Sorghum stalk rots are a continual but increasing threat to Australian sorghum producers. A number of pathogens can cause stalk rots in sorghum, with *Macrophomina phaseolina* (the cause of charcoal rot) and several *Fusarium* species (the causal agents of fusarium stalk rot) being the most important in Australia. Both diseases occur late in the season and may be associated with plant lodging. In Kansas, USA, average annual losses due to sorghum stalk rots are estimated at 4%, with up to 50% in some areas, and incidence as high as 100% in individual paddocks (Jardine and Leslie 1992). It is likely that similar losses would occur in Australia. In the 2008/09 cropping season there was a high incidence of stalk rotting fungi found in all of the sorghum growing regions from the Liverpool Plains to Central Queensland.

Lodging is often the first sign of stalk rot, but in most plants infected with fusarium stalk rot there is a brown-reddish purple discoloration of the stem. When the stem is split, the pith and outer tissues have an orange-red colour, often concentrated at the nodes. Charcoal rot infection results in the stem immediately above ground level turning spongy, and when the stems are split small black resting bodies (microsclerotes) will be seen adhering to strands of the water/nutrient conducting tissues.

The *Fusarium* and charcoal rot pathogens can survive between crops in stubble or on other hosts. *Macrophomina phaseolina* has a very wide host range, including all major summer field crops and many common summer and winter weeds. By contrast, the dominant *Fusarium* species which attack grain sorghum, *F. thapsinum* and *F. andiyazi*, are not known to infect other field crops. Zero/minimal tillage tends to favour their survival in stubble, and successive sorghum crops will gradually build up the level of these pathogens in the soil.

There is good evidence that the *Fusarium* species and *Macrophomina phaseolina* associated with sorghum stalk rot infect and grow slowly in the roots and/or crown of sorghum plants while they are alive and actively growing. The onset of stress from moisture deficit or desiccation results in a rapid growth and invasion of the stem, which can ultimately result in stalk rot and lodging.

Previously, *Fusarium moniliforme* was known as the causal agent of fusarium stalk rot, but this species has now been sub-divided into a number of different species (Leslie and Marasas 2002). Breeding for resistance to fusarium stalk rot has been a relatively slow and difficult process, perhaps due to the number of different species involved. A recent study in New South Wales on a few selected paddocks revealed 19 *Fusarium* species to be associated with stalk rot, with five species commonly recovered (Petrovic, Walsh et al. 2009). As found overseas, *F. thapsinum* and *F. andiyazi* were the dominant species recovered from stalk rot-infected plants in these paddocks, and their relative abundance changed from the Liverpool Plains to the Goondiwindi region (Petrovic, Walsh et al. 2009).
As part of the GRDC-funded project, Northern Integrated Disease Management, surveys are being undertaken in the sorghum growing regions throughout Queensland over the next few cropping seasons to collect and identify the *Fusarium* species associated with stalk rot, determine their relative importance and distribution, and assess their role in lodging.

To date, a total of 230 *Fusarium* isolates have been collected from fusarium stalk rot-infected plants grown throughout Queensland and northern New South Wales during the 2008-09 and 2009-10 cropping seasons. Approximately half of these isolates have been identified, and results to date suggest that *F. thapsinum* and *F. andiyazi* are the two major species associated with fusarium stalk rot in the northern region, with *F. thapsinum* being the dominant species. Collection of diseased stalks will continue over the next few growing seasons. Future R&D activities will focus on developing integrated disease management packages which will incorporate resistance and agronomic practices to minimise the influence of stalk rotting pathogens on sorghum stalk rot and lodging in the northern region.

Lodged plants caused by fusarium stalk rot
Plants with charcoal rot, caused by *Macrophomina phaseolina*, typically have spongy stems, and when split open have small black resting bodies (microsclerotes) adhering to shredded pith tissue.

Characteristic internal reddening of stem tissue, caused by fusarium stalk rot.
References


Fusarium in sorghum, do we understand all of the losses?

Derek Gunn, Agromax Consulting.

As consultants monitoring sorghum on the Liverpool plains, stalk rot or lodging associated with Fusarium may not be a problem in every season but Fusarium symptoms in sorghum are not hard to locate on a year to year basis. With the trend over time of increasing average sorghum yields (improved nutritional/agronomic management), and the value of sorghum as a rotational tool for crown rot (F. pseudograminearum) management in our winter cereals, we are seeing an increase in sorghum frequency on the plains and an increase in post harvest sorghum residue. Unlike the majority of crops grown in these systems, there is no conclusive data to suggest that a rotation of sorghum on sorghum or multiples of this rotation has a high risk of disease carryover for the next sorghum crop. There is however increasing awareness of Fusarium presence in non lodging crops and increased interest in the role that sorghum stubble may be playing in the head blight (F. graminearum) lifecycle and inter-seasonal continuity.

Currently on the Liverpool plains we are monitoring non lodging sorghum crops that are displaying high levels of symptoms often associated with Fusarium including chalky, shredded, off white inner stalk tissue, dark coffee colour stained lower tiller nodes, premature senescence and drooping of the rachis and spikelets, weakening of tiller structural integrity at crown or at any of the tiller nodes, proliferation of pink or cream coloured spores at lower / mid nodes on stem tissue under leaf sheaths and darkened, decomposing central stem tissue.

The most significant concern with these symptoms, other than 'when will my sorghum start to fall over', is the possible yield loss we are incurring long before we see lodging. Many other questions arise from here including the impact of glyphosate desiccation sprays on the
lodging severity in Fusarium infected crops, varietal susceptibility, nutrient availability and its relationship with late carbohydrate remobilisation and the effect of time of sowing. Population isolation work also indicates that there are as many as 19 different types of Fusarium present in sorghum grown in NW NSW, which raises the question is one strain more attributable to plant tissue breakdown than another. Regardless, it would be difficult to argue that if the plant vascular tissue is being compromised to the point of tillers breaking off abnormally that there had been no disruption at all to phloem or xylem tissue functionality and resultant yield potential.

The final piece to the puzzle, if you believe we are losing yield, is how to control Fusarium accumulation in our sorghum crops. If we see Fusarium at low levels in crops every year, what triggers the progression from sub clinical infection to 10% lodging. Will we need to monitor Fusarium levels in-crop or in-stubble as a rotation decision making tool or can we control its build up with in-furrow and foliar fungicide applications. One thing is certain, as we look for our next 5% average yield increase from sorghum crops, Fusarium will receive more attention.

**Stalk rots in sorghum – Trial activity**

*By Lawrie Price NGA, Lisa Keller and Malcolm Ryley, Agri-Science Qld, DEEDI*

Sorghum is a significant part of crop rotations in our region and in some areas has become the dominant crop. Growers and consultants on the Liverpool Plains have seen fungal stalk rots such as the fusarium stalk rots and charcoal rot in their fields and know that in some seasons they can cause yield loss through lodging. Questions raised to the Northern Grower Alliance in autumn 2009 included “Can these pathogens cause yield loss in the absence of lodging?” and “Is there a link between spray-out of sorghum with glyphosate and lodging?”

After consultation with Mal Ryley and Lisa Keller of Agri-Science Queensland (DEEDI) and with seed companies Pacific Seeds and Pioneer, NGA commenced some ‘pilot’ trial work with two trials conducted by Clare Felton-Taylor during the 2009-10 summer season. In the trials there were a total of four varieties each with different combinations of inoculum source (natural background level vs infected grain vs infected stubble) x spray out with glyphosate vs no spray out.

Adopting an inoculated plot technique similar to that developed by DEEDI and NSW I&I winter cereal pathologists to investigate crown rot, Lisa and Mal were able to grow sorghum infecting fusarium strains onto pearl millet grain, which was then placed in the planting furrow at sowing. Additionally *Fusarium* infected sorghum stubble was mulched then placed over the planting rows as a second method of artificially infecting plots. Sites near Bellata and Mullailey with little history of sorghum were selected for the trials to minimize the risk of background infections of sorghum stalk rot pathogens. The sites were sown in early November and both experienced very tough dry conditions until Christmas then mild wet
conditions through to harvest. The DEEDI team provided the critical pathology expertise and were able to collect samples from both sites at the seedling stage and again at harvest to determine what pathogens are present and infection levels.

At Bellata the mulched stubble treatment reduced establishment and reduced the number of heads per metre of row. This could be due to physical factors and/or unknown pathogens. However there was no effect on yield on any of the 4 varieties in the trial. All varieties yielded over 7.5 tonnes/ha with no lodging apparent.

At Mullaley there were no significant differences in establishment. There was a trend towards increased head number and increased yield where stubble had been laid over the planting row.

At the seedling stage, a total of twenty plants from each treatment were inspected for the presence of *Fusarium*, which was indicated by plants showing red root discoulouration. *Fusarium* was detected in all treatments at the seedling stage, suggesting that there was a background level already present in the soil at both sites, despite sorghum not being grown there in recent years. There were no distinct differences in relative resistance of the hybrids to the disease at the seedling stage. Thirty *Fusarium* isolates were collected from seedlings displaying red discoulouration, and were predominantly identified as *F. thapsinum* and *F. andiyazi*.

At plant maturity, a total of ten plants from each plot were again visually assessed for the presence and severity of fusarium stalk rot. Presumably due to less favourable weather conditions for disease development, fusarium stalk rot was only detected in a few treatments. Fusarium stalk rot was detected in close to 100% of plants sprayed with glyphosate, compared to less than 1% infection in the remaining un-sprayed treatments; demonstrating the significant role plant stress plays in disease development. All varieties were susceptible to the disease, and it was difficult to determine any major differences between them. Another significant finding from the trials was the presence of fusarium stalk rot in the control treatments, despite no sorghum being grown at the Bellata site for 5 years, and no sorghum ever grown at the Mullaley site.

We know from experience with crown rot of wheat that yield impacts are very low in years with a soft finish such as we have experienced, and these trials suggests a similar effect may occur with fusarium stalk rot of sorghum. However, different fusarium species are active on sorghum and we do not yet know how they respond to seasonal conditions.

Three major conclusions can be made from these initial field trials -

- Fusarium stalk rot was detected in the Mullaley site where sorghum has never been grown, at levels similar to those detected at the Bellata site, where sorghum has not been grown for 5 years. The *Fusarium* species that cause sorghum stalk rot are not
known to infect other crops, so their presence in these paddocks may suggest possible survival on grasses, or movement in soil or water from infected paddocks.

- Fusarium stalk rot developed rapidly in plants sprayed with glyphosate. In seasons with a hard finish, when stress occurs in the late vegetative and/or early seed fill stages, a glyphosate application prior to harvest could result in severely diseased stalks, and possibly lodged plants.

- In these trials, characterized by a soft finish, no lodging occurred and there were no differences in yield between treatments.

Plant infected with fusarium stalk rot from a glyphosate treatment beside a healthy plant from an un-sprayed treatment. Plants infected with fusarium stalk rot have distinct internal red discolouration.
Fusarium stalk rot in adult plants averaged across the four varieties

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Bellata</th>
<th>Mullaley</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average number of nodes with discolouration</td>
<td>Average number of nodes with discolouration</td>
</tr>
<tr>
<td>Nil</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Inoculum</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>Stubble</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>8.6</td>
<td>6.9</td>
</tr>
</tbody>
</table>