fact sheet

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# Vert update:

## The latest in vert research.

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**The pathogen**

Verticillium wilt is caused by the soil-borne fungal pathogen *Vertillicum dahliae*. Recent research has found that in Australian cotton there are currently three strains of *V. dahliae*; two non-defoliating strains (VCGs 2A and 4B) and a defoliating strain (VCG 1A). It is unclear why only now the disease is causing such significant damage in some fields.

**Symptoms**

Characteristic symptoms of Verticillium wilt include wilted plants, leaf mottle and necrosis, defoliation and in some cases the death of plants. All plants from which *V. dahliae* has been isolated showed internal vascular discolouration however not all plants showed external symptoms.

Internal symptoms can be checked by cutting the stem at the base of the plant just above the soil. An infected plant will reveal flecked brown discolouration of the vascular tissues running from the main root up into the stem. Severe cases of Verticillium wilt can be easily mistaken for Fusarium wilt, and there are instances where both diseases have been found in the same field. Multiple stems should be sent for diagnosis to increase the opportunity in detecting multiple pathogens and/or strains of a pathogen.

**Economic impact**

Once introduced to a field or farm, *V. dahliae* is almost impossible to eradicate. Failure to control the build-up of inoculum can result in very large yield losses and fields becoming unsuitable for cotton production. Reports from growers estimate yield losses range from 10–62 per cent.

**What can you do?**

**Assessments of fields for signs of Verticillium wilt.**
Establish one or more transects across the field and assess for the presence or absence of disease symptoms in plants in every 10th row. The presence of the disease is best determined by checking for the characteristic brown internal discolouration within the lower stem.

**Sending plant samples for diagnosis**

It is important that plants suspected of Verticillium infection are analysed by a pathologist to determine what strain (or VCG) of pathogen is present and rule out the possibility of a Fusarium pathogen.

Please PHONE your state pathologist FIRST before sending any samples to confirm the address and to ensure that samples will be processed appropriately on arrival. Send samples early in the week to avoid delays over the weekend. Include information about the field on the sample sheet (see page 127, Cotton Pest Management Guide 2016-17 for a form and check list on sending plant samples for diagnosis).

*Flecked brown discolouration in the vascular tissues.*

Best Practice

## What is the research telling us?

Research conducted by NSW DPI and QDAF (through support from CRDC) has shed light on methods of managing and controlling Verticillium wilt. Below are some of the current integrated disease management (IDM) strategies and new research developments.

| IDM strategies | Current knowledge | Research developments |
|---|---|---|
| **Strains of Verticillium wilt** | | |
| Find out what strains are present | In Australian cotton there are currently three strains of *V. dahliae*; two non-defoliating strains (VCGs 2A and 4B) and a defoliating strain (VCG 1A).<br><br>The examination of the NSW DPI historical culture collections helped establish that the defoliating 1A strain has been in Australian cotton for at least 20–30 years however has previously not been identified.<br><br>Important factors for Verticillium wilt of cotton are inoculum density, timing of infection, environmental conditions and pathotype of *V. dahliae* in soils (overseas defoliating (D) and non-defoliating (ND)); in Australia VCGs 1A (D) and 2A (ND) are virulent and VCG 4B (ND) is mild in comparison), plant age, host resistance, air and soil temperature, soil moisture, and the availability of potassium and nitrogen to growing plants. | **Strain severity**<br>There has not been enough research conducted to know if one strain is more severe than the other. However a QDAF pot trial conducted under controlled environmental conditions and a given inoculum concentration, showed that both strains (VCG 1A and VCG 2A) can cause severe disease and defoliate plants. However, there was also variability in the virulence of isolates within VCG 2A. Some isolates were as mild as VCG 4B, while others under the same conditions were highly virulent, causing plant defoliation and death. This result differs from what has been observed overseas for these strains. Further trials screening a larger number of isolates from all VCGs under environmental conditions that favour all strains needs to be conducted as well as field trial assessment.<br><br>**Symptoms of the different strains**<br>International research has shown that on cotton, VCG1A isolates induce severe foliar symptoms, stunting with epinasty (downward bending leaves) followed by yellowing, necrosis and finally defoliation. Disease progresses rapidly with a high percentage of plant mortality. VCG2B as a group is less virulent than VCG1A and induces no defoliation or only partial defoliation, with some isolates exhibiting similar virulence to VCG1A. VCG2A and VCG4B isolates induce mild to moderate symptoms without defoliation, slow disease progress, and no plant mortality.<br><br>In Australia there has not yet been research to determine if initial symptoms differ for defoliating and non-defoliating strains in Australian cotton. Research overseas has shown that for a given inoculum density, epidemics caused by the defoliating pathotype of *V. dahliae* develop earlier and more rapidly than those caused by the non-defoliating pathotype. Therefore, the defoliating pathotype may induce a larger effect on all cotton growth parameters and yield of affected plants compared to the non-defoliating strain. |
| **Planting** | | |
| Use highest V-rank variety | Cotton varieties that are less susceptible to Verticillium wilt are the cornerstone for management of this disease. The level of resistance is communicated through the V-rank which is assigned to each variety. Current varieties that are resistant at 25-27 °C are susceptible at 20-22 °C. | The number of sites used for V-rank trials has been expanded. In addition to the CSIRO small plot trial, which has been the source of V-ranks in the past, nine CSD box trials were also conducted last season. These trials were located over three valleys and represented high and low disease pressure and both defoliating and non-defoliating strains of Verticillium. Although it is currently not well known how V-rank relates to strain, there was a consistent trend across the trials and the current rankings fit well with the individual trial results. The increased number of trial site will be continued in the future with any possible link to strain being monitored. |

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| **In crop management** | | |
| Manage for 'earliness' and avoid cool and wet conditions. | Verticillium wilt is most severe during extended wet or overcast weather and or waterlogging and in late maturing crops. Verticillium wilt is favoured by cooler temperatures. Extending the period of crop growth late in the season increases this risk. | **Black root rot and Verticillium interaction**<br>Black root rot delays development of the crop and in effect 'steals time' slowing maturity with this also delaying the crop at the end of the season. Pushing the last irrigation to add further yield to the crop can allow the crop to be exposed to cooler weather which is ideal for Verticillium.<br><br>NSW DPI has investigated a link between incidence of black root rot early in the season and incidence of Verticillium late in the season. Statistical analysis of the long term data for each NSW cotton valley showed a slight trend for the Namoi Valley, however the correlation was weak. For all other valleys there was no trend or correlation.<br><br>A growth room pot trial studied the effect of dual infection on the severity of black root rot disease (rated on a scale of 1-10). Plants that were infected by both pathogens had significantly higher severity of black root rot. Average disease severity rose from 4.6 when infected with the black root rot pathogen alone to 6.2 when dual infected.<br><br>**Favourable environmental conditions**<br>Some international literature suggests that some strains are more virulent at higher temperatures. The non-defoliating strain VCG 2A from cotton has an optimum temperature for growth of 24 °C, whereas the defoliating strain VCG 1A has an optimum of 27 °C. This may mean that, where the defoliating strain is present, Verticillium Wilt symptoms may be seen more often and further north. |
| Irrigation management | Throughout the season avoid over-watering and waterlogging where possible and avoid late season irrigations that extend maturity. Reducing irrigation runoff will reduce the amount of inoculum moved in tail water and around the farm. Research overseas has shown that disease incidence increases with irrigation rate. | **Risk in shallow root systems**<br>Dr Stephen Allen found that overhead irrigation promoted shallower root systems. This may increase disease as *V.dahliae* inoculum is concentrated in this region.<br><br>**Inoculum location**<br>Recent NSW DPI research has found that most (76 per cent more) of the inoculum in furrow irrigated fields is found in the top 10cm of the permanent bed soil profile compared to 11-20cm. Microsclerotia were also recorded in the furrows; however, inoculum was 59 per cent higher in the beds. |
| Nutrient management | Verticillium wilt is favoured by excessive use of nitrogen which results in late season growth. Potassium is an important nutrient for natural plant defences; consequently, potassium deficiency has been associated with more severe symptoms. Avoid other stresses such as root damage from inter-row cultivation. | QDAF are currently investigating the effect of nitrogen rate on disease incidence in replicated strip field trials. |
| **After harvest** | | |
| Stubble management | Aim to ensure that crops destruction occurs soon after picking to reduce the build-up of inoculum. In fields where Verticillium wilt is present the incorporation of cotton residues soon after harvest is beneficial as it allows for the rapid breakdown of plant material. Raking and burning the whole field is NOT recommended as raking is likely to spread the pathogen (if present). | Two replicated field trials conducted by NSW DPI and CSD in 2015-16 season showed no significant effect of raking and burning stubble on inoculum levels in soil. Raking and burning did not remove all the trash containing microsclerotia. In fact it moved inoculum around in the small trash material. |

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| **Rotation crops** | | |
| Non-host crop rotation and control alternative hosts | Crop rotation with non-host crops (i.e. sorghum and cereal crops) may help reduce Verticillium wilt incidence. Research suggests that the greatest benefit from rotation would be observed when the rotations are initiated early, before inoculum builds up to high levels in the soil and avoiding back to back cotton.<br><br>Research in the USA showed that the strategy of crop rotation and moderate irrigation gave the best returns overall in a cotton field infested with Verticillium wilt.<br><br>*V. dahliae* has a large host range causing vascular wilt on more than 250 plant species. Volunteer and ratoon cotton, soybeans, 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 | **Classifying hosts under Australian conditions**<br>There is some host specificity between strains. Research is currently underway to better understand this and to clarify and confirm what is classed as Verticillium wilt hosts and non-hosts in Australian environments in comparison to what international literature reports.<br><br>International literature and some recent QDAF pot trials with Australian strains suggest that mung bean, chickpea and faba beans may also be hosts. This is yet to be tested under Australian field conditions.<br><br>NSW DPI studied the effect of rotating wheat, sorghum and fallows on soil inoculum levels. Results showed a significant reduction in inoculum from an average 745ppg in 2013 to 124ppg in 2014 and 2ppg in 2016.<br><br>**Asymptomatic hosts**<br>In the scientific literature, observations of *V. dahliae* as an endophyte colonizing asymptomatic plant species have been documented. Many of these asymptomatic plants are cereal crops, used in crop rotations as part of management for Verticillium wilts and weeds, which may be present in fields along with cultivated crops. Associations between *V. dahliae* and monocot plants, although limited, result mostly from inoculation studies and not from field sampling. Although these studies imply that *V. dahliae* can be an endophyte in one situation and a pathogen in another, additional research, particularly under field conditions, is clearly needed.<br><br>Inoculation studies overseas showed that several cereal species significantly lowered numbers of microsclerotia found in aerial parts and roots of cereal crops in comparison with the host plant, suggesting that these asymptomatic plants may not be as adequate as hosts in the short term but, over time, the fungal population can be maintained within the environment to some degree.<br><br>An asymptomatic host is a better choice than a symptomatic host, because the pathogen does not cause disease on these crops and fewer microsclerotia are produced on roots and aerial parts.<br><br>Over time, the fungal population may be maintained or increased. Research is needed to investigate the potential for asymptomatic hosts to affect inoculum of *Verticillium dahliae* in Australian soils. |
| **Frequently asked question** | | |
| Is *Verticillium dahliae* seed-borne? | *V. dahliae* is seed-borne in some crops and weeds (eg. spinach, lettuce, Noogoora Burr). There is mixed opinion in the scientific literature as to whether *V. dahliae* is seed-borne in cotton. | QDAF in collaboration with CSIRO are testing cotton seed from Verticillium infected plants to determine if this pathogen is seed-borne. To date, no *V. dahliae* has been isolated from seed. Testing is on-going. |

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## Remember: Come Clean. Go Clean

Verticillium is effectively spread over long distances in soil attached to boots, vehicles, farm equipment and in water (irrigation and overland flows). It can also be transferred in infected plant material. Until more is understood about why this disease is worsening, it is important that the industry reduces the spread.

If your farm is free from this disease, try to keep it this way. If you already have vert, prevent the introduction of different strains and reduce spread around the farm.

**For more information, contact:**
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## Current verticillium research

**CRDC-supported research:**
**Development of a molecular tool to quantify Verticillium inoculum levels in soils**
NSW DPI will develop and optimise an accurate and rapid means of quantifying *V. dahliae* propagules over a wide range of inoculum densities in Australian agricultural soils. This fee-for-service support tool for growers will assist integrated management strategies and assessment risk of Verticillium wilt prior to planting. This technology would further allow the development of thresholds for disease potential based on inoculum density in soil.

For more information, contact Dr Karen Kirkby:
karen.kirkby@dpi.nsw.gov.au

**New Pathology Survey**
The annual disease survey is being reviewed. Going forward the survey will work closely with CottonInfo to review regional issues to ensure these are incorporated into the survey. Geospatial recording of data combined with strategic biological analysis will allow the analysis of composition and abundance of microbial communities, cotton pathology data, and management practices to address system questions on disease management such as impact of rotation or stubble management as well as more complex analysis such as variety x management system x environment, which will allow an understanding of requirements for disease suppressive soils. Research gaps identified through this process will be addressed through pot trials or grower led trials as required.

For more information, contact Dr Linda Smith:
linda.smith@daf.qld.gov.au

**CottonInfo/QDAF Crop Rotational Trials**
CottonInfo are working with growers, consultants and QDAF to establish a series of regional trials to address questions about rotation crops and the factors that contribute to disease severity such as inoculum load, soil type and nutrition. Growers with significant Verticillium issues will be following a three year rotation to assess the impact of different rotations on soil inoculum levels. Other fields with obvious high and low disease areas will be assessed to determine if soil type and/or nutrition status influences inoculum levels in addition to crop rotation. CottonInfo Regional Extension Officers in these areas will work with researchers to communicate new research to industry.

For more information, contact Sharna Holman:
sharna.holman@daf.qld.gov.au

**CSIRO-supported research:**
Over the last few years, CSIRO has invested significant effort in identifying new improved sources of resistance to verticillium and characterising this at a molecular level. While greenhouse bioassays are used for much of this work, there is no substitute for field sites. The number of verticillium field nurseries used in the breeding program has increased from one to four and these are used to elevate commercial varieties and elite lines together with a range of other germplasm (overseas varieties, undomesticated germplasm etc.).

For more information, contact Dr Warwick Stiller:
warwick.stiller@csiro.au

**CSD-supported research:**
In addition to increasing the number of sites used in V-rank trials, CSD's Extension and Development team are also working on management influences on Verticillium severity including plant population, plant date, nitrogen nutrition, irrigation interval and variety. CSD are also screening fungicides and actively looking for novel chemistry which will assist in the management of the disease.

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