PLANT PATHOLOGY SERIES

TIMELY INFORMATION

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Managing Aflatoxins in Corn

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Aflatoxins are naturally occurring toxic compounds that are produced by *Aspergillus flavus* and related fungi. These fungi are found everywhere-- in soil, plant debris or other rotting vegetative material; however, they are most often associated with corn grain, peanuts and cottonseed. Following seed and ear infection, these fungi produce aflatoxins which accumulate in grain. Ingestion of aflatoxin contaminated grain and feed can be toxic, especially to poultry and young animals. Therefore, feed and grain is routinely tested for the presence of these compounds, and contaminated grain may be rejected at a buying point.

Figure 1

Fungi that produce aflatoxins will readily infect corn by means of airborne spores. These spores move readily through the air, on breezes and winds, which makes control difficult. Kernel infection in the field can occur through the silk, cob, or by direct contact. Infection of kernels can happen in the field during grain filling or post-harvest during storage and handling. In severe cases, the olive-green mass of hyphae and spores of *A. flavus* may sometimes be seen covering the kernels under the husk of field corn (Figure 1).

Aflatoxin contamination is more likely in Alabama and other parts of the Southern US than in the Corn Belt because of the prevailing climate.

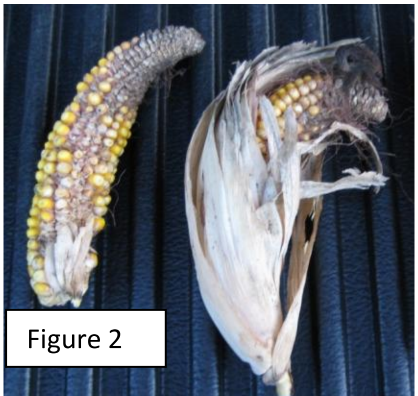

Figure 2

Figure 3

High temperatures favor the growth of the fungi and production of aflatoxins. Dry weather patterns stress plants such that infection by these fungi is more likely to occur. In addition, kernel damage attributed to insect pests such as stink bugs (Figure 2), corn earworm (Figure 3), and corn weevils is closely linked with *A. flavus* colonization and subsequent aflatoxin contamination. Finally, there is little if any hybrid resistance to infection by these fungi and the few decontamination processes that have been proven successful have not been granted federal approval for use.

Stressful Conditions

The south's climatic conditions are such that there is a potential for aflatoxin in corn almost every year. Historically, aflatoxin problems have been greatest during years when severe summer droughts were accompanied with high temperatures. Insect damage to ears and stalks has also been associated with increased aflatoxin levels.

In order to minimize the likelihood of high aflatoxin contamination in a corn crop, it is important to use sound agronomic practices during crop production, and to properly dry and store grain.

Cropping Decisions

Among the first choices to be made for minimizing aflatoxins in corn is which cultivar to plant. Currently, no cultivars are known to be resistant to fungal infection or aflatoxin accumulation. However, a well-adapted variety will withstand normal stresses better than a non-adapted hybrid. For Alabama, some hybrid comparisons can be found in the annual report "Evaluations of Corn Hybrids in Alabama" found through the Alabama Crops Portal. Since ear damage by insects can contribute to aflatoxin problems, varieties with selected Bt traits, particularly the VT3 Pro technology, may have fewer issues with aflatoxin contamination. It is important to keep in mind, however, that the occurrence of aflatoxins in corn is a complex, and the presence of Bt traits will not provide complete control. More information concerning the Bt traits in corn and their range of activity can be found in the ACES publication "2010 Buyer's Guide for Bt Corn in Alabama." Drought tolerance and, if known, a tight ear husk can also contribute to aflatoxin minimization.

Planting time is also an important decision relative to minimizing aflatoxins in corn. One report recently noted that a critical period for stress on corn occurs between 65 and 85 days after planting (Hawkins et al., 2008). In general, the more days during this period with average daily temperatures exceeding 77°F, the greater the risk of an aflatoxin problem. Table 1 provides some information about when daily temperature averages 77°F or higher might occur in different parts of Alabama. It may be possible to avoid temperature stress through 85 days after planting by planting earlier rather than later within the recommended intervals and by planting a cultivar with early maturity.

Table 1. Dates for normal daily averages ≥ 77° F and record high temperatures ≥ 95° F for four Alabama locations.

Location	Recommended planting dates	Normal period when daily average is ≥ 77 F	Earliest and latest recorded dates when daily maximum ≥ 95 F.
Decatur	25 Mar – 15 May	29 June – 10 Aug	13 May, 6 Oct
Montgomery	15 Mar – 30 Apr	10 June – 11 Sept	11 May, 21 Sept
Dothan	1 Mar – 20 Apr	30 May – 9 Sept	2 May, 5 Oct
Mobile (airport)	1 Mar – 20 Apr	31 May – 15 Sept	10 June, 19 Sept

Adequate nitrogen fertility is essential for maximizing corn yield. There have also been reports (Tubajika et al., 1999; Blandino et al., 2008) that appropriate nitrogen levels can contribute to minimizing the risk of aflatoxin contamination in corn. Specifically, in Louisiana it was shown that aflatoxin content of grain decreased with increasing amount of N fertilizer applied to corn at the six-leaf stage (Table 2). It should be noted that the weather during this study was warm (from 30 to 90 DAP, daily temperatures averaged 74.5° and 81° F in each of two study years) and aflatoxin contamination was excessively high.

Table 2. Amount of nitrogen fertility and relative aflatoxin content in corn, as reported By Tubajika et al., 1999.

Nitrogen fertility*	Relative aflatoxin content in grain
0	100%
10 lb starter	80%
50 lbs at 6-leaf stage	72%
100 lbs at 6-leaf stage	62%
224 lbs at 6-leaf stage	41%

*Pounds actual nitrogen per acre.

Other plant stresses that could affect aflatoxin problems, especially when weather might be marginal for an optimal crop, include weed problems and excessive plant populations. However, there have not been any conclusive reports showing that weedy fields or high plant densities consistently have higher levels of aflatoxin contamination.

In addition to temperature stress, as noted above, moisture stress can affect aflatoxin in corn. A corn plant's need for water is greatest from silking to early dent, and as much as 2 inches of water per week may be required by the plant. Table 3 provides some detail indicating that the overall chance of drought occurring during the months of corn growth is about 38%.

Table 3. For May, June and July, the number of years from 1995 through 2009, when total monthly rainfall was less than 3 inches.

	May	June	July
Belle Mina	8 out of 15	7 out of 15	8 out of 15
Sand Mountain*	2 out of 9	5 out of 9	3 out of 10
Fairhope	7 out of 15	5 out of 15	0 out of 15

*no rainfall data available before 2000.

Aflatoxin Suppression

Although aflatoxins are produced by fungi, fungicides have never proven effective for preventing *A. flavus* colonization of the grain or preventing aflatoxin formation. However, in recent years, biological control has shown some promise in minimizing aflatoxin contamination in several crops (Isakeit et al., 2008) including corn and peanut. This biological product contains a strain of *A. flavus* that does not produce any toxins, i.e., it is atoxigenic. When this atoxigenic *A. flavus* is applied to corn, the naturally-occurring aflatoxin-producing *A. flavus* strains are displaced by the introduced strain and less likely to infect the grain. This product is sold as Aflaguard® and its efficacy needs to be demonstrated throughout Alabama. For effective suppression of the aflatoxin-producing strains of *A. flavus*, aerial application of 20 pounds per acre of Alfaguard® should be made just before tasseling and active silking occurs. Optimum results will be obtained if application is made when abundant moisture is available, such as soon after a rain or irrigation. While Alfaguard® does not prevent aflatoxin accumulation, toxin concentration in grain is greatly reduced.

Harvest Timing

Producers may reduce the continued accumulation of aflatoxin in corn grain in the field by harvesting corn before it reaches the industry standard of 15.5 percent moisture. Corn reaches physiological maturity at about 30 percent moisture and can be harvested any time thereafter.

Detection

Methods historically used for aflatoxin detection range from visual observations to complex lab analyses. Observation and recognition of the aflatoxin-producing fungi on corn grain is a 'first alert' for the problem, but these fungi are not always easy to find. Historically a "black light" test was used to detect fungal metabolites in corn and other grains. However, fluorescence that might be seen in corn under black light is not due to aflatoxin presence, but to another metabolite called 'kojic acid.' Kojic acid detection with a black light could indicate that aflatoxigenic fungi had infested the grain and that aflatoxins might also be present, however, additional chemical analyses should be done to ascertain aflatoxin levels.

Chemical analyses can be performed on request by a number of certified labs, such as those run by state departments of agriculture. There are also a number of commercially available test kits that are approved for aflatoxin determination by the USDA Grain Inspection, Packers and Stockyards Administration (USDA-GIPSA, 2009).

Sampling and Testing

Aflatoxin detection is extremely variable due to the fact that very few kernels (less than 0.1%) are normally contaminated with aflatoxin. These few contaminated kernels, however, can have extremely high concentrations of aflatoxins. For example, in a study published in 1975 (Anderson et al., 1975), two corn kernels were found to contain 601,600 ppb aflatoxin. If these were the only two kernels with aflatoxin in 100 lbs of corn, the whole batch of corn would have been acceptable for feed with $\leq$ 20 ppb contamination. However, if the sampling process happened to catch these two kernels, the 100 lbs would be rejected from further processing.

Sampling processes are improved when proper techniques are used and large sample sizes are collected. USDA-GIPSA (2009) requires at least a two pound sample of corn be collected from a truck, and increasing sample sizes are required from larger loads. This 2 lb. sample should actually be collected by taking several subsamples from the single truck, and each of these subsamples should be taken from different places and at different depths in the grain.

The entire sample (i.e., 2 lbs from a truck) should be ground before subsamples for assays are removed. This improves distribution of contaminated particles to a subsample. Testers may also grind particles finer, increase the size of the subsample, and increase number of analyses per sample to reduce variability. The latter two recommendations, however, will increase the time and expense involved with the analytical procedure and may be impractical in some situations.

Action Levels

The United States Food and Drug Administration action levels for corn contaminated with aflatoxin establish guidelines for specific uses. Research indicates that aflatoxin-contaminated corn within these action levels will not injure the health of specific animals listed or humans consuming foods derived from these animals.

FDA action levels for aflatoxin-contaminated corn include the following:

Maximum level	**Use**
20 ppb:	Human food, feed for immature animals (including poultry) or dairy animals, or unknown destination
100 ppb:	Feed for breeding cattle, breeding swine, or mature poultry
200 ppb:	Feed for finishing swine of greater than 100 pounds
300 ppb:	Feed for finishing beef cattle

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