Reducing Aflatoxins in Groundnuts through Integrated Management and Biocontrol

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The groundnut, or peanut (*Arachis hypogaea* L.), is an important food and fodder crop in the farming systems of developing countries. The seed is high in oil (close to 50 percent for many varieties) and protein (~26 percent) and an important source of vitamins and dietary fiber. Groundnuts, like all legumes, are also important due to their ability to fix atmospheric nitrogen, a critical and often limiting nutrient for crops in degraded soils. Global groundnut production is concentrated in Africa (40 percent) and Asia (55 percent). As discussed in other briefs in this series, high aflatoxin levels pose human health risks and are also a barrier to expanding trade in and commercial use of groundnuts and other crops.

Aflatoxins in groundnuts

Aflatoxins are chemical metabolites naturally produced by the soilborne saprophytic fungi *Aspergillus flavus* (*A. flavus*) and *A. parasiticus* (or less commonly by *A. nomius*) that contaminate groundnuts and other crops in the field or during post-harvest handling. Contamination varies from year to year as well as within the field and is particularly high when plants are exposed to stresses toward the end of the growing season. Preharvest infection and aflatoxin contamination often occur when the plant is exposed to moisture and heat stress during pod development, when pods are damaged by insects or nematodes or when they are mechanically damaged during cultural operations. Due to the reliance on rainfall for watering crops and the recent variations experienced with weather patterns, these conditions commonly occur. Postharvest infection in groundnuts is influenced by shelling methodology, relative humidity, temperature, and insect damage. Some strains of *A. flavus* also produce cyclopiazonic acid (CPA), a harmful mycotoxin that is currently not regulated (Abbas et al. 2011). In most developing countries the level of aflatoxin contamination is extremely high. For example, results of recent studies in Mali have shown levels of contamination in groundnuts in excess of 3,000 parts per billion (ppb) with a mean contamination of 164 ppb (Waliyar et al., forthcoming). These levels are much higher than international standards allow for human consumption (4 ppb in the EU and 20 ppb in the United States). Results from Mali have revealed that only 30–55 percent of all groundnut products are safe to eat by EU standards (Waliyar et al., forthcoming). Further, results from our studies in Mali show that granaries have a significantly higher aflatoxin load during the storage period (October to June) due to high moisture and temperatures recorded during this time of year (IFPRI 2012). It is thus imperative to improve management of aflatoxins in groundnuts for food, health, and nutritional security.

Management of aflatoxins

Several approaches to reducing aflatoxin contamination have been proposed (Table 1). The rationale for most aflatoxin management practices relates to the effective management of moisture, particularly after the cessation of rains, to ensure that plants will not undergo moisture stress. It is also important to ensure that pods are well formed and not breached by pathogens or insects. On-farm tests have been conducted in several countries in Asia and Africa to investigate not just technologies, such as the use of varieties that are tolerant of or resistant varieties to *A. flavus*, but also cultural practices, such as the use of soil amendments, and postharvest handling on yield and aflatoxin contamination.

Tolerant varieties

Rural farmers in developing countries are often resource poor and have a limited ability to implement integrated management approaches. Host plant resistance, when combined with pre- and post-harvest strategies, is thus often the most practical and effective approach. For the past decade, breeding groundnut varieties resistant

TABLE 1 Good agricultural practices (GAPs) for aflatoxin management

Preharvest GAPs	At-harvest and postharvest GAPs
• Use of *A. flavus* resistant/tolerant varieties	• Harvesting the crop at the correct maturity
• Selection of healthy seeds	• Use of water-harvesting to preserve available moisture
• Early planting	• Use of *A. flavus* resistant/tolerant varieties
• Avoidance of mono-cropping	• Avoidance of damage to pods during harvest
• Application of *Trichoderma* at 1 kilogram/hectare	• Drying seed to 8 percent moisture level
• Plowing before sowing	• Stripping the pod immediately after drying
• Appropriate weeding	• Removing immature pods attached to the haulms
• Application of farmyard manure at 2.5 tons/hectare before planting	• Removing damaged, shriveled, and immature pods
• Treatment of foliar diseases using 1–2 sprayings of Kavach	• Not mixing clean harvested pods with gleaned pods
• Application of lime or gypsum at 400 kilogram/hectare at flowering	• Avoidance of re-humidification of pods during shelling or in storage
• Mulching with crop residues at 40 days after planting	• Fumigation of pods with insecticide to avoid insect damage during storage
• Maintenance of optimal density of plants in the field	
• Avoidance of end-of-season drought through irrigation (if possible)	
• Removal of dead plants from the field before harvest	

Source: Authors' compilation, 2013.

to *A. flavus* infection has been a focus of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). A number of varieties with resistance to or tolerance of *A. flavus* infection and aflatoxin contamination have been released or are in various stages of testing. Study results indicate that, despite high variation in *A. flavus* infection and subsequent aflatoxin incidence, significant improvement in the level of varietal resistance (less than 20 ppb contamination) is possible because we were able to identify varieties that showed less than 4 ppb aflatoxin—in comparison to susceptible varieties with more than 2,000 ppb. Breeding efforts have focused on reducing groundnut maturity periods to escape end-of-season drought, and the emphasis has been on the identification of short-duration farmer-preferred lines with resistance to or tolerance of *Aspergillus* spp.

Preharvest management

A number of agronomic practices minimize preharvest infection by *A. flavus* (Table 2). Among them are the applications of lime (or any calcium source) and farmyard manure (FYM). Studies have shown that application of lime alone can reduce aflatoxin contamination by 72 percent, while application of FYM reduces aflatoxins by 42 percent under field conditions. When combined, the two treatments result in aflatoxin contamination being reduced up to 84 percent.

At-harvest and postharvest management

Cultural practices, starting with harvesting the crop at the right maturity and wind row drying, have been shown to be effective in reducing aflatoxin contamination in groundnuts. In addition, management practices—such as using appropriate drying techniques (including drying on raised surfaces or on mats), reducing kernel moisture content to 8 percent, proper threshing methods, and sorting the kernels before sale or consumption—significantly influence the level of aflatoxin contamination. Aflatoxin reduction under these practices can vary from 63 to 88 percent depending on location. Practices such as wetting groundnut shells to facilitate shelling increase the risk of aflatoxin contamination.

Biocontrol agents

A biocontrol agent refers to a microbial antagonist that keeps the disease-causing agents in check by reducing their populations to economically insignificant levels around the susceptible or target host organ/tissue, resulting in no disease incidence. Several bacterial and fungal biocontrol agents have already been screened all over the world to identify potential antagonists to *A. flavus*.

Although promising biocontrol agents have been identified for groundnut aflatoxin management, research is more advanced on other crops such as maize (brief 16). In terms of the peanut, one commercial non-toxigenic *A. flavus* strain, NRRL 21882, has been commercialized (as Afla-guard®) thus far in the United States (Dorner 2005). However, its efficacy in multi-environment and multi-state conditions and under longer time horizons has yet to be understood. ICRISAT has identified a host of potential biocontrol agents that work against aflatoxin-producing molds in groundnuts, including antagonistic bacteria (*Pseudomonas* spp), fungi (*Trichoderma* spp), and actinomycetes (*Streptomyces* spp) strains. Promising biocontrol agents tested under greenhouse and field conditions in Africa and Asia proved to be very effective in reducing aflatoxin contamination by 79 percent (Harini et al. 2011). Efficacy demonstrations in the field with these biocontrol agents also were effective. ICRISAT is working with commercial providers to assess the potential of making the biocontrol agents more widely available to small-scale farmers.

TABLE 2 Percent reduction in aflatoxin contamination by single or multiple agronomic practices

Agronomic practice	Aflatoxin reduction
Cereal crop residues	28
Farmyard Manure (FYM)	42
Combination of FYM and residues	53
Lime	72
Combination of lime and residues	82
Combination of FYM, lime, and residues	83
Combination FYM and lime	84

Sources: Waliyar et al., 2006, 2007.

Conclusions

There are various simple cultural and other practices that can be used to manage aflatoxins in groundnuts. To enhance the management of aflatoxins in groundnuts, it is recommended that locally adaptable practices be identified, tested on-farm, and scaled up for groundnut farmers. Biocontrol is also a promising strategy for future development. Challenges to the adoption and use of good practices for aflatoxin management include lack of farmer knowledge, little market reward for quality due to a lack of standards and diagnostics, and little attention to this issue from policymakers.

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