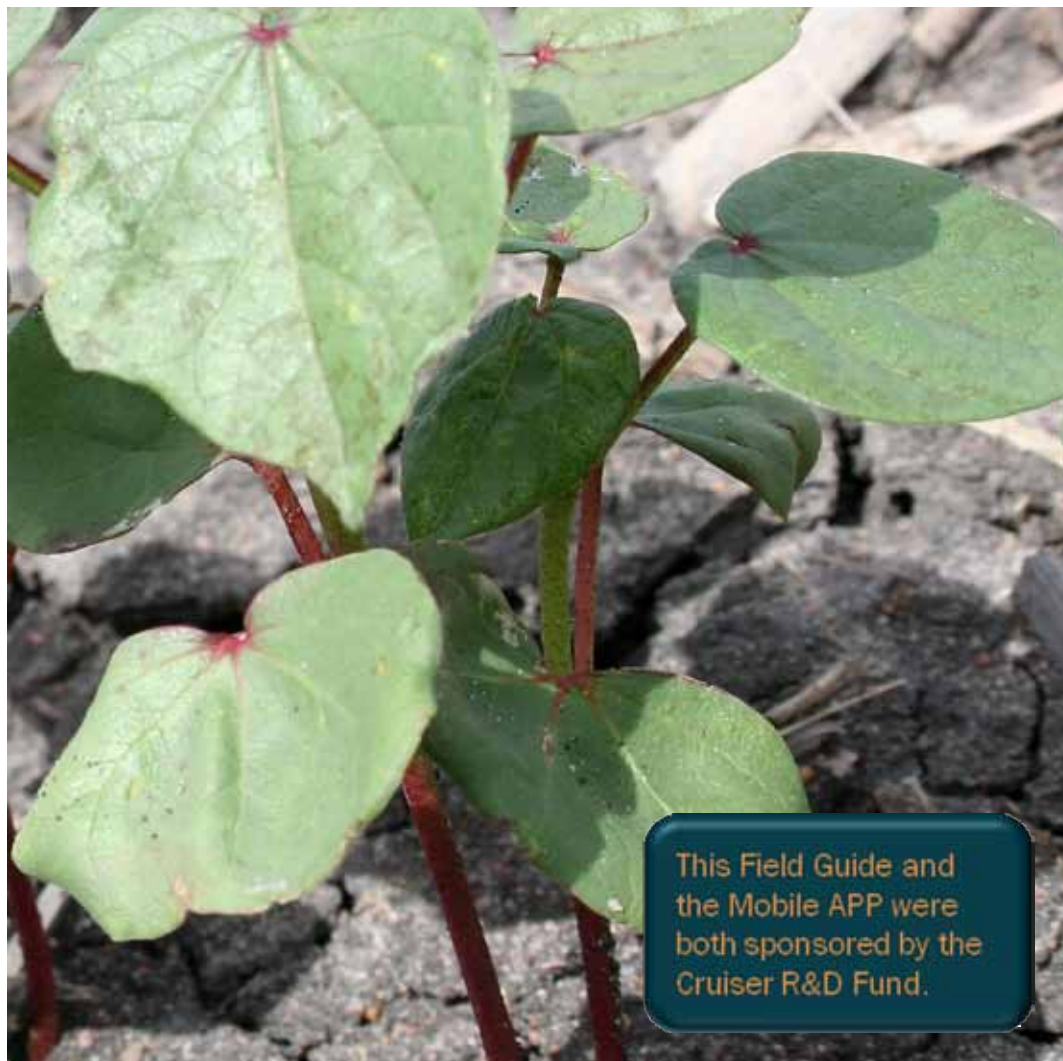
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# Cotton Symptoms Guide

## tips on using this PDF...

This document is comprehensively bookmarked.

Be sure to view bookmarks if viewing on a tablet.

Active link regions circled – (NB you may need to update to a more comprehensive PDF viewer than those provided as a standard on some tablets to access this functionality).

- When using the key pages click on the symptom of interest to be taken to that page
- When viewing a cotton symptom click on the top left of the page to return to the first page of the key

**All go to pages are linked**

**2 Symptoms key**

*What's wrong with my cotton crop?*

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**Click to return to page 1 of key**

**10 Alternaria leaf spot**

**A** **ALTERNARIA** leaf spot is caused by a fungal pathogen that can be carried over on infected cotton residues from the previous season.

**Symptoms**  
Brown, grey brown or tan lesions (spots) on cotyledons, leaves, bracts and bolls varying from 1 to 10mm in diameter.  
Rapid defoliation can occur when a susceptible crop (eg. Pima varieties) is exposed to favourable conditions. Affected leaves develop an abscission layer, senesce and drop to the ground.

**Environmental factors**  
Favoured by either repeated heavy dews or extended periods of wet weather.  
Favoured by physiological or nutritional stress (eg. heavy fruit load or low potassium).

**Looks like**  
Symptoms generally more severe on lower leaves. Plants are most susceptible at the seedling stage.

and late in the season when the crop begins to 'out' or, especially following premature senescence.  
Lesions can have dark brown or purple margins and sometimes have obvious concentric zones.

**Affected leaves develop an abscission layer, senesce and drop to the ground.**

