Research Proposal: Ghana Peanut Value Chain Interventions

Description

Using Applied Research and Technology Transfer to Minimize Aflatoxin Contamination and Increase Production, Quality and Marketing of Peanut in Ghana

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Geographical Locations

Ghana

Project Duration

October 1, 2013 – July 30, 2017

Executive Summary

A wide range of abiotic and biotic stresses negatively impact peanut production in the field and contribute to reduced quality of marketed peanut in Ghana and West Africa in general. Aflatoxin, produced by *Aspergillus flavus*, negatively impacts health when humans and livestock consume contaminated products. Aflatoxin contamination can occur and increase at all steps of the peanut supply chain including production in the field, storage in fields and

villages, and in processed products. Interventions at each step of the supply chain can minimize aflatoxin contamination. Improved production in the field including pest resistant cultivars, adequate soil fertility and plant nutrition, and synchronization of peanut pod growth phase with adequate soil moisture can increase peanut yield and quality and minimize aflatoxin production. Adequate and timely drying of farmer stock peanut minimizes additional production of aflatoxin during storage in villages prior to marketing. Effective processing of farmer stock and shelled stock peanut can also reduce aflatoxin prior to purchase and consumption. Strategies that mitigate aflatoxin are not employed sufficiently in rural areas of Ghana. Determining current practices by farmers, conducting research to mitigate aflatoxin and improve peanut quality, and transferring appropriate technology to farmers are needed to improve productivity, profits, and quality of peanut and to increase safety of peanut products consumed by humans and livestock.

The primary platform for addressing aflatoxin contamination of peanut in the supply chain in Ghana will be activities at 9 villages in northern and central Ghana. Interventions at each step of the supply chain will be implemented and aflatoxin contamination determined. Research will be conducted at two institutions associated with the Savanna Agricultural Research Institute (SARI) and at the Crops Research Institute (CRI) to develop appropriate production and pest management strategies and evaluate new germplasm suitable for the region. Results from efforts at villages and research stations will be presented to farmers using the Farmer Field School approach and appropriate posters, bulletins and manuals. Graduate student training will be linked closely to activities in villages and research stations.

Results from the project will provide farmers in Ghana with information on documented interventions that reduce aflatoxin contamination of peanut throughout the supply chain. Improved productivity and quality of peanut coupled with acceptable levels of aflatoxin in peanut products will improve access to local, regional, national and international markets leading to enhanced economic viability of farmers and their communities.

Project Description

Goal

To identify current practices involved in production, storage and processing of peanut that contribute to aflatoxin contamination and develop, implement and evaluate strategies to reduce aflatoxin contamination.

Relevance and Justification

Mycotoxins have significant economic impacts on a number of crops around the world including peanut (Schmale, 2013). The Food and Agriculture Organization has estimated that 25% of the world's crops are affected by mycotoxin each year (Schmale, 2013). A recent World Bank study indicated that the European Union regulation on aflatoxins costs Africa $750 million annually in export of cereals, dried fruit and nuts (Agyei, 2013). Although losses faced by the global economy are estimated at $1.2 billion, African economies lose about $450 million annually to aflatoxin contamination (Atser, 2009).

Peanut is an important component of diets in Ghana with production most prominent in central and northern regions, especially in the Savanna region where conditions are favorable for aflatoxin development (Craufurd et al., 2006). Aflatoxin levels are often high in peanut and other crops in this region (Craufurd et al., 2006). Peanut in the supply chain continues to contain aflatoxin at levels exceeding those defined as safe for human consumption. Inefficient and marginally effective production and pest management strategies, poor soil fertility, limited irrigation, susceptible cultivars, and weather patterns as well as poor drying and storage practices create high risk conditions for contamination by aflatoxin for human and livestock consumption. Improved production and pest management in the field and more effective handling and storage practices after harvest are known to mitigate *Aspergillus* survival and subsequent production of aflatoxin. Practices employed during processing also can impact aflatoxin present in products marketed to consumers. Timely sowing can minimize exposure to droughts which exacerbate aflatoxin (Craufurd et al., 2006). Drought-tolerant cultivars are less susceptible to aflatoxin contamination. Stacking pods to allow effective field drying and sorting and discarding aflatoxin-contaminated pods will improve quality of peanut. Sorting peanut prior to processing can impact aflatoxin contamination (Awuah et al., 2006).

While there is considerable understanding of factors that influence prevalence of *Aspergillus* in the field, storage, and processing, the demonstration and transfer of technology to end users are limited in many areas of Ghana. Human capital is in place at institutions in Ghana, including but not limited to the Ministry of Food and Agriculture (MOFA), Kwame Nkrumah University of Science and Technology (KNUST), Savanna Agricultural Research Institute (SARI) and Crops Research Institute (CRI), to develop strategies to mitigate aflatoxin contamination in peanut. However, resources are needed to develop comprehensive programs in the field, storage, and processing to mitigate aflatoxin contamination and to transfer appropriate interventions at the farm level. In order to reduce aflatoxin contamination and improve the quality and quantity of peanut for local consumption and regional and possibly international markets, additional research and technology transfer are needed. Moreover, markets that reward farmers for peanut with low aflatoxin contamination are needed to provide incentives for technology adoption. New markets, such as those created by Hershey's announcement to build a peanut processing facility north of Kumasi and the subsequent effort to procure high quality peanut, is a good example of what is required. Ghana's political stability for many years, the presence of internal and external capital investment, and increased interest in international markets place the country in a position to lead the West African region in improving human health. And, improving the value chain of peanut by increasing production and availability of high quality, aflatoxin-free peanut at the farm level and in markets will be an essential element in such improvements.

Research Plan

Nine objectives will be addressed to achieve the goal of increasing productivity and mitigating aflatoxin contamination in the supply chain. Each objective is listed below. The platform to address 6 objectives will be 9 villages in Ghana. The broad objective is to address aflatoxin in these 9 villages with comprehensive programs in production, storage and processing. Success in the 9 villages outlined here will be extended to other villages in the future. This approach resembles that of the UN Millennium Village effort over the past decade but is much more modest in scope and is designed specifically toward aflatoxin mitigation. However, many of the interventions outlined for aflatoxin mitigation will improve efficiency and economics of peanut production, storage, and processing.

Objective(s)

1. Nine villages in northern and central Ghana (5 in northern Ghana and 4 near Kumasi) will be surveyed during December 2013 through January 2014 to determine practices employed to produce, store and process peanut. Once current management practices employed in the field, during storage and processing are determined for each village, plans will be made to compare interventions. Two levels of aflatoxin mitigation will be compared within each village at each step in the supply chain. Level 1 includes production, storage and processing of peanut using current practices in villages. Level 2 involves incorporating

interventions for production, storage, and processing that are feasible for small-scale farmers, traders and processors.

Production practices will include on-time sowing dates compared to normal or delayed sowing; incorporation of cultivars with demonstrated resistance to pests including aflatoxin producing mold; irrigation where feasible; applying pesticides for disease, insects and weeds; and improved fertility programs. Efficient harvesting techniques to minimize the amount of time plants are present in the field before removing pods will be compared.

Post-harvest storage will evaluate appropriate technologies that will reduce the incidences of mold growth through moisture control in the peanut. The project will use the unique and innovative approach known as PIIM (Peanut Industry incubator Model) to fast tracks food processing and product development cycles ensuring safe (aflatoxin free and microbiologically safe) and peanut based products. This model requires early engagement in partnerships between research institutions and private food industry partners (IP), and agreement during early stage of development work of research project through intensive interactions. Previously developed and successfully implemented processing technology to sort aflatoxin in the processing stream will be transferred to peanut processors to produce aflatoxin free peanut based products. This approach will also include development of good manufacturing practices such as HACCP and facilitate the development of value added peanut based products that will increase the livelihood.

A sufficient quantity of peanut will be planted in each village to allow production of adequate amounts of peanut under levels 1 and 2 prior to harvest to compare proven storage and processing techniques. Concentration of aflatoxin will be determined when peanut is dug (prior to field drying, storage and processing). This measurement will allow conclusions to be drawn from in-field production and pest management strategies. Depending upon survey data, two or more strategies during drying and pre-marketing storage will be compared. Upon removal of peanut from pre-market storage, aflatoxin levels will be determined. Peanut will then be marketed and local processers will prepare two or more products sold in the market. Aflatoxin contamination will be determined periodically after processing, using appropriate techniques designed to minimize aflatoxin compared to current standards. This procedure will include appropriate replication of treatments and controls. The objective is to determine the most vulnerable step in the supply chain that impacts aflatoxin contamination and identify interventions that reduce aflatoxin contamination.

For example, in each village 500 kg of unshelled farm stock peanut will be produced under both level 1 (current) and level 2 (improved) production and pest management practices for each of 4 replications (total of 2,000 kg farmer stock). The 500 kg for each level of production will be divided into two intervention programs designed to reduce aflatoxin at drying and storage points of the supply chain (current and improved practices). Peanut from each of these interventions will be further divided into two interventions at the processor level (current and improved practices). A minimum of 120 samples will be processed for aflatoxin contamination throughout the entire chain in each village during each year. However, additional sampling may be necessary to ensure presence of aflatoxin is known going into the next step of drying and storage and processing to manage variability and experimental error. This constitutes 1,080 samples per year when considering the 9 villages and 3,240 samples over the duration of three growing seasons.

Schematic for one of four replications within one village indicating steps where samples are collected for aflatoxin determination. Abbreviations: F1 and F2, field practices 1 and 2, respective; D1 and D2, drying practices 1 and 2, respectively; S1 and S2, storage practices 1 and 2, respectively; P1 and P2, processing practices, respectively. Practice 1 is the current set of practices used in villages. Practice 2 is the improved set of practices recommended by PMIL.																Number of samples
F1								F2								2
D1				D2				D1				D2				4
S1		S2		S1		S2		S1		S2		S1		S2		8
P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	16
Total																30

Incidence of other biotic as well as abiotic stresses and daily rainfall will be documented in the field. Similarly, pests along with relative humidity and temperature will be recorded during drying and storage. Appropriate measurements and observations will be documented during processing.

Potential adverse consequences of interventions on the natural environment will be considered when designing the protocols. Prior to use of pesticides including herbicides, insecticides and fungicides, the Management Entity will review the proposed plan for approval by USAID. Pesticides will not be procured or used until USAID approval has been granted. When pesticides are used a stewardship program related to human health and environmental protection will be discussed.

2. Detailed comparisons of pest management and production practices will be conducted at SARI, CRI, and selected villages. In on-station trials, pesticides will be evaluated for cost- effective management using appropriate small-scale equipment to more efficiently and uniformly apply pesticides, and reduce workload for women farmers. Small and light weight threshers and peanut shellers, appropriate for women will be evaluated. On-farm demonstrations in villages in collaboration with MOFA will show-case improved cultivars, pesticides, fertilizers, and appropriate mechanization to intensify and improve peanut production using advanced production integrated management strategies. Efficient production and pest management practices (such as herbicides for weed control) provide benefits outside of farming because they reduce labor required to produce peanut and other crops and increase time available to pursue educational opportunities or other areas of employment. Increased production and improved quality also decrease land area needed for peanut and may allow farmers to diversify their operations. Research is needed to establish the benefit of new technologies, especially pesticides, which increase productivity. System modeling in connection with economic analyses will be used to evaluate cost-benefit ratios relative to resource limitations, input use, management practices, and cultivar improvement for intensifying peanut production under climatic constraints in Ghana. Systems modeling with the CROPGRO-Peanut model will be used to evaluate optimum sowing date and cultivar life cycle type relative to long-term weather for given regions in Ghana, in an effort to enhance yield, but also minimize extent of drought during pod-filling.

   A preliminary version of that model is capable of predicting aflatoxin production under field growth conditions.

   As was noted for objective 1, potential adverse consequences of interventions on the natural environment will be considered when protocols are designed. Prior to use of pesticides, Management Entity will review the proposed plan for approval by USAID. Pesticides will not be procured or used until USAID approval has been granted. When pesticides are used a stewardship program related to human health and environmental protection will be discussed.

3. Evaluation of new germplasm from ICRISAT, US, and African breeders will be undertaken with a focus on reducing not only aflatoxin but other stresses that limit peanut yield and quality of peanut. Multi-location trials to evaluate improved peanut varieties will be conducted at three on-station sites in Ghana (Tamale, Wa, and Kumasi) to evaluate new lines from ICRISAT, US and African breeders. The following traits will be emphasized: a) yield, b) resistance to leaf spot, c) tolerance to drought and heat stress, d) seed quality (seed germination/stand in farmer fields, and e) aflatoxin (pre-harvest). Incoming lines will be suggested by plant breeders.

4. The most promising lines from objective 3 (in fact from prior CRSP research) will be aimed for release, multiplication, and distribution to farmers, aided by on-farm demonstrations in Objective 2 to encourage variety acceptance. We will work with farmers' communities and MOFA, to improve the seed multiplication of improved cultivars and seed distribution to farmers. Until now, farmers in Ghana have grown unimproved short-cycle cultivars on degraded soils with no fertilizer input and no disease control. Improved cultivars and technologies do not seem to be getting to the farmers. CRSP-sponsored multi-location variety trials conducted over the past 2 years at 2 sites in Ghana and 2 sites in Burkina Faso show that improved cultivars (ICRISAT releases or derived lines) are 80% higher yielding than the three farmer checks.
   These improved lines have greater leaf spot resistance and higher partitioning to pods. One of the two highest yielding lines is actually a released cultivar, Nkati-Sari, but it is not in farmer hands because seed release and distribution programs are not working.

   CSIR-Crops Research Institute under the previous peanut CRSP had two peanut varieties (early and late maturing) endorsed and officially released on 7th August 2012 by the national variety release committee in Ghana. The two varieties have been respectively named CSIR-CRI-"Yenyawoso" literally means there is no one like you and CSIR-CRI-"Otuhia" meaning drives poverty away in the local parlance. The two varieties have pod yields-2.7 ton/ha and 2.4 ton/ha respectively as against a local variety with pod yield of 1.4 ton/ha. These improved cultivars have moderately or greater resistance to leaf spot, moderate resistance to nematodes and soil arthropod pests. By the release of the two peanut varieties, there is the need to produce more seeds and distribute to our farmers as part of an objective of enhancing and improving the standard of living of the poor resource farmer.

5. As results become available, local extension personnel and researchers will provide the information through Farmer Field Schools and On-Farm Demonstrations in the targeted villages. These programs will be offered in each village during years 2, 3, and 4. Preparation of a production manual that includes all aspects of production, pest management, storage, processing and economics. Other appropriate technology transfer information such as posters, facts sheets, and farmers hand books will be developed and distributed. Attempts will be made to prepare these in English and local languages.

6. Three female nationals will receive graduate training at KNUST in the following three subject matter areas: 1) agronomy and pest management, 2) agricultural engineering (post- harvest handling and storage), and 3) food science (processing) with a core focus on aflatoxin mitigation. Student research will be conducted in the nine villages with PMIL partners described in objective 1 supplemented by research at SARI, CRI, and KNUST associated with objectives 2 and 3. Each student will travel to US on short-term assignment to evaluate US production, storage and processing systems and to present research findings at appropriate conferences. Undergraduate students at Virginia Tech will be involved in developing storage solutions associated with the project. Through other funding sources, these students will be viable for travel to Ghana for implementation and testing of solutions they develop. Funds from PMIL will also be used to partially support graduate student degree programs at US institutions.

Role of each scientist/partner

David Jordan

will coordinate the project among partner institutions in US and Africa. He will be involved in developing aflatoxin mitigation strategies during production and handling and storage and will be involved in extension efforts associated with Farmer Field Schools. He will assist with graduate training of the students involved in agronomy and pest management aspects of the project at KNUST.

Rick Brandenburg
will assist David Jordan in administering the project and will be involved in developing aflatoxin mitigation strategies during production and handling and storage and will be involved in extension efforts associated with Farmer Field Schools. He will also be involved in assisting with graduate training of one student involved in agronomy and pest management aspects of the project.

Ken Boote
will focus on coordinating germplasm evaluations and systems comparisons at SARI and CRI facilities in cooperation with Mumuni Abudulai, Jessie Naab, Moses Brandford Mochiah, and Grace Bulfrey-Arku. He will advise Ghanaian scientists on conducting on-farm trials of cultivars, management, production, and harvest technologies.

Greg MacDonald
will assist with developing protocols associated with testing of aflatoxin at each level of the supply chain and will contribute to planning activities associated with research at SARI, CRI and villages. He will advise Ghanaian scientists on conducting on-farm trials of cultivars, management, production, and harvest technologies.

Jinru Chen
will be involved with developing approaches to minimizing aflatoxin development during handling and storage prior to processing. Along with Dick Phillips and Mark Heflin, the team will develop and evaluate a solar peanut dryer in improving the safety and quality of peanut. The team will also use composting to turn aflatoxin contaminated wastes into value added agricultural products. Jinru Chen will also be involved with the graduate student involved in agricultural engineering at KNUST.

Dick Phillips
will assist Jinru Chen in her efforts.

Kumar Mallikarjunan
will focus his activities on interventions to minimize aflatoxin during processing. He will be involved in graduate education for the student in food science at KNUST. Along with Dr. Chinnan, he will lead the Peanut Industry Incubator Model and will be responsible for HACCP/GMP training of processors in the region. He will be involved in graduate education for the student in food science. Dr. Manjeet Chinnan from University of Georgia will assist Dr. Mallikarjunan with the above tasks as well as scientists and processors relative

to technology transfer to ensure presence of aflatoxin-free peanut in the market. Dr. Agnes Budu from University of Ghana will work with Dr. Mallikarjunan on post-harvest handling, processing and product development.

Maria Balota
will assist David Jordan, Rick Brandenburg, and Ken Boote in developing strategies to minimize aflatoxin in the field through research efforts associated with SARI, CRI, and villages.

Boris Bravo-Ureta
in collaboration with A. Dankyi will work on survey and sample design, and related analysis that will be used in each village in the first year of the program. Follow-up surveys will be performed to determine overall effectiveness of the interventions.

Mumuni Abudulai
will be involved in three villages in the Tamale area of northern Ghana. He will make arrangements with local villages to acquire access to land for testing purposes and Farmer Field Schools. He will also be the primary lead at SARI in Tamale for conducting detailed trials with Ken Boote and others.

Jessie Naab
will be involved in three villages in the Wa area of northern Ghana. He will make arrangements with local villages to acquire access to land for testing purposes and Farmer Field Schools. He will also be the primary lead at SARI in Wa for conducting detailed trials with Ken Boote and others.

Moses Brandford Mochiah
will serve as the lead PI in Ghana and will coordinate research and village activities with Jessie Naab and Mumuni Abudulai. He will also be involved in the three selected villages near Kumasi area of Ghana. He will make arrangements with local villages to acquire access to land for testing purposes and Farmer Field Schools. He will also be the primary lead at CRI in Kumasi for conducting detailed trials with Ken Boote and others.

Grace Bulfrey-Arku
will assist Moses Mochiah in coordinating the project administratively in Ghana. She will assist in performing research projects at CRI and in villages. She also will be the lead contact with William Ellis and Richard Akromah at KNUST.

Israel Dzomeku
will assist Mumuni Abudulai and Jesse Naab in performing research projects

especially those related to weed management at SARI and in villages.

Richard Akromah
will assist by finding three graduate students and appropriate advisors in fields of agronomy, agricultural engineering, and food science.

William Ellis
will assist by processing aflatoxin samples and by providing expertise in sample collection and interpretation of results.

Awere Ansong Dankyi
will collaborate with Boris Bravo-Ureta in surveying villages prior to interventions and with follow-up surveys and analysis.

James Y Asibuo
will assist with germplasm evaluations and will provide insight and guidance in release of new varieties from the program. He will also provide insight into the peanut variety supply chain.

Tim Williams
will assist with overall implementation of the project.

Manjeet Chinnan
will assist Kumar Mallikarjunan in activities associated with food science and processing issues.

John Erikson
will assist in cultivar evaluations and production practice comparisons at SARI and CRI facilities in cooperation with Mumuni Abudulai, Jessie Naab, Moses Brandford Mochiah, and Grace Bulfrey-Arku. He will advise Ghanaian scientists on conducting on-farm trials of cultivars, management, production, and harvest technologies.

Tim Brenneman
will provide expertise to US and African cooperators on disease management in the field.

Mark Heflin
will assist Jinru Chen and Dick Phillips in their efforts. He will be responsible for design and fabrication of a solar peanut dryer and a composting system.

Mike Owusu-Akayaw
will assist Dr. Mochiah with CRI with Farmer Field schools and village activities in the Kumasi area of central Ghana.

Agnes Budu

will work with Kumar Mallikarjunan, Manjeet Chinna and KNUST partners relative to processing activities.

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Annual work plan, milestones and timeline

General Project Outline for Ghana PMIL Team

December 2013 – January 2014

Survey 9 villages in Ghana relative to production, drying and storage, and processing practices. Plan germplasm and systems experiments and secure germplasm seed from various sources. Identify and select processors for partnering in the PIIM.

January 2013

Inception workshop in Accra, Ghana to allow discussions among partners prior to implementation of the project.

November 2013-February 2014

Assess survey data from villages to determine appropriate interventions in time for planting in March 2014. Identify graduate students as outlined in objective 6. Begin developing production, storage and processing manual as described in objective 5. Conduct HACCP workshop and aflatoxin management for processors and traders. Develop good agricultural practices for farmers to implement for afltoxin management at the farm level. Identify storage solutions at the farm level for further evaluation.

March 2014-September 2014

Conduct research outlined in objectives 1-4 at SARI, CRI and in 9 villages; collect aflatoxin samples at appropriate points as outlined in objective 1; and perform on-farm and Farmer Field School programs at villages. Work with PIIM partners for process development to produce value added peanut based products.

October 2014-December 2014

Analyze and interpret data from all experiments. December 2014-February 2015: Adjust procedures if needed for 2015 research including addition of new cultivars for objective 2. Complete first draft of production, storage and processing manual as described in objective 5. Conduct HACCP workshop for processors and traders and conduct follow-up workshop for early HACCP participants. Collect peanut products from markets for aflatoxin evaluation.

March 2015-September 2015

Conduct research outlined in objectives 1-4 at SARI, CRI and in 9 villages; collect aflatoxin samples at appropriate intervals as outlined in objective 1; and perform on-farm and Farmer Field School programs at villages. Conduct product/process development research with PIIM partners and University of Ghana.

October 2015-December 2015

Analyze and interpret data from all experiments.

December 2015-February 2016

Adjust procedures if needed for 2016 research such as adding new cultivars. Complete production, storage and processing manual as described in objective 5 and distribute to farmers and their advisors. Conduct HACCP workshop and evaluate implementation of HACCP. Collect peanut products from markets and PIIM partners for aflatoxin evaluation.

March 2016-September 2016

Conduct the research outlined in objectives 1-4 at SARI, CRI, and in 9 villages; and perform on-farm and Farmer Field School programs at all villages. Conduct research on product/process development with PIMM partners and University of Ghana. Prepare manuscripts.

October 2016-December 2016

Analyze and interpret data from all experiments.

January 2017-September 2017

Prepare and submit manuscripts for peer-reviewed literature from research conducted in villages, SARI, CRI, KNUST, University of Ghana and PIMM partners. Print and distribute educational educations at regional and national levels in Ghana.

Gender Considerations

Many smallholder farmers in Ghana are women (citation). Improving yields, minimizing loss during storage, and providing a high quality peanut to markets will improve the livelihood of women and their families and communities. Women will be involved in all Farmer Field School activities and will be given equal access to all technology and developments from the project. Graduate student training will focus on women with three female Ghana nationals trained during the project.

Outcomes and Impacts

The following data will be recorded:

1. Number of farmers adopting specific practices to minimize aflatoxin
2. Number of farmers adopting new released cultivars
3. Number of farmers adopting new production practices (use of herbicide or fungicide, improved spray equipment)
4. Number of farmers adopting new drying methods
5. Number of farmers adopting new seed storage methods
6. Number of new cultivars recommended for release (from the multi-location trials on station)
7. A solar peanut dryer will be developed and evaluated
8. A composting system will be developed and evaluated
9. Five graduate students will be trained
10. The project will improve food security by reducing peanut loss caused by post-harvest aflatoxin contamination
11. It will help eliminate environmental sources of aflatoxin contamination and reduce the incidence of liver disease due to consumption of aflatoxin contaminated peanuts and peanut butter products
12. Value added peanut based products will be developed and will result in an increase in livelihood for small to medium scale processors
13. Appropriate and affordable storage solutions for management and reduction of aflatoxin at the farm level
14. Implementation of HACCP and other good manufacturing practices and subsequent reduction in aflatoxin contamination in finished peanut products

15. Market development for value added peanut based products

Institution Scope of Work

North Carolina State University

Scope of Work

David Jordan will coordinate the project among partner institutions in US and Africa. He will be involved in developing aflatoxin mitigation strategies during production and handling and storage and will be involved in extension efforts associated with Farmer Field Schools. He will assist with graduate training of the students involved in agronomy and pest management aspects of the project at KNUST. Rick Brandenburg will assist David Jordan in administering the project and will be involved in developing aflatoxin mitigation strategies during production and handling and storage and will be involved in extension efforts associated with Farmer Field Schools. He will also be involved in assisting with graduate training of one student involved in agronomy and pest management aspects of the project.

University of Florida

Scope of Work

Investigators
Kenneth J. Boote (PI), Greg MacDonald (Co-PI), and John Erickson (Co-PI)

Title
Using Applied Research and Technology Transfer to Minimize Aflatoxin Contamination and Increase Yield, Quality and Marketing of Peanut in Ghana

Overview
The primary platform for addressing aflatoxin contamination of peanut in the supply chain in Ghana will be activities at 9 villages in northern and central Ghana, where interventions at each step of the supply chain will be implemented and aflatoxin contamination determined (Objective 1 – Ghana scientists with Jordan & Brandenburg, NC State). Research will be conducted at the Savanna Agricultural Research Institute (SARI) in Wa and Tamale, and at the Crops Research Institute (CRI) in Kumasi to develop appropriate production and pest management strategies and evaluate new germplasm appropriate for the region (Objectives 2, 3, and 4 – Ghanian scientists, with Boote, MacDonald, Erickson, UF, also NC State researchers). Results from efforts at villages and research stations will be presented to farmers using the Farmer Field School approach and appropriate posters, bulletins and manuals

(Objective 5 – Ghanian scientists, with NC State researchers). Graduate student training will be linked closely to activities in villages and research stations (Objective 6 – Ghanian scientists).

Objective 2

Detailed comparisons of pest management and production practices will be conducted at SARI, CRI, and selected villages. In on-station trials, pesticides will be evaluated for cost-effective management using appropriate small-scale equipment to more efficiently and uniformly apply pesticides. Small and light weight threshers and peanut shellers, appropriate for women will be evaluated. On-farm demonstrations in villages in collaboration with MOFA will show-case improved cultivars, pesticides, fertilizers, and appropriate mechanization to intensify and improve peanut production using advanced production integrated management strategies.

Objective 3

Evaluation of improved cultivars from ICRISAT, US, and African breeders in multi-location trials at Tamale, Wa, and Kumasi with a focus on improving yield, increasing leafspot resistance, reducing aflatoxin and minimizing other stresses that limit yield and quality of peanut.

Objective 4

The most promising lines after testing will be aimed for release, multiplication, and distribution to farmers, aided by on-farm demonstrations in Objective 2 to encourage variety acceptance. We will work with farmers' communities and the Ministry of Agriculture, to improve the seed multiplication of improved cultivars and seed distribution to farmers.

Objective 5

Results from efforts at villages and research stations will be presented to farmers using the Farmer Field School approach and appropriate posters, bulletins and manuals.

Objective 6

Graduate student training will be linked closely to activities in villages and research stations.

Role of each UF scientist:

Kenneth Boote

will assist with coordinating multi-location variety trials and production practice evaluations at SARI and CRI station research sites in cooperation with Mumuni Abudulai, Jessie Naab, Moses Mochiah, and Grace Bolfrey-Arku (objective 3), and make recommendations toward cultivar release, multiplication, and distribution (objective 4). He will advise Ghanian scientists on conducting on-farm trials of cultivars, management, production, and harvest technologies (objective 4). He will conduct systems modeling evaluations of cultivars and practices over multiple soils and weather seasons, and he will assist Agricultural Economist Boris Bravo-Ureta in project assessment.

Greg MacDonald

will advise on evaluation of production practices (herbicides, fungicides, and appropriate equipment) at SARI and CRI station research sites in cooperation with Mumuni Abudulai, Jessie Naab, Moses Mochiah, and Grace Bolfrey-Arku (objective 3). He will advise Ghanian scientists on conducting on-farm trials of cultivars, management, production, and harvest technologies (objective 4). He will advise on development of production manuals (objectives 5). He will assist with developing protocols associated with testing of aflatoxin at each level of the supply chain and will contribute to planning activities associated with research at SARI, CRI and villages (objective 1).

John Erickson

will assist with coordinating multi-location variety trials and production practice evaluations at SARI and CRI station research sites in cooperation with Mumuni Abudulai, Jessie Naab, Moses Mochiah, and Grace Bolfrey-Arku (objective 3). He will advise Ghanian scientists on conducting on-farm trials of cultivars, management, production, and harvest technologies (objective 4).

Training of Visiting Graduate Students

If one of the Ghanian female graduate students obtaining degree at institution in Ghana comes to UF for short-term visit for training, we will jointly provide a means of training. Possible training areas could include use of equipment and methods for application of herbicides and fungicides (with MacDonald), or seed certification- multiplication-distribution (Foundation Seed or Dr. Tillman).

University of Georgia

Scope of Work

This proposed research will use physical and biological approaches to improve the peanut value chain in Ghana. Specific objectives of the project include 1) reduce postharvest peanut loss due to mycotoxin contamination by developing a solar peanut dryer, 2) use composting to turn mycotoxin contaminated peanut shells and kernels to organic fertilizers, and 3) develop human resource capacity by training graduate students to become experts in the proposed research field. The proposed research is expected to have a significant impact on the peanut value chain in Ghana.

Project Description

Goal

The goal of the project is to use physical and biological approaches to improve the peanut value chain in Ghana.

Relevance and Justification

2.1. Food insecurity and mycotoxin associated economic losses

The world population is expected to exceed 9 billion by 2050 (United Nation, 2009). To support a population of this size, the current level of food production will have to increase by 70% (Food and Agriculture Organization, 2009). Increase in agriculture production consumes natural resources that are becoming increasingly scarce (Hodges *et al.*, 2011). One alternative to increase food availability for a growing population is to implement technologies that will significantly reduce postharvest losses. Crop contamination with mycotoxin remains to be one of the primary causes of postharvest loss. Mycotoxin has significant economic impacts on a number of crops including peanuts (Schmale,2013). The Food and Agriculture Organization has estimated that 25% of the world's crops are affected by mycotoxin each year (Schmale, 2013). A recent World Bank study indicated that the European Union regulation on aflatoxins costs Africa $750 million annually in export of cereals, dried fruit and nuts (Agyei, 2013). Although losses faced by the global economy are estimated at $1.2 billion, African economies lose about $450 million annually to aflatoxin contamination (Atser, 2009). At least 5 to 15% of the peanut harvested in Ghana were discarded during sorting (Awuah et al., 2006). Inappropriate harvesting methods, inadequate drying practice and poor storage conditions are among primary reasons for postharvest mycotoxin contamination.

2.2. Poor agricultural practice and improper handling of mycotoxin contaminated peanut wastes

A previous study found that peanut shells produced in Northern Ghana are often used as a mulching material around homes (Tsigbey, 2003). When the mulching material is contaminated with mycotoxin-producing molds it is likely to become environmental source of mycotoxin contamination in future peanut production cycles. Mycotoxin contaminated peanut kernels are often processed into peanut butter which is fed to children. The process of sorting and peanut butter production concentrates mycotoxin, and consumption of mycotoxin contaminated peanut butter remains to be an under-reported and under-recognized cause of liver damages in Ghana (Ghana News Agency, 2005).

Studies have shown that proper composting can drastically reduce the number of pathogens in animal wastes (Martin, 2005). Heat generated at thermogenic stage of composting should be sufficient to kill mycotoxin producing molds (Anonymous, 2012). Although mycotoxin is extremely heat resistant, treatment with 0.5-2% ammonia at ambient or elevated temperature reduces the toxin level considerably (Potty, 2009). These levels of ammonia could be achieved 3 naturally if contaminated kernels (rich in nitrogen containing proteins) are composted concurrently with peanut shells.

2.3. Limited capacity development and short supply of qualified human resources

The 2013 Africa Capacity Indicator Report indicated that massive discoveries of natural resources in Africa had generated critical concerns on the quality of human resource capabilities to manage these resources to the benefit of the people.

Research Plan

3.1. Objectives

A. Develop and use a solar peanut dryer to reduce peanut losses caused by postharvest mycotoxin contamination
B. Develop and use a composting system to turn mycotoxin contaminated peanut shells and kernels to organic fertilizers
C. Develop human resource capacity by training graduate students to become experts in the proposed research field.

3.2. Role of each scientist/partner

Dr. Jinru Chen will oversee the technical and budgetary aspects of the project. She will work closely with Mr. Mark Heflin on the design and construction of the solar dryer and composting system. She will be responsible for evaluating the efficacy of the dryer in improving peanut safety and of the compositing system in detoxifying aflatoxin, inactivating aflatoxin producing molds and other pathogens, and producing high quality organic fertilizers.

Dr. Robert Phillips will assist Mr. Mark Heflin for the design and construction of the peanut dryer and composting system. He will also be responsible for evaluating the efficacy of the peanut dryer in improving the quality of peanuts and determining the quality of the organic fertilizers.

Mr. Mark Heflin will be responsible for the design, construction and optimization of the solar peanut dryer and composting system.

3.3. Annual work plan, milestones and timeline

3.3.1. Work plan

Design and build a solar peanut dryer
The concept for the solar peanut dryer consists of a solar collector for heating air which would be ducted to a two-drum dryer which is manually turned. The drum will have a provided port 4 for manually loading the materials to be dried. The same mechanism that rotates the drums, in horizontal orientation, will rotate the fan that will circulate the heated air through the drum and return it to the solar collector. A portion of the air will be exhausted from the system to remove water vapor. The roller support structure for the two-drum dryer will be so constructed as to allow the drums to tilt, allowing the dried material to be ejected from the dryer by continued rotation. We plan to use a prototype conceptual solar dryer to demonstrate, on a small scale, the practicality and low cost of a future larger system. Evaluate the performance of the peanut dryer.

The performance of the solar drying system will be evaluated using three collector tilt angles (30,45 and 60o from horizontal). The following parameters will be measured: (a) radiation incident on the collector, (b) air temperatures at various locations in the collector and dryer, (c) relative humidity of air.

Solar radiation will be measured by a solar meter. To measure the temperature of air at various locations of the collector and dryer, K-type thermo-couples will be installed at various points along the length and width of the solar dryer. All temperature data will be registered at an interval of 15 min. Drying test will start at 9:00 am and stop at 3:00 pm. Relative humidity of air will be monitored through a control sensor (Omega, Stamford, CT) that was run by a HP data acquisition/switch unit (Hewlett Packard, Palo Alto, CA) controlled by a computer. Moisture contents of the peanuts entering and leaving the solar drier will be also documented.

Use of solar dryer to improve the safety, quality and shelf life of peanuts
Color changes of the peanuts from solar drying and conventional, open air sun

drying will be determined and compared. Peanut color will be determined using a colorimeter. Effect of solar drying on vitamin E content of peanuts will be determined by direct solvent extraction and normal phase HPLC (Shin et al., 2009). Aflatoxins in dried peanuts will be analyzed by an HPLC method previously published by Reif and Metzger (1995) with necessary modifications.

Peanuts dried by different methods will be store in containers or bags of different materials such as mild steel, moisture barrier polymers, and etc. Packaged peanuts will be stored for an extended period of time. The extent of lipid oxidation and counts of total aerobic bacteria and total yeasts and molds will be determined periodically during peanut storage. Counts of aflatoxin producing *Aspergillus flavus* will be determined using a modified Rose Bengal Agar and APAF Base Medium supplemented with dichloran and chloramphenicol. Content of alfatoxins will be determined using the method described above.

Effect of drying method on the relationship between drying rate and the moisture content of peanuts will be statistically evaluated using Statistica software version 8.0 (StatSoft Inc., Oklahoma, USA). The mean differences of color values, vitamin E levels, aflatoxin contents of 5 peanuts, extent of lipid oxidation and populations of various microbial counts of solar dried and open-air sun dried peanuts will be analyzed using Duncan's Multiple Range Test.

Design and build a composting system

A composting system concept we propose consists of an enclosed trench or trough in which the materials would be manually loaded. A cylindrical rolling crusher will be mounted in the trough and manually operated to grind the materials to enhance the composting process, increasing the exposed surface area for bacterial action. Crushing in this manner provides an inexpensive alternative to shredding machinery. A similar cylindrical stirring device will be mounted in the trough and also manually operated to periodically turn or stir the materials to facilitate the oxygen penetration and promote microbial breakdown of the organic matter. Seals will be provided to contain dust and mold spores within the system. As an alternative, a separate inexpensive crushing-shredding device will be investigated that spreads the organic matter throughout the trough.

Our prototype will be a small functional working scale model of a larger future system. The concept and working model will demonstrate the successful design of an inexpensive system that can be duplicated with materials primarily found in host countries.

Evaluate the performance of the composting system
Two types of raw materials will be composed: peanut shells and kernels with natural levels of aflatoxins and aflatoxin-producing mold contamination as well as peanut shells and kernels artificially inoculated with aflatoxin-producing *A. flavus*.

Small quantity of manure compost will be placed into water and allow it steep. The resulting compost tea solution will be applied to the raw materials in the composting system described above. The temperature, moisture content, aflatoxin level, aflatoxin-producing mold counts as well as populations of other significant pathogens will be determined during, as well as at the end of, the composting process. The temperature and time combination required for detoxifying aflatoxins and inactivating aflatoxin-producing molds will be determined.

Evaluate the quality of the organic fertilizers
The quality of an organic fertilizer can be determined by its nutritional content or its ability to provide nutrients to a crop. In the present study, the nutrient content of the fertilizers will be determined. Chemical analysis will be conducted to quantify organic carbon (Walkley and Black, 1934), available nitrogen (Subbaiah and Asija, 1956), available phosphorus (Olsen et al., 1954) and available potassium (Hanway and Heidel, 1952). The ability of the fertilizer to provide nutrients to peanut crops will be studied in collaboration with Ghanaian collaborators.

3.3.2. Milestone and timeline

Year 1
A peanut solar dryer will be designed and built, and the mechanical performance of the dryer will be evaluated. By the end of year 1, the peanut dryer and information on its performance will be available. A graduate student will start his/her training in the first year of the project.

Year 2
The efficacy of the solar dryer in improving the safety, quality and shelf life of freshly harvested peanuts will be evaluated. By the end of year 2, information on the efficacy data will be available. The graduate student will have completed his or her course work and started working on the research project.

Year 3
A composting system will be designed and built, and the mechanical performance of the system will be evaluated. The technology on the solar drier will be transferred to host country. Training on the graduate student will continue.

Year 4
The effectiveness of composting in detoxifying aflatoxin and inactivating aflatoxin producing molds and other pathogens will be evaluated. The nutrient quality of the organic fertilizers will be evaluated.

Virginia Tech

Scope of Work

Team of researchers from Virginia Tech, University of Georgia and University of Ghana will work on post-harvest storage and value added product/process development. Post-harvest storage solutions will be developed that are affordable and appropriate to Ghana. The design of storage solutions and process development of value added products will be conducted as a part of undergraduate research and capstone design project at Virginia Tech. The students will work with local clients in Ghana in identifying design solutions and implementation of such solutions.

The project will use the unique and innovative approach known as PIIM (Peanut Industry incubator Model) to fast track the food process and product development cycle ensuring safe (aflatoxin free and microbiologically safe) and nutritious peanut based products. This model requires early engagement in partnerships between research institutions and private food industry partners (IP), and agreement during early stage of development work of research project through intensive interactions. In addition, this approach will include development of good manufacturing practices such as HACCP and facilitate the development of value added peanut based products that will increase the livelihood. Women owned and small-scale peanut processors will be identified and will be partnered to work in this PIIM. A processing technology was developed under USAID Peanut CRSP program in SE Asia for sorting aflatoxin contaminated peanuts. This sorting process technology has been implemented in the Philippines, Thailand, and Uganda and then in Ghana to a limited extent. This technology will be used to ensure development of aflatoxin free peanut products. Training the processors on good manufacturing practices and Hazard Analysis Critical Control Points will address the reduction of aflatoxin in the finished product. A graduate student from University of Ghana will perform process and product development activities.

Subaward PI: Dr. Manjeet Chinnan, Prof Emeritus, University of Georgia

Dr. Manjeet Chinnan will work with Mallikarjunan from Virginia Tech on post-harvest handling, storage and value added product/process development in Ghana. The design of handling and storage solutions and process development of value added products would be conducted as a part of undergraduate research and capstone design project at Virginia Tech. The students will work with local clients in the region in identifying design solutions and implementation of such solutions. Dr. Chinnan will provide technical expertise as necessary.

The project will use the unique and innovative approach known as PIIM (Peanut Industry incubator Model) to fast track the food process and product development cycle ensuring safe (aflatoxin free and microbiologically safe) and nutritious peanut based products. This model requires early engagement in partnerships between research institutions and private food industry partners (IP), and agreement during early stage of development work of research project through intensive interactions. Women owned and small-scale peanut processors will be identified and will be partnered to work in this PIIM. In addition, Dr. Chinnan will assist in training and implementation of processing sorting technology for producing aflatoxin free peanut based products.

University of Connecticut

Scope of Work

Boris Bravo-Ureta (BB-U), in collaboration with A. Dankyi, and economist with the Crops Research Institute in Ghana funded directly by NCSU, and Graduate students at UCONN, will work on survey and sample design, and related analysis that will be used in each village in the first year of the program. Follow-up surveys will be performed to determine overall effectiveness of the interventions toward the end of the Project.

Professor Bravo-Ureta will have a graduate student partially funded by the project in in Years 1 and 2, and in Year 4. The activities to undertaken during the Project are as follows:

October 2013 – December 2014:
Contribute to survey design and implementation to collect data from 9 villages in Ghana relative to production, drying and storage, and processing practices. Hire graduate student for the Project for the first 1.5 years of the project.

January - December 2014:
Contribute to the analysis of the survey data from villages to determine appropriate interventions in time for planting in March 2014. Dr. BB-U will travel to Ghana in January 2014 to work with the team on data analysis and report writing and on plans for the work to done over the Project's life.

Design the procedures to evaluate the economic performance of relevant Project interventions including the expected profitability of varieties to be released under objective 4.

January 2015 - June 2015:
Prepare cost and return information based on the data collected from the first round of surveys. Begin to develop the economic dimension of the manual described in objective 7. Prepare a publication focusing on farm profitability.

July 2015 - June 2016:
Dr. BB-U will be available for consultation with the Team as needed. He will Travel to Ghana to prepare for additional field work. He will provide a 2-day workshop on farm level profitability analysis. Second graduate students will be hired.

July 2016 - June 2017:
Dr. BB-U along with the graduate student will undertake the final analysis of data collected over the life of the project in order to evaluate key interventions. Materials will be prepared for dissemination and publication. Dr. BB-U will travel to Ghana to present final results and work on final report with the local team members.

Savanna Agricultural Research Institute

Scope of Work

Investigators
Mumuni Abudulai (PI-Tamale), Jesse B. Naab (PI-Wa)

Title
Using Applied Research and Technology Transfer to Minimize Aflatoxin Contamination and Increase Yield, Quality and Marketing of Peanut in Ghana

Overview
The primary platform for addressing aflatoxin contamination of peanut in the supply chain in Ghana will be activities at 5 villages in northern, where interventions at each step of the supply chain will be implemented and aflatoxin contamination determined (Objective 1 – Ghanaian scientists with Boris Bravo-Ureta, David Jordan & Rick Brandenburg, NC State). Research will be conducted at the CSIR-Savanna Agricultural Research Institute (CSIR-SARI) in Tamale and Wa to develop appropriate production and pest management strategies and evaluate new germplasm appropriate for the region (Objectives 2, 3, and 4 – Ghanaian scientists, with Boote, MacDonald,

Erickson, UF; and Jordan and Brandenburg, NCSU). Results from efforts at villages and research stations will be presented to farmers using the Farmer Field School approach, on-farm demonstrations and appropriate posters, bulletins and manuals (Objective 5– Ghanaian scientists, with Jordan and Brandenburg). Graduate student training will be linked closely to activities in villages and research stations (Objective 6 – Ghanaian scientists).

Objective 1

Five villages near Tamale and Wa in northern Ghana will be surveyed during October 2013 through January 2014 to determine practices employed by farmers to produce, store and process peanut.

Objective 2

Detailed comparisons of pest management and production practices will be conducted at CSIR-SARI and in five selected villages near Tamale and Wa. In on-station trials, pesticides will be evaluated for cost-effective management using appropriate small-scale equipment to more efficiently and uniformly apply pesticides. On-farm demonstrations in villages in collaboration with MoFA will be conducted to show-case improved cultivars, pesticides, and production technologies to improve peanut production using advanced production and integrated management strategies.

Objective 3

Evaluation of improved cultivars from ICRISAT, US, and local sources in multi-location trials at Tamale and Wa with a focus on improving yield, increasing leafspot resistance, reducing aflatoxin and minimizing other stresses that limit yield and quality of peanut.

Objective 4

The most promising lines after testing will be aimed for release, multiplication, and distribution to farmers, aided by on-farm demonstrations in Objective 2 to encourage variety acceptance. We will work with farmers' communities and the Ministry of Agriculture, to improve the seed multiplication of improved cultivars and seed distribution to farmers.

Objective 5

Results from efforts at villages and research stations will be presented to farmers using the Farmer Field School approach, on-farm demonstrations and appropriate posters, bulletins and manuals during years 2, 3, and 4.

Objective 6

Graduate student training will be linked closely to activities in villages and research stations.

Kwame Nkrumah University of Science and Technology

Scope of Work

Investigators
Drs. Moses Brandford Mochiah (PI) and Grace Bolfrey-Arku (Co-PI)

Overview

Objective 1

Ghana scientists with Jordan & Brandenburg, NC State will conduct research at the Crops Research Institute (CRI) in Kumasi to develop appropriate production and pest management strategies and evaluate new germplasm appropriate for the region (Objectives 2, 3, and 4 – Ghanaian scientists, with Boote, MacDonald, Erickson, UF, also NC State researchers). Results from efforts at villages and research stations will be presented to farmers using the Farmer Field School approach and appropriate posters, bulletins and manuals (Objective 5 – Ghanaian scientists, with NC State researchers). Graduate student training will be linked closely to activities in villages and research stations (Objective 6 – Ghanaian scientists).

Objective 2

Detailed comparisons of pest management and production practices will be conducted at CRI, and 4 selected villages. In on-station trials, pesticides will be evaluated for cost-effective management using appropriate small-scale equipment to more efficiently and uniformly apply pesticides. Small and light weight threshers and peanut shellers, appropriate for women will be evaluated. On-farm demonstrations in villages in collaboration with MOFA will show-case improved cultivars, pesticides, fertilizers, and appropriate mechanization to intensify and improve peanut production using advanced production integrated management strategies.

Objective 3

Evaluation of improved cultivars from ICRISAT, US, and African breeders in multi-location trials at Kumasi with a focus on improving yield, increasing leaf spot resistance, reducing aflatoxin and minimizing other stresses that limit yield and quality of peanut.

Objective 4

The most promising lines after testing will be aimed for release, multiplication, and distribution to farmers, aided by on-farm demonstrations in Objective 2 to encourage variety acceptance. We will work with farmers' communities and the Ministry of Agriculture, to improve the seed multiplication of improved cultivars and seed distribution to farmers.

Objective 5

Results from efforts at villages and research stations will be presented to farmers using the Farmer Field School approach and appropriate posters, bulletins and manuals.

Objective 6

Graduate student training will be linked closely to activities in villages and CSIR- CRI on-stations research.

Faculty will be involved in education of 3 Master of Science students at KNUST in areas of: 1) production/pest management, 2) food science; and 3) agricultural engineering. Students will partner with PMIL team with SARI and CRI for their research either in targeted villages or replicated trials on research stations at Wa, Tamale and Kumasi. Aflatoxin samples collected in villages and research stations will be processed at KNUST using proven sampling and analyses protocols. A processing workshop will be held at KNUST.