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Understanding Fumonisin Contamination of Corn: Contrasts and Comparisons With Aflatoxin

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Fumonisins are toxins produced by a few species of fungi in the genus *Fusarium*. They are carcinogens and can cause illness in livestock, particularly in horses. The primary corn-infecting producers of fumonisin are *Fusarium verticillioides* (older name is *F. moniliforme*) and *F. proliferatum*. Not all strains of these fungi produce fumonisin and of those that do, there is variation in relative amounts produced. Similarly, there is great variation in the toxigenicity of strains of the fungi, *Aspergillus flavus* and *A. parasiticus*, which produce the aflatoxins. This variation in the toxin-producing ability (be it aflatoxins or fumonisins) of strains can partly explain the variability of mycotoxin contamination in different areas of the state or even among fields within a particular growing area.

Fusarium verticillioides is more prevalent on corn growing in southern states, as compared with the midwestern states, where other *Fusarium* species occur more frequently. Like *A. flavus*, which is the predominant species of *Aspergillus* on corn in Texas, *F. verticillioides* is adapted to warmer climates.

A. flavus is a weak pathogen. Under drought conditions, it can cause an ear rot, producing obvious light green, fuzzy growth on kernels. Damage to the ear and particularly to the kernels is generally required before infection can occur. In contrast, *F. verticillioides* is more capable of growing into non-injured plant tissue. It causes an ear rot during periods of wet weather. The symptoms of this ear rot are a white growth on kernels, as well as white streaks on the kernel that have a radiating pattern (known as "starburst"). *F. verticillioides* also causes a stalk rot.

While *A. flavus* infects the seed, it is not a seed-borne pathogen. Thus, the fungus within seed can not infect the crop that develops from planted seed. *A. flavus* is a soilborne pathogen. The fungus survives between crops as spores or other resting structures (sclerotia) associated with crop debris. Spores originating from crop debris, either within a field, or blown by the wind from adjacent fields, infect corn during or after flowering. *F. verticillioides* is seedborne and the fungus can grow without producing symptoms within stalks and leaves of the growing plant, although these infections do not frequently lead to kernel infection. However, *F. verticillioides* is also a soilborne pathogen. Crop residue is a major source of spores that infect the kernels. Additionally, spores can be produced on infected tassels and these spores can also be dispersed within a field, either by wind or splashing water.

Both pathogens can infect and grow down the silks of intact ears, into the vicinity of kernels. The major difference is that *F. verticillioides* can grow into intact kernels, while *A. flavus* infrequently does so. Typically, *A. flavus* entry requires a wound,

either an injury caused by insects, or cracks in the pericarp caused by drought stress. However, fumonisin contamination can be more severe in association with insect injury. *F. verticillioides* can take advantage of wounds that insects create, and insects can move this fungus around. Higher levels of fumonisin are associated with damaged kernels, as compared with intact kernels.

With both pathogens, a kernel can be infected, can have mycotoxin present, and yet show no symptoms. Kernels may be infected, but the mycotoxin may not be present. Mycotoxin production following seed infection are affected by weather conditions in the field. Additionally, mycotoxins can increase after harvest if grain is stored at improper moisture contents and/or temperatures.

In Texas, field temperatures are usually suitable for growth of both *A. flavus and F. verticillioides*. In the kernel, aflatoxin is produced at lower moisture contents than fumonisin. For aflatoxin production, the optimal kernel moisture is 18%, with a range of roughly 16-20%. With fumonisin, the highest levels were seen with 20% moisture, and production (as well as fungal growth) ceased at less than 18%.

In one study of *F. verticillioides*, the fungus was detected in corn 4-5 weeks after flowering, and fumonisin was detected one week after appearance of the fungus. Infection with *A. flavus* can start at the time of flowering, and aflatoxin accumulation occurs quickly after infection and can continue through the growing season.

Studies of simultaneous inoculation of ears with both these pathogens showed that *F. verticillioides* is a better competitor than A*. flavus*. The consequence was that *F. verticillioides* reduced *A. flavus* colonization and subsequent aflatoxin production. Under field conditions, spores of both pathogens may not simultaneously be present. The fate of the crop depends upon weather conditions, as they affect availability of fungal spores and the susceptibility of the plant. Dry weather conditions, particularly drought, favor aflatoxin contamination because injury to the kernel predisposes it to fungal colonization. Wet weather conditions can favor fumonisin contamination, in part, because of a greater dispersal of spores.

As is the case with aflatoxin, the level of contamination with fumonisin can vary from kernel to kernel. This variation can confound subsequent detection of contamination if care is not taken with sample size and sampling technique.

As is the case with aflatoxin, the occurrence of fumonisin contamination will vary from season to season. Control of pre-harvest contamination is also difficult. There are no commercial hybrids with natural resistance to fumonisin, but there are differences in accumulation in hybrids. This has also been observed with aflatoxin (but with different hybrids). Although it is possible to breed for resistance to Fusarium ear rot, it is more difficult to evaluate genotypes for resistance to a problem that is, like aflatoxin contamination, not visible in the field. Fumonisin contamination has been lowered, but not eliminated, in field trials, using transgenic hybrids (Bt corn). Total elimination will not occur because, as is the case with aflatoxin contamination, insects are not the sole or the most important predisposing factor. There is more basic research underway for control based on competitive exclusion, utilizing an endophytic *Bacillus* sp. and non-toxigenic isolates of *F. verticillioides*. Since there is a high association of fumonisin with broken kernels, it may be possible to reduce levels in contaminated grain by removing them.

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