Beneficial Fungi for Aflatoxin Control

Ranajit Bandyopadhyay IITA
Peter Cotty USDA-ARS
Jacob Mignouna AATF
Margaret McDaniel USDA-FAS
Aflatoxin: What is it?

• Highly toxic metabolite produced by the ubiquitous *Aspergillus flavus* fungus
• The fungus infects crops and produces the toxin in the field and in stores
• Fungus carried from field to store
• Contamination possible without visible signs of the fungus
• Some predisposing factors:
  – pre-harvest high temperature & drought stress
  – wet conditions at harvest and post-harvest periods
  – insect damage
Field trials offer hope of conquering food toxin

Semiu Ebalololu
26 June 2009 | EN

[LAGOS] The elimination of deadly aflatoxin, which contaminates food crops in Sub-Saharan Africa, is a step closer now scientists have shown that a control method works well in large-scale field trials.

Aflatoxin is a poison produced by the fungus Aspergillus flavus. It contaminates crops such as maize, groundnuts, cassava and yam, either in the field during times of stress — such as drought or insect infestation — or as a result of poor storage conditions.

More than 4.5 billion people in developing countries may be chronically exposed to aflatoxin in their food, putting them at risk of diseases such as cancer. Africa also loses about US$450 million in lost revenue from contaminated export grain.

Scientists from the Nigeria-based International Institute of Tropical Agriculture (IITA), the United States Department of Agriculture and the African Agricultural Technology Foundation in Kenya have been working together to develop a biological control method to reduce the amount of aflatoxin contamination in...
Fungal communities differ in aflatoxin-producing ability & this influences crop vulnerability to contamination.

Some strains produce a lot (toxigenic), and others no aflatoxin (atoxigenic).

Competitive exclusion (one strain competing to exclude another) is the biocontrol principle practiced.

Shift strain profile from toxigenic to atoxigenic.

Thus, aflatoxin contamination reduced.

We identify and promote only native beneficial strains.

On average, S strain isolates produce much more aflatoxin than L strain isolates.
Aflatoxin Biocontrol Facts

Crops are infected by complex communities of diverse fungi. Fungal communities differ in aflatoxin-producing ability, and this influences crop vulnerability to contamination. Atoxigenic strains can be used to reduce aflatoxin-producing ability.

There are many atoxigenics. Select safe strains best adapted to cropping systems, ecosystems, and climates.

Atoxigenics are already present on the crop. Just increase the frequency of endemic strains and natural interference with contamination.

Treatments may have long-term influence and cumulative benefits. More than one crop may benefit from the applied strain.

Atoxigenic strains can be applied without increasing infection and without increasing the overall quantity of *A. flavus* on the crop and throughout the environment.

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How does Biocontrol Work?

Sporulation on moist soil

3-20 days

30-33 grains m\(^{-2}\)

Broadcast @ 10 kg/ha 2-3 weeks before flowering

Soil colonization

Wind

Insects

Spores

Hyphal network in seed pericarp

Inoculum on sorghum grain carrier

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B-aflatoxin in stored maize grains from untreated and atoxigenic treated plots

<table>
<thead>
<tr>
<th>Location</th>
<th>Treatment</th>
<th>Stored</th>
<th>Poorly stored</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Aflatoxin (ppb)</td>
<td>Reduction (%)</td>
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<tr>
<td>Ibadan</td>
<td>Control</td>
<td>42</td>
<td>73</td>
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<tr>
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<td>Treated</td>
<td>11*</td>
<td>105**</td>
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<td>Ikene</td>
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<td>54</td>
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<td>Mokwa</td>
<td>Control</td>
<td>50</td>
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<td>Treated</td>
<td>7*</td>
<td>149**</td>
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* $P < 0.05$, ** $P < 0.01$
Recovery of released strains from soil and grain of control and treated plots

Recovery of released atoxigenic strains (%)

Soil before inoculation
Soil at harvest
Grain at harvest

Control*  Treated*

*Mean of four sites
Ex-Ante Impact Assessment of Aflatoxin Biocontrol in Nigeria

• DALYs saved: 103,000 to 184,000
• Cost-effectiveness ratio: 5.1 – 24.8
• Benefits are likely to be higher if all health impacts from aflatoxin exposure are considered.

Wu & Khlangwiset (2010) Food Additives & Contaminants
10-kg boxes of AflaSafe ready for deployment
Explaining aflatoxin and biological control to farmers in their fields
Farmers treating maize and groundnut fields with AflaSafe

Aflatoxin reduction at corn harvest:
- 2009: 80%
- 2010: 89%

71% and 52% carry-over of inoculum 1 & 2 years after application

Aflatoxin reduction at peanut harvest:
- 2009: 96%
- 2010: 98%

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Different Levels of aflatoxin in AflaSafe™ treated and untreated fields at harvest

![Bar chart showing farmers' fields (%)](www.iita.org)
Farmers treating groundnut fields with AflaSafe

Aflatoxin Reduction: 87% at harvest

Senegal

Farmers harvesting and threshing groundnut
## Focus Countries and Stages of Development

<table>
<thead>
<tr>
<th>Country</th>
<th>Strain identification</th>
<th>Partnerships</th>
<th>Commercialization</th>
<th>Capacity development</th>
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<tbody>
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- **Completed**
- **Partially started**
- **Yet to start**
How do we Generate Demand in the Medium-Term

- Enable development of native beneficials in key countries
- Develop manufacturing capacity
- Create awareness about aflatoxin
- Demonstrate efficacy of Aflasafe
- Incentivize use of Aflasafe by the poor
- Train farmers in aflatoxin management
- Enable aflatoxin testing of products
- Link Aflasafe users to food and feed market

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<th>Structure of Pull Mechanism</th>
<th>Pros</th>
<th>Cons</th>
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| 1. Buy Aflasafe directly, give to smallholder farmers for free OR highly subsidize and bundle with other inputs such as fertilizer | • Easiest way to clearly incentivize manufacturing | • Distribution difficult to do and verify
• No monetary incentive for farmer (fully reliant on health education effort)
• Creates precedent of giving Aflasafe away for free, distorting market |
| 2. Pay for performance: survey maize fields and reward contractor (& farmer?) for prevalence of Aflasafe strains OR reduction in overall aflatoxin contamination in an area | • Ensures money is provided for successful adoption by farmers, aligning subsidy with ultimate objective. | • Need for costly surveys, both baseline and results, with results potentially questioned
• As above precedent of Aflasafe given free/below cost is established
• No clear partner to take on contracting role |
| 3. Buy Aflatoxin-free ag products (like maize), creating a ‘premium’ value-chain | • Establishes precedent for farmers buying Aflasafe
• Creates new commodity category of aflatoxin free maize with price premium
• Introduces aflatoxin testing at many points of the value chain | • Requires careful coordination among a number of additional players
• More difficult to explain to manufacturer when trying to incentivize investment
• Involves all the tricky aspects of a maize purchasing subsidy |
Aflatoxins in food and feed pervasive in Africa

Biological control in conjunction with other management practices can dramatically reduce aflatoxin contamination

Large scale manufacturing and commercialization of biocontrol agents a prerequisite for adoption.

Aflatoxin mitigation plan developed

Linkage being developed with other organizations for downstream dissemination activities for biocontrol

Support and partnership needed from national governments, donors/investors, private food sector, farmer groups, and regulators

Africa-wide Initiative on Aflatoxin biocontrol can improve health and income of African people
Pre-Harvest Aflatoxin Management
Factors influencing fungal growth and toxin development

Pre Harvest

• Growth cracks, mechanical injury and damage by pests to grains leads to infestation by fungi.

• Toxins are produced under high temperatures, drought, high insect activity prior to harvest.

• Wet conditions at harvest leading longer duration for drying in the field after grain maturity

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Pre-Harvest Management

• Plant less susceptible varieties, if available
• Biological control
• Adjustments in planting dates
• Reduce plant stress
  – Water management (irrigation, mulching)
  – Lower plant population
  – Use of FYM and gypsum (primarily for groundnut)
  – Foliar disease control (primarily for groundnut)
• Harvesting at 13 to 15% grain moisture
• Insect control and removal of insect damaged cobs and lodged plants at harvest
• No effective fungicides for aflatoxin control
Less Aflatoxin Susceptible, High-Yielding Yellow Maize Hybrids

Less toxin – high yield

Aflatoxin (ppb) and Grain yield (kg/ha) for different hybrids:

- **A0901-6**: Aflatoxin 334 ppb, Grain yield 4,000 kg/ha
- **A0901-4**: Aflatoxin 396 ppb, Grain yield 4,000 kg/ha
- **A0901-16**: Aflatoxin 400 ppb, Grain yield 4,000 kg/ha
- **A0901-22**: Aflatoxin 488 ppb, Grain yield 4,000 kg/ha
- **A0901-36**: Aflatoxin 800 ppb, Grain yield 4,000 kg/ha
- **A0901-14**: Aflatoxin 809 ppb, Grain yield 4,000 kg/ha
- **A0901-25**: Aflatoxin 816 ppb, Grain yield 4,000 kg/ha
- **A0901-29**: Aflatoxin 956 ppb, Grain yield 4,000 kg/ha
- **OBA SUPER 2 (released hybrid)**: Aflatoxin 5743 ppb, Grain yield 4,000 kg/ha

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