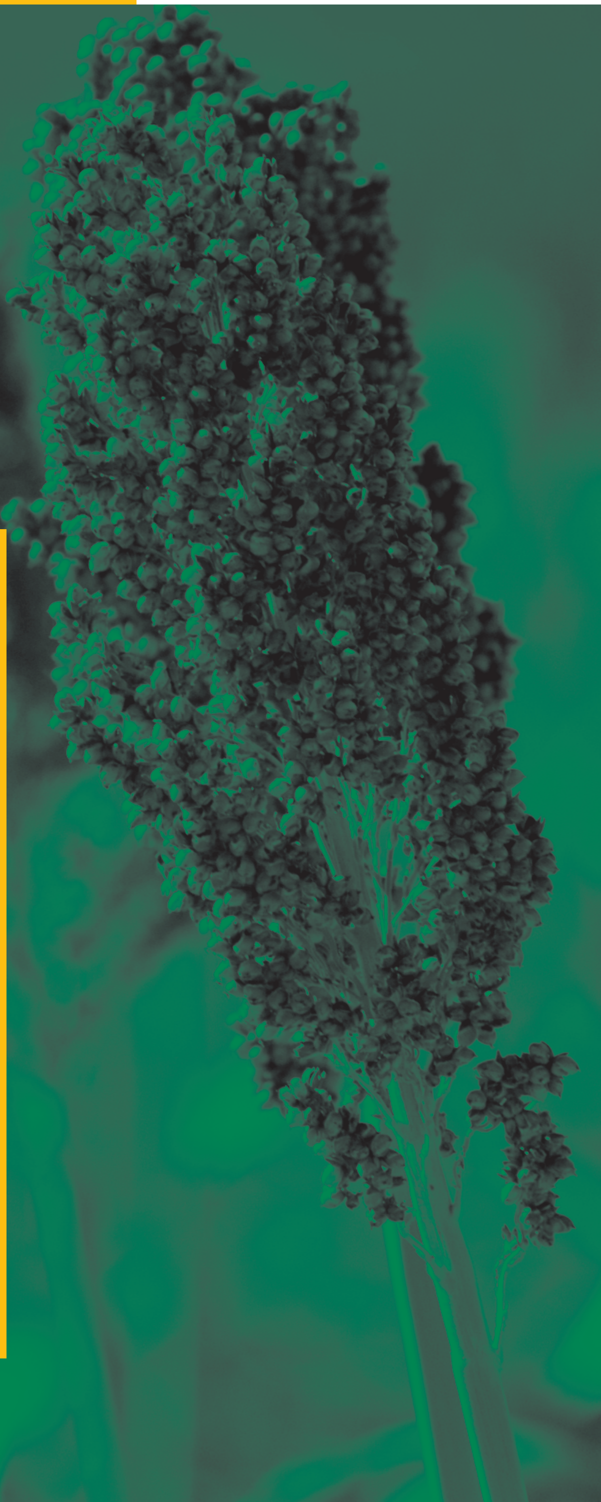
NORTHERN
FEBRUARY 2017

GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION



SORGHUM

SECTION 9

DISEASES

SORGHUM ERGOT (CLAVICEPS AFRICANA) | FUSARIUM STALK ROT (FUSARIUM SPP.) | CHARCOAL ROT (MACROPHOMINA PHASEOLINA) | RUST (PUCCINIA PURPUREA) | JOHNSON GRASS MOSAIC VIRUS | HEAD SMUT (SPORISORIUM REILIANUM) | LEAF BLIGHT (EXSEROHILUM TURCICUM)

Diseases

9.1 Sorghum ergot (*Claviceps africana*)

MORE INFORMATION

http://www.daff.qld.gov.au/plants/field-crops-and-pastures/research/sorghum-research-program

Sorghum ergot is a fungus whose spores compete with pollen at flowering. Ergots are creamy-coloured sclerotes usually smaller than sorghum seed that replace the developing seed.

Sorghum ergot has been found in late-flowering commercial grain crops in northern NSW. It has also occurred in seed production crops in the Macquarie Valley and at Boggabri, and in late-flowering forage sorghum crops in the Moree and Gunnedah districts. It is difficult to estimate the impact of sorghum ergot on yields of commercial grain crops in NSW.

The fungus infects sorghum heads at flowering and is favoured by mild temperatures (15–30°C), high humidity and overcast conditions. Ergot spores compete with pollen in the unfertilised florets, decreasing grain-set and potential yield (Figure 1). [1]

Breeding lines with high resistance to ergot have been funded by GRDC and bred by the Department of Agriculture, Fisheries and Forestry Queensland (QDAF) Sorghum Breeding team, and released under licence to the private breeding companies. If the transfer of resistance to hybrids is successful, the use of ergot-resistant lines will not only significantly reduce the risk from ergot, but also allow the broadening of planting windows. [2]

Figure 1: *Honeydew oozing on a grain sorghum head caused by* Claviceps africana *(ergot).*

Photo: QDAF Qld

1 N Moore, L Serafin, L Jenkins (2014) Grain sorghum. Summer crop production guide 2014, pp. 5–16, NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/303485/Summer-crop-production-guide-2014.pdf

2 QDAF (2011) Disease management for sorghum. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/sorghum/disease-management

9.1.1 Recommended practices to minimise risk

Agronomic practices can minimise risk of sorghum ergot:

- Sow at recommended times.
- Ensure even flowering (use press-wheels, high-germination seed, accurate seed depth control; good crop nutrition, wide row spacing (90–100 cm), especially with hybrids that tiller heavily, and consider pre-harvest kill-off of tillers using glyphosate herbicide)
- Graze forage sorghum heavily to delay flowering until after grain sorghum has flowered. This reduces inoculum levels and hence the potential for ergot infection of grain sorghum.
- Crops should be inspected for ergot 10–14 days after flowering during cool, wet weather, particularly around the edges.
- Estimate infection levels of ~100 heads (an average level of <0.3% or 1% of infected spikelet per head should be safe, depending on the intended use of the grain).
- Spray-out plants if late tillers are infected.
- Increase fan speed of headers to maximise sclerote removal during harvesting.
- Harvest heavily contaminated areas of the crop separately.
- Consider mixing ergot-contaminated sorghum with clean seed to reduce ergot sclerote levels to <0.3% or 0.1%, depending on the intended use of the grain. [3]

To reduce the risk of ergot in northern NSW, plant crops by early January so that they flower by mid-March (when the weather is hotter and drier than it is later in autumn). Crops with poor pollination risk the same infections as do forage sorghum crops, tillers of late-flowering plants, late-sown grain crops and those affected by cold temperatures during flowering.

Sorghum ergot can cause harvest delays, with the sticky honeydew clogging machinery. At levels >0.3% by weight, ergot is toxic to livestock. If precautions are in place to ensure that ergot levels are <0.3% by weight, the grain is within safe usage levels for many end-users. [4]

If planting outside the recommended window, growers need to aim for an evenly flowering crop to ensure large quantities of highly viable pollen during flowering, because flowers that are fertilised by pollen are resistant to infection by the ergot spores.

In late-planted crops, a quick-maturing, low-tillering hybrid will also help to minimise the ergot risk. Even then, ergot can develop if there is persistent rainfall during the flowering period.

Pre-harvest spraying of grain sorghum crops with a herbicide registered for that purpose (e.g. glyphosate) is commonly used to aid in rapid plant dry-down and harvesting. In ergot-affected crops, it will also assist in stopping the production of honeydew. [5]

9.1.2 The impact of wet summers

Wet summers often encourage growers to consider planting a late-summer grain sorghum crop.

However, crops planted after the end of January in southern Queensland and mid-February in central Queensland run an increased risk of ergot infection, an airborne fungal disease that is favoured by cool wet conditions during flowering.

3 QDAF (2011) Wet summers increase ergot risk in sorghum. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/sorghum/disease-management/wet-summers-increase-ergot-risk-in-sorghum

4 N Moore, L Serafin, L Jenkins (2014) Grain sorghum. Summer crop production guide 2014, pp. 5–16, NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/303485/Summer-crop-production-guide-2014.pdf

5 QDAF (2011) Wet summers increase ergot risk in sorghum. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/sorghum/disease-management/wet-summers-increase-ergot-risk-in-sorghum

In a La Niña year, the chances of these conditions occurring from April onwards, when late-planted crops will flower, are higher than in other years. [6]

9.1.3 How ergot affects the crop

The disease reduces yield through poor seed set and can cause harvesting difficulties from the sticky honeydew on the heads. Honeydew is modified plant sap, so it will be produced from infected heads for as long as the plant is alive. [7] Fungal bodies, called sclerotes, which replace the seed, are toxic to livestock, particularly cows, sows and beef cattle.

There is no known resistance to ergot in Australian grain sorghum hybrids, and fungicide control is not practical because of the high cost of the effective fungicides. Therefore, management relies on good agronomic practices.

9.1.4 Impact on animals

Research by QDAF has clearly shown that milk production in lactating cows and sows can be seriously reduced if there is >0.3% by weight of ergot sclerotes in sorghum grain.

Weight gains in feedlot cattle can be significantly impaired by even lower ergot levels of 0.1%. Limits set on ergot-infected sorghum grain intended for stockfeed reflect these critical levels. [8]

9.1.5 At harvest

At harvest, a high percentage of sclerotes are blown from the header because they are lighter than sorghum grain, so increasing the header fan speed may further reduce the levels of contamination. The worst affected parts of the paddock should be harvested last and kept separate from areas with less ergot. [9]

What to do with ergot-infected crops

Marketing options are limited for grain that is contaminated by ergot above the legislated limits. It can be mixed with clean grain to reduce the levels of contamination. Laying hens, broiler chickens and growing pigs >20 kg are generally more tolerant of ergot than other livestock, so those markets offers an option for ergot-affected grain at or near the 0.3% limit. [10]

MORE INFORMATION

vGRDC Update Paper: Disease control in summer crops and management strategies to minimise financial losses

9.2 Fusarium stalk rot (*Fusarium* spp.)

Fusarium stalk rot in sorghum is caused by a range of *Fusarium* species; however, research by QDAF has identified *Fusarium thapsinum* and *F. andiyazi* as the major species causing disease in Australia (Figure 2).

6 QDAF (2011) Wet summers increase ergot risk in sorghum. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/sorghum/disease-management/wet-summers-increase-ergot-risk-in-sorghum

7 QDAF (2011) Wet summers increase ergot risk in sorghum. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/sorghum/disease-management/wet-summers-increase-ergot-risk-in-sorghum

8 QDAF (2011) Wet summers increase ergot risk in sorghum. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/sorghum/disease-management/wet-summers-increase-ergot-risk-in-sorghum

9 QDAF (2011) Wet summers increase ergot risk in sorghum. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/sorghum/disease-management/wet-summers-increase-ergot-risk-in-sorghum

10 QDAF (2011) Wet summers increase ergot risk in sorghum. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/sorghum/disease-management/wet-summers-increase-ergot-risk-in-sorghum

MORE INFORMATION

http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/sorghum/disease-management/fusarium-stalk-rot

Figure 2: *Fusarium stalk rot causes red internal discoloration of sorghum stalks*

Photo: QDAF, Qld

9.2.1 Symptoms

The most obvious and important of symptoms is crop lodging. However an orange-red discoloration of the pith tissue inside the stalks, often centred around the nodes, also occurs. [11]

Lodging is often the first obvious sign of Fusarium stalk rot in sorghum plants, but the diagnostic symptoms of the disease are usually not evident until the plants are stressed. When a stalk infected by *Fusarium* is split lengthwise, a pink–red discoloration is evident from ground level up the stem.

Stalks can be infected by *Fusarium* but not lodge; this depends on the strength of the stalk, and on the speed at which *Fusarium* invades the stalk. The latter is influenced by the severity of the stress and perhaps by the tolerance of the hybrid. *Fusarium* or other stalk-rotting pathogens may not be the sole cause of crop lodging; physiological (non-biotic) stress factors can often be the cause. [12]

MORE INFORMATION

http://espace.library.uq.edu.au/view/UQ:270992

http://ausgrain.com.au/Back%20Issues/194ndgrn09/Nv-lodging.pdf

http://www.grdc.com.au/uploads/documents/2010ASGCPowerPointPresentationsPDF/Keller_FusariumInSorghum_slides.pdf

http://www.nga.org.au/results-and-publications/download/48/australian-grain-articles/diseases-1/fusarium-stalk-rot-of-sorghum-may-2010.pdf

9.2.2 Conditions favouring development

Fusarium stalk rot is favoured by a period of physiological stress. This may be moisture stress as a result of seasonal conditions or stress caused by the application of a desiccant. Additional research is required to differentiate between the main causes of *Fusarium* spp. and charcoal rot (*Macrophomina phaseolina*).

9.2.3 Management

Any practices that minimise moisture stress on the crop should be encouraged. However, rotation with non-host crops is also recommended. Currently, sorghum species are the only known hosts of *Fusarium thapsinum* and *F. andiyazi.* The use of desiccants is suspected of increasing crop lodging; so, when they are applied to sorghum crops, harvesting should be carried out as soon as practical. [13]

During a La Niña summer, sorghum crops are at increased risk from Fusarium stalk rot. The mild wet weather is conducive to root infection from the soil-borne *Fusarium* species, which in turn can result in increased stalk rot. Climatic stress during late

11 N Moore, L Serafin, L Jenkins (2014) Grain sorghum. Summer crop production guide 2014, pp. 5–16, NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/303485/Summer-crop-production-guide-2014.pdf

12 QDAF (2011) Fusarium stalk rot. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/sorghum/disease-management/fusarium-stalk-rot

13 N Moore, L Serafin, L Jenkins (2014) Grain sorghum. Summer crop production guide 2014, pp. 5–16, NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/303485/Summer-crop-production-guide-2014.pdf

grainfill, or after pre-harvest spraying, can lead to rapid development of stalk rot and may result in lodging. [14]

For further information see Charcoal rot 9.3.3 Management

9.2.4 Northern Grower Alliance trials

Trials were conducted by the Northern Grower Alliance (NGA) in collaboration with QDAF pathologists in the 2009–10 (two trials) and 2010–11 (one trial) seasons in northern NSW and southern Queensland to address the questions:

- Can *Fusarium* species (and *Macrophomina phaseolina*) cause yield loss in the absence of lodging?
- Is there a link between spray-out of sorghum with glyphosate and lodging?

The following treatments were used in one or more of the trials:

- four varieties in 2009–10, two varieties in 2010–11
- +/– *Fusarium* inoculum (grown on sterile pearl millet seed or stubble from infected crop) (all trials)
- +/– fungicide seed dressing (2010–11 trial only)
- +/– two fungicide sprays (2009–10 trial only)
- +/– desiccant spray of glyphosate (all trials)

In 2009–10, the roots of 20 young plants from each plot were inspected for the presence of red discoloration (a symptom of *Fusarium* infection), and 30 isolates were obtained from randomly selected plants in uninoculated plots. In all trials, ~7–10 days after glyphosate had been applied to the appropriate plots, 10 plants from each plot were cut off at ground level, the stalks split lengthwise and the numbers of discoloured internodes counted. In the 2010–11 trial, a second rating was made 24 days after the first. All three trials were harvested and the grain yield of every plot was measured.

Major findings of the trials

Inoculum

The roots of plants in all treatments in the 2009–10 trials were discoloured, including plants in treatments that had not been inoculated; either *F. thapsinum* or *F. andiyazi* was isolated from all 30 roots. This result suggests that the *Fusarium* species were already present at high levels in the soil at both sites, despite sorghum having not been grown at one site for 4 years, and in living memory at the other. In the 2009–10 trials, a similar amount of stalk discoloration occurred in the inoculated and non-inoculated plots that had been sprayed with glyphosate. In the 2010–11 trial, the mean stalk-rot severity ratings of the treatments that were not inoculated were consistently lower than those that were inoculated.

Fungicides

Neither the seed dressing treatment (2010–11 trial) nor the fungicide spray treatment (2009–10 trials) significantly reduced the incidence or severity of internal stalk discoloration due to *Fusarium* infection.

Desiccation

In the 2009–10 trials, at harvest there was little stalk discoloration in non-desiccated treatments (average 0–0.6 internodes discoloured, depending on the treatment) but significant discoloration in desiccated plots (average 6.1–9.3 internodes). Similarly, in the 2010–11 trial there was a higher mean number of discoloured nodes in every treatment that had a glyphosate application compared with the same treatment without the glyphosate application, with the differences being statistically significant

14 QDAF (2011) Fusarium stalk rot. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/sorghum/disease-management/fusarium-stalk-rot

(average of glyphosate sprayed plots 3.8 internodes, average of unsprayed plots 1.5 internodes).

Variety

Two hybrids (A and B) were common to the three trials. In all trials, hybrid A had significantly more stalk discoloration than hybrid B after the glyphosate sprays. In the 2010–11 trial, when no desiccant was applied there were no statistical differences in final stalk-rot severity between the two varieties. However, in the sprayed treatments, stalk rot developed more rapidly in hybrid B than in hybrid A, and in unsprayed treatments, the reverse was true. These results suggest that there may be differences in the response of hybrids to pre-harvest desiccant sprays.

Yield

Lodging did not occur in any of the three trials. There were no significant differences in yield between treatments in any of the three trials, indicating that Fusarium stalk rot did not cause yield loss in the absence of lodging after the soft finishes experienced in the trials. It is possible that yield losses from Fusarium stalk rot could occur in the absence of lodging during a hard finish.

Strategies for managing Fusarium stalk rot

- Agronomic practices to minimise stress need to be followed. Crops should be sown into paddocks with good soil moisture, and row spacing and plant densities should be optimum for the paddock situation to reduce moisture stress. Weeds need to be managed not only to minimise moisture stress but also to eliminate a possible method of carryover onto grass weeds of the *Fusarium* species that cause stalk rot. Despite the ability of *F. thapsinum* and *F. andiyazi* to survive for up to 3 years in infected stubble, overseas work indicates that nil or minimum tillage practices can significantly reduce the incidence of Fusarium stalk rot compared with conventional tillage practices.
- Rotations with non-host crops will reduce the build-up of the *Fusarium* species that cause stalk rot. Based on current knowledge, sorghum species are the only known hosts of *F. thapsinum* and *F. andiyazi*, the dominant species causing stalk rot in the northern grains region. Although maize has not been recorded as a host of *F. thapsinum* in Australia, it is possible that the pathogen could survive on maize stubble, based on overseas reports. Evidence from the 2011 season indicates that the wheat head blight fungus, *Fusarium graminearum*, can colonise sorghum plants when there are high inoculum levels in the field and prolonged wet weather during flowering. Therefore, care should be taken when using sorghum in rotation with wheat in regions where the climate favours the carryover of high inoculum levels of *F. graminearum*.
- The use of desiccant herbicide to aid in harvesting should be carefully evaluated in paddocks where sorghum stalk-rotting pathogens have been found in the past. The desiccant herbicide must be applied when >95% of the seed is at the 'black layer' stage, because there is some evidence that lodging is more likely to occur the earlier that crops are sprayed. Prompt harvesting after desiccation will minimise the impact of lodging if stalk-rotting pathogens are present. Results from the 2010–11 trial indicate that Fusarium stalk rot can also develop in the absence of desiccation, so harvesting should not be delayed even when crops are not sprayed out.
- Lodging resistance is a major trait that seed companies select for in their development of new hybrids. Selection sites may or may not have a history of *Fusarium* or charcoal rot infection, so resistance to the stalk-rotting pathogens may or may not be a component of lodging resistance. There is evidence that hybrids with good 'staygreen' resistance have a better tolerance to invasion by *Macrophomina phaseolina* than 'non-staygreen' hybrids, but there is no clear evidence that it confers tolerance to stalk invasion by *Fusarium* species. Preliminary work conducted in conjunction with NGA suggests that commercial

MORE INFORMATION

http://www.nga.org.au/results-and-publications/download/48/australian-grain-articles/diseases-1/fusarium-stalk-rot-of-sorghum-may-2010.pdf

http://www.nga.org.au/results-and-publications/download/48/australian-grain-articles/diseases-1/fusarium-stalk-rot-of-sorghum-may-2010.pdf

PODCAST

Arthur Gearon grower at Chinchilla Queensland and GRDC northern panellist discusses the impact of charcoal rot on sorghum yield and management options. GRDC Podcast: 122 The Right Water - the missing ingredient in successful spraying

hybrids differ in their tolerance to the development of Fusarium stalk rot; this area of research needs further investigation. [15]

9.3 Charcoal rot (*Macrophomina phaseolina*)

Charcoal rot in sorghum is caused by the soil borne fungus *Macrophomina phaseolina* and is a major stalk rotting disease in sorghum which can lead to plant lodging. The causal agent, *M. phaseolina* can infect via the roots of sorghum plants at almost any stage of plant growth, but develops more rapidly in plants closer to maturity.

The fungus is widely distributed throughout Australia infecting the root and stems of over 400 plant species (all major summer field crops and many summer and winter weeds). The microsclerotes can survive in the soil and on stubble for >4 years. It is uncertain what soil conditions are necessary to reduce the survival of microsclerotes in Australia but overseas studies indicate wet soil can significantly impede their survival. [16]

9.3.1 Symptoms

The pathogen is easily identifiable when stems are split longitudinally. The characteristic appearance of black microsclerota (resting bodies) in the vascular tissue and inside the rind of the stalk results in a 'peppered' look in conjunction with shredded internal vascular tissue which is grey/charcoal in colour.

9.3.2 Conditions favouring development

Extensive colonisation of stem tissue generally occurs post flowering when plants are placed under a stress, such as unfavourable environmental conditions, particularly hot, dry conditions. This can be further exacerbated by the application of defoliants which also act as a stressor, further promoting growth and invasion of the stem. [17]

9.3.3 Management

Management strategies for *Fusarium* stalk rot and charcoal rot are closely related. There are no effective foliar fungicides for either disease. Management strategies that need to be taken into consideration include the following: [18]

- Soil moisture—planting into adequate soil moisture and ensure row spacing and plant populations are suitable for the field and seasonal situation, to minimise possible post flowering moisture stress.
- Adequate nutrition—application of adequate fertilisers should be exercised to maintain plant health and vigour reducing nutrient related stress. More specifically, excessive N and low levels of K should be avoided.
- Crop rotations—rotating out of susceptible crop hosts can be effective in reducing the build-up of *Fusarium* and/or *M. phaseolina* which may have occurred in mono-cropping systems. Currently, the host range of *F. thapsinum* and *F. andiyazi* is thought to be limited, providing a number of options for rotations. However, alterations and additions to the list are possible as maize is thought to host *F. thapsinum* at low levels and more recently a survey overseas has found infection of *F. thapsinium* on soybean seed. In Australia, surveys and research into possible hosts, including the role of stubble from alternative non-hosts is still ongoing. Rotating out of susceptible crop hosts is more difficult with

15 M Ryley, L Kelly, L Price (2011) Fusarium stalk rot in sorghum types, damage and management. GRDC Update Papers 13 September 2011

16 J White, S Thompson, M Ryley, S Blake, C Douglas (2015) Disease control in summer crops and management strategies to minimise financial losses, GRDC Update Papers 31 July 2015, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/Disease-control-in-summer-crops-and-management-strategies-to-minimise-financial-losses

17 J White, S Thompson, M Ryley, S Blake, C Douglas (2015) Disease control in summer crops and management strategies to minimise financial losses, GRDC Update Papers 31 July 2015, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/Disease-control-in-summer-crops-and-management-strategies-to-minimise-financial-losses

18 J White, S Thompson, M Ryley, S Blake, C Douglas (2015) Disease control in summer crops and management strategies to minimise financial losses, GRDC Update Papers 31 July 2015, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/Disease-control-in-summer-crops-and-management-strategies-to-minimise-financial-losses

M. phaseolina due to its extensive host list. Overseas research suggests that the build-up of microsclerotes is less in some hosts than in others; in some U.S. trials the number of microsclerotes in the soil after several crops of sorghum was less than the numbers after maize or soybeans. This type of rotational farming systems work has not yet been conducted in Australia.

- Use of lodging resistant, drought tolerant, non-senescent varieties. In the absence of information regarding the genetics for resistance for *M. phaseolina* and *Fusarium*, which are not well understood, the use of cultivars which include some or all of the combined characteristics (drought tolerance, staygreen, standability) may reduce the development of disease, particularly charcoal rot. While evidence has previously shown that staygreen lines have a better tolerance to *M. phaseolina* invasion than senescent lines, there is no conclusive evidence yet to suggest that this holds true for *Fusarium* species. Preliminary results from field trials where cultivars were colonised with both *M. phaseolina* and *Fusarium*, demonstrate that assessment of disease levels based on internal lesion lengths correlated well with assessments for lodging. However, the absence of lodging does not preclude high incidence levels of either disease, which means caution should be taken to avoid build-up of disease unknowingly, particularly in monoculture systems.
- Application and timing of desiccant and harvest. Timing of application of a desiccant must be assessed with a number of factors in mind. Early application of a desiccant can increase stress and lodging potential (if applied when <95% seed are at black layer) as much as a desiccant applied too late, particularly if lodging is already occurring and disease incidence is high. Timely harvest once application of the desiccant has been applied is essential. Preliminary results demonstrate some varietal differences in reaction to application of a desiccant which needs further investigation to determine its role, if any in affecting structural integrity of the stem.

9.4 Rust (*Puccinia purpurea*)

9.4.1 Symptoms

Early symptoms on leaves are small purple–red or tan spots. These enlarge to produce elongated raised pustules that break open to release brown, powdery masses of spores.

Sorghum rust is more serious in late-sown crops or susceptible hybrids in humid areas. If the disease is serious, leaves are destroyed and pinching of the grain results. Select hybrids with resistance for late planting.

Leaf rust is a serious disease in susceptible hybrids in humid coastal areas. The incidence of leaf rust in northern NSW has increased in recent years.

9.4.2 Conditions favouring development

The spores germinate on wet leaves, penetrating the leaf and will then take ~10–14 days for the pustules to appear. The spores are primarily dispersed by wind. Little is known about the fungus but suggestions are that the rust tends to occur in cool wet conditions.

9.4.3 Management

Although rust often appears in autumn at the end of grainfill in northern NSW, it does not usually reduce yields. If severe it can reduce yields and contribute to lodging in susceptible hybrids. [19]

19 N Moore, L Serafin, L Jenkins (2014) Grain sorghum. Summer crop production guide 2014, pp. 5–16, NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/303485/Summer-crop-production-guide-2014.pdf

9.5 Johnson grass mosaic virus

9.5.1 Symptoms

Symptoms of this virus are a mosaic (light and dark-green lines on veins):

- red leaf (severe leaf reddening, followed by formation of red spots or large areas of dead tissue)
- red stripe (red or tan stripes parallel to the veins)

Hybrids developing red leaf or red stripe reaction should not be sown late, as the disease can be serious, causing stunting and death in some plants. The virus is spread from plant to plant by aphids.

Control by planting resistant hybrids. A strain of the virus exists in south and central Queensland that can infect resistant hybrids. [20]

9.6 Head smut (*Sporisorium reilianum*)

9.6.1 Symptoms

Symptoms appear at the booting stage when the head is replaced by a mass of black spores enclosed in a white fungal membrane:

- This membrane ruptures on emergence of the head and releases the spores.
- Partially affected heads are sterile.

Head smut is a soil-borne disease favoured by cool weather. It may also be introduced on the seed. Control by sowing resistant hybrids. Also avoid sowing susceptible hybrids in cool weather. [21]

9.7 Leaf blight (*Exserohilum turcicum*)

9.7.1 Symptoms

Symptoms are large elliptical spots up to 20 mm wide and 100 mm long, initially water-soaked, but drying to straw-coloured spots with red, purple or tan margins, depending on the hybrid.

Spores produced on leaf spots during moist weather are spread by wind. The fungus survives on undecomposed sorghum residues, volunteer sorghum plants and Johnson grass. Severe disease can cause pinched grain and lower yields. The disease may be serious on susceptible hybrids under humid conditions and in coastal areas.

Control by sowing resistant hybrids where the disease may be a problem. [22]

20 QDAF (2011) Disease management for sorghum. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/sorghum/disease-management

21 QDAF (2011) Disease management for sorghum. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/sorghum/disease-management

22 QDAF (2011) Disease management for sorghum. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/sorghum/disease-management