**CONTEXT**

The U.S. Agency for International Development (USAID) Bureau for Food Security (BFS) implements the Feed the Future initiative as the United States’ contribution to a collaborative global effort supporting country-owned processes and plans for improving food security. Science & technology feature prominently in the initiative through research investments with an array of partners. Among the key partners in implementing Feed the Future research programs are the 24 Feed the Future Innovation Labs. The Innovation Labs engage U.S. universities and colleges in collaboration with developing country research partners to conduct agricultural research and human and institutional capacity development (HICD) in support of joint U.S.-host country food security goals.

The Feed the Future Innovation Lab for Collaborative Research on Peanut Productivity and Mycotoxin Control ends in 2017. As groundnut (*Arachis hypogea*, peanut) is a priority within Feed the Future, USAID seeks to develop new research program(s) to address key researchable questions related to this crop. These questions may span the use of groundnut as feed/fodder for livestock, its integration in smallholder production systems, post-harvest processing, value-addition, markets and consumption.

BFS will host a web-based Groundnut AgExchange June 14-15, 2016 to solicit global, public input in defining key research and capacity development priorities which BFS will use to help inform the development of new research programs.

During the AgExchange, we encourage participants to reference peer-reviewed literature to further explain the points and/or elevate important issues. Where peer-reviewed literature is not yet available, other sources of information may be offered, including professional experience. As this AgExchange covers many diverse areas, we encourage respondents to focus on those questions of greatest interest.

**RATIONALE**

A recent (March 22-23) AgExchange examined research priorities for grain legume crops\(^1\) and many of the issues raised in those discussions and the corresponding white paper are relevant to groundnut. However, there are some important differences for groundnut which need to be borne in mind.

Groundnuts have a high oil and protein content and can be eaten directly or processed for oil, and the cake used for animal feed. They have a considerable trade and export market and can therefore provide income. The export market is regulated according to quality, notably with limits on aflatoxin contamination.

Groundnut is a major world commodity and ranking 23\(^{rd}\) in value among all agricultural commodities and 16\(^{th}\) of crop commodities (FAOSTAT), with an annual value of approximately $20 billion. Groundnut production in USAID target countries represents a little less than 7% of the world’s area under groundnut production. Substantial international trade in groundnut has direct consequences for its price and availability. International trade can buffer against national-level price reductions when total production increases (either through increased area or increased productivity) and when international quality standards can be met. In Malawi the USAID supported 'doubled up legume' initiative has promoted a groundnut - pigeonpea, maize - pigeonpea rotation which has been adopted, providing nutritional benefits and soil health (Glover et al. 2012\(^2\), Reganold & Glover 2016). An impact assessment of groundnut research in Malawi (Tsusaka et al. 2016) has been

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\(^1\) [https://agrilinks.org/agexchange/shaping-feed-future-research-agenda-agexchange-grain-legumes](https://agrilinks.org/agexchange/shaping-feed-future-research-agenda-agexchange-grain-legumes)

\(^2\) see also Snapp S.S. et al. (2010) Biodiversity can support a greener revolution in Africa. PNAS 107: 20840-20845. cited in Glover et al
broadly favourable, but showed that the growth in groundnut production over the past ca. 20 years has been mostly due to an increase in the area under cultivation (ca. 50,000 to 350,000 ha) rather than an increase in productivity (ca. 0.6 to 1.0 t/ha). No doubt increasing the area under production is promoted by the improvement in yield potential and stability.

Groundnut haulm is a good source of nutrition for farm animals (Blümmel M. et al. 2012) and can be traded locally. Groundnuts are harvested from below ground, and this involves removing some of the below-ground organic matter. The contribution of groundnut to soil health is thus mainly from its consequence for soil microflora and the lack of a requirement for inorganic N fertilization with the associated mitigation of energy demand and greenhouse gas production. A contribution of the crop to soil organic matter can be achieved indirectly through the use of animal manure.

The primary goals of investments in groundnut research for development are therefore to improve smallholder farm income and farm sustainability while contributing directly (as food) and indirectly (e.g. as feed/forage for farm animals) to diversifying household diets.

**Research Focus**

This e-consultation seeks to identify critical researchable questions to improve groundnut productivity and income generation in the context of known and foreseeable constraints and opportunities. By tapping into the global community of groundnut experts to identify areas of inquiry that merit future research investment, we aim to identify critical research outputs that will maximize the economic, environmental, and nutrition benefits for smallholder farmers that derive from groundnut production.

To achieve this, an understanding of the relationship between crop performance in farmers' fields and its social, economic and environmental context is required, notably taking account of value addition through processing. We posit that groundnut production is a critical component of sustainable and profitable smallholder production systems, and increased availability and accessibility of high quality groundnuts can contribute to improvements in dietary diversity in regions where it is directly consumed or indirectly as a feed/fodder option for farm animals. Further, increasing groundnut productivity, including closing the yield gap and mitigating post-harvest losses, is critical to achieving more sustainable and financially profitable smallholder production systems, while improving the availability and accessibility of nutritionally dense foods.

Genomic studies of groundnut are well advanced and this information is in use for understanding trait inheritance and diversity (Bertioli et al 2016, Leal-Bertioli et al 2016) although for some studies groups of trait measures co-locate on the genome and/or lie on unassigned genomic regions (Pandey et al 2016); the opportunities for genetic analysis of productivity related traits in groundnut seem good. Of note is the potential for dual use groundnut: although there is a weak negative association between pod yield and haulm nitrogen content (Blummel et al 2012) there is considerable variation within this trend suggesting that a genetic analysis of the potential of improvement of groundnut for dual use should be feasible.

Aflatoxin levels remain high in some locations (Kana et al. 2013 in the range from just over to 10 times US limits see also http://agris.fao.org/agris-search/search.do?recordID=QB2015103573), and sorting grain has associated difficulties (Matumba et al. 2015). Understanding how aflatoxins fit into the broader array of challenges for groundnuts to contribute to diet quality improvements in Feed the Future geographies is a topic proposed within this AgExchange.

Below, we identify 11 thematic areas critical to successful groundnut value chains, and pose a series of questions intended to elicit informative responses from AgExchange participants. First, we want to clarify our rationale.
1 Focal geography

A subset of the USAID Feed the Future target countries\(^3\) have substantial engagement in groundnut production (see right). Does the current area under production in these countries adequately reflect the weight of investment needed or is the cost/benefit ratio reflected in other attributes of production? Research program(s) are intended to generate global or regional public goods, that is, research outputs such as generalizable knowledge and/or technologies that can be widely adopted (beyond a single country). Given the geographic focus of Feed the Future, what are the various capacities and/or opportunities in these countries where research activities could generate outputs relevant beyond national boundaries? For example, the Zambian Agricultural Research Institute has been designated a Regional Center of Leadership for food legumes research under the three-country research program led by the national agricultural research programs, APPSA\(^4\).

Question 1.1

*Within these geographic parameters, what are the main challenges for groundnut producers and/or processors that can benefit from research investment?*

Question 1.2

*What kinds of other networks or opportunities could be leveraged to improve the ability of USAID-funded groundnut research to broadly impact farmers, processors, and consumers along the groundnut value chain?*

2. What’s the nature of market demand for groundnuts (and which markets)?

How demand is partitioned between on-farm consumption, trading in local markets, regional and international trade must be understood to ensure research outputs respond to these demands. As demand trends change over time, and because research outputs are only available in the medium-

\(^{3}\) http://www.feedthefuture.gov/countries

The current list comprises Bangladesh, Cambodia, Ethiopia, Ghana, Guatemala, Haiti, Honduras, Kenya, Liberia, Malawi, Mali, Mozambique, Nepal, Rwanda, Senegal, Tajikistan, Tanzania, Uganda, Zambia. However, changes in this list may occur in response to Initiative-level shifts in target countries under future phases of Feed the Future.

to-longer term, understanding the nature of these demand trends is critical to prioritizing current research for future benefits. Similarly, differentiated gender roles with respect to decision-making and steps along the value chain need to be better understood in relation to income generation and nutritional outcomes (see Bhaumik et al 2014) to ensure that research is oriented in ways that benefit both men and women. Beyond simply demand for grain, markets for haulms for use in animal feed are robust in some areas.

**Question 2.1**
What is currently known about market demand for groundnuts, haulms, and groundnut seed in FTF countries?

**Question 2.2.1**
To what extent is the use of groundnut haulm for animal feed a factor in farmers’ decision making? Does this vary for men and women farmers? If so, how?

**Question 2.2.2**
What is the relative value of grain and haulm to farmers and how does this vary with time and location? Does this vary for men and women farmers? If so, how?

3. Processing and value-addition

Processing of groundnut adds value and can be realised at different stages. How does processing, shelling, crushing, affect the return to farmers and how is this influenced by the availability of storage facilities or other post-harvest factors (drying techniques, etc)? How does access and ownership of equipment / facilities influence local processing and value addition activities?

**Question 3.1**
What technological or knowledge constraints currently limit opportunities for local value-added processing of groundnut? Does this differ for men and women? If so, how?

**Question 3.2**
How do the market demands differ according to the degree of processing?

**Question 3.3**
How does access to / benefit from technology vary according to gender?

**Question 3.4**
What kind of partnership structures would promote development of relevant research outputs that are taken up by end users?

4 Groundnut in the context of smallholder farming systems

For smallholder farmers, what is the relative importance of different uses of groundnut, including direct human consumption, as feed/fodder (or cake) for farm animals, as a cash crop and to provide ecosystem services?

**Question 4.1**
To what extent does groundnut contribute directly to the household diet (as food) vs indirectly (as animal feed) or as a cash crop?

**Question 4.2**
How can smallholder farmers optimally balance economic returns from production with the needs to improve soil health, increase longer-term sustainability of total farm production, and maintain
desired levels of household groundnut consumption? Does this differ among women and men? If so, how?

5 Yield gap, and post-harvest loss

For groundnut in Feed the Future target countries yields are in the range 0.3 to 3.3 t/ha and with the exception of three very large values in the FAO data (7 & 25 t/ha), major producers achieve yields in the range of 3 to 4 t/ha, so yield gaps are not necessarily of major concern in some of these countries. The graph on the right plots production vs yield by country (FAOSTAT), clearly the country where the greatest impact would be obtained by increasing yield is Senegal, whereas this would have little effect in Tajikistan or Kenya unless substantial new and less productive areas were dedicated to groundnut. Closing the yield gap offers greatest potential where production is large but the yield is relatively low. The sources of these gaps need to be identified and discriminated by location, season, crop and socio-economic factors (e.g. water limitation, pests, disease, soil infertility, seed quality/germination, etc.) and interactions between factors so they can be prioritised for intervention with due regard to the variability among and within smallholder farms.

Aflatoxin research on groundnut has been closely linked to crop improvement research. The extent to which this linkage is synergistic with reducing the yield gap should be considered. Regional and global trade in groundnuts requires attention to quality considerations with particular emphasis on aflatoxin contamination. Given the quality demands in global markets, and the human health benefits from high quality groundnuts, how does aflatoxin contamination rank relative to other production constraints among smallholders? A discussion on research priorities on mycotoxins will be the subject of a separate consultation, but the goal of this question is to clarify the relative importance of aflatoxins as a focus of research efforts oriented towards groundnut production in Feed the Future countries.

**Question 5.1**
Can research be undertaken in ways that accelerate progress in reducing yield gaps and post-harvest losses? If so, how?

**Question 5.1.1**
What disciplines must be brought to bear on reducing the yield gap and post-harvest losses?

**Question 5.1.2**
Are there any particular factors that contribute to the yield gap and post-harvest losses that rise above all others, and should be prioritized? If so, why, and in which region?

**Question 5.1.3**
How might mechanization mitigate yield gaps and/or post-harvest losses?

**Question 5.2**
What proportion of effort should be directed specifically at reducing the risk of aflatoxin contamination and what are the key research questions in this regard?
6 Modelling

Models can integrate information from diverse research disciplines to predict likely outcomes and should take account of external resources pertaining to the physical environment; such as the survey of African soils\(^5\), and climate models\(^6\); the social, agricultural and economic environment such as compiled in the Atlas of African Research and Development\(^7\). Crop physiological models offer an opportunity to connect these diverse data sources to genetic analyses of crop performance. How might this be achieved for groundnut and whether it would be a useful strategy needs discussion.

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<th>Question 6</th>
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<td>How might crop modelling with respect to genetic variation and variation in agricultural practice provide insights to priorities for biophysical research activities? What other types of information should be incorporated into models?</td>
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7 Seed Systems

Week seed systems are a major constraint to the production and dissemination of improved varieties and can critically limit the value of breeding investments. Knowledge gaps remain regarding best practices to promote smallholder access to quality seed and new varieties—and this varies by location. The extent to which the availability of quality seed still constrains farmers' choice with respect to groundnut cultivation should be considered as does the separation of the grain and seed supply.

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<td>What key researchable questions would be most informative to USAID’s development efforts to design and support effective, sustainable seed system for groundnut? What are the critical knowledge gaps that must be filled?</td>
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<td>Question 7.1</td>
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<td>The quality of seed available to farmers contributes to crop establishment. Based on this knowledge, could interventions (genetic or physiological) that improve the maintenance of seed quality be used to mitigate crop losses associated with poor establishment?</td>
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8. Nutrition

What is known about the extent to which groundnut contributes to improved nutrition and health outcomes in Feed the Future target countries and what are the pathways (direct consumption, sale and use of income on purchase of other foods, etc.)?

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<td>Given the focus of Feed the Future on improving nutrition among women and children under the age of five years, what are the priority research questions, if any, to further understand the nutritional role/function of groundnut in the diet in these populations?</td>
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\(^5\) e.g. AGIS http://www.agis.agric.za/agisweb/soils

\(^6\) e.g. IPCC http://www.ipcc-data.org/sim/gcm_monthly/ or CIMP5 http://cmip-pcmdi.llnl.gov/cmip5/index.html

\(^7\) http://agatlas.org/
9. Soil fertility and soil health

Legume production is well understood to contribute to soil fertility and soil health, but this may be reduced in the case of groundnut because the soil is disturbed at harvest and soil organic matter is removed. What is known about the effect of groundnut production for soil health and the performance of following crops? The extent to which groundnut production is hampered by soil degradation or poor nutrient (and water) supply needs to be considered including in the context of doubled-up legume (Glover et al 2012) systems.

| Question 9.1 |
| In order to optimize N fixation and P assimilation in smallholder legume production systems, where is the balance of research effort best placed with respect to the host plant and microbial symbionts (bacterial, fungal, etc.)? |

| Question 9.2 |
| What research is needed to identify how groundnut can be deployed to optimise water use within a production system? |

| Question 9.3 |
| In degraded soils/production environments, what is the evidence of the value of groundnut production relative to other legume species? What research is needed in these environments? |

10. Capacity development

Key assets for capacity development lie in U.S. Universities, especially as mediated by the Feed the Future Innovation Labs. These programs involve collaboration between U.S. University and host country scientists among other partners such as international agriculture research centers, private sector, and development assistance organizations. These programs primarily involve advanced degree training in the US, the host country, and/or in third countries. As many scientists in the field are nearing retirement, understanding the key disciplines and research domains that would benefit from new training opportunities for scientists would enable a more strategic allocation of advanced degree training opportunities.

| Question 10 |
| What key constraints in human capacity are particular to groundnut, and must be addressed to foster a robust groundnut research community? |

11. Effective partnerships

Partnerships need to strengthen researchers’ capacity to conduct high-impact research-for-development, while promoting constructive interactions between a wide range of partners and stakeholders. The Feed the Future Research Strategy calls for partnership and collaboration with U.S. and local university communities, the global donor community, international, regional and national NGOs and IGOs, USAID Missions, civil society organizations, implementing partners including extension agents, health service providers, and private sector partners as well as national agricultural research institutes, farmers and community members. Research efforts must identify key partnership opportunities as a means to leverage investments both in development and research.

| Question 11 |
What potential partners have not been fully utilized in the context of groundnut research, and how can they take ownership of their role in joint actions? What existing partnerships have proven effective and why?

REFERENCES


