BecA-CSIRO aflatoxin project:

Capacity and Action for Aflatoxin Reduction in Eastern Africa (CAAREA)

biosciences eastern and central africa

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Queensland Government Department of Employment, Economic Development and Innovation

The University Of Queensland AUSTRALIA

Queensland Alliance for Agriculture & Food Innovation

Cornell University Founded A.D. 1865

University of Minnesota

CAAREA Phase II Objectives

Focus: aflatoxin in preharvest maize in Kenya and Tanzania.
Considered ongoing projects for synergy and impact.

1. Establish aflatoxin diagnostics platform at BecA-ILRI
2. Characterize maize fungi from around Kenya and Tanzania
3. Screen maize germplasm for resistance
4. Test modelling as a potential predictive tool and use to contextualize findings regionally (risk map)
5. National breeders will affect subsequent changes to maize breeding programs in Kenya and Tanzania





Phase II output highlights

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Capacity and Action for Aflatoxin Reduction in East Africa (CAAREA)

research impact pathway

Diagnostics can be applied to different toxins in different crop and livestock commodities

Information helps Govt Ministries and industry develop improved food safety guidelines

Science outputs assist National maize breeders & seed traders to improve maize varieties in circulation

Development outcomes

Direct science outputs

Science outputs inform variety development changes in National breeding programs

Kenya and Tanzania risk maps produced using spatial models overlayed with management information and climate data

Farmer surveys help understand levels of contamination of varieties & agronomic management

Innovation platform explicitly involved in project as partners or via workshops, field trials, surveys etc.

Samples collected and sent to newly established Mycotoxin diagnostics platform at BecA Hub

Postharvest screening of field trial materials

Project team

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Aflatoxin/nutritional analysis capacity lacking in East Africa

Comprehensive labs lacking for research and capacity building.

Regulator lab capacity limited and long delays to results.

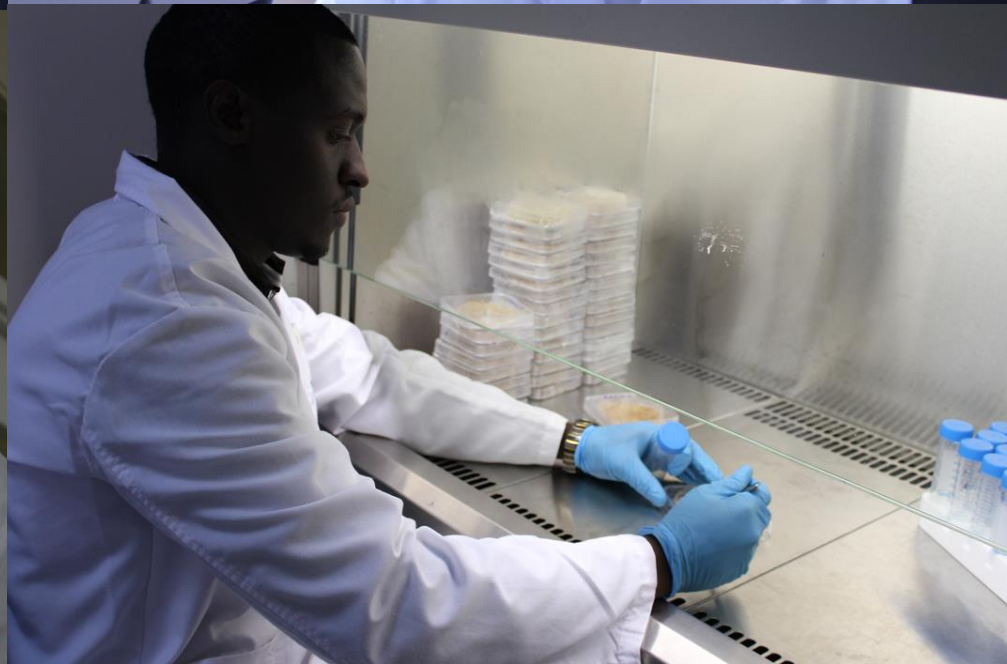
Private sector labs emerging, but limited capacity and expensive.

Lack of reference labs for the community.

2009-mid 2011
BecA aflatoxin team/lab bench

Aug-Nov 2011
Univ of Nairobi (Okoth lab)

BecA-ILRI Hub mycotoxin platform

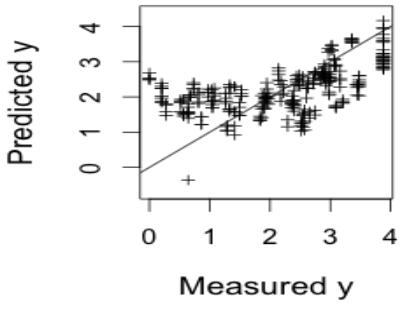


Mycotoxin-nutritional analysis platform

Mycotoxin-nutritional analysis platform

Mycotoxin and wider nutritional analysis platform established:
UPLC (LCMS early 2014)
VICAM
ELISA
FT-NIR
GC-MS
AAS
UV-VIS

BSL2 Mycology lab
BSL2 Milling Room (Romer mills, inoculated samples)
Sorter (Peason, USDA),…



Sampling and Diagnostics Development

Sampling protocols under development based on single ear/single kernel analysis.

New diagnostics suited to African context under development:

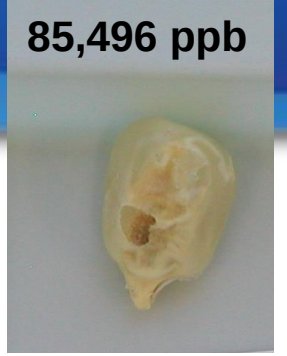
- Electronic nose: proof of concept in progress
- NIR: calibration development (within samples): best suited to single kernel sorting, not for determination of legal limit in kernels or flour
- 2014: several others being integrated (field-mobile diagnostics)

Single kernel analysis and sorting

Single Kernel Analysis

NIR/spectral scans
(BecA team)

Single Kernel Sorting

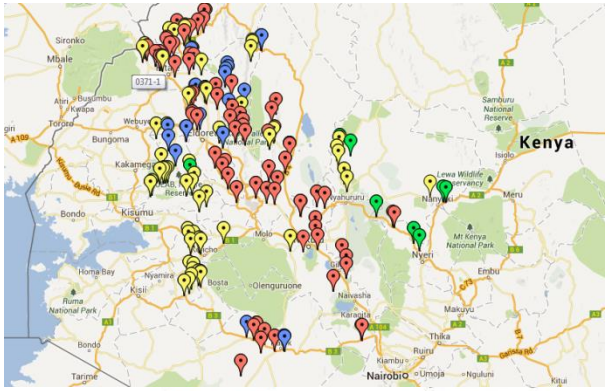


Modeling: risk mapping and prediction

Component 1: risk mapping, GxE(xM) analysis

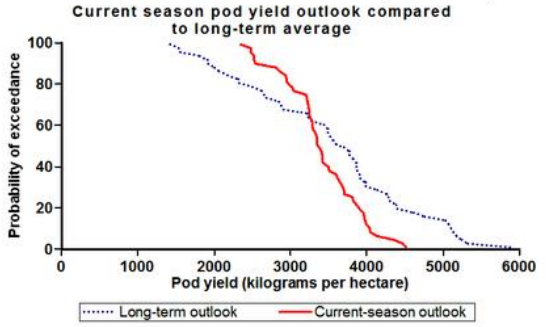
Survey team/tools finalized.

Ongoing on farm survey to generate risk maps and other tools.



Component 2: APSIM modeling

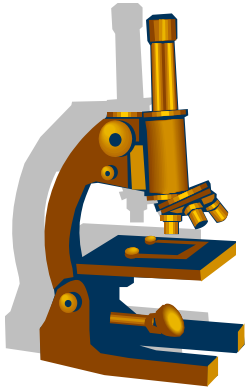
First APSIM model developed for aflatoxin in maize – accurate in field trial prediction.



Scope

- Risk and Intervention Analysis
  - Farm surveys
  - Maize genotyping
  - Aflatoxin mapping
  - Risk analyses
  - Risk reducing scenarios

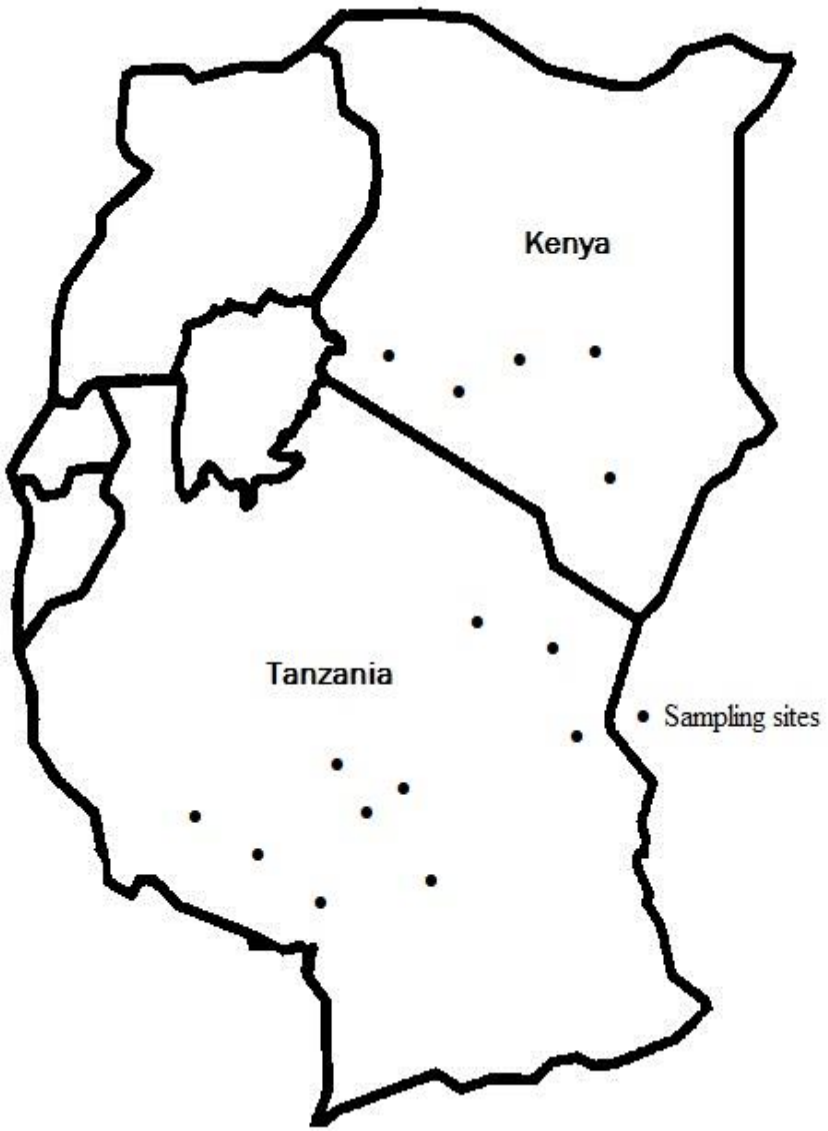
- Process-based risk modelling

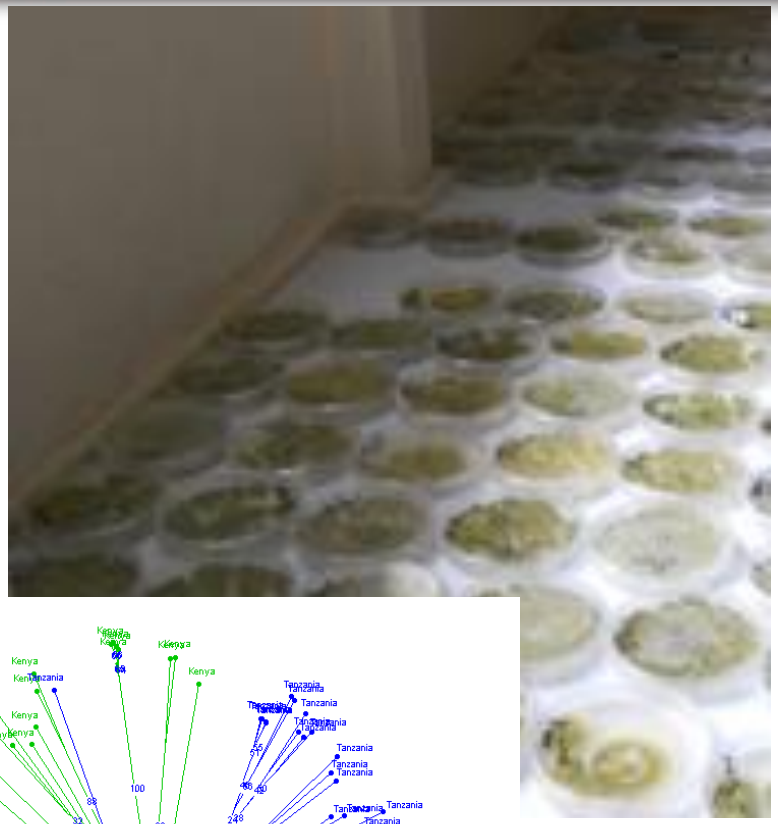


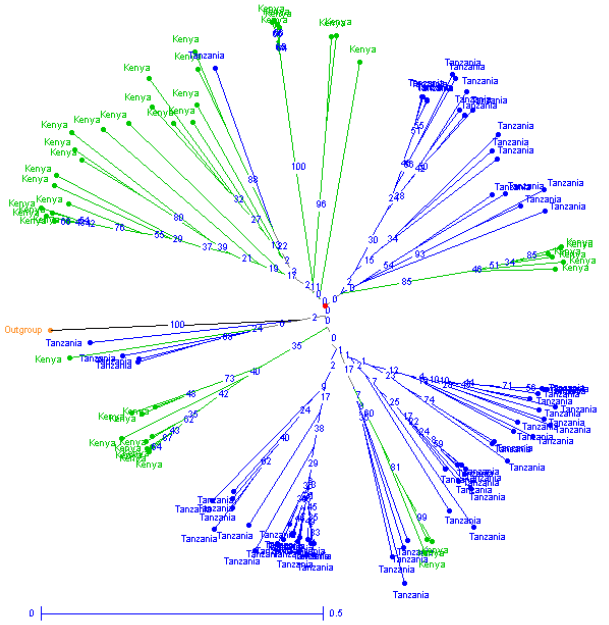
Modelling Aflatoxin production

- Biophysical crop model (APSIM) to simulate Aflatoxin risk
- Timing and severity of moisture stress in maize
- Subsequent colonization and risk of Aflatoxin contamination

Fungal survey







Overall conclusions

1. Preharvest maize contains a range of toxigenic fungi, including high occurrence of *Fusarium* in all AEZs.
2. The interaction between aflatoxin B1 production per isolate and altitude was found to be positive and significant (***r* = 0.21; *p* = 0.035**).
3. Toxigenic *A. flavus* is found in all AEZs, so inter-AEZ traded maize may be already inoculated from HL (good or bad?).
4. More investigations are needed to reduce preharvest toxigenic *A. flavus* infection and subsequent aflatoxin contamination
5. Investigations on *Fusarium* species and their toxin are needed in the region

6. Isolates (including atoxigenic) available for use → biobanks.

Inoculated Field Trials: Kenya and Tanzania

Fungal survey, inoculum production, NARI capacity and teamwork.

First inoculated aflatoxin field trials in the region (KARI and ARI).

Fungal isolation and inoculum production: MARI.

Significance between genotypes (analysis ongoing) → GBS → BREEDING.

Capacity building













Capacity building

Institutional capacity:

BecA-ILRI Hub platform

NARI capacity and international linkages

Human capacity:

Team/network

BecA team expertise

Graduate students: 4 MSc, 4 PhD (3 AusAID scholarships)

ARI and KARI teams

6 ABCFs hosted

Regional capacity:

Platform used by 10 institutions (aside from CAAREA)
with >12 more coming/in discussion. Includes Nutrition PhD program.

Established accepted lab design (milling) for aflatoxin work in Kenya.

Linked with PACA for use on priority issues – ABCF nominations.

Samuel Mutiga, Cornell PhD student, Kenya

Research Project (5 years)

- 2009/2010: Survey on mycotoxin occurrence in western Kenya
- 2010/2011: Survey on mycotoxin occurrence, and statistical analysis of factors for aflatoxin occurrence and accumulation in Eastern Kenya
- 2012: Effect of sorting of maize at posho mills on aflatoxin and fumonisin levels in Eastern Kenya
- Genetics and dissection of components of aflatoxin resistance in maize test-crosses grown under two nitrogen regimes in Eastern Kenya

Publications in Preparation

- S. K. Mutiga, V. Were, V. Hoffmann, J. Harvey, R. Darnell, M. G. Milgroom and R. J. Nelson: **Mycotoxin occurrence in western Kenya: A cross-sectional and longitudinal assessment of maize contamination at local hammer mills and grain stores**
- S. K. Mutiga, V. Were, V. Hoffmann, J. Harvey, R. Darnell, M. G. Milgroom and R. J. Nelson: **Mycotoxins on maize in eastern Kenya: assessing extent and drivers of contamination based on a survey conducted at village-based hammer mills**
- S. K. Mutiga, B. Das, J. Harvey, and R. J. Nelson: **Association mapping for aflatoxin resistance in maize test-crosses under low soil nitrogen in Eastern Kenya**.
- S. K. Mutiga, B. Das, M. Fletcher, G. Fox, J. Harvey, and R. J. Nelson: **Association of kernel characteristics with aflatoxin accumulation in maize test-crosses**


Moving to phase II

CAAREA II --- Development Alliance for Aflatoxin Reduction

The project will create an integrated vehicle with a capacity to reduce aflatoxin in maize across the food chain.

Move current activities and outputs to impact

Activities:

1) **Establish a vehicle to address aflatoxin contamination across the food chain**
2) **Enhance and expand use of the BecA-ILRI Hub platform**
3) **Support the development of node labs (NARI, Uni, private sector; Kenya, Tanzania, Ethiopia)**
4) **Validate and deploy mobile diagnostics**
5) **Validate and pilot interventions for contaminated grain (sorting, decontamination)**
6) **Finalize risk mapping and advance APSIM model (pathosystem research)**
7) **Validate integrated sets of aflatoxin intervention measures on farm, at storage and in mills**
8) **Capacity building**

Move current activities and outputs to impact

Next phase intervention levels:

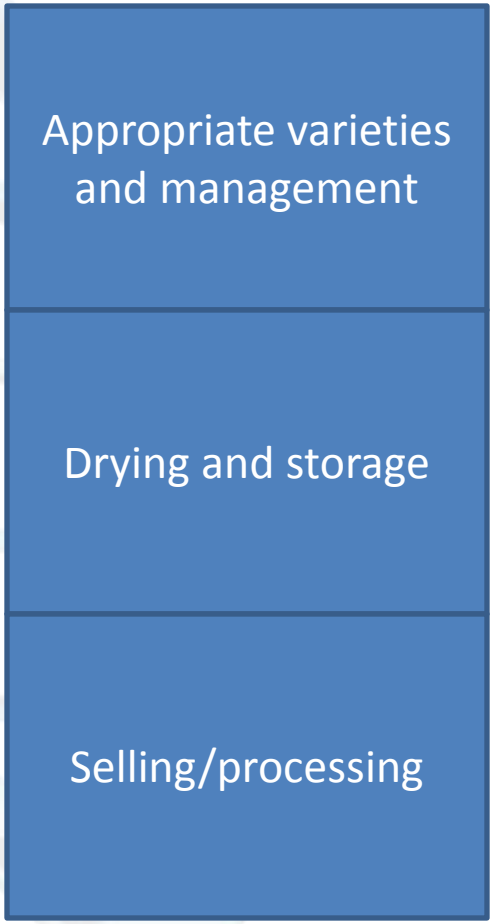
1) **Reduce risk as much as possible on farm (varieties, management)**

2) **Surveillance to identify emerging hotspots (APSIM, mobile/networked diagnostics)**

3) **Targeting interventions as issues emerge (testing, decontamination, alternative uses)**

4) **R4D alliance – enabling environment, vehicle addressing the problem. COLLABORATIONS FOR INTERVENTION PILOTING**

Integrated system for aflatoxin reduction



Varieties matched to environments
Management practices
Integration of best practices and interventions

In season surveillance:
-APSIM model, track emerging risk areas
-mobile diagnostics

Contaminated grain:
-mobile diagnostics
-kernel sorting
-decontamination (traditional or advanced-mobile)

Integration of others' technologies – **collaboration** (eg, drying, storage systems,…)

Estimated impact

Uptake of improved varieties, Kenya & Tanzania: 10.6 million

Kenya Cereal Millers Association – sampling/diagnostics: 10 million

Additional pathways to impact:

World Food Program

FIPS **Pilot with ~100,000 people, scalable to their 1 million farmers (Kenya and Tanzania)**

Acknowledgements - team

AusAID – funding and input
CSIRO/Partnership leaders
Governments of Kenya and Tanzania
BecA team; ILRI

Project team:

BecA-ILRI Hub: Jagger Harvey (Project Leader, geneticist); Benoit Gnonlonfin (postdoc, mycologist); Samuel Mutiga (Cornell PhD student) ; James Wainaina; Immaculate Wanjuki, Warwick Turner (QDAFF), Robert Ngeno
KARI: James Karanja (national maize breeder), Anne Gichangi (socioeconomist) and teams
ARI: Arnold Mushongi (national maize breeder) and team
Ministry of Agriculture: Deogratias Lwezaura (agricultural economist) and team
Open University of Tanzania: Said Massomo (plant pathologist)
CSIRO: Ross Darnell (biometrician); Nai Tran-Dinh (mycologist); Stephen Trowell and Amalia Berna (biosensor technology)

CSIRO/HarvestChoice: Darren Kriticos (ecological modeller; risk mapping leader)

Univ. Queensland/QAAFI: Mary Fletcher (natural product organic chemist), Glen Fox (NIR, cereal chemist), Loraine Watson (lab management)

QDAFF: Yash Chauhan (APSIM modelling)
Cornell University: Rebecca Nelson (molecular plant pathologist), Michael Milgroom (fungal population biologist), Matt Stasciewicz
HarvestChoice/Univ. Minnesota: Phil Pardey and Jason Beddow
University of Pretoria/HarvestChoice: Frikkie Liebenberg
Australian graduate students: Ben Temba, Titilayo Falade, Vincent Were

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