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Sorghum Grain Mold: Sustainable Pest Management Strategies

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Healthy (left) and grain mold infected (right) sorghum heads (Courtesy of Gary Odvody)

> Globally, grain mold is one of the leading constraints to the production of sorghum.

Sorghum head with severe grain mold infection resulting in 100% yield loss (Courtesy of Gary Odvody)

Global losses due to grain mold are estimated to be $130 million annually. Sorghum grain mold is caused by a complex of fungal species, the most important being *Fusarium thapsinum* and *Curvularia lunata.* An additional 25 fungal genera are secondary invaders. Grain mold reduces the quantity of food available, as the fungus consumes a portion of the grain, and reduces the quality and economic value of what remains by producing pigments and toxins that make the grain less palatable and nutritious. *Fusarium* spp. and the secondarily invading *Aspergillus* spp. may produce toxins such as aflatoxins (a highly carcinogenic and toxic secondary metabolite chemical), fumonisins and moniliformin which reduce the quality of the grain as a food/feed source. The toxins are associated with a variety of human and animal health problems including acute toxicity and death, birth defects, increased disease susceptibility and reduced growth in infants and children. Fungi that cause grain mold are also linked with stand establishment problems because the infected seeds produced often germinate poorly and the seedlings may be killed by the fungi that accompanied the seed.

Grain mold on sorghum reduces yield and seed quality as it discolors both the inside and outside of the grain (see photos). Effects range from cosmetic deterioration of the pericarp to substantial deterioration of the endosperm and embryo which reduces the protein content and the acceptability by food and feed

Grain mold infected sorghum heads (left and right) and healthy sorghum heads (middle) (Courtesy of Gary Odvody)

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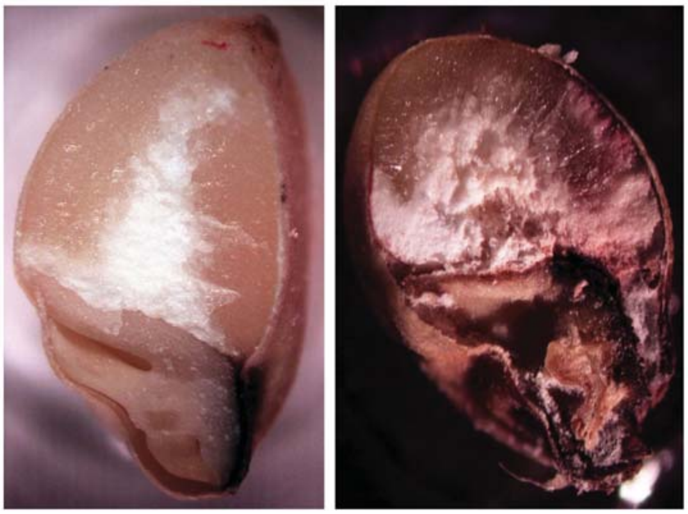
Healthy SC170 sorghum grains (left) and SC170 grains infected with the primary fungal grain mold pathogens *Fusarium thapsinum* (center) and *Curvularia lunata* (right)

***Aspergillus* as seen under an electron microscope**

Structure of aflatoxin B1



Healthy (left) and molded (right) cross sections of sorghum cultivar Tx430 caryopses (grains). Note deterioraton of the embryo and endosperm which negates the value of grain to food and feed processors.

processors. There is a distinct diversity in the appearance of the various grain mold pathogens as indicated in the photo below. The genetic diversity complicates the breeding of sorghum for resistance to the fungi.

Currently recommended control methods, including host plant resistance, have had limited success in significantly reducing grain mold in farmers' fields. Thus, INTSORMIL scientists are searching for novel approaches to effectively manage grain mold. Two control approaches are being tested by INTSORMIL PIs John Leslie and Chris Little, Kansas State University plant pathologists; (1) a competition approach known as "competitive exclusion" and (2) the use of the fungus's own sex pheromones as a growth inhibitor.

The ***competitive exclusion*** is a type of biological control in which a fungal strain such as *Aspergillus* AF36, that does not produce aflatoxins (atoxigenic strain), competes with the toxigenic *Aspergillus* strains for infection sites on the plants. Artificial infection with the atoxigenic strain overwhelms the fungal population and the toxigenic strains. With less infection by the toxigenic strains fewer toxins are produced in the plant or the grain. The atoxigenic strain may be applied as a pesticidal spray to sorghum heads, but is more likely to be applied as a pretreatment when the field is fallow or freshly plowed. When applied to the soil, the atoxigenic strains may persist in sufficient numbers to provide control for several years. *Aspergillus flavus* AF36 is an EPA registered biocompetitive pesticide which is used to treat cotton fields in Arizona to prevent contamination of cottonseed with aflatoxin. Leslie's group is currently identifying and testing various strains and species of *Fusarium* associated with sorghum to see if they can competitively displace the normal sorghum fungi. The most effective atoxigenic strains will be selected for testing as biocontrol agents. In such cases, inocula could be produced at a relatively low cost. Although significant and important single season effects can be achieved with this strategy, the greatest potential is in long-term and area-wide influences. These long-term effects offer potential to modify fungal communities distributed across entire agricultural areas.

Diversity of *Fusarium* spp. isolated from naturally molded (field collected) sorgum caryopses

The second strategy involves the use of the ***fungal sex pheromones*** which block or retard spore germination thereby providing time for the plant to progress to a stage where it escapes the disease altogether. The pheromones are small peptides, 10-12 amino acids in length, that are cut from longer polypeptides before being released into the environment. The peptides could be applied as a conventional spray. However, a long term objective is to incorporate, via plant transformation technologies, a gene into sorghum that could retard or inhibit the germination of *Fusarium* spores by producing in situ peptides that are related to the fungal sex pheromones. Providing host resistance to grain mold in this way would be an effective method of control.

Both strategies are likely to be sustainable as they rely on fundamental characters of grain mold fungi that are difficult to alter. Reduced mycotoxins in the grain will improve the nutritional quality of sorghum and millet and reduced disease pressure will increase the grain yield and yield stability. Development and transfer of these strategies to farmers will have a significant impact on improving food security, especially in regions of the world, such as Africa, where sorghum serves as a major form of human food and as a feed grain for livestock and poultry.

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