The Feed the Future Legume Innovation Lab

Grain Legume Research Conference

Ouagadougou, Burkina Faso
13 to 18 August 2017

hosted by the

Feed the Future Innovation Lab for
Collaborative Research on Grain Legumes
(Feed the Future Legume Innovation Lab)

in partnership with the

Institut de l'Environnement et des Recherches
Agricoles (INERA) – Burkina Faso
An institute of the Centre National de la Recherche Scientifique et Technologique (CNRST)

Legume Innovation Lab

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ACKNOWLEDGMENTS

The Management Office of the Feed the Future Innovation Lab for Collaborative Research on Grain Legumes (Feed the Future Legume Innovation Lab) wishes to express its sincere gratitude to the following institutions and persons who have contributed in a substantial manner to the 2017 Feed the Future Legume Innovation Lab Grain Legume Research Conference, 13 to 18 August 2017.

- To **Feed the Future,** for recognizing the strategic importance of grain legumes as a nutritious staple food in diets and their role in contributing to the sustainability and economic viability of smallholder farms in Africa and Latin America as articulated in the Feed the Future Global Food Security Research Strategy. In particular, Feed the Future is to be thanked for its financial support of the 2017 Feed the Future Legume Innovation Lab Grain Legume Research Conference in Ouagadougou, Burkina Faso, through the Feed the Future Legume Innovation Lab.

- To **Michigan State University (MSU),** in particular, the College of Agriculture and Natural Resources (represented by Dr. Douglas Buhler, Director, MSU AgBioResearch, and Assistant Vice President for Research and Graduate Studies, and the Center for Global Connections (Gretchen Neisler, Director), plus the Office of International Studies and Programs (Steven Hanson, Dean), for their support of MSU's role as the Management Entity for the Feed the Future Legume Innovation Lab and their financial contributions to the success of the 2017 Feed the Future Legume Innovation Lab Grain Legume Research Conference, Burkina Faso.

- To the **Invited Guest Speakers** (Dr. Paco Sereme, Dr. Jess Lowenberg-DeBoer, Pr. Alkassoum Maïga, Dr. Robert Bertram, Dr. Douglas Buhler, Pr. Roger H. Nébié, Dr. Jennifer "Vern" Long, and Dr. Abdou Tenkouano) in anticipation of their informed, insightful, and thought-provoking presentations that will enlighten and stimulate conversations regarding future research needs and priorities to significantly enhance grain legume productivity and improve the nutrition of the poor, especially among women and young children.

- To all the **U.S. and Host Country Principal Investigators and Collaborators and Affiliate Partner Institutions** for their commitment and dedication to achieving the research, outreach, and capacity strengthening objectives of their respective projects in the Feed the Future Legume Innovation Lab, and for contributing in diverse, meaningful ways to the 2017 Feed the Future Legume Innovation Lab Grain Legume Research Conference so that knowledge and technology development on grain legumes are advanced.

- To the valued **Institutional Partners** (PABRA/CIAT, IITA, Bill and Melinda Gates Foundation) who support and collaborate with the international community of Feed the Future Legume Innovation Lab scientists. Your scientific capacities and cooperation are vital to the success of both Feed the Future Legume Innovation Lab and NARS research.

- To the **Technical Management Advisory Committee (TMAC) and its Chair, Dr. Julia Kornegay**, who serve an extremely important advisory function to USAID and the Management Office of

the Feed the Future Legume Innovation Lab for Collaborative Research on Grain Legumes. The TMAC-Plus's review of abstracts and leadership in development of the conference program, including the assignment of research papers to the oral and poster sessions for the 2017 Grain Legume Research Conference, are greatly appreciated.

- To the **Conference Coordinating Committee** in the Feed the Future Legume Innovation Lab Management Office at MSU (Kade Sharrow, program coordinator; Angelica Santos, financial officer; Marguerite Halversen, communications manager; and Elisa Lawriw, accountant) who ensured that all participants obtained an airline ticket and a visa, made all hotel and meeting facilities arrangements, prepared the program and other documents required for the meeting, and will be present throughout the meeting to serve the participants and to enhance the quality of the meeting experience.

Dr. Irvin E. Widders, Director

Dr. Cynthia Donovan, Deputy Director

Feed the Future Innovation Lab for Collaborative Research on Grain Legumes

Michigan State University

WELCOME

It is my great pleasure to welcome you to the Feed the Future Legume Innovation Lab Grain Legume Research Conference in Ouagadougou, Burkina Faso, co-hosted in partnership with the Institut de l'Environnement et des Recherches Agricoles (INERA) – Burkina Faso, an institute of the Centre National de la Recherche Scientifique et Technologique.

Since its early days as the Bean/Cowpea and Dry Grain Pulses Collaborative Research Support Programs (CRSPs), the Feed the Future Legume Innovation Lab has supported strategic cowpea research projects in West Africa. It therefore only seems fitting that the final conference of the 2013 to 2017 program be held in Burkina Faso where we have much history of collaboration in impactful grain legume research that is benefitting the world's most vulnerable populations, smallholder farmers.

The Feed the Future Legume Innovation Lab Grain Legume Research Conference is one of the finest international gatherings to present advances on increasing grain legume productivity; strengthening grain legume value chains; enhancing nutrition, especially among women and children, through the consumption of grain legumes; and improving outcomes of research and capacity strengthening to ensure greater developmental impact aimed at benefitting smallholder farmers and the villages and communities in which they work.

This conference, from 13 to 18 August 2017, promises to offer oral and poster presentations of research achievements focused on advances in technology development, improvements in management practices, new knowledge, and evidence of developmental impacts from the program's long-term grain legume research investments. Research over the past ten years has led to significant advancements in knowledge in such diverse areas as integrated pest management, use of molecular tools in bean and cowpea breeding, and the role of grain legumes in child nutrition and gut health.

As the final conference of the 2013-2017 Feed the Future Legume Innovation Lab program, our goals this week include showcasing the specific and overall research and institutional strengthening achievements of the international community of LIL scientists and considering how our research outputs can sustainable improve the livelihoods, resilience and nutritional status of smallholder grain legume farmers, value chain stakeholders, and consumers in Sub-Saharan Africa and Latin America.

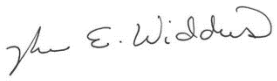
The Management Office anticipates that the Feed the Future Legume Innovation Lab Grain Legume Research Conference will be a wonderful opportunity to share the latest insights of collaborative research as well as get to know Burkina Faso, particularly during our field trip on Thursday, 17 August. INERA has organized a bus excursion for all of us to visit the Gourcy locality in Northern Burkina Faso, where we'll have the opportunity to see farmer production of foundation and/or certified seed of improved cowpea varieties. Visits to local farms have always been a highlight of Feed the Future Legume Innovation Lab conferences. This visit, with its focus on scaling up access to improved varieties of cowpea seed through local efforts, promises to continue the tradition.

USAID has sponsored grain legume research at Michigan State University and its partner U.S. universities for almost forty years, since the Bean/Cowpea Collaboration Research Support Program (CRSP) began in

1980. The Feed the Future Legume Innovation Lab is honored to be part of that legacy and looks forward to a future in which the outputs of these worthy research and institutional strengthening projects are realizing the intended development outcomes of improving the livelihoods of the stakeholders of grain legume value-chains around the world.

Welcome to Ouagadougou, Burkina Faso

Sincerely,



Irvin E. Widders
Director
Feed the Future Legume Innovation Lab
Michigan State University

Feed the Future Legume Innovation Lab Grain Legume Research Conference

13 – 18 August 2017, Ouagadougou, Burkina Faso

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Feed the Future Legume Innovation Lab Grain Legume Research Conference

13 – 18 August 2017

Laico Ouaga 2000 Hotel
Ouagadougou, Burkina Faso

CONFERENCE PROGRAM

Sunday, 13 August

2:00 – 5:00 pm	Conference Registration (near entrance to Waongo 1)
2:00 – 5:00 pm	LIL Business Office Open (will be open additional hours, as posted during the week)
6:30 pm	Conference Welcome Reception, Laico Ouaga 2000 Hotel, Poolside (Benkadi Room if the weather is poor)
3:00 – 6:30 pm	Poster set up in Waongo 2

Monday, 14 August

7:00 am	Conference Registration (near entrance to Waongo 1)
	Poster set up in Waongo 2
8:30 – 10:30 am	**Inaugural Session of the Conference** – Waongo 1 (120 minutes) **Moderator:** TBD
	Jacob Ouedraogo, Ingénieur Agronome, Ministre de l'Agriculture et des Aménagements Hydrauliques, Burkina Faso
	Alkassoum Maïga, Professeur, Ministre de l'Enseignement Supérieur, de la Recherche Scientifique et de l'Innovation
	Roger Nébié, Professeur, Délégué General du Centre National de la Recherche Scientifique et Technologique (CNRST)
	Abdou Tenkouano, Executive Director, CORAF/WECARD
	Representative, United States Embassy to Burkina Faso
	Robert Bertram, Chief Scientist, Bureau for Food Security, U.S. Agency for International Development (USAID)
	Douglas Buhler, Associate Vice President for Research and Director of MSU AgBioResearch, Michigan State University

Irvin Widders, Director, Feed the Future Legume Innovation Lab, Michigan State University

10:30 – 11:00 am Break and group photo

11:00 am – 12:30 pm **Inaugural Keynote Presentations** – Waongo 1

11:00 *Importance of Cowpea to the Livelihoods of Smallholder Farmers in Burkina Faso and INERA's Research Efforts to Address Challenges and Opportunities Facing the Cowpea Sector*
Dr. Paco Sereme, Research Director, INERA, Burkina Faso (40 min)

11:40 *Agriculture for Nutrition: Legumes in the Lead*
Dr. Robert Bertram, Chief Scientist, Bureau for Food Security, U.S. Agency for International Development (USAID) (40 min)

12:30 pm Lunch

2:00 – 4:00 pm **Plenary Session 1 – *Human Health and Nutrition*** – Waongo 1
Moderator: Karen Cichy, USDA/ARS, Michigan State University (5 minutes)

2:05 **PL1-1** *Impact of LIL on capacity building and interdisciplinary work in agriculture and nutrition. Panel discussion*
Panel Leader: Kenneth Maleta, University of Malawi School of Medicine
Participants: Celina Wille, Carolina Molina, Yankho Kaimila (25 minutes)

2:30 **PL1-2** *Legumes, growth and development in young Malawian children*
Mark Manary, Washington University in St. Louis School of Medicine

2:45 **PL1-3** *MASFRIJOL, nutrition-sensitive lessons for indigenous, rural families in Guatemala's Western Highlands*
Carolina Molina, MASFRIJOL Program, Michigan State University

3:00 **PL1-4** *Impact of legume supplementation on child growth and infectious symptoms in 6-12-month-old Malawian children*
Chrissie Thakwalakwa, University of Malawi School of Medicine

3:15 **PL1-5** *Impacts of improved bean varieties and yields on Guatemalan households*
Celina Wille, Utah State University

3:30 **PL1-6** *Legumes and the microbiota in young Malawian children*
Isabel Ordiz, Washington University in St. Louis School of Medicine

4:00 – 4:30 pm Break

4:30 - 6:00 pm **Panel Discussion – *Scaling Up and Achieving Impact*** – Waongo 1
Moderator: Cynthia Donovan, Michigan State University (5 minutes)

Keynote Presentation: Jess Lowenberg-DeBoer, Purdue University (30 minutes)
Panelists:
Jess Lowenberg-DeBoer, Purdue University
Jennifer "Vern" Long, Bureau for Food Security, USAID
Hamidou Traore, Director, INERA-Burkina Faso
Abdou Tenkouano, Executive Director, CORAF/WECARD

6:30 pm Dinner on your own

Tuesday, 15 August

8:00 – 10:00 am **Plenary Session 2 – *Genetic Improvement of Grain Legumes*** – Waongo 1
Moderator: Kelvin Kamfwa, University of Zambia (5 minutes)

8:05 **PL2-1** *Open phenotyping and analytics tools that bridge the gaps between the lab and the world: Towards knowledge-driven plant breeding of legumes for local and regional solutions*
Lead Presentation: David Kramer, Michigan State University (25 minutes)

8:30 **PL2-2** *Genome-wide association analysis for terminal drought tolerance in Andean common beans*
Isaac Dramadri, Michigan State University

8:45 **PL2-3** *Marker-assisted backcrossing for* Striga *resistance in cowpea*
Moussa Diangar, Institut Senegalais de Recherches Agricoles

9:00 **PL2-4** *Marker-assisted pyramiding of seed size QTL into a popular Senegal cowpea cultivar*
Sassoum Lo, University of California- Riverside

9:15 **PL2-5** *Genetic diversity of the Guatemalan climbing bean collection*
Maria Gabriela Tobar Piñón, North Dakota State University

9:30 **PL2-6** *Advances in tepary bean* (Phaseolus acutifolius *A. Gray*) *genetics and breeding*
Timothy Porch, USDA-ARS, Puerto Rico

10:00 – 10:30 am Break

10:30 am – 12:30 pm **Poster Session A** – Waongo 2
Presenters of **odd-numbered** posters should be at their poster during this session for discussion.

12:30 – 2:00 pm Lunch

2:00 – 4:00 pm **Concurrent Sessions 1A and 1B**

2:00 pm **CS1A: *Genetic Improvement of Grain Legumes*: Abiotic Stresses** – Waongo 1
Moderator: Juan Osorno, North Dakota State University (5 minutes)

2:05 **CS1A-1** *Selection of common bean to broad environmental adaptation in Haiti*
Raphael Colbert, Université Quisqueya, Haiti

2:20 **CS1A-2** *Determination of cold tolerance QTLs in Cowpea* (Vigna unguiculata *L. Walp.*) *via high throughput photosynthetic phenotyping*
Donghee Hoh, Michigan State University

2:35 **CS1A-3** *Harnessing PhotosynQ-connected Phenotyping Technologies for Common Bean Breeding in Zambia*
Kelvin Kamfwa, University of Zambia

2:50 **CS1A-4** *Physiological components of heat and drought tolerance differences in* Phaseolus vulgaris *and* P. acutifolius
James D. Kelly, Michigan State University

3:05 **CS1A-5** *Thermo-tolerance of photosynthesis in cowpea, tepary and common bean at the juvenile stage*
Isaac Osei-Bonsu, Michigan State University

3:20 **CS1A-6** *Effect of drought on bean cooking time using germplasm selected for drought, common bacterial blight, and root rot resistance for Uganda and Zambia*
Carlos A Urrea, University of Nebraska

2:00 pm **CS1B: *Integrated Crop Management: Soil Fertility and IPM* –** Benkadi
Moderator: Onesimus Semalulu, National Agricultural Research Organisation, Uganda (5 minutes)

2:05 **CS1B-1** *Farmer field test of neem-based* (Azadirachta indica) *and entomopathogenic* MaviNPV virus *formulations on the main insect pests of cowpea in Niger*
Maimouna Abdourahmane, Institut National de la Recherche Agronomique du Niger

2:20 **CS1B-2** *Farmers' preferences for chemical versus biological pest control methods: Evidence from choice experiments conducted in Burkina Faso*
Mywish Maredia, Michigan State University

2:35 **CS1B-3** *On-farm assessment of local neem oil against flower thrips and cowpea pod borer,* Maruca vitrata *Fabricius*
Fousséni Traore, Institut de l'Environnement et de Recherches Agricoles, Burkina Faso

2:40 **CS1B-4** *PhotosynQ: Empowering collection of direct crop physiological measurements on smallholder farms*
Dan TerAvest, Michigan State University

2:55 **CS1B-5** *Optimizing fertilizer application in common bean* (Phaseolus vulgaris *L.*) *in Gurúè, northern Mozambique*
Ricardo M. Maria, Instituto de Investigação Agrária de Moçambique

3:10 **CS1B-6** *Strengthening the indigenous soil classification system using GIS-based mapping of the Buganda catena, Uganda*
B.A. Miller, Iowa State University

4:00 – 4:30 pm Break

4:30 – 6:00 pm **Concurrent Sessions 2A AND 2B**

4:30 pm **CS2A: *Communication, Adoption and Willingness to Pay for Technology*** – Waongo 1
Moderator: Ebby Luvaga, Iowa State University (5 minutes)

4:35 **CS2A-1** *Comparative effectiveness of video animation delivered by smartphones versus printed images in communicating bean-growing recommended practices to farmers in Uganda and Mozambique*
Eric Abbott, Iowa State University

4:50 **CS2A-2** *An assessment of localized animated educational videos* (*LAV) versus traditional extension presentations or LAV followed by extension agent discussions among farmers in Benin and Niger*
Julia Bello-Bravo, Michigan State University

5:05 **CS2A-3** *Socioeconomics determinants for adoption of improved technologies disseminated through Farmer Field Schools for cowpea production in Maradi and Zinder, Niger*
Amadou Laouali, Institut National de la Recherche Agronomique du Niger

5:15 **CS2A-4** *Inclusive innovation space: The bean value chain innovation platform in Masaka district, central Uganda*
Naboth Bwambale, Iowa State University

5:30 **CS2A-5** *Towards improving access to high quality bean seed in Nicaragua: How much are farmers willing to pay?*
Robert Shupp, Michigan State University

4:30 pm **CS2B: *Panel Discussion: Institutional Capacity Strengthening* –** Benkadi
Lead Presentation and Moderator: Mywish Maredia, Michigan State University (30 minutes)

5:00 **Panelists:**
Robin Buruchara, International Center for Tropical Agriculture
Tracy Powell, Bureau for Food Security, USAID
Gabriela Piñón, North Dakota State University
Kelvin Kamfwa, University of Zambia

6:30 pm Dinner on your own
Legume Scholars Dinner (by invitation only)

Wednesday, 16 August

8:00 – 10:00 am **Plenary Session 3 - *Farmer Decision Making, Policy, Economics and Value Chains* –** Waongo 1
Moderator: Kennedy Muimui, Zambia Agriculture Research Institute (5 minutes)

8:05 **PL3-1** *Development of cowpea varieties with consumer- and farmer-preferred traits in Burkina Faso*
Lead Presentation: Joseph Batieno Benoit, Institut de l'Environnement et de Recherches Agricoles, Burkina Faso (25 minutes)

8:30 **PL3-2** *Factors influencing cowpea farmers' willingness to pay for quality seeds in Burkina Faso*
Nathalie Me-Nsope, Michigan State University

8:45 **PL3-3** *Towards 2050: Projecting legume consumption and production under alternative socioeconomic and resource conditions*
Ralph Armah, Kansas State University

9:00 **PL3-4** *Rapid Appraisal of a mobile app linking researchers with extension officers and bean farmers in Gurúè District, Mozambique*
Sostino Mocumbe, Instituto de Investigação Agrária de Moçambique

9:15 **PL3-5** *Factors affecting bean consumption among Lusaka residents*
Mukwiti Mwiinga, University of Zambia

9:30 **PL3-6** *Small-scale community seed production to enhance the sustainability of bean improved variety dissemination: Evidence from the Western Highlands of Guatemala*
Luis Flores, Michigan State University

10:00 – 10:30 am Break

10:30 – 12:30 pm **Concurrent Sessions 3A and 3B**

10:30 am **CS3A: *Genetic Improvement of Grain Legumes*: *Biotic Stresses* –** Waongo 1
Moderator: Consuelo Estevez, University of Puerto Rico, Mayaquez (5 minutes)

10:35 **CS3A-1** *Evaluation of selected cowpea (*Vigna unguiculata *L. Walp.) lines for thrips resistance* (Megalurothrips sjöstedti) *in Burkina Faso*
Hamadou Sidibe, Institut de l'Environnement et de Recherches Agricoles, Burkina Faso

10:50 **CS3A-2** *Identification of cowpea* (Vigna unguiculata *L. Walp.*) *lines and polymorphic gene-based microsatellite markers for the resistance to aphids* (Aphis Craccivora *Koch*)
P. Adelaide Ouedraogo, Institut de l'Environnement et de Recherches Agricoles, Burkina Faso

11:05 **CS3A-3** *A novel root-knot nematode resistance QTL in cowpea accession FN-2-9-04 from Mozambique*
Arsenio Ndeve, University of California, Riverside

11:20 **CS3A-4** *Rust resistance in the Guatemalan climbing bean germplasm collection*
Luz de María Montejo, North Dakota State University

11:35 **CS3A-5** *Employing host plant resistance (HPR) in the control of cowpea aphids and* Striga gesnerioides *in Northern Ghana*
Gloria Kubi Tetteh, University of Cape Coast, Ghana

11:50 **CS3A-6** *Identification of sources of resistance to* Alectra vogelii *in cowpea* (Vigna unguiculata *L. Walp.) germplasm in Burkina Faso*
Zakaria Dieni, Institut de l'Environnement et de Recherches Agricoles

10:30 am **CS3B: *Challenges in Grain Legume Seed Systems*** – Benkadi
Moderator: Juan Carlos Rosas, Escuela Agricola Panamericana – Zamorano, Honduras (5 minutes)

10:35 **CS3B-1** *Adoption of improved bean varieties in Haiti: An assessment using farm surveys, bean seed supply chain analysis, and DNA fingerprinting*
Mywish Maredia, Michigan State University

10:50 **CS3B-2** *A local success story on cowpea production and distribution comprised by a national project*
Dieudonné Ilboudo, Institut de l'Environnement et de Recherches Agricoles – Burkina Faso

11:05 **CS3B-3** *Haiti Hurricane Matthew bean seed relief effort: Lessons learned and recommendations for future similar situations*
Reginald Cean, Inter-American Institute for Cooperation on Agriculture, Haiti

11:20 **CS3B-4** *Farmers' willingness to pay for quality seeds of bean varieties with preferred traits: Evidence from two Central American countries*
David DeYoung, Michigan State University

11:35 **CS3B-5** *Strategic partnerships and extension education tools for reaching geographically disperse, low literacy and language-diverse beneficiaries in Guatemala with MASFRIJOL project*
Salvador Castellanos, MASFRIJOL, Michigan State University

11:50 **CS3B-6** *Production systems and seed technology diffusion in Burkina Faso: The case of SFDIAB project*
Eveline Compaore Sawadogo, Institut de l'Environnement et de Recherches Agricoles, Burkina Faso

12:30 – 2:00 pm Lunch

2:00 – 4:00 pm **Poster Session B** – Waongo 2 (120 minutes)

Presenters of **even-numbered** posters should be at their poster during this session for discussion.

4:00 – 4:30 pm Break

4:30 – 6:00 pm **Concurrent Sessions 4A and 4B**

4:30 pm **CS4A: *Genetic Improvement of Grain Legumes*** – Waongo 1
Moderator: Francis Kusi, Savanna Agricultural Research Institute (5 minutes)

4:35 **CS4A-1** *Two new climbing bean varieties adapted to the milpa system in the highlands of Guatemala*
Juan M. Osorno, North Dakota State University

4:50 **CS4A-2** *Blackeye cowpea varietal improvement program for California and the USA*
Bao Lam Huynh, University of California, Riverside

5:05 **CS4A-3** *Screening bean lines in Guatemala for resistance to the common and Mexican bean weevil*
Angela Miranda, Instituto de Ciencia y Tecnologia Agricolas, Guatemala

5:20 **CS4A-4** *Genetic improvement in Uganda's Andean bean breeding program*
Stanley T. Nkalubo, National Crops Resources Research Institute

5:35 **CS4A-5** *Genetic improvement of cowpea to overcome biotic stress and drought constraints to grain productivity*
Philip A. Roberts, University of California, Riverside

4:30 pm **CS4B: *Consumer Preference, Farmers' Decisions, and Production Aspects*** – Benkadi
Moderator: Fredy Kilima, Sokoine University of Agriculture, Tanzania (5 minutes)

4:35 **CS4B-1** *Social and economic factors in farmer decision making for improved soil fertility management and increased bean production in Uganda*
Rob Mazur, Iowa State University

4:50 **CS4B-2** *Market participation of smallholder common bean producers in Malawi*
Yanjanani Lifeyo, Lilongwe University of Agriculture and Natural Resources

5:05 **CS4B-3** *Role of food choice determinants and nutrition interventions in Sub-Saharan Africa: Consumer insights based on peanut consumption in Malawi*
Aggrey Gama, University of Georgia

5:20 **CS4B-4** *Crossing the threshold: An analysis of factors affecting household consumption of recommended weekly common bean servings in urban Lilongwe, Malawi*
Edwin Kenamu, Lilongwe University of Agriculture and Natural Resources

5:35 **CS4B-5** *Utilizing imperfect and inconsistent data: Economic feasibility analysis of common bean production in Uganda and Mozambique*
Ebby Luvaga, Iowa State University

6:30 pm Dinner on your own

Thursday, 17 August

8:00 – 4:00 pm **Conference Field Trip** – To the Gourcy locality in Northern Burkina Faso to see farmer production of Foundation and Certified Seed of improved cowpea varieties. Buses will depart from the Laico Ouaga 2000 Hotel.

4:00 – 6:00 pm Posters to be removed from Waongo 2 by 6:00 pm

7:00 pm **Gala Dinner – Cascade Room, Laico Ouaga 2000 Hotel**
Traditional entertainment
Awards Ceremony (TMAC)

Friday, 18 August

8:00 – 8:15 am Discussion of conference logistics

8:15 – 10:00 am **Plenary Session 4 – *Integrated Crop Management (Soil Fertility and IPM)*** – Waongo 1
Moderator: Russel Yost, University of Hawaii, Hilo (5 minutes)

8:20 **PL4-1** *Science-driven pest management saves cowpea farms from insect pests*
Lead Presentation: Manuele Tamò, International Institute for Tropical Agriculture (25 minutes)

8:45 **PL4-2** *Integrated Pest Management (IPM) in cowpea cropping systems in West Africa: From genomics to biocontrol agents, biopesticides, and extension*
Barry Pittendrigh, Michigan State University

9:00 **PL4-3** *Biopesticide test of neem seed (*Azadirachta indica *A. Juss.*) *extract and* MaviNPV *Virus for the control of main insect pests of cowpea* (Vigna unguiculata *L. Walp.*) *in Niger*
Ousseina Abdoulaye Zakari, Institut National de la Recherche Agronomique du Niger

9:15 **PL4-4** *Development and impact of a bean market enhancement innovation platform in Uganda*
Robert Mazur, Iowa State University

9:30 **PL4-5** *Developing a methodology for mapping local soil types along the Buganda Catena, Uganda*
Moses Tenywa, Makerere University, Uganda

10:00 – 10:30 am Break

10:30 – 12:00 pm **Plenary Session – *Reflections on the Feed the Future Legume Innovation Lab***
Moderator: Barry Pittendrigh, Michigan State University

10:30 *Feed the Future Legume Innovation Lab legacy of research and institutional capacity strengthening achievements and impacts*
Irvin Widders, Director, Feed the Future Legume Innovation Lab, Michigan State University

11:00 *USAID perspectives on the performance and impacts of the Feed the Future Legume Innovation Lab*
Jennifer "Vern" Long, Office of Agriculture Research and Policy, Bureau for Food Security, USAID

11:30 *Contributions of Feed the Future Legume Innovation Lab technologies and knowledge to improving agriculture and rural livelihoods in Western Africa*
Abdou Tenkouano, Executive Director, West and Central African Council for Agricultural Research and Development (CORAF/WECARD)

12:00 – 12:30 pm **Closing Session of Conference**

12:30 pm Lunch

2:00 – 5:30 pm Bus shuttle to Artisan Market in Ouagadougou

Time TBD TMAC meeting

Evening departures from Ouagadougou International Airport

Saturday, 19 August

Small group meetings

Departures from Ouagadougou International Airport

Index of Abstracts for Oral Presentations

(Indexed by Theme)

Plenary Session: PL1 Human Health and Nutrition

Plenary Session	Presenter	Title	Day and Time
PL1-1	Kenneth Maleta	Impact of LIL on capacity building and interdisciplinary work in agriculture and nutrition in Malawi (Sub-Saharan Africa) (Panel)	**Monday, 2:05 pm**
PL1-2	Mark Manary	Legumes, growth and development in young Malawian children	**Monday, 2:30 pm**
PL1-3	Carolina Molina	MASFRIJOL, nutrition-sensitive lessons for indigenous, rural families in Guatemala's Western Highlands	**Monday, 2:45 pm**
PL1-4	Chrissie Thakwalakwa	Impact of legume supplementation on child growth and infectious symptoms in 6-12-month-old Malawian children	**Monday, 3:00 pm**
PL1-5	Celina Wille	Impacts of Improved Bean Varieties and Yields on Guatemalan Households	**Monday, 3:15 pm**
PL1-6	Isabel Ordiz	Legumes and the microbiota in young Malawian children	**Monday, 3:30 pm**

Plenary Session: PL2 Genetic Improvement of Grain Legumes

PL2-1	David Kramer	Open phenotyping and analytics tools that bridge the gaps between the lab and the world: Towards knowledge-driven plant breeding of legumes for local and regional solutions	**Tuesday, 8:05 am**
PL2-2	I. Dramadri	Genome-wide association analysis for terminal drought tolerance in Andean common beans	**Tuesday, 8:30 am**
PL2-3	Moussa Diangar	Marker-assisted backcrossing for *Striga* resistance in cowpea	**Tuesday, 8:45 am**
PL2-4	Sassoum Lo	Marker-assisted pyramiding of seed size QTL into a popular Senegal cowpea cultivar	**Tuesday, 9:00 am**
PL2-5	Maria Gabriela Tobar Piñón	Genetic diversity of the Guatemalan climbing bean collection	**Tuesday, 9:15 am**
PL2-6	T. G. Porch	Advances in tepary bean (*Phaseolus acutifolius* A. Gray) genetics and breeding	**Tuesday, 9:30 am**

Plenary Session: PL3 Farmer Decision Making, Policy, Economics, and Value Chains

PL3-1	Joseph Batieno Benoit	Development of cowpea varieties with consumer- and farmer-preferred traits in Burkina Faso	**Wed, 8:05 am**
PL3-2	Nathalie Me-Nsope	Factors influencing cowpea farmers' willingness to pay for quality seeds in Burkina Faso	**Wed, 8:30 am**
PL3-3	Ralph Armah	Towards 2050: Projecting legume consumption and production under alternative socioeconomic and resource conditions	**Wed, 8:45 am**
PL3-4	Sostino Mocumbe	Rapid appraisal of a mobile app linking researchers with extension officers and bean farmers in Gurúè District, Mozambique	**Wed, 9:00 am**
PL3-5	Mukwiti Mwiinga	Factors affecting bean consumption among Lusaka Residents	**Wed, 9:15 am**
PL3-6	Luis Flores	Small-scale community seed production to enhance the sustainability of bean improved variety dissemination: Evidence from the Western Highlands of Guatemala.	**Wed, 9:30 am**

Plenary Session: PL4 Integrated Crop Management (Soil Fertility and IPM)

PL4-1	Manuele Tamò	Science-driven pest management saves cowpea farms from insect pests	**Thursday, 8:20 am**
PL4-2	Barry Pittendrigh	Integrated Pest Management (IPM) in cowpea cropping systems in West Africa: From genomics to biocontrol agents, biopesticides, and extension	**Thursday, 8:45 am**
PL4-3	Ousseina Abdoulaye Zakari	Biopesticide test of neem seed (*Azadirachta indica* A. Juss.) extract and MaviNPV Virus for the control of main insect pests of cowpea (*Vigna unguiculata* L. Walp.) in Niger	**Thursday, 9:00 am**
PL4-4	Robert Mazur	Development and impact of a bean market enhancement innovation platform in Uganda	**Thursday, 9:15 am**
PL4-5	Moses Tenywa	Developing a methodology for mapping local soil types along the Buganda Catena, Uganda	**Thursday, 9:30 am**

Concurrent Session CS1A: Genetic Improvement of Grain Legumes: Abiotic Stresses

CS1A-1	Raphael Colbert	Selection of common bean to broad environmental adaptation in Haiti	**Tuesday, 2:05 pm**
CS1A-2	Donghee Hoh	Determination of cold tolerance QTLs in Cowpea (*Vigna unguiculata* L. Walp.) via high throughput photosynthetic phenotyping	**Tuesday, 2:20 pm**
CS1A-3	Kelvin Kamfwa	Harnessing PhotosynQ-connected Phenotyping Technologies for Common Bean Breeding in Zambia	**Tuesday, 2:35 pm**

CS1A-4	J. D. Kelly	Physiological components of heat and drought tolerance differences in *Phaseolus vulgaris* and *P. acutifolius*	**Tuesday, 2:50 pm**
CS1A-5	Isaac Osei-Bonsu	Thermo-tolerance of photosynthesis in cowpea, tepary and common bean at the juvenile stage	**Tuesday, 3:05 pm**
CS1A-6	Carlos A. Urrea	Effect of drought on bean cooking time using germplasm selected for drought, common bacterial blight, and root rot resistance for Uganda and Zambia	**Tuesday, 3:20 pm**

Concurrent Session CS1B: Integrated Crop Management: Soil Fertility and IPM

CS1B-1	Maimouna Abdourahmane	Farmer field test of neem-based (*Azadirachta indica*) and entomopathogenic MaviNPV virus formulations on the main insect pests of cowpea in Niger	**Tuesday, 2:05 pm**
CS1B-2	Mywish Maredia	Farmers' preferences for chemical versus biological pest control methods: Evidence from choice experiments conducted in Burkina Faso	**Tuesday, 2:20 pm**
CS1B-3	Fousséni Traore	On-farm assessment of local neem oil against flowers thrips and cowpea pod borer, *Maruca vitrata* Fabricius	**Tuesday, 2:35 pm**
CS1B-4	Dan TerAvest	PhotosynQ: Empowering collection of direct crop physiological measurements on smallholder farms	**Tuesday, 2:50 pm**
CS1B-5	Ricardo M. Maria	Optimizing fertilizer application in common bean (*Phaseolus vulgaris* L.) in Gurúè, northern Mozambique	**Tuesday, 3:05 pm**
CS1B-6	B.A. Miller	Strengthening the indigenous soil classification system using GIS-based mapping of the Buganda catena, Uganda	**Tuesday, 3:20 pm**

Concurrent Session CS2A: Communication, Adoption, and Willingness to Pay for Technology

CS2A-1	Eric Abbott	Comparative effectiveness of video animation delivered by smartphones versus printed images in communicating bean-growing recommended practices to farmers in Uganda and Mozambique	**Tuesday, 4:35 pm**
CS2A-2	Julia Bello-Bravo	An assessment of localized animated educational videos (LAV) versus traditional extension presentations or LAV followed by extension agent discussions among farmers in Benin and Niger	**Tuesday, 4:50 pm**
CS2A-3	Amadou Laouali	Socioeconomics determinants for adoption of improved technologies disseminated through Farmer Field Schools for cowpea production in Maradi and Zinder, Niger	**Tuesday, 5:05 pm**

CS2A-4	Naboth Bwambale	Inclusive innovation space: The bean value chain innovation platform in Masaka district, central Uganda	**Tuesday, 5:20 pm**
CS2A-5	Robert Shupp	Towards improving access to high quality bean seed in Nicaragua: How much are farmers willing to pay?	**Tuesday, 5:35 pm**

Concurrent Session CS3A: Genetic Improvement of Grain Legumes: Biotic Stresses

CS3A-1	Hamadou Sidibe	Evaluation of selected cowpea (*Vigna unguiculata* L. Walp.) lines for thrips resistance (*Megalurothrips sjöstedti*) in Burkina Faso	**Wed, 10:35 am**
CS3A-2	P. Adelaide Ouedraogo	Identification of cowpea (*Vigna unguiculata* L. Walp.) lines and polymorphic gene-based microsatellite markers for the resistance to aphids (*Aphis Craccivora* Koch)	**Wed, 10:50 am**
CS3A-3	Arsenio Ndeve	A novel root-knot nematode resistance QTL in cowpea accession FN-2-9-04 from Mozambique.	**Wed, 11:05 am**
CS3A-4	Luz de María Montejo	Rust resistance in the Guatemalan climbing bean germplasm collection	**Wed, 11:20 am**
CS3A-5	Gloria Kubi Tetteh	Employing host plant resistance (HPR) in the control of cowpea aphids and *Striga gesnerioides* in Northern Ghana	**Wed, 11:35 am**
CS3A-6	Zakaria Dieni	Identification of sources of resistance to *Alectra vogelii* in cowpea (*Vigna unguiculata* L. Walp.) germplasm in Burkina Faso.	**Wed, 11:50 am**

Concurrent Session CS3B: Challenges in Grain Legume Seed Systems

CS3B-1	Mywish Maredia	Adoption of improved bean varieties in Haiti: An assessment using farm surveys, bean seed supply chain analysis, and DNA fingerprinting	**Wed, 10:35 am**
CS3B-2	Dieudonné Ilboudo	A local success story on cowpea production and distribution comprised by a national project	**Wed, 10:50 am**
CS3B-3	Reginald Cean	Haiti Hurricane Matthew bean seed relief effort: Lessons learned and recommendations for future similar situations	**Wed, 11:05 am**
CS3B-4	David DeYoung	Farmers' willingness to pay for quality seeds of bean varieties with preferred traits: Evidence from two Central American countries	**Wed, 11:20 am**
CS3B-5	Salvador Castellanos	Strategic partnerships and extension education tools for reaching geographically disperse, low literacy and language-diverse beneficiaries in Guatemala with MASFRIJOL project	**Wed, 11:35 am**
CS3B-6	Eveline MFW Compaore Sawadogo	Production systems and seed technology diffusion in Burkina Faso: The case of SFDIAB project	**Wed, 11:50 am**

Concurrent Session CS4A: Genetic Improvement of Grain Legumes

CS4A-1	Juan M. Osorno	Two new climbing bean varieties adapted to the milpa system in the highlands of Guatemala	**Wed, 4:35 pm**
CS4A-2	Bao Lam Huynh	Blackeye cowpea varietal improvement program for California and the USA	**Wed, 4:50 pm**
CS4A-3	Angela Miranda	Screening bean lines in Guatemala for resistance to the common and Mexican bean weevil	**Wed, 5:05 pm**
CS4A-4	Stanley T. Nkalubo	Genetic improvement in Uganda's Andean bean breeding program	**Wed, 5:20 pm**
CS4A-5	Philip A. Roberts	Genetic improvement of cowpea to overcome biotic stress and drought constraints to grain productivity	**Wed, 5:35 pm**

Concurrent Session CS4B: Consumer Preference, Farmers' Decisions, and Production Aspects

CS4B-1	Rob Mazur	Social and economic factors in farmer decision making for improved soil fertility management and increased bean production in Uganda	**Wed, 4:35 pm**
CS4B-2	Yanjanani Lifeyo	Market participation of smallholder common bean producers in Malawi	**Wed, 4:50 pm**
CS4B-3	Aggrey Gama	Role of food choice determinants and nutrition interventions in Sub-Saharan Africa: Consumer insights based on peanut consumption in Malawi	**Wed, 5:05 pm**
CS4B-4	Edwin Kenamu	Crossing the threshold: An analysis of factors affecting household consumption of recommended weekly common bean servings in urban Lilongwe, Malawi	**Wed, 5:20 pm**
CS4B-5	Ebby Luvaga	Utilizing imperfect and inconsistent data: Economic feasibility analysis of common bean production in Uganda and Mozambique	**Wed, 5:35 pm**

Abstracts for Oral Presentations: Plenary Sessions (PL)

PL1 Human Health and Nutrition

PL1-1 Impact of LIL on capacity building and interdisciplinary work in agriculture and nutrition in Malawi (Sub-Saharan Africa) (Panel)

Ken Maleta, Celina Wille, Carolina Molina, and Yankho Kaimila

The LIL noted that in spite of heavy investment in bean, cowpea and chickpea research through international agricultural research centres (CIAT, IITA, ICRISAT, etc.), the human resource capacity in national Agriculture Research Systems (NARS) in developing countries remains weak. Due to emerging issues (climate change, biofortification, nutritional enhancement), new research opportunities (molecular technologies) and attrition of research scientists, sustained commitment to train new scientists was urgently recognized.

As one of its objectives, the LIL positioned itself to enhance research capacity building through leveraging partnerships between high- and low-income countries and institutions as well as south-south research capacity development initiatives. In this panel discussion, researchers from Sub-Saharan Africa region and Northern institutions will share and reflect on their experiences on research capacity building and inter-disciplinary research.

1. How well did the current system of partnerships address the challenges and factors for successful research capacity building and inter-disciplinary partnerships?
2. What examples of educational partnerships for research training and PhDs with public/private institutions, including south-south partnerships, were utilized (sandwich, distance and e-learning learning, joint supervision) and how well have they worked in practice in the context of the innovation lab?
3. How can we address the challenges of mentorship and supervision in research training capacity building?
4. What are the factors that have influenced successful partnerships?
5. What further inputs are needed from southern institutions to overcome critical constraints such as employment conditions, and retention of staff locally? How to support networking of researchers and institutions? And what would be the optimal and changing role of the northern institution in these partnerships?
6. How can universities be incentivized to engage in international research and inter-disciplinary partnerships; and can we learn from successful existing approaches? How can the needs of the northern institution/ university in maintaining these partnerships/ collaborations be addressed, e.g., funding challenges?

PL1-2 Legumes, growth and development in young Malawian children

Mark Manary, Isabel Ordiz, Ken Maleta, Chrissie Thakwalakwa, Yanko Kaimila, Oscar Divala and Teresa Ngoma

Background: Stunting, failing to reach one's optimal physical, cognitive, economic and health potential, affects over 60 million children in Africa. The UN sustainable development goals (SDGs) aim for sharp reductions in stunting in the next 15 years.

Methods: Two large randomized, single blind controlled clinical trials in young rural Malawian children aged 6-12 months and 12-36 months were conducted in 2015-17 to determine the

effect of cowpea or common bean supplementation on stunting and gut health. The legumes provided about 15% of the estimated required dietary energy daily, and were grown locally. The legumes also provided greater quantities and more diverse dietary fiber, the determinant of the gut microbiota. Children were closely monitored every two weeks. In addition to extensive anthropometric and morbidity monitoring, fecal, urine and blood samples were collected at regular intervals. These data provide a comprehensive picture of these vulnerable children's health and nutritional status and how it was impacted by inclusion of legumes in the diet.

Results: Over 700 children participated in the studies in two agroecological zones in Malawi. The legumes were fully acceptable for daily use in these populations, no adverse effects were observed. Gut health was better understood in terms of its traditional measure, the dual sugar permeability test. Novel biomarkers of gut were also developed. New methods to interpret tests for gut health were developed that are applicable to the problem of stunting everywhere in Africa. In certain age groups cowpea was found to affect better linear growth. Novel metabolite data suggest the mechanism by which legumes improve gut health as well.

Conclusion: The overall findings suggest cowpea and common bean can play a role in reducing stunting in children in Sub-Saharan Africa and should be included in future research and operational work as the international community strives to reach the SDGs.

MASFRIJOL, nutrition-sensitive lessons for indigenous, rural families in Guatemala's Western Highlands **PL1-3**

Carolina D Molina, Sharon L Hoerr, Celina Wille, Salvador Castellanos, Luis Flores

To address growth stunting and malnutrition in Guatemala's Western Highlands, USAID funded a dual-approach project, called MASFRIJOL (Spanish for *more beans*), with the following components: 1) distribution of improved bean seed varieties to rural families living at high altitudes and 2) education delivered in local villages on both nutrition and bean production.

This paper describes the nutrition curriculum designed for indigenous, low literacy families living in remote farming villages. Community assessments identified the necessary agronomic educational needs: 1) differentiating improved from non-improved varieties, 2) germination tests, 3) soil preparation, 4) pest and weed control, 5) harvest, and 6) post-harvest and seed storage techniques. Nutrition education topics included 1) chronic malnutrition—what it is and how to prevent it, 2) enhancing protein quality with beans, 3) feeding the 6-11-month-old child, 4) feeding the one- to two-year-old child, 5) diet in and during pregnancy and lactation, 6) nutritious, economical recipes, and 7) eating more local greens.

Each lesson began with a short video featuring families from rural Guatemalan villages to illustrate the key concepts. Each lesson featured at least one recipe demonstration or other skill-building activity. Five lessons included a one-item, visual pre- and post-test of a key concept, such as how tall a two-year-old child should be

or how many spoonsful of beans/day to feed the same child each day. Results from several sessions (N=480) showed that only 49 percent of the pre-test attendees knew the right answer to a question on the minimum height for a two-year-old child (70 cm), but this increased to 63 percent post-test.

This MASFRIJOL curriculum is unique both in being a food-based rather than a supplement-based approach to malnutrition and through its link between improving agriculture and nutrition education. MASFRIJOL exemplifies nutrition-sensitive agriculture as proposed by FAO (2015).

PL1-4 **Impact of legume supplementation on child growth and infectious symptoms in 6-12-month-old Malawian children**

Chrissie Thakwalakwa, Kenneth Maleta, Yankho Kaimila, Oscar Divala, Theresa Nakoma, Kenneth Maleta, Mark Manary

Background: Environmental enteric dysfunction (EED), which is strongly related to marginal diets, recurrent infections and inflammation, has been recognised as an important contributing factor to physical and cognitive stunting, limited resilience to acute infections and, ultimately, global childhood mortality. There is need to identify interventions to improve diet and decrease markers of inflammation to improve growth. Legumes are believed to have the needed qualities.

Methods: This was a single blind block randomized clinical trial in two rural communities in southern Malawi. It was conducted to determine if legume-based complementary foods would improve growth and reduce infections. Children aged 6 months were randomized to receive common bean, cowpea or control (corn-soy blend flour) daily as a complementary food for 6 months. They were followed up at 2, 6, 12,18 and 24 weeks after enrollment. Primary outcome was linear growth. Secondary outcomes included presence of infectious symptoms. Anthropometric measurements, checking for episodes of infectious symptoms and food supply were done during follow up visits.

Anticipated results: Baseline characteristics would be similar in all the groups. There would be an improvement in growth with cowpea supplementation as compared to control supplementation. Infectious symptoms would be common in this population.

Potential conclusion: It is anticipated that in this population, supplementation of children with legume-based complementary foods would improve growth. Infectious symptoms like diarrhea and fever would be common in this population.

PL1-5 **Impacts of Improved bean varieties and yields on Guatemalan Households**

Celina Wille, Salvador Castellanos, Luis Flores Carolina D Molina, Sharon L Hoerr

MASFRIJOL is a USAID project in Guatemala's Western Highlands implemented in 2014 to increase bean productivity and improve nutrition among smallholder farmers and their families. The project's methods include not only introducing improved bean varieties and providing agriculture education to help farming families achieve greater crop yields but also teaching household leaders the nutritional value of eating beans along with simple, appealing ways to prepare them. The project aims to increase bean consumption to at least three times/week from 1.5 times/week, which is insufficient for nutritional health.

Harvest data collected from 1,155 MASFRIJOL beneficiaries from 2014 to 2016 show, on average, a 50 percent increase in yields (to 711.5 kg/ha from 474 kg/ha) from planting improved bean seed varieties versus locally obtained seed. With higher productivity comes

the assumption of improved food security; however, increased consumption and improved dietary quality do not always correlate. This lack of correlation between increased harvests and improved nutrition is why MASFRIJOL combined the distribution of improved bean seed with not only agricultural education but also nutrition education focused on eating more beans and, further, encouraging families to increase such consumption through practical workshops that included recipes for all ages.

MASFRIJOL investigated project effectiveness using the Most Significant Change research methodology to collect data from participant (men and women) interviews across 16 of the project's 280 communities. Data analysis indicated that "improved yields improved bean consumption" when combined with nutrition education that encouraged increased bean consumption and provided practical means to implement the new knowledge: bean-based formula for infants, appealing bean-based meals for young children, and new, appealing recipes for the whole family. Other participant-reported impacts include food security for longer time periods, the prioritization of bean consumption due to focused nutrition education, and ensuring small children and pregnant women eat sufficient beans.

PL1-6

Legumes and the microbiota in young Malawian children

Isabel Ordiz, Mark Manary, Ken Maleta, Chrissie Thakwalakwa, Yanko Kaimila, Oscar Divala and Teresa Ngoma

Background: The effect of dysbiosis and immature gut microbiota has been associated with the growth and development of stunted children in developing countries. The role of gut microbiome in nutrient transformation, immune response and metabolic signaling was explored in rural Malawian children.

Methods: In a randomized legume supplementation intervention with either cowpea or common bean providing about 15% of dietary energy, 402 young kids (5.5 - 6.5 months) were approached, 357 were randomized and 45 kids were excluded. Supplementation was continued for 6 months.

Stool samples were collected on enrollment and after 2, 6, 12, 18 and 24 weeks of supplementation. Stools were collected fresh and flash frozen in liquid nitrogen and stored at -80C.

Bacterial genomic DNA was extracted from fecal samples. Initially, 60 children designated as growth faltering or with adequate growth were chosen from the 3 supplementation groups. Although this included 360 potential samples, only 346 fecal samples were available; genomic DNAs were extracted using PowerSoil DNA isolation kits. The v4 variable regions of bacterial 16S rRNA genes was amplified by PCR and sequenced. Additionally, 1600 samples will be sequenced, analyzed, and the microbiota, metabolome and microbiome characterized.

Results: Of the 120 kids assigned to consume cowpea flour, 121 kids assigned common bean flour, and 116 kids assigned corn soy blend flour, 99, 99 and 93 completed the study, respectively. Preliminary microbiota analysis of 81 older children (12-23 months) with different degrees of EED at enrollment, we did not identify a profound fecal dysbiosis, but 6 genera were identified with significant differences with EED. Megasphaera, Mitsuokella and Sutterella were higher in EED and Succinivibrio, Klebsiella and Clostridium_XI were lower in EED.

Conclusion: Patterns of the fecal microbiota and microbiome are associated with different degrees of growth faltering in children receiving legume supplementation.

PL2 Genetic Improvement of Grain Legumes

PL2-1

Open phenotyping and analytics tools that bridge the gaps between the lab and the world: Towards knowledge-driven plant breeding of legumes for local and regional solutions

David M. Kramer, Susan Chipandwe, Dan TerAvest, Sebastian Kuhlgert, Isaac Osei-Bonsu, Donghee Hoh, Robert Zegarac, Atsuko Kanazawa, Philip A. Roberts, Bao-Lam Huynh, Tim Close, Maria Munoz-Amatriain, Sassoum Lo, Marcia Carvalho, Wayne Loescher and Kelvin Kamfwa

Rapid and sustainable improvements in the productivity and robustness of agriculture are urgently needed to meet human food requirements and overcome entrenched poverty. Addressing these issues requires dramatic increases in plant productivity, often in currently "marginal" land. This is especially true for small farms which constitute the vast majority of farmers and farmland, but have the most diversity in conditions, management and crops, and not been well targeted by the large research efforts.

To address this issue, we have developed the PhotosynQ platform (www.photosynq.org), which aims to change the way we approach key plant science and agricultural research by 1) developing and distributing sophisticated, yet inexpensive, open and cloud-connected scientific instruments (such as the MultispeQ) that allow users around the world to probe the status of crops and their local environments; 2) engage these communities to collect unique sets of previously unavailable plant phenotyping data; 3) applying advanced analytics on aggregated data sets to reveal trends that determine crop productivity and robustness; and 4) enable local data-driven agricultural solutions for directing crop management and breeding, especially for production on "marginal lands."

The presentation will describe how the new tools are being used on legume crops worldwide, with an emphasis on recent efforts to build an open, accessible platform for knowledge-driven plant breeding by identifying genetic loci that confer better performance under the conditions critical for local production. Specifically, we will demonstrate that the platform can be used to identify, with high sensitivity, QTLs for cold, heat and drought stresses using GWAS and RIL libraries in common bean, cowpeas and tepary beans.

PL2-2

Genome-wide association analysis for terminal drought tolerance in andean common beans

O. I. Dramadri, S. T. Nkalubo, and J. D. Kelly

Drought stress is becoming an increasingly important abiotic stress limiting productivity of common bean (*Phaseolus vulgaris*. L.) globally. In this study, we evaluated a panel of 247 Andean common bean genotypes and performed genome-wide association (GWAS) analysis to identify genomic regions associated with drought tolerance at pod filling stage of common bean development. The genotypes were planted at Namulonge and Kasese in Western Uganda under irrigated and non-irrigated conditions with two replications during the 2016B season. Drought stress was applied by withholding watering after flowering from all genotypes grown under non-irrigated condition. Data was collected on agronomic traits such as days to 50% flowering, plant height, days to harvest maturity, partitioning, and yield component traits.

Single nucleotide polymorphism (SNP) markers from the BARCBean6K_3 Beadchip containing 5398 SNPs were filtered and used to perform SNP-trait associations for SPAD using a Mixed

Linear Model (MLM) implemented in software program TASSEL. Significance threshold for SNPs was determined using the Bonferonni corrected p=1.4x 10-5 (for ? = 0.05 and 3568 SNPs). The agronomic and yield component traits measured varied significantly (P<0.05) among the 247 genotypes evaluated under irrigated and non-irrigated conditions at both sites. However, significant genomic regions associated with pod partitioning index (PPI) under non-irrigated conditions were detected at 3,466,123 to 5,032,818 Mb (1.5Mb) on chromosome 7 (Pv07), and at 34,026,183 to 34,556,171 Mb (530kb) on Pv09. This study has demonstrated the effectiveness of GWAS analysis in identifying genomic regions associated with partitioning of assimilates under terminal drought stress, and consequently providing insights into the genetic architecture of biomass partitioning under drought stress at the critical pod filling stage in common bean development.

PL2-3 **Marker-assisted backcrossing for *Striga* resistance in cowpea**

Moussa Diangar, Elisabeth Diop, Sassoum Lo, Daniel Fonceka, Bao-Lam Huynh and Ndiaga Cisse

Striga resistance lacks on high yielding varieties cultivated in Senegal. In order to provide farmers adapted cultivars suitable to infested fields, breeding lines were developed by introgressing *Striga* resistance from an IITA line IT97K-499-39 to Melakh an ISRA elite line known for its extra earliness. Repeated pot screening allowed backcrossing of a hybrid to Melakh. Progenies were advanced until BC1F4 where field phenotyping for agronomic performances were assessed. Eighty one BC1F5 and 75 BC1F6 were pot phenotyped for *Striga* reaction at Bambey. The two Populations were also screened with 4 primers C42-2B, 61R-M2, 6673-2R and 10811-1R using BIONEER Accu-Power PCR premix at CERAAS. Bulked Segregant analysis revealed C42-2B more linked to genes then used in application of marker-assisted selection for population development as validated. Simultaneously, prior to SNP genotyping BC1F6 populations were multiplied in UCR and DNA extraction were perfomed using the KASP platform. Background SNPs revealed L134 line with 80% of the recurrent parent then backcrossed to the recipient to obtain 3 BC2F1 plants. Plants were genotyped to C42-2B, 2 out of three carried the resistant allele and used to obtain BC3F1s. When pot screened all BC3s to *Striga* reaction, no attachment were observed while 4 out of 9 segregated with the microsatellite marker. Subsequent backcross lines were advanced to BC4F2 and 86 families were obtained. Polyacrylamid gel displayed 15 resistant lines in which 7 homozygotes. The study highlights the accuracy and efficiency in using the MABC approach for improving cowpea.

PL2-4 **Marker-assisted pyramiding of seed size QTL into a popular Senegal cowpea cultivar**

Sassoum Lo, María Muñoz-Amatriaín, Mitchell Lucas, Ndiaga Cisse, Philip A. Roberts, Timothy J. Close

Cowpea (*Vigna unguiculata*) is a warm season legume cultivated extensively in West and Central Africa. Cowpea is one of the highest sources of protein, folic acid and several vitamins for many people in Sub-Saharan Africa. Incorporating information on consumer preferences is important for decisions on developing improved cowpea cultivars, and increased seed size is one of the targeted preferred traits.

In order to develop new cowpea cultivars with large seed, SNP markers are being used to introgress two seed size QTL (Css-1, Css-4) from the RIL “113-4-6-14-1” (CB27/IT82E-18 x CB27) into “Pakau” a popular cultivar in Senegal. These QTL were mapped in a previous study,

and the same data were re-analyzed using genotyping data from the 60K SNP iSelect array. A total of 16566 high quality SNPs segregated in this population and were used in QTL mapping to identify additional SNPs linked to both QTL regions. A total of 91 SNPs were identified in the Css-1 and Css-4 QTL regions. Those SNPs were used for Marker-assisted backcrossing of Css-1 and Css-4 into "Pakau" and to analyze the QTL content of the backcross progenies. Four combinations of the positive (large seed size) alleles of the two QTL were observed in the backcross progenies and were analyzed to test the effect on seed phenotype of these QTL in the Pakau genetic background: no positive QTL alleles, positive allele of Css-1 only, positive allele of Css-4 only, and positive alleles of both QTL.

The primary output of this work will contribute to the development of improved cultivars with larger seed size which will increase consumer preference and market demand. Future studies will include determining the effect of increasing seed size on both yield and the nutritional quality of cowpea.

PL2-5 **Genetic diversity of the Guatemalan climbing bean collection**

Tobar Piñón, María Gabriela; Samira Mafi Moghaddam, Rian Lee, Julio C. Villatoro Mérida, Juan M Osorno, Phillip E. McClean

Common bean (*Phaseolus vulgaris* L.) is the most important legume crop for human consumption in the world. In Guatemala, it occupies 17.8% of available production area. Bean is also the primary source of protein in the daily diet in the country, where 8 out of 10 native children of 5-years-old or younger suffer from chronic malnutrition, the highest level in Latin America. For this reason, food security plays a key role in the development of a healthy country.

At this point, bean breeders are challenged to increase seed yield while maintaining seed quality and breeding for diseases resistance. Guatemalan climbing beans have been suggested to represent race Guatemala, a new race in the Middle American gene pool. Interestingly, these beans are grown in the highlands of Guatemala where poverty is the highest, and it may represent a source of new alleles for bean improvement. The objectives of this research were to evaluate and describe the population structure, genetic diversity, and genetic differentiation of a Guatemalan climbing bean collection of 369 accessions, and to perform a genome-wide association study (GWAS) to map important agronomic traits.

78,754 single nucleotide polymorphisms (SNPs) were used for the analysis. Population structure was analyzed using STRUCTURE 2.3.4, principal component analysis, and a maximum-likelihood tree. Genetic diversity was analyzed estimating the expected heterozygosity (He) and polymorphic information content (PIC). All population structure analyses showed that the Guatemalan collection is strongly differentiated when compared to races Mesoamerica and Durango-Jalisco. PIC and He showed that Guatemalan accessions were the less diverse; this indicates that relatedness is high between the accessions. GWAS showed new markers associated with important traits such as Rust (*Uromyces appendiculatus* F. Strauss) resistance. These results demonstrate that Race Guatemala is represented by Guatemalan climbing beans and is a potential source of alleles for breeding programs.

PL2-6 **Advances in tepary bean (*Phaseolus acutifolius* A. Gray) genetics and breeding**

T.G. Porch, I. Rodriguez, J.P. Hart, A. Vargas, J.C. Rosas, M. Brick, J.S. Beaver

Tepary bean is a drought and heat-tolerant sister species of common bean with similar nutritional characteristics and with potential for expanded production in agroecological zones

that are marginal due to abiotic stress. A key to expanded production of this orphan crop is the improvement of biotic stress tolerance, such as resistance to bean common mosaic virus (BCMV, BCMNV), bean golden yellow mosaic virus (BGYMV), and rust resistance for tropical and temperate zones. Using the recently developed tepary diversity panel (TDP) and a RIL population, G40001/G40022, GWAS and QTL analyses were conducted on key agronomic, disease and seed characteristics under multiple conditions in field and greenhouse trials.

A roughly equal number of wild and cultivated tepary accessions compose the 314 lines in the TDP and there are 140 F5-derived lines in the RIL population that were all genotyped using ApeKI genotyping-by-sequencing and aligned to the *P. vulgaris* reference genome. Agronomic, phenological, and seed characteristics were mapped and the trial results are informing the selection of parents in the breeding program that has developed novel germplasm, including the released small white TARS-Tep 22. These data were also used to evaluate the population structure and geographical distribution of the TDP, and are informing the development of additional tepary bean genomic resource

PL3 Farmer Decision Making, Policy, Economics and Value Chains

PL3-1

Development of cowpea varieties with consumer- and farmer-preferred traits in Burkina Faso

Joseph Batieno Benoit, Jean-Baptiste Tignegre, Hamadou Sidibe, Hamadou Zongo, Serge Zida, Leandre Poda, Soumabere Coulibaly, Timothy Close, Philip Roberts, Jeremy Ouedraogo

Cowpea (*Vigna unguiculata*) is an important grain legume in West Africa. The grain, which contains on average 25% protein, is a major supplement for humans and animals. In addition to its food value, cowpea is an important component of farming systems due to its capability for nitrogen fixation, which reduces the requirement and cost for external nitrogen supply through organic and inorganic fertilizers. Cowpea has some tolerance to drought. It is thus widely cultivated in the three zones in Burkina Faso: Sahel (300-600 mm rainfall), north Sudan (600-900 mm rainfall) and south Sudan (900-1200 mm rainfall). Notwithstanding the attributes that make the crop important, it has a number of biotic and abiotic constraints. In the past, varieties were developed for farmers and released to them without their involvement. That led to low adoption rates of new varieties that had been developed at significant financial and time expense. This was revealed from different Participatory Rural Appraisals (PRA) conducted in 2008, 2009 and 2012 in Burkina Faso. Based on those assessments, new lines have been developed by combining conventional and molecular breeding with farmer participatory breeding. The cowpea development by this approach demonstrates how the involvement of farmers can help in variety popularization and replacement in Burkina Faso.

PL3-2

Factors Influencing cowpea farmers' willing-ness to pay for quality seeds in Burkina Faso

Nathalie M. Me-Nsope, Mywish K. Maredia, Robert Shupp, and Dieudonne Ilboudo

Increasingly erratic weather/climatic conditions and the corresponding effects on crop yields are accentuating the need for farmers to plant good quality seeds of improved varieties. However, for self-pollinated crops like cowpeas (*Vigna unguiculata*), for which "seed" is highly

competitive with "grain" when used as planting material, the demand for seeds of good quality is often negatively affected by several factors, including, the price of quality seeds and the common practice of "recycling" grains as seed.

In this paper, we analyze cowpea farmers' willingness to pay (WTP) for three types of seed products (Certified, Quality Declared, and own-saved/recycled) in Burkina Faso using the Becker-DeGroot-Marschak bidding experiments. Our goal is to understand i) how the perceived differential performance of different types of seeds translate into farmers' WTP for these seeds and ii) the factors which determine the WTP for each type of "seed" product.

We designed two WTP experiments—a non-blind and a blind experiment. In the non-blind experiment, each farmer reveals his/her WTP for each seed type knowing which of the three seed types they are buying. In the blind experiment, each farmer is presented with two pictures of plots planted to each of the three types of seed products, one picture at the flowering stage and the other at the harvest stage. Without knowing which picture represents which seed type, the farmer is given some time to perceive the performance characteristics or key quality attributes of each type of "seed" product, after which he/she is asked to reveal the willingness to pay for each seed product. A total sample of 300 cowpea farmers were interviewed. We expect the results from this research to guide policies and interventions to improve the demand for quality seeds of improved varieties, thereby increasing cowpea productivity and reducing poverty amongst smallholder cowpea farmer.

PL3-3 Towards 2050: Projecting legume consumption and production under alternative socioeconomic and resource conditions

Vincent Amanor-Boadu and Ralph Armah

Increasing global incomes and populations (The World Bank 2017) have enhanced awareness about the health benefits of legumes and other plant-based diets (Schwingshackl et al. 2017), leading to an increasing proportion of vegetarians and vegans in various populations (Thompson 2016). Legumes, thus, are expected to play an increasingly important role in meeting protein and other nutrition needs of a more prosperous population confronted by intensified resource competition as we march towards 2050.

Despite the foregoing, knowledge about where and whether legume production expansion will occur to sustain consumption is lacking. Additionally, the socioeconomic and resource conditions that will support the expansion in production and consumption have not been assessed. This research addresses these gaps using statistical analysis and system dynamic modeling. Preliminary results show that although total global legume harvested area increased by more than 22% from about 61.4 million hectares between 1990 and 2013, growth was mainly in Southeast Asia, Sub-Saharan Africa and South America. However, production growth in these regions did not match population growth. Additionally, while developing countries' average per capita legume consumption of about 8 kg/year was double that of developed countries, their yields were much lower.

The foregoing suggests volume opportunity among low-income consumers and value opportunity among high-income consumers regardless of whether they reside in developing or developed countries. Producers, thus, may gear their production towards the segment that matches their production capabilities. There will be demand for innovative approaches to policymaking and implementation in both private and public spheres to facilitate the legume industry's ability to respond to the

foregoing changes. Researchers and practitioners need to develop and deliver capacity-enhancing programs across the supply chain to help stakeholders meet the demands of the changing market and resource conditions.

PL3-4

Rapid appraisal of a mobile app linking researchers with extension officers and bean farmers in Gurúè District, Mozambique

S. Mocumbe, E. Abbott, R. Mazur, R. Maria

Research Problem: Rapid diffusion of mobile phones (including feature phones and smartphones) and improvements in broadband networks in Africa have made it possible to use mobile phone apps to deliver research-based information to enhance common bean production. A World Bank review of 92 developing country projects using mobile apps found that 45% of them focused on agricultural dissemination/feedback activities (Qiang et al. 2012). However, effective use of smartphone apps requires participation by both creators and potential users.

Method: This research conducted pilot field rapid appraisals of a prototype smartphone app developed by the Agricultural Research Institute of Mozambique (IIAM) with 24 agricultural extension personnel and 11 bean farmers in Gurúè District, Mozambique. They were shown smartphones that contained a new mobile app providing research-based information about bean production, and the appraisal focused on whether or not such a system might be useful to them.

Key findings:

- Both extension officers and farmers rated the mobile app as being potentially one of the most effective agricultural information sources because they could access it anytime or anyplace.
- Extension officers have smartphones now, and have already tried other agricultural mobile apps. They saw high potential for use of the app for research-based information about pests and diseases, soil types and bean varieties.
- Farmers were enthusiastic about the potential of smartphone mobile apps, but at present they lack smartphones and any previous experience with either smartphones or apps. They still prefer printed materials.

Significance of results: Since agricultural extension officers already have smartphones, the IIAM app offers significant potential for reaching them directly whenever they want with scientifically based information on all aspects of bean production. Most farmers lack smartphones now, so the IIAM app, although liked by farmers, has only limited potential for them at present.

Factors affecting bean consumption among Lusaka residents PL3-5

Mwiinga Mukwiti, Tembo Gelson

This study looked at the factors that determine the consumption of beans among households in Lusaka district. Its main objective was to provide basic information on bean consumption in Lusaka district. More specifically, the study sought to:

- Understand the characteristics of bean consumers,
- Identify the factors that affect the quantities of dry beans consumed by the households.

Data used in this study was obtained through a bean consumption survey conducted in 2015 by the Feed the Future Legume Innovation Lab at the University of Zambia. This data was structured for the purpose of conducting choice experiment on beans consumers in Zambia. A sample of 844 households in seven constituencies of Lusaka were interviewed.

Descriptive statistics on the interviewed households generated information on (1) the socioeconomic characteristics of the households (2) importance ranking of beans as a food security crop and (3) the bean varieties consumed by the households.

Econometric analysis involved a simple regression model estimated by Ordinary Least Square (OLS). The dependent variable in the model was per capita bean consumption per month and the explanatory variables were socioeconomic characteristics postulated by theory and empirical evidence.

The key findings of the study were that

- Dry beans is an important food item to Lusaka residents
- Considered by majority as critical to household food security
- The most popularly consumed bean variety is “Kabulangeti” and is consumed as a main dish or as a complement to the main dish
- Bean consumption message has filtered very well to the elite but remains a challenge among the poor
- Households with children consume less beans per capita - this needs further exploring and follow up: Nutrition and agricultural programming needs to view beans using this “new” lens.

PL3-6 **Small-scale community seed production to enhance the sustainability of bean improved variety dissemination: Evidence from the Western Highlands of Guatemala.**

Luis Flores, Salvador Castellanos, Carolina Molina, Celina Wille, Sharon Hoerr, Irvin Widders.

Most of the documented experiences and development projects connected with promoting and disseminating improved bean

seed varieties include sustainability challenges. The near absence of private sector operators dedicated to producing common bean seed leads to the need for such projects so that small-scale, economically constrained farmers can access such technology.

MASFRIJOL, a USAID-funded initiative in Guatemala supported by the Feed the Future Legume Innovation Lab, is such a project. With the dual objective of improving black bean yields and increasing family bean consumption, MASFRIJOL launched community seed depots (CSDs) as a mechanism designed to ensure that seed of improved varieties would be continuously produced in the target communities by the best local bean farmers.

The strategy was initiated in 2016 with 47 seed depots, of which 33 continued producing seed in 2017, motivated by their capacity to produce and to sell quality seed successfully. Productive CSDs led to the start of 48 additional seed depots in new communities—from which 85 percent have shown capacity to produce seed at above average yields and to find a market. Seed depots are small plots with access to irrigation to ensure production in the dry season without fear of crop loses or damage from drought from 440 m2 to 2,622 m2. MASFRIJOL provides CSDs with minimum agricultural inputs and equipment for crop management, harvest, and seed conditioning. This paper presents data on yields and seed sale price for seed depots that harvested during 2016. Important lessons learned regarding the major factors of success and failure are also provided

PL4 Integrated Crop Management (Soil Fertility and IPM)

PL4-1

Science-driven pest management saves cowpea farms from insect pests

M Tamò, E Dannon, B Datinon, C Dabiré, F Traoré, B Pittendrigh, R Srinivasan

Cowpea suffers from important yield losses due to the attack of insect pests. Although chemical pesticides can provide a quick relief, in most cases the negative side-effect outweigh the benefits. Hence, there is a need for a more sustainable and safe pest control approach.

We show how science-driven pest management has developed and deployed biological control agents that are as efficient as chemical pesti-cides in controlling the target pest, the pod borer *M. vitrata*, without any of the negative impacts on human, animal and environ-mental health. Our focus is on two exotic parasitoids, *Phanerotoma syleptae* and *Therophilus javanus*, found attacking this pest in its putative area of origin in Asia, with field parasitism rates up to 60%. Upon obtainment of release permits by the respective national authorities, a total of 101,600 adult parasitoids – 60,100 in Benin (30,300 *T. javanus* and 29,800 *P. syleptae*) and 41,500 in Burkina Faso (23,000 *T. javanus* and 18,500 *P. syleptae*) were released with the participation of local communities in 2016.

Our release strategy targeted different agro-ecologies and host-plant habitats depending on the parasitoid species. Both parasitoids were recovered from cowpea and from wild host plants in Benin and Burkina Faso during the 2016 cropping season, and continue to be recovered as of April 2017, more than one year after initial experimental releases.

We estimate these biocontrol agents to impact over 60,000 cowpea farmers with a reduction of yield losses by 40-60% in the next two years. Another effort is targeted towards investigating pest management approaches for the pod bug *Clavigralla tomentosicollis* by augmenting egg parasitoid activity using aggregation pheromones. We have identified male- and female-specific volatiles, with the male-specific aggregation pheromones being the most relevant. Their cues that attract egg parasitoids have also been identified. This information will be used to develop novel management systems.

PL4-2

Integrated Pest Management (IPM) in cowpea cropping systems in West Africa: From genomics to biocontrol agents, biopesticides, and extension

B Pittendrigh, C Dabire-Binso, I Baoua, F Traore, A Laouali, S Asante, H Braimah, M Mochaih, B Datinon, E Biaou, J Bello-Bravo, and M.Tamò

Within the West African context, cowpea crops are impacted by a complex of pest species that individually or in combination dramatically reduce yield of this important protein source. There has been an ongoing need for Integrated Pest Management (IPM) strategies to minimize this pest complex. IPM involves the combined use of biological control agents, cultural control practices, and biopesticides. All of these control strategies rely on knowledge-based decision processes of when and where to most effec-tively deploy the correct tools for pest control.

Within the context of the development of an IPM strategy for the pests of cowpeas within a West African context, we have (1) studied this pest complex, using both field work and molecular biology tools, (2) developed logical control strategies ready for scaling, including biocontrol agents, biopesticides and cultural control practices, and (3) successfully created and tested novel deployment processes for effective scaling of these approaches. We have used emerging genomic technologies that has led to a “systems” perspective of IPM for the control of pests of cowpea and other crops. This

emerging field, which we refer to as "IPM-omics," builds upon recent advances in genome sequencing technologies and detection of large-scale gene polymorphisms, which are becoming economically feasible for pest insect systems. IPM-omics also involves the use of information and communications technologies both to collect critical information on pest populations and to deploy practical IPM solutions.

The "systems" perspective has facilitated the effective evaluation, modification, and optimization of IPM strategies. However, any resultant IPM program for crop pests will also require that extension agents, government agencies, and nongovernmental organizations have the ability to easily access and deploy the IPM research findings through information and communications technologies. Our program is well-positioned for the scaling of a cowpea IPM program within a West African context.

PL4-3 **Biopesticide test of neem seed (*Azadirachta indica* A. Juss.) extract and *MaviNPV Virus* for the control of main insect pests of cowpea (*Vigna unguiculata* L. Walp.) in Niger**

Zakari O. Abdoulaye, *I.Baoua*, *S. Boureima*, *L. Amadou*, *M. Tamò, S. Mahamane S, B. R. Pittendrigh*

While cowpea (*Vigna unguiculata* L. Walp) occupies an important place as a legume food in the diet of rural and urban populations in Niger, its yield in the Sahelian zone remains low due to insect predation. During the 2014-2016 cropping seasons, tests were conducted on the effectiveness of various biopesticides at the INRAN Maradi station using the IT90K372-1-2 variety of cowpea. A Fisher block design with eight repetitions generated six treatment methods: (1) *MaviNPV virus* alone, 2) aqueous neem seed extract, 3) *MaviNPV* + TopBio [neem oil emulsified concentrate], (4) neem oil, (5) chemical pesticide [CONQUEST 88 EC], and (6) an untreated control.

Over the three cropping seasons, neem seed aqueous extract treatment resulted in 3.3 times fewer *Maruca vitrata* Fabricius larvae, 8.5 times fewer *Clavigralla tomentosicollis* (Stal.) larvae and adults, and 3.6 times fewer *Megalurothrips sjostedti* larvae and adults compared to the control treatment. Average crop yields were 6.7, 4.6, 5.1, and 4.0 times greater respectively for the aqueous neem seed extract, neem oil, MaviNPV virus alone, and MaviNPV + TopBio treatments, respectively over the three years experimentation. Importantly, neem seed aqueous extract, neem oil, Mavi NPV, and Topbio + MaviNPV combination treatments recorded respective a yield increases of 670.80, 463.07, 513.79 and 395.59%. The largest yield increase was observed with neem seeds extract. This study reinforces initiatives for the use of biopesticides for the control the main cowpeas' insect pests in the Sahel because it offer a more cost-effective and less harmful alternative.

PL4-4 **Development and impact of a bean market enhancement innovation platform in Uganda**

Richard Miiro, Moses Tenywa, Robert Mazur, Onesmus Semalulu, Jafali Matege, Stewart Kyebogola, Kayondo Mugagga, Eric Abbot, Charles Katabalwa, Fred Kabango, Methodious Kasujja, Andrew Lenssen, Isabirye Abbas, and Naboth Bwambale

Statement of the problem or hypothesis: Multi-stakeholder innovation platforms (IP) address challenges of smallholder farmers because their characteristically flexible, innovative and unstructured development pattern meets farmers' individual and collective livelihood goals. Evaluation of IP success is needed to justify investment in building and supporting them. A knowledge gap exists regarding IP performance from the perspective of various actors. A study was conducted to evaluate the perceived performance of two 2½ -year-old IPs whose development was supported by a Feed the Future Legume Innovation Lab

project focused on improving soil fertility for bean productivity enhancement in Uganda. Measurements of performance at: (i) governance and management, (ii) member loyalty and facilitation effectiveness, (iii) demand driven research, (iv) access to bean production and post-harvest knowledge and technologies, (v) access to production inputs, finance and risk management services, (vi) farmer institutions development, and (vii) networking and knowledge exchange were made for all actors who participated in the IPs.

Key findings: Results reveal that more women farmers than men farmers acknowledged greater benefit on most of the production related items. IPs are perceived as less effective on governance, specifically in rules of engagement and decision making. Less than 50% score on networking and knowledge exchange and moderate scores were given on access to inputs, finance and risk management. The highest scores are given by stakeholders on the contribution of demand driven research and for access of bean production information.

Significance of the findings to grain legumes: The results are significant for widespread dissemination of grain legumes research, development activities and enhancing market access for beans, as well as demonstrating the need for continuous research with farmers to address ongoing problems, and support all bean value chain actors.

PL4-5 **Developing a methodology for mapping local soil types along the Buganda Catena, Uganda**

M.M. Tenywa, O. Semalulu, R. Miiro, S. Kyebogola, P. Kyomuhendo, C.L. Kizza, J.G.M., Majaliwa, J. Nampijja, A.W. Lenssen, and R. Mazur

Farmer's knowledge about their soils is valuable but inadequate for sustainable management. They depend on the indigenous soil classification system (ISCS) because the existing soil maps scale (FAO-UNESCO-ISRIC, 1990) cannot support farm level decision making. Participatory action research and learning in Masaka District, Uganda, improved the ISCS by developing a methodology for mapping local soil types and capturing hierarchical aspects of ISCS.

An iterative process started with focus group discussions (FGDs) of existing local soil types in 3 locations, sketching local soil types, transferring information to charts, sketching on area topo sheet (1:50,000) and participatory mapping of soil types on enlarged (1:5,000) toposheets. Farmers then guided ground-truthing of local soil class boundaries with 2m accuracy GPS geo-referenced and demarcated boundaries. FGDs queried hitherto nonhier-archical soil classification based on either color or texture and adapted it into a hierarchical system that combined both. Local soil maps produced by farmers without a toposheets were well done but of limited use because of scale issues. Guided by toposheets (1:50,000), farmers distinguished and mapped different soils as distributed along the Buganda catena.

Results from using enlarged topo-sheets (1:5,000) confirmed its power in capturing local soil differences more accurately. Based on ISCS, farmers use soil characteristics (e.g. color, texture, stoniness) to distinguish among local soil types. Farmers identified five indigenous soil types distinguished on the basis of colour [*liddugavu* (black), *limyufumyufu* (reddish)], texture [*lubumbabumba* (clayey), *lusenyusenyu* (sandy)] and stoniness [*luyinjayinja* (gravelley)]. The major soils were based on mutually inclusive colour and stone properties (e.g., black or reddish, with or without stones). We rejected the null hypothesis that ISCS was non-hierarchical, and confirm that a generic soil type has sub-types on which the improvements in the hierarchies can be made.

Abstracts for Oral Presentations: Concurrent Sessions

CS1A: Genetic Improvement of Grain Legumes: Abiotic Stresses

CS1A-1

Selection of common bean to broad environmental adaptation in Haiti

Raphael W. Colbert, *Diana Joseph, James S. Beaver, Timothy G. Porch, Juan Carlos Rosas*

Common bean (*Phaseolus vulgaris* L.) cultivars in Haiti need adaptation to a broad range of environments and resistance to the most important diseases such as Bean Golden Yellow Mosaic Virus. The Legume Breeding Program (LBP), a collaborative effort of the AREA project (USAID funded through IFAS/University of Florida) and Université Quisqueya, evaluated elite breeding lines from the Feed the Future Legume Innovation Lab project (S01.A4) to identify potential parental lines and improved varieties having traits of economic value.

During 2016, un-fertilized field trials were conducted during the winter months at Cabaret, a lowland (32 masl) environment, and during the summer months at Kenscoff, a highland (1,800 masl) environment. In Cabaret, 212 lines from three market classes (black, red, and red mottled) were planted using a randomized complete block design with two replications. Sixty-four lines yielded ? 1,000 kg/ha and had resistant disease scores. These lines were grown in Kenscoff using the same experimental design. Among the selections that exceeded the 1000-kilogram threshold at Cabaret (national average yield is 600 kg/ha), 25 lines yielded between 1,300 and 1,900 kg/ha at Kenscoff. Twenty lines were selected for further evaluation and use in the breeding program. Red mottled lines had an average 100-seed weight of 32 g whereas seed weights of black and small red lines averaged 22 g. Small red and black bean lines had less leafhopper damage than red mottled lines. In the lowland environment, the lines reached physiological maturity approximately 72 days after planting while in the highland environment reaching this stage of development needed 20 more days. In conclusion, the selected lines showed broad adaptation to the agroecological zones of Haiti. The most promising lines were used as parents to generate F1 populations. Further tests are ongoing in alkaline and salty soils as well as in an intermediate altitude (900-1,200 m) environments.

CS1A-2

Determination of cold tolerance QTLs in cowpea (*Vigna unguiculata* L. Walp.) via high throughput photosynthetic phenotyping

Donghee Hoh, Isaac Osei-Bonsu; Jeffrey Cruz, Philip Roberts, Bao-Lam Huynh, Oliver Tessmer, Timothy Close, Linda Savage, David Hall, David Kramer

There is increasing the need for improvement of the efficiency, robustness, and sustainability of food crops, which is exacerbated by changes in climate, loss of arable land and increased populations. Cowpea (*Vigna unguiculata* L. Walp.) is a warm season grain legume crop commonly cultivated in developing countries (Muchero, 2009). It is an important source of protein and symbiotic nitrogen fixation. In addition, many varieties have resistance to drought, low soil fertility (Ehlers and Hall, 1997). However, heat stress during the flowering stage and insects infestations during hot summers can decrease crop yields. In addition, low nighttime temperatures limit the crop to more temperate zones. One approach to avoiding these temperatures is to shift to early planting (when seasonal temperatures tend to be low). It can be considered an opportunity to avoid the insect attacks and heat stress. However, a major concern is how the chilling stress impacts plant performance/yield.

The goal of this research is to identify genes and mechanisms related to chilling stress tolerance. Here, we studied the responses of photosynthesis and growth to low night and day temperatures in 79 recombinant inbred lines (RILs) using two complementary high throughput phenotyping platforms designed to the bridge the gaps between the lab and the field.

We found that there is considerable natural variation that can be exploited for quantitative trait locus (QTL) mapping and subsequent breeding efforts. Cold sensitive is strongly associated with increased photoprotective and photodamage responses of the photosynthetic apparatus, consistent with a mechanism for sensitivity involving the thylakoid proton motive force-induced damage to photosystem II. Also, we found that time dependent QTLs differ depending on the photosynthetic trait used for mapping, but most of the traits have overlapping QTLs at end of chr 8 and 11 under the cold stress. In addition, QTLs linked to leaf movements were mapped in different QTL regions. These observations not only validate both photosynthetic phenotyping platforms for QTL mapping but also identify the regions related chilling stress tolerance.

CS1A-3 **Harnessing PhotosynQ-connected phenotyping technologies for common bean breeding in Zambia**

Kelvin Kamfwa, Susan Chipandwe, Dan TerAvest, and David Kramer

Common bean (*Phaseolus vulgaris*) is a food security crop, and a major source of protein for many households in Zambia. Drought is a major cause of common bean yield losses in Zambia. Despite the existence of genetic variation for drought tolerance within common bean and its related species, progress in breeding for drought tolerance remains challenging because of its genetic complexity. Additionally, lack of affordable equipment and data analytics, especially in developing countries that could provide reliable, high quality measurements of phenotypic parameters under local field conditions has contributed to slow progress in breeding for drought tolerance. In this work, we demonstrated the use of a new, open PhotosynQ platform (www.photosynq.org), together with a low-cost plant phenotyping instrument called MultispeQ, to perform a complete genome-wide association analysis. Using the Andean diversity panel of common bean grown, we identified several strong quantitative trait loci (QTL) for genomic regions controlling photosynthetic performance under moisture stress in Zambia. Previous work using the PhotosynQ demonstrated a strong link between the photosynthetic parameters measured by MultispeQ and ultimate crop yield, suggesting that these QTL may be important for improving crop performance. These initial results demonstrate the potential of the PhotosynQ and MultispeQ as useful phenotyping tools in breeding for drought tolerance in common bean. In the next phase of work, we plan to make the integrated phenotyping/analytics tools available to a broader community and to provide a first-level test of their ability to be used in crop improvement.

CS1A-4 **Physiological components of heat and drought tolerance differences in *Phaseolus vulgaris* and *P. acutifolius***

Jesse R. Traub, Wayne Loescher, James D. Kelly

Common bean (*Phaseolus vulgaris*) is an important food crop, especially in East Africa, Central and South America. Subsistence farmer yields in these areas are limited by drought sensitive bean cultivars. Further, heat often exacerbates drought effects, and due to effects on transpiration and evaporative cooling drought affects the capacity to resist heat stress. Consequently, breeders need to improve both drought and heat tolerance. Using gas

exchange, new fluorescence parameters, and metabolomics, we assessed genotypes with varying degrees of stress tolerance, including tepary (*P. acutifolius*) bean, to find traits correlated with both drought and heat tolerance.

Metabolomic studies showed that most components changed little with drought stress, but leaf concentrations of certain soluble carbohydrates increased with drought, sometimes dramatically, especially in more tolerant genotypes, suggesting correlations with tolerance and observed leaf water potentials. Abscisic acid increased substantially, but genotypic differences were unrelated to tolerance. Drought affected numerous photosynthetic traits. Assimilation versus CO2 concentration analyses did not indicate parameters related to drought tolerance, but rubisco carboxylation and electron transport rates were clearly related to general productivity. Lower stomatal conductances were invariably associated with drought tolerance regardless of water treatment, and grafting showed that stomatal conductance and tolerance were primarily controlled by shoot factors, not roots. Increasing temperatures over several days showed no effects until 45°C when gas exchange, fluorescence, oxidative stress, and visual assessments indicated distinct genotypic differences in heat tolerance even under well-watered conditions. Tepary was particularly heat tolerant even when stomatal conductance was quite limited indicating distinct adaptations to temperature stress. Breeders could use several of these methods to supplement field data and characterize stress tolerance of bean lines. Although breeders should emphasize selection for lower stomatal conductances to improve drought tolerance in bean germplasm, they need to consider the impact of lower conductance on heat tolerance.

Thermo-tolerance of photosynthesis in cowpea, tepary and common bean at the juvenile stage **CS1A-5**

Isaac Osei-Bonsu, Donghee Hoh, Wayne Loescher, Dan TerAvest, David M. Kramer

Improving crop tolerance to abiotic stresses such as heat is a major focus of breeding programs, necessitated by the threat of climate change and the need to feed an ever growing population. Photosynthesis is a foremost determinant of plant productivity; however, it is sensitive to heat stress. This positions the need for improving photosynthetic capacity under heat stress as an important breeding target. Towards this ultimate goal, we sought to determine tolerance of photosynthesis to heat stress in three legumes with differing tolerance to heat stress namely cowpea, tepary and common bean and to identify mechanisms responsible for tolerance in these species. A new chlorophyll fluorescence-based instrument (MultispeQ) connected to the photosynQ platform (www.photosynq.org) and gas exchange techniques were used to probe photosynthesis in vivo, enabling testing under a wide range of temperature conditions (30 – 45°C) in a growth chamber.

Contrary to previous reports, we found tepary bean to be more sensitive to heat stress at the seedling and juvenile stages compared to cowpea, although the common bean genotype, Zorro, was the most sensitive of all the three legumes. Sensitivity to heat stress was aggravated at 45°C day temperature, irrespective of the night temperature. We observed interactions between relative humidity in growth chamber and within-species heat stress tolerance, reinforcing the importance of breeding for specific agro-ecological zones. Analysis of leaf lipid and fatty acid content revealed remodeling of polar lipids with significant changes in molar ratio of mono- and di- galactosyl diacyl glycerol (MGDG and

DGDG). Tolerance of the photosynthetic apparatus was associated with high phosphatidylcholine (PC) and saturated fatty acid (16:0 and 18:0) content as well as stomatal conductance, implicating cooling through transpiration as a mechanism for coping with heat stress. Our findings point to the need for a more holistic approach to breeding for heat stress tolerance.

CS1A-6 **Effect of drought on bean cooking time using germplasm selected for drought, common bacterial blight, and root rot resistance for Uganda and Zambia**

Carlos A. Urrea, Stanley Nkalubo, Kennedy Muimui, James D. Kelly, James Steadman, and Eduardo Valentin Cruzado

Drought and common bacterial blight (CBB) are the most limiting abiotic and biotic stresses, respectively, affecting dry bean production worldwide. Drought can affect cooking time. Cooking time is a major concern in Africa because longer cooking time requires use of more energy resources. This is particularly an issue in countries where firewood is scarce as rural households depend on firewood for cooking. In 2015, two trials were assembled and dispatched to Uganda and Zambia for testing at both locations under normal and drought conditions and for CBB screening. The study conducted at Michell, Nebraska in 2016, explored the effect of drought on cooking time for the above entries plus additional entries that are sources of root rot resistance. This was accomplished by comparing the cooking time of beans grown under drought and non-drought conditions. The lines were grown in replicated trials in adjacent irrigated (non-stressed, NS) and non-irrigated (drought-stressed, DS) plots. Both NS and DS blocks were irrigated until flowering to ensure good plant establishment and normal vegetative growth. Thereafter, the stressed block was not irrigated. After beans were harvested and stored for four to five months, a Matson Bean cooker was used to evaluate the effect of drought on cooking time. Seed from each plot was processed separately using the following procedures. A 60-seed sample was soaked in distilled water overnight (16 h). Distilled water was added to the cooker and heated to 98°C, then 24 of the pre-soaked seeds were placed in the template in the cooker to align the seeds with the plungers. An observer recorded the time when the beans were placed in the cooker and when 80% were cooked (indicated by the plungers dropping). Some sources of drought, CBB, and root resistance grown under DS took longer to cook than grown under NS conditions.

CS1B: Integrated Crop Management: Soil Fertility and IPM

CS1B-1 **Farmer field test of neem-based (*Azadirachta indica*) and entomopathogenic *MaviNPV virus* formulations on the main insect pests of cowpea in Niger**

M. Abdourahmane, I. Baoua, L. Amadou, S. Mahamane, M.Tamò, B.R. Pittendrigh

While cowpea is the most widely grown legume in Niger, its yield remains low due to insect predation. This study compared the effectiveness of biopesticides on the principal cowpea insect pest at 32 villages in the Zinder region of Niger. A randomized block design with two repetitions for three sites per locality generated the following treatments: (1) synthetic pesticide, (2) 5% neem seed extract, (3) neem oil, (4) *MaviNPV virus* alone, (5) *MaviNPV virus* + TopBio (emulsified concentrate of neem oil), and (6) an untreated control.

While all treatments reduced the population and damage of *Clavigralla tomentosicollis* Stal.

and *Maruca vitrata* Fabricius, 5% neem seed extract was comparable the synthetic pesticide. The grain yield was 980 kg/ha, five times higher than grain yield for the control plot and comparable to the synthetic pesticide grain yield of 1078 kg/ha. Neem Oil, MaviNPV + TopBio, and MaviNPV alone yielded 610, 563, and 454 kg/ha, respectively. Given that the expense as well as the environmental and human dangers of synthetic pesticides have limited their use in the region, these results suggest that treatment by biopesticides provides a viable alternative. That is, insofar as cowpea yields in the Sahel region have remained low in part because farmers cannot and do not use synthetic pesticides, their greater effectiveness notwithstanding, biopesticides offer a more cost-effective and more socially and environmentally sustainable alternative.

CS1B-2 **Farmers' preferences for chemical versus biological pest control methods: Evidence from choice experiments conducted in Burkina Faso**

Mywish K. Maredia, Nathalie Me-Nsope, M. Ortega Newman, L. David, and Dieudonne Ilboudo

Cowpea (*Vigna unguiculata*) is an important staple in Burkina Faso. Data collected from cowpea growers in Burkina Faso in 2012 showed that the main biotic stress affecting the crop was insect pest, especially the legume pod borer (*Maruca vitrata*), for which conventional plant breeding has not been effective. Confronted with the need to adopt pest control methods that effectively minimize insect pest damage to the crop, smallholder farmers are applying chemical or synthetic pesticides, which are not only expensive and unsustainable, but also pose serious health and environmental risks due to the toxic ingredients contained in them.

Recognizing these challenges, IPM specialists have identified biological pest control strategies —- involving natural enemies (parasitoids) combined with botanical biopesticides —as alternative and more sustainable pest control strategies. Biological pest control methods are also attractive because they are affordable, effective, and do not pose any health risk to farmers and consumers.

In this paper, we use choice experiment (CE) method to elicit farmer' stated preferences for biological pest control strategy compared to existing pest control methods based on synthetic/chemical pesticides. The study is conducted across 35 cowpea producing villages in Burkina Faso, and 16 cowpea farmers were randomly selected per village (n=560) for the survey and CE. To understand the effect of sharing the information about the health and environmental impacts of alternative pest control method on farmer's preference for biological versus chemical pesticides, we divided our total sample into three sub-samples and randomly administered to each farmer one of the following three information treatments: i) health effects ii) environmental effects, and iii) both. By predicting the willingness to adopt biological pest control interventions, the findings of our research will provide useful input into policy discussions on strategies for promoting wide spread adoption of biological pest control strategies amongst smallholder farmers in Burkina Faso.

CS1B-3 **On-farm assessment of local neem oil against flowers thrips and cowpea pod borer *Maruca Vitrata* Fabricius**

Y. Théodore Ouedraogo, Fousséni Traore, Antoine Waongo, N. Malick Ba, Clémentine Dabire, Antoine Sanon, and Barry Pittendrigh

Insect pests are a major constraint on cowpea cultivation. Biopesticides are an alternative to chemicals because of their environment friendly effect, that would reduce insect populations. These biopesticides are most often used

without information on dosage, yet essential for economic, efficient and effective use. The purpose of this study is to assess the effectiveness of cold and hot extracted neem oils and to determine the effective concentration against thrips and *Maruca* populations.

The study was carried out in the farmer environment using the improved variety named Tiligre. The following (oil/water) concentrations: 1l/80l, 1l/60l, 1l/40l and 1l/20l were applied once a week for each type of neem on randomized plots replicated four times plus absolute control and reference plots. The oils were applied by spraying at the 40, 47, 54, and 61 days after planting. The average number of thrips and *Maruca vitrata* per flower and yields were the main parameters measured.

The results obtained show that at an equal concentration the cold-extracted neem oil significantly reduces the number of thrip per flower than those hot-extracted. These oils did not have a proven reductive effect on *Maruca* larvae. Reduction of the level of thrips per flower and yield gains are not dose-dependent. Thus, the concentration of 1 liter of cold-extracted oil per 20 liters of water significantly reduces the thrips population that hot-extract at the same concentration. On the other hand, it is the concentration of 1 liter of cold-extracted neem oil for 80 liters of water which leads to increase the yield. The implications of these results are discussed for better efficient use in the smallholder area.

CS1B-4 **PhotosynQ: Empowering collection of direct crop physiological measurements on smallholder farms**

Dan TerAvest, Frank Mnthambala, Donald Siyeni, David M. Kramer

Ensuring that the most appropriate technologies are available to smallholder farmers, whether they are new crop varieties, tools or cropping systems, requires robust on-farm experimentation. Currently, most on-farm research is limited to crop production outputs like yield, which only provide details about what happened and not why it happened. The MultispeQ instrument, a sophisticated hand-held plant health meter, allows researchers to collect detailed crop physiological measurements quickly. The MultispeQ connects to the cloud-based PhotosynQ platform, which allows for rapid visualization, analysis and discussion of data and results by researchers from across the globe.

Over the past two years, we have collaborated with field researchers in Malawi to collect over 20,000 MultispeQ measurements on more than 200 smallholder farms. On-farm projects featuring grain legumes included 1) analyzing the effects of different input use and planting densities on soybean and groundnut production; 2) evaluating grain legume varieties on smallholder farms; and 3) assessing the impact of different grain legume rotations on subsequent maize production.

Using PhotosynQ, researchers were able to map the heterogeneity of crop health across farms and districts. Direct crop physiological measurements allowed local researchers to understand how different varieties, or plants under different management regimes, regulated captured light within the photo-synthetic processes in response to their environment. Finally, relative chlorophyll content and the quantum efficiencies of photosystem two and other energy losses, of which the latter two are novel MultispeQ measurements, were significantly correlated with grain yields under smallholder farm conditions.

Strengthening the capacity of scientists in the grain legume sector to draw links between plant regulatory processes and farm management will enhance the ability of researchers to predict how plants respond to farm conditions. This, combined with large sets of standardized data,

can empower more sophisticated analyses to better tailor recommendations to individual farmers' agroecological and socioeconomic conditions.

CS1B-5 **Optimizing fertilizer application in common bean (*Phaseolus vulgaris* L.) in Gurúè, northern Mozambique**

Ricardo M. Maria, Unasse Saide Waite

Common bean (*Phaseolus vulgaris* L.) is the main source of income of majority of farmers of Mepuagiua and Tetete in Gurúè District, northern Mozambique. The average yield under farmer's production system does not exceed 200 kg ha-1 due poor soil fertility, lack of quality seed, drought and pest damage.

A study was carried out to investigate bean response to applied N, P, S in Gurúè District. An incomplete factorial treatment structure in randomized complete block design with three replications were used for determining responsiveness of common bean on the various soils to applied nutrients. The most profitable fertilizer combinations were also assessed. Elemental fertilizer nutrients were supplied as urea (45% N), triple superphosphate (46% P2O5), gypsum (17.5% S). Two improved bean varieties (NUA 45 and VTTT) were compared which were developed by the Institute of Agricultural Research of Mozambique (IIAM) breeding program. A composite soil sampling from surface and subsurface layers in each replication were conducted prior to establishment of field experiment for physical and chemical analyses.

Results indicates no statistically significant difference between VTTT and NUA 45 at p=95. There is statistically significant differences among fertilizer rate. The mean yield range from 556 and 2376.7 kg ha-1 for NUA 45 and 481 and 2153 kg ha-1 for VTTT. The highest yield was attained with 20 kg N ha-1, 15 kg P ha-1 and 15 kg S ha-1 for NUA 45 and 20 kg N ha-1, 15 kg P ha-1 and 15 kg S ha-1 for VTTT. NUA 45 appears to be more responsive to fertilizer application. The addition of sulphur had a positive additive effect on both varieties which suggests that these soils are P and S deficient.

CS1B-6 **Strengthening the indigenous soil classification system using GIS-based mapping of the Buganda catena, Uganda**

B.A. Miller, C.L. Burras, O. Semalulu, C.L. Kizza, J.G.M. Majaliwa, M.M. Tenywa, R. Mazur

Smallholder farmers with limited access to soil testing can benefit from soil mapping that considers landscape position to provide an improved understanding of their potential soil quality.

This study was conceived to improve local soil knowledge about the spatial distribution of soil types and processes driving those patterns. Soils studied belong to the Buganda catena, an area long recognized for having upland soils forming on ferricrete-capped hilltops and lowland soils forming on incised bedrock, but with less attention given to variability along hillsides. Local soil knowledge was strongly emphasized to ensure that results built upon existing knowledge and would be interpretable by farmers. The major local soil types were lidugavu (black), limyufumyufu (reddish), luyinjayinja (stony), which were hierarchized into black or red, each with or without stones. Lubumbabumba (black clayey) was used as an additional subdivision of black soil. Understanding of the distribution of these soil types was captured by local farmers sketching soil maps for their own village.

Soil samples were taken on a 150-meter grid and tested for Munsell color, pH, and nutrient levels using inexpensive equipment. GIS analysis indicated soil color, an indicator of soil fertility, was related to a combination of slope gradient and relative elevation. However, spatial analysis also indicated more investigation was needed

to fully understand the occurrence of stony soils. Considering the hillslope processes of erosion and deposition suggested a utility to farmers for differentiating between black soils at different landscape positions. These concepts can be communicated with a block diagram, an automated classification of topography, or a participatory mapping of village soils with the assistance of GIS. We advocate that future work be done by participatory mapping of soils at the village level assisted by GIS for more accurate soil maps and to better connect village members to the value of such maps.

CS2A: Communication, Adoption, and Willingness to Pay for Technology

CS2A-1

Comparative effectiveness of video animation delivered by smartphones versus printed images in communicating bean-growing recommended practices to farmers in Uganda and Mozambique

Eric Abbott, Richard Miiro,Rob Mazur, Sostino Mocumbe, Barry Pittendrigh, Julia Bello-Bravo, Matege Jafali

Central Issue/Problem: Smartphones are beginning to diffuse among farmers in Uganda and Mozambique, and they offer an important new channel for providing legume crop information. Extension services have been effective, but declines in funding over time have limited their ability to reach farmers. Video animations delivered by smartphones have been created by Scientific Animations Without Borders (SAWBO) via a participatory process that provides key bean production guidance to farmers in their local languages. Previous research has shown that these video animations can be effective when delivered to small groups of farmers via smartphones. However, previous smartphone trials have seldom included systematic controlled comparisons with alternative delivery methods such as printed materials. The current study utilizes a field experiment that compares effectiveness of each method in terms of (1) Learning; (2) Acceptance or rejection of recommendations; (3) Level of excitement generated.

Methods: This was a field experiment. Small groups of farmers (including men and women) were randomly assigned to see either a video message or a set of visual printed materials on four recommended common bean practices. Following the experimental treatment, a post-test measured message impacts.

Key Findings: Farmers learned the four recommendations for improved common bean production regardless of whether they saw the video or the set of printed materials. Perhaps because few had ever seen educational animation messages via smartphones, they were more excited receiving messages this way. The video animation was especially effective with women since more of them lacked formal education needed to read text in printed materials.

Significance of Findings for Grain Legume Development: This research demonstrates that as smartphones become increasingly available to farmers, they can be used effectively along with existing extension and print materials to reach farmers.

CS2A-2 **An assessment of localized animated educational videos (LAV) versus traditional extension presentations or LAV followed by extension agent discussions among farmers in Benin and Niger**

Julia Bello-Bravo, Elie Ayitondji Dannon, Ousseina Abdoulaye Zakari, Amadou Laouali, Ibrahim Baoua, Manuele Tamò, and Barry Robert Pittendrigh

Integrated pest management in grain legume cropping systems will ultimately need to include methods of disseminating knowledge on scientifically validated and effective locally usable integrated pest management (IPM) strategies for farmers in a format and language they will understand, using highly cost effective mechanisms for sharing of such knowledge across different cultural groups that speak a diversity of languages. To this end, Scientific Animations Without Borders has created linguistically and dialectically localized animated educational videos (LAV) on IPM strategies useful in cowpea cropping systems.

In the first study, we compared the efficacy of LAV against traditional learning extension (TLE) presentations for learning gains of knowledge around agricultural- and healthcare-related topics within a rural population in Benin. While both approaches demonstrated learning gains, LAV resulted in significantly higher test scores and more detailed knowledge retention. A key contribution of this research, moreover, involves the use of mobile phone technologies to further disseminate educational information. That is, a majority of participants expressed both a preference for the LAV teaching approach and a heightened interest in digitally sharing the information from the educational animations with others.

Because the animations are, by design, readily accessible to mobile phones via Africa's explosively expanding digital infrastructure, this heightened interest in sharing the animated videos also transforms each study participant into a potential a learning node and point of dissemination for the educational video's material as well. A second study in Niger demonstrated, with rural populations in Niger, that animations on their own were highly effective for learning gains, however, discussions with extension agents after watching the LAV "topped off" participant learning gains. Thus, LAV can be simply distributed by extension agents/networks or can be used even more effectively as the starting point in a conversation between the extension agent and the target rural population.

CS2A-3 **Socioeconomics determinants for adoption of improved technologies disseminated through Farmer Field Schools for cowpea production in Maradi and Zinder, Niger**

M. M.Rabé, I. Baoua, R. Adeoti, L. Sitou, L. Amadou, S. Mahamane, Barry R. Pittendrigh

To enhance the food security of cowpea as one of the most important staples food in Sub-Saharan Africa, the Farmer Field School project introduced newly developed, improved technologies to increase crop yields in the Maradi and Zinder regions of Niger.

This study of 300 producers in the region sought to identify both the entomological constraints of cowpea production and to determine factors that affect the adoption of agricultural technologies by producers. Using the LOGIT regression model, the study found: (1) that 61% of producers identified the pod sucking bug, Clavigralla tomentosicollis Stall, and aphids, Aphis craccivora Koch, as the main insect crop pests; (2) that the average adoption rates of technology were 74.9% for improved varieties, 57.2% for chemical pesticides, 20% for organic and NPK fertilizer in combination, 21.7% for NPK fertilizer alone, 7.4% for neem seed extract as a biopesticide, and 5.7% for the respect of

sowing density innovation, and ratios 2 to 16 times higher with trained producers compared to untrained ones; (3) that the variables "training by Farmer Field School" and "access to credit" have positively influenced the adoption of improved varieties, biopesticides, and fertilizers; (4) that gender positively determined application of recommended sowing density and the use of fertilizers; and (5) that age statistically associated with differences around adoption of sowing densities. While this data informs implementations of innovative technologies related to cowpea production, they also help to inform and improve rural extension programs around those innovative technologies.

CS2A-4 **Inclusive innovation space? the bean value chain innovation platform in Masaka district, central Uganda**

Naboth Bwambale, Robert Mazur

Agricultural research for development (AR4D) can play a significant role in generating, promoting and facilitating dissemination of new agricultural knowledge and technologies for sustained and increased productivity. By facilitating interaction, negotiation, and collective action involving smallholder farmers, researchers, service providers and other stakeholders within a value chain, innovation platforms (IPs) can create spaces for sharing of ideas and knowledge, and collaborative learning in an inclusive manner, benefitting those excluded from mainstream AR4D in design, experimentation, development and adaptation.

IPs are premised to orchestrate co-development and adaptation of knowledge and innovations influenced by markets, policies, rules and regulations, and cultural norms – actors' values and norms. To date, there is limited documentation of how the formation and functioning of IPs enhance inclusive innovation - a critical gap for addressing barriers to adoption of innovations and improved livelihoods.

This study of a major beans IP in Uganda applies Swaans' (2014) framework using qualitative methods (focus group discussions and IP meeting reports since establishment in 2014) to evaluate the mechanisms and extent of inclusive participation in AR4D activities to improve bean productivity and marketing. The framework examines: (1) the formation process – IP design and structuring processes, diversity among IP stakeholders, governance, and problem identification; and (2) functioning - learning and innovation through regular and interactive joint planning, action and reflection, levels of stakeholder participation, information sharing and communication, facilitation, and resources mobilization (financial, human and physical).

CS2A-5 **Towards improving access to high quality bean seed in Nicaragua: How much are farmers willing to pay?**

Robert Shupp, Mywish Maredia, Byron Reyes, Sean Posey, Carlos Rodríguez, Róger Urbina

One relatively simple way to increase smallholder farmers' bean yields is to improve the quality of the seed used. Improved seed quality should lead to higher germination rates, better pest resistance and an overall healthier and more vigorous plants and thus higher yields. The use of higher quality seed in a smallholder context can be hampered by several factors including availability, trust in the source, and the price premium required to purchase.

This study focuses on the latter and investigates the willingness-to-pay (WTP) for higher quality seed. Specifically, we will implement double-blind farmer-run field trials in 12 villages in Nicaragua using three different qualities of bean (*Phaseolus vulgaris*) seed of the same variety – Certified, Quality Declared (QDS), and

recycled. Village farmers will participate in two field days (at flowering and just before harvest) to observe plot differences and will participate in ranking activities. To elicit the WTP for the different seed qualities, 40-60 farmers in each village will participate in both an auction (Becker-DeGroot-Marschak mechanism) and a real choice experiment (RCE) during the last field day. Both the auction and RCE will be incentivized in that one will be chosen randomly and the outcome enforced (i.e., the farmer will buy seed at the chosen price). RCEs are relatively new and, relative to auctions, are thought to better replicate an actual shopping decision. Since most previous studies investigating WTP for seed have used auction-based mechanisms, including the RCE and auction mechanism will allow us to compare our results to previous studies while also potentially eliciting more accurate WTP estimates. The WTP results from this study will help identify the demand for QDS and Certified seed over recycled seed. This knowledge can be used to encourage more production and marketing of these higher quality seeds with an eye towards improving availability from trusted sources.

CS3A*:* Genetic Improvement of Grain Legumes: Biotic Stresses

CS3A-1

Evaluation of selected cowpea (*Vigna unguiculata* L. Walp.) lines for thrips resistance (*Megalurothrips sjöstedti*) in Burkina Faso

Hamadou Sidibe, Benoit Joseph Batieno, Idrissa Ouedraogo, Hamidou Zongo, Serge Zida, Leandre Poda, Soumabere Coulibaly, Timothy Close, Jean-Baptiste Tignegre, Bao-Lam Huynh, Philip Roberts, and Jeremy Ouedraogo

Cowpea, (*Vigna unguiculata* L. Walp.), is one of the most important grain legumes grown inarid and semi-arid areas of Africa. The crop is of great importance in the fight against malnutrition and poverty and it contributes to the achievement of food self-sufficiency. However, its production is suppressed by numerous abiotic and biotic constraints, among which are several insect pests including flower Thrips (*Megalurothrips sjöstedti*). They belong to the family Thripidae in the order Thysanoptera, and cause significant damage to the cultivation of cowpea especially during flowering time. The objective of this study was to evaluate the behavior of eight lines against Thrips in a search for resistance. A randomized complete block experimental design was used with three replications and two blocks (insecticide-treated and non-treated blocks). Genotypes were planted in plastic pots, each with a single cowpea plant. At flower bud initiation stage the pots were covered with sleeve cages and artificially infested with Thrips. The results obtained identified both resistant varieties and susceptible varieties to Thrips populations. The best genotypes were those that had a low number of thrips per flower and had high pod production. On this basis, breeding line KVx780-1 was the best genotype compared to KVx780-6. For the current varieties being popularized, Nafi was the best compared to Gourgou, Komcallé and Tiligré. The results confirmed the susceptibility of the variety KN-1, tolerance of the variety KVx165-14-1, and resistance of the variety TVx3236.

CS3A-2

Identification of cowpea (*Vigna unguiculata* L. Walp.) lines and polymorphic gene-based microsatellite markers for the resistance to aphids (*Aphis Craccivora* Koch)

P. Adelaide Ouedraogo, Jean-Baptiste Tignegre, Benoit Joseph Batieno, Leandre Poda, Fousseni Traore, Jeremy Ouedraogo, Bao-Lam Huynh, Philip Roberts, and Timothy Close

Cowpea (*Vigna unguiculata* L. Walp.) is an important food legume and an essential

component of cropping systems in the semi-arid tropics. West Africa alone produces about 80% of the world production. However, grain yield remains among the lowest in these areas. It rarely exceeds 400 to 500 kg per hectare in traditional production system. Yield losses related to insect pest can reach 100% in Sub-Saharan Africa when no control measure is taken. The cowpea aphids, *Aphis craccivora* Koch is one of the insects causing serious yield losses in cowpea.

The aim of this study was to contribute to the increase in the yield of cowpea by the identification of aphid resistant lines and resistance-linked polymorphic gene-based markers for use in breeding.

To achieve this goal, ten varieties (B301; KVx295-2-124-99; SARC1-91-1; SARC1-57-2; IT97K-556-6; NS1; N°2300; NS-Farako-Ba; CB27 and KN-1) were infested with three strains of aphids and their resistance was evaluated. One known resistant line (IT97K-556-6) and one susceptible line (KN-1) were used as controls. For the identification of polymorphic gene-based markers, susceptible Tiligre and resistant KVx295-2-124-99 were screened with ninety six microsatellite (SSR) markers.

The present study allowed to identify resistant and moderately resistant varieties to each of the three aphids' strains. The variety IT97K-556-6 is found to be the most resistant for having been resistant to all the three strains of aphids. The variety N ° 2300 is the most susceptible. It was susceptible to all the three strains of aphids. The analysis of the infestation evolution showed that IT97K-556-6 has exhibited the higher level of antibiosis. It was the least favorable to the development of aphids and NS-1 was the most favorable. KN-1 considered as susceptible control was found to be resistant. The study also revealed that the strain of Kamboinsé is similar to the Pobé one and that these two strains are different from the strain of Bobo. The aphids strain of Pobé was the most virulent and the Bobo one the most aggressive. Additionally twenty-four polymorphic gene-based markers over ninety-six were identified, representing a polymorphism rate of 25%.

A novel root-knot nematode resistance qtl in cowpea accession FN-2-9-04 from Mozambique **CS3A-3**

Arsenio Ndeve, William. C. Matthews, Jansen. R. P. Santos, Bao-Lam Huynh, Yi-Ning Guo, Sassoum Lo, María Muñoz Amatriaín, Timothy. J. Close, and Philip. A. Roberts

The root-knot nematode (RKN) species, *Meloidogyne incognita* and *M. javanica*, cause substantial root system damage and suppress yield of susceptible cowpea cultivars. Narrow-based genetic resistance, provided by the Rk gene, supports cowpea production in many RKN-infested areas; however, the occurrence of Rk-virulent RKN populations has undermined the effectiveness of this resistance.

The dynamics and virulence plasticity in RKN populations demand broadening the genetic base of resistance in elite cowpea cultivars. As part of this goal, F1 and F2 populations from the cross CB46-Null (susceptible) x FN-2-9-04 (resistant) were phenotyped for root galling (Rg) and egg mass production (Em) in response to M. javanica under controlled growth chamber and greenhouse conditions. In addition, F2:3 families of the same cross were phenotyped for Rg in response to Rk-avirulent *M. incognita* and *M. javanica* in the field. The Rg and Em phenotypes of the F1 indicated that resistance to *M. javanica* in FN-2-9-04 is partially dominant. Midparent-offspring regression (h2) analysis of 7 F2 populations indicated that the resistance is highly heritable ($h2 = 0.76 \pm 0.1$, $R2 = 0.52$, $p < 0.05$).

Analysis of allelism in CB46 x FN-2-9-04 F2 populations and QTL analysis in CB46-Null x FN-2-9-04 F2:3 population showed that FN-2-9-04

also carries the Rk locus homologous to that present in cv. CB46, but its broad-based resistance is conferred by a novel QTL with additive effect identified on chromosome 1 (old LG4) of the cowpea consensus genetic map. This novel resistance to *M. javanica* in FN-2-9-04 is important for broadening RKN resistance in elite cowpea cultivars.

CS3A-4 **Rust resistance in the Guatemalan climbing bean germplasm collection**

Luz de María Montejo, J.M. Osorno, P. McClean, J. Steadman, S. McCoy, and J.C. Villatoro

Common bean (*Phaseolus vulgaris* L.) is the main source of quality protein, fiber, and iron for Guatemalan's poorest households, where per capita consumption is approximately 8.3 kg per year. However, bean productivity is affected by abiotic and biotic stresses. One biotic factor is bean rust (*Uromyces appendiculatus*) (Pers) Unger, which can cause up to 100% yield losses. In addition, it is problematic due to its abundant genetic diversity for virulence. There is limited information about bean rust virulence in many locations of Guatemala, especially at mid-altitude highlands, where climbing beans are mostly cultivated. Climbing beans have received less attention and breeding efforts compared to bush types, but can be a potential source of resistance.

The main objectives of this projects are: 1) to identify the race diversity of bean rust from the Western Highlands in Guatemala; 2) to evaluate disease reaction of the climbing bean in Guatemalan germplasm to rust races from Guatemala and North Dakota; 3) to identify genomic regions associated with rust resistance and 4) to identify reliable molecular markers that could be used in Markers Assisted Selection (MAS). A recent study conducted at this region found six different virulent patterns across 12 locations showing the high rust diversity in Guatemala. During the 2015 growing season, 23 bean rust samples were collected from 11 locations across three departments in the Western Highlands. Pathogen characterization was performed by single pustule inoculation on a set of 12 differential lines and two races were identified: 63-1 and 31-1. These two races from Guatemala and race 20-3 from North Dakota were used to evaluate the climbing bean germplasm. Approximately, 81% of accessions showed resistant reaction to the race 63-1, 75% to race 31-1, and 85% to race 20-3. Genome-wide Association Studies (GWAS) are under analysis by using 78,754 SNP markers.

CS3A-5 **Employing host plant resistance (HPR) in the control of cowpea aphids and *Striga gesnerioides* in northern Ghana**

G.T. Kubi, F. Kusi, A.T. Asare, M. Botchey

The incidence of the phloem-sucking cowpea aphid (*Aphis craccivora*) and plant-parasitic weed *Striga gesnerioides* on legumes continue to be major constraints in legume production. Their direct damage coupled with indirect effects of predisposing the crop to other pathogens leads to massive yield losses in extreme cases. Cowpea as a grain legume is considered an important crop in Northern Ghana, well noted for its drought tolerance and adaption to marginal soils, but yield expectancy is not achieved due to numerous biotic stresses of which both aphids and *Striga* play key damaging roles.

The indiscriminate use of agro-chemicals as a fundamental means of control of aphids is not only expensive for the smallholder farmer but also has adverse environmental concerns. Cultivating resistant cowpea varieties thus presents an environmentally friendly and economically sound approach. Seven newly improved *Striga gesnerioides* resistant cowpea lines obtained from the University of Cape Coast (UCC) were screened for aphid resistance

using both phenotypic data scores and the SSR marker, CP171/172. From the preliminary results, two aphid resistant lines (UC96-241 & UC96-513) and two aphid susceptible lines (UC96-11 & UC96-471) were selected. These lines were crossed to a known aphid-resistant line, SARC 1-57-2 with the aim of improving the field resistance of the susceptible lines and also to determine the genetic relatedness of the resistant lines from UCC to the SARC 1-57-2 line. If different genes are found controlling resistance, then gene pyramiding will be our ultimate goal to develop a more durable aphid resistant cowpea genotype.

CS3A-6 **Identification of sources of resistance to *Alectra vogelii* in cowpea (*Vigna unguiculata* L. Walp.) germplasm in Burkina Faso.**

Zakaria Dieni, Jean-Baptiste S. Tignegre, Benoit Joseph Batieno, Pangirayi Tongoona, Jeremy T. Ouedraogo, Bao-Lam Huynh, Philip Roberts, and Timothy Close

In Burkina Faso, cowpea serves as both food and cash crop generating important income for farmers. However, cowpea production is hampered by several abiotic and biotic constraints among which *Alectra vogelii* that reduce cowpea productivity. This parasitic weed that has been neglected is now an important threat to cowpea production in the country. Though genetic resistance studies for cowpea resistance to *Alectra vogelii* in Burkina Faso were not done so far. Therefore, cowpea genotypes were screened in pots, infested with *Alectra vogelii* seed from Koupéla, at Kamboinsé research station to identify sources of resistance.

This study showed differential reaction of cowpea genotypes to *Alectra vogelii*. The severity of *Alectra vogelii* effect could be used as the most important parameter to access cowpea resistance to *Alectra vogelii*. Genotypes KVx414-22-2, KVx 165-14-1, Komcallé, IT99K-573-2-1, IT98K-205-8, IT86D10-10, IT93K-693-2 and B301 were identified for their resistance to Alectra vogelii. Komcallé and IT98K-205-8 are improved and farmers' adopted varieties. The others genotypes are potential donor parents for breeding new, adapted and *Alectra*-resistant genotypes.

CS3B: Challenges in Grain Legume Seed Systems

CS3B-1 **Adoption of improved bean varieties in Haiti: An assessment using farm surveys, bean seed supply chain analysis, and DNA fingerprinting**

M.K. Maredia; D. DeYoung, E. Prophete, C.D. Joseph, J. Beaver, T. Porch

Common beans (*Phaseolus vulgaris*) are an important part of the Haitian diet. Over the past 20 years, the national and regional collaborative research efforts have resulted in the development and release of improved bean cultivars that have greater disease resistance, improved agronomic traits and higher seed yield potential than local landraces. These investments in bean research have also been accompanied by systematic efforts by the government and NGO partners in dissemination of seeds of these varieties to bean farmers. There are however, no rigorous studies, either based on representative farm surveys or other approaches to track the use and adoption of seeds of improved bean varieties in Haiti.

To address this knowledge gap, we conducted a study to estimate the adoption of improved bean varieties by farmers in Haiti using both a survey-based approach and DNA fingerprinting. Data and seed samples were collected from a representative sample of bean farmers, and bean vendors from more than 20 markets around the country, and from different players along the bean seed value chain. Seed samples

collected from farmers, markets and value chain were analyzed using genotyping-by-sequencing (GBS) and SNP marker technology to identify the genetic diversity of bean varieties planted by farmers and available in the 'seed system' and their relationship to known released varieties and landraces.

Seed collection has recently been completed and DNA analysis is ongoing. We expect the results of this study to provide systematic and rigorous evidence on the identity of bean varieties planted by farmers and available to them throughout the seed system (through both formal and informal channels). The results will help assess the success or failure of past seed dissemination efforts, and to derive lessons on making such efforts more effective in increasing the adoption of improved bean varieties by farmers in Haiti and elsewhere.

CS3B-2 **A local success story on cowpea production and distribution comprised by a national project**

D Ilboudo, Mariam D. Balima, M. Maredia

Millions of smallholder farmers worldwide rely on the informal seed system (i.e., own harvest or grain accessed from the market) as the main source for seed. Although this informal seed system is able to meet diverse seed needs at lower cost, it is not directly linked with the research system, and thus not able to quickly channel improved varieties generated by the research system.

This paper presents a case study of how a farmer association in Burkina-Faso called Association-Song-Koaadba (ASK) has addressed these challenges for the past 20 years, but is now facing an existential threat due to the building of a new Ouagadougou airport in the Donsin area where ASK operates. With the help of INERA, ASK has trained its members from close to 100 villages to become part-time seed entrepreneurs to produce quality declared seeds (QDS) of improved cowpea varieties for sale to other farmers. The presence of ASK in the communities has brought several benefits, including: a) access to improved varieties of cowpea generated by INERA; b) access to quality seed; and c) timely availability of seed for planting. A back-of-the-envelope calculation of the potential production gains to the communities from the access to improved seeds is estimated to be in the range of 140-700 million CFA francs per year dépending on the assumptions about the grain price, which is a function of the timing of the sales.

But now due to a project to build a new Ouagadougou airport, ASK members from a dozen of villages in the heart of the ASK area (Donsin) are forced to leave. By 2016, the population of these ten villages where ASK operates has been displaced totally and they have lost their land. The paper will describe how ASK is coping with this displacement and seeking various initiatives to survive its business model.

CS3B-3 **Haiti Hurricane Matthew bean seed relief effort: Lessons learned and recommendations for future similar situations**

Luis Flores and Reginald Cean

Hurricane Matthew wiped out short-cycle and perennial food crops in Southwestern Haiti on 3 October 2016, exacerbating food insecurity in the region. A seed relief effort, Mwen Gen Pwa, was rapidly implemented by the Feed the Future Legume Innovation Lab with USAID support. Quality seed of improved three bean varieties were distributed to >10,000 smallholder farmers by mid-February 2017.

Deemed a successful endeavor in the short term, three major lessons were gained from this experience that should be considered by others facing similar rapid disaster response challenges in the future. First, access to geographically mapped information on bean production areas,

farmer preferences of market classes, agro-ecological data (soil fertility, rainfall, disease incidence, etc.) as well as varietal performance data for a country are essential for the selection of appropriate varieties for introduction into a region affected by a disaster. It is also advisable to introduce seed of multiple varieties with adaptations to the range of unique agro-ecologies of a region and to provide farmers with options. Second, collaboration with a network of grassroots community-based farmer organizations as well as public institutions and international NGOs is crucial for rapid dissemination of seed to needy farmers. In the context of Mwen Gen Pwa, the networking with 129 beneficiary organizations greatly facilitated monitoring, provision of technical assistance and the collection of crop data in an efficient and cost effective manner. Finally, the provision of technical assistance on appropriate management practices (e.g., plant spacing, fertilization, planting time and disease/insect management) is as important to farmer success with growing new varieties as the improved genetics in the seed.

CS3B-4 **Farmers' willingness to pay for quality seeds of bean varieties with preferred traits: evidence from two Central American countries**

David DeYoung and Mywish K. Maredia

Common beans (*Phaseolus vulgaris*) are important staple crops in Guatemala and Honduras. For bean breeders, knowing farmer preferences for varietal traits is important to target their research efforts. Also, understanding farmers' willingness to pay for seeds of improved varieties is important for designing effective seed system strategies. We use a dataset of beneficiary farmers of the Bean Technology Dissemination (BTD) project that received high quality seeds of improved varieties between 2010 and 2013, to determine farmers' willingness to pay (WTP) for bean seed according to their ranked varietal preferences. Farmers were asked to rank varietal preferences and state their willingness to pay for a pound of quality bean seed of an improved variety that had their desired characteristics. Overall, yield was the most important trait. Women ranked grain yield and cooking time higher than men while men ranked resistance to disease, insects and storage pests higher than women. Using a regression analysis, and controlling for individual characteristics that could affect willingness to pay, farmers are willing to pay on average between $0.01 and $0.03 more per pound for seed of a variety with a desired trait as the importance of that trait increases by one point on a 10 point scale. These desired traits include disease and insect resistance, cooking time, and yield.

When we analyze male respondents exclusively, the only trait that significantly influenced their WTP for bean seed was market acceptability or the price they would receive for selling the grain. Women respondents' WTP was significantly influenced by their preference for disease resistance, shorter cooking time, yield, early maturity and taste of beans in the green stage.

Our results provide information on bean varietal preferences and WTP estimates that can guide future research and development strategies in two important bean producing countries in Central America.

CS3B-5 **Strategic partnerships and extension education tools for reaching geographically disperse, low literacy and language-diverse beneficiaries in Guatemala with MASFRIJOL project**

S Castellanos, L Flores, C Wille, C Molina, S Hoerr

MASFRIJOL, a four-year USAID project managed by the Feed the Future Legume Innovation Lab in collaboration with the Institute of Agricultural Science and Technology (ICTA), targets food-insecure households in Guatemala's western highlands by, in part, providing access to bean seed of improved

varieties. Spread over a large and geographically remote area, this indigenous population is one of the most impoverished and malnourished in the Western Hemisphere, is characterized by low literacy levels, and is composed of diverse cultures and languages.

With the goal of reaching 30,000 families in four years to distribute improved bean seed varieties that will improve grain yields, strategic partnerships were formed with existing in-country organizations to apply more innovative extension methods more efficiently in such a challenging environment. Innovative extension practices included the use of classrooms on wheels that traveled from village to village, department to department to bring information right to the recipients; the development of culturally appropriate videos aligned to topic-specific, demonstration-based nutrition and agriculture lessons; and other teaching and marketing tools.

With a small staff of extension educators, MASFRIJOL and ICTA technical staff provided critical training and support in the field on better agricultural practices and why and how to improve dietary nutrition using beans across five departments over 30 municipalities. Collaboration with other USAID Projects, local NGOs, and key governmental partnerships with the Ministry of Health and the Ministry of Agriculture has been equally important to the feasibility of implementing the project successfully, particularly in regard to expediting seed distribution and educational outreach in the remote target communities. This paper will explore how MASFRIJOL developed these partnerships and how they worked together to improve agricultural practices and nutrition in Guatemala's western highlands.

Production systems and seed technology diffusion in Burkina Faso: the case of SFDIAB project **CS3B-6**

Eveline MFW Compaore Sawadogo

In Burkina Faso, the agricultural sector employs the vast majority of the work force and accounted for an estimated 32 percent of Gross Domestic Product. Thus, there have been several attempts to modernize the sector. So far, these attempts go through three main aspects: First, the modernization of the sector refers to the improvement of soil quality. Second, it is related to the seed quality improvement. More recently it came to the attention that agricultural finances are one of the core issue for optimizing the productivity by increasing new technologies take-up by farmers. However, all these arguments tend to assume the efficacy of innovation in disconnection from production systems in which they are used.

The objective for this paper is to demonstrate that there is a relationship between stratifications in production systems and seed innovation. Based on a quantitative and qualitative research from the North (Yako et Koursi), the Central South (Po) and the Central West (Sapouy) of Burkina Faso, this paper uses the Social Construction of Technology (SCOT) as an analytical tool to understand such a mechanism so that one can understand how production system shapes farmer entrepreneurship, their judgement of innovation and economic behavior.

The paper will first give a description of the production systems of farmers involved in SFDIAB project. Then it will evaluate the degree of adoption of the project's proposed

innovations in relation to seed (Cowpea and maze). Finally, the third section brings the analyses of the two previous sections together to discuss the logic of farmers' entrepreneurial spirit in agriculture in Burkina Faso.

By highlighting the stratification of the production systems and its implication for new seed technology adoption, this paper contributes to the Feed the Future Legume Innovation Lab initiatives as it provides basis for tailoring innovation dissemination in developing countries such as Burkina Faso.

CS4A: Genetic Improvement of Grain Legumes

CS4A-1

Two new climbing bean varieties adapted to the milpa system in the Highlands of Guatemala

JM Osorno, P McClean, JC Villatoro, AN Miranda, J Moscoso, K Agreda, and LF Aldana

Common bean (*Phaseolus vulgaris* L.) is the most important food legume and both bush-type beans and climbing beans are grown worldwide. However, climbing bean production is only present in few regions within specific countries in Africa (e.g., Rwanda, Uganda) and Central/South America (Guatemala, Southern Mexico, Ecuador, Peru, and Colombia).

Historically, climbing beans have received less attention and breeding efforts worldwide in comparison with the bush-type beans commonly grown in the lowlands. Maize and beans are the main staple food in most poor households in Guatemala. Per capita bean consumption is approximately 12kg per year. Still, 45% of children age 5 and younger are malnourished. Intercropping (locally known as Milpa) is the main production system in the highlands, where maize-bean is the most common. Unfortunately, on-farm productivity of these climbing beans is approximately 1/4 of their genetic yield potential mostly due to the lack of improved cultivars that can withstand biotic and abiotic stresses. In addition, production is made with almost no inputs of fertilizers and/or other chemicals.

Breeding efforts made by ICTA since 2007 have led to the release of two new Improved varieties. ICTA-Labor Ovalle seed yields are on average 172kg/ha higher than the local check, but this yield difference varied depending on the region and trial between 50 and 403kg/ha. ICTA-Utatlan seed yields were 200kg/ha higher than the local check. Yield difference varies between 90 and 600 kg/ha. In addition, ICTA-Utatlan has a very early maturity, which is good for food security purposes when food is scarce during the middle-end of the growing season. More than 3,300 kg of each variety have been distributed to growers and it was planted commercially in the 2017 growing season. Additional testing of these varieties would show if they can be adopted in other countries/regions.

CS4A-2

Blackeye cowpea varietal improvement program for California and the USA

BL Huynh, NE Clark, CA Frate, WC Matthews, TJ Close, PA Roberts

Cowpea (*Vigna unguiculata* L. Walp.) is a nutritious food legume crop grown in Sub-Saharan Africa and other warm-to-hot regions worldwide. In the United States, including the Central Valley of California, cowpeas are grown as blackeyes or black-eyed peas for dry-grain production and soil nitrogen fixation for following crops in rotations.

Aphids, lygus bug, root-knot nematodes and *Fusarium* wilt disease are prevalent in this region, in part due to the large-scale production

of cotton and alfalfa, causing significant reductions in yield and seed quality of current blackeye cultivars. The California dry bean industry together with the USAID Feed the Future Innovation Lab for Collaborative Research on Grain Legumes supports our program to develop improved blackeye varieties for California and the USA. Sources of genetic resistance to the aforementioned biotic stresses were found in African cowpea germplasm and are being bred into susceptible blackeye cultivars using both conventional and molecular breeding strategies. Advanced breeding lines with stacked resistance loci were developed and are being evaluated in on-station and commercial field trials for cultivar release potential. The genetic loci conferring biotic resistance discovered in the US can also be used in African cowpea improvement in production areas that share common biotic stress species and biotypes.

CS4A-3 **Screening bean lines in Guatemala for resistance to the common and Mexican bean weevil**

Julio Villatoro, Angela Miranda, Edgardo Carrillo, Jessica Moscoso, Karen Agreda, James Beaver, Timothy Porch, and Juan C. Rosas

In Guatemala, the common bean weevil (*Acanthoscelides obtectus* Say) and the Mexican bean weevil (*Zabrotes subfasciatus* Boheman 1833) are responsible for significant losses in stored bean seed.

Fifteen bean breeding lines from the University of Puerto Rico were evaluated in the highlands (Quetzaltenango and Chimaltenango) and lowlands (San Jerónimo) of Guatemala to identify sources of resistance to weevil damage. Experimental units consisted of single bottles containing 20 seeds. Each bottle was infested with 20 adults of the common bean weevil in the highland trials and 20 adults of the Mexican bean weevil at the lowland location. Completely randomized design with three replicates were used. Initial and final seed weight, number of damaged seed, number of holes per seed were evaluated at 30, 45 and 60 days after infestation. At Chimaltenango and Quetzaltenango (highlands), the lines PR1429-4, PR-1464-6, PR1303-(121-129) and PR1303-42 had 4%, 2%, 2% and 0%, respectively for damaged seed and 8%, 4%, 2% and 0%, respectively for numbers of holes per seed at 60 days after infestation.

At San Jerónimo (lowlands), PR1303- (121-129) was moderately resistant to the Mexican bean weevil, with 28% of the seeds damaged at 60 days after infestation. The control variety, ICTA Hunapú, had 100% damaged seed in San Jerónimo at 60 days after infestation. PR1303-(121-129) was included as an entry in the 2017 black bean yield trials in Guatemala. The weevil resistant lines were included as parents in the crossing block in Chimaltenango to introduce weevil resistance into future bean varieties developed and released by ICTA.

Genetic improvement in Uganda's Andean bean breeding program **CS4A-4**

Stanley T. Nkalubo, Blessing A.Odogwu, Boris M.E. Alladassi, Evarist Basil, Isaac Dramadri, Dennis Katuramu, Gabriel Luyima, Karen Cichy, Carols Urrea, James Steadman and James Kelly

The common bean (*Phaseolus vulgaris*) is the most important legume grown and consumed in Uganda and contributes over 45% of the total human dietary protein, thus playing a significant role in ensuring food and nutrition security. Despite this importance, the coexistence of multiple biotic and abiotic stresses on the crop in farmers' fields at the same time, has greatly undermined the production potential.

As a way of overcoming these production constraints for especially the Andean genotypes that are majorly grown by Ugandan farmers, collaborative research efforts were initiated

towards the development of new bean lines with resistance to multiple foliar pathogens, tolerance to drought and with nutritional and fast cooking qualities.

Research activities undertaken resulted in the acquisition of 6 different nurseries comprising of >750 bean accessions that have been utilised in evaluations and multiple crosses (>150) to introgress multiples resistances into back-grounds of susceptible Ugandan germplasm. Additional activities led to discovery of a number of lines with good resistance to rust (309, CNC, P1181996, Mexico 235, Redland pioneer, Oura Negro & Aurora); CBB (NE2-14-8, NE17-14-29, NE14-09-78 & VAX3); BCMV (SCR 48, SCN 9 & SCN 6) and tolerance to drought (ADP-102, ADP-41, ADP-47& ADP-660). In addition, a couple of fast cooking lines from ADP panel series were evaluated on-farm with famers identifying superior genotypes with both market and consumption preference traits. Other research outputs included collection, isolation, characterization and determination of incidences, severities and understanding modes of inheritance to resistances of key foliar dis-eases (rust, CBB, BCMV) in Ugandan elite lines.

These outputs so far generated are envisaged to contribute to the development of varieties and germplasm with high yield potential, improved resistance to multiple pathogens, and water use efficiency under limited soil water conditions, and contribute to improved yield and on-farm profitability for especially the resource poor farmers.

CS4A-5 **Genetic improvement of cowpea to overcome biotic stress and drought constraints to grain productivity**

Philip Roberts, Timothy J. Close, Bao-Lam Huyhn, Ndiaga Cisse, Joseph Batieno, Issa Drabo,F. Kusi, Atokple, D.K. Ibrahom, Maria Munoz-Amatriain, Ousmane Boukar, Christian Fatokun, Arsenio Ndeve, Sassoum Lo, Richard Agyare

On-farm cowpea (*Vigna unguiculata* L. Walp.) yields of traditional varieties in Africa are on average 5-fold lower than potential yields due in large part to several key biotic and abiotic stresses. Development of cowpea cultivars that resist or tolerate these stresses is a particularly desirable strategy for this crop because it is grown mostly by resource-poor farmers, many of whom are women who lack access to capital.

Collaborative breeding by three African NARS partner programs with UC Riverside and IITA, supported by USAID Feed the Future Legume Innovation Lab and associated projects have identified resistance and tolerance traits for key pests including cowpea aphid, flower thrips and pod-sucking bugs. These traits are in various stages of molecular characterization of their genome organization for use in molecular breeding schemes.

The goal of the project is to identify and introgress resistance traits into elite cowpea varieties and combine them with drought tolerance. Data from field and greenhouse phenotype screening for resistance, and from SNP and SSR genotyping are deployed in QTL analysis for trait-marker associations, which are then applied in breeding selection. Breeding strategies include simple MABC to more complex MARS and MAGIC-based crossing and selection schemes. This talk will review current progress and accomplishments of LIL Project SO1.A5, including breeder and foundation seed development and release of elite new cowpea varieties, coupled with training activities at both the graduate degree and short-term technical levels to strengthen capacity in the partner NARS programs.

CS4B: Consumer Preference, Farmers' Decisions, and Production Aspects

CS4B-1 Social and economic factors in farmer decision making for improved soil fertility management and increased bean production in Uganda

Rob Mazur, Richard Miiro, Eric Abbott, Moses Tenywa, Ebby Luvaga, and Onesmus Semalulu

Problem: Poor and declining soil fertility is a significant constraint to common bean productivity in Africa. Addressing soil-related constraints requires enhancing smallholder farmers' capabilities to diagnose and find solutions. Identifying social, cultural and economic factors that limit adoption of improved management practices and technologies (MPT) is essential for widespread adoption.

Methods: We examine activities of two multi-stakeholder bean value chain innovation platforms (IPs) in Uganda to characterize the social context of experimentation, learning and adoption of MPT. To understand smallholder farmer decision making, we use data from household baseline survey in southwest Uganda (2014) and interviews and focus group discussions (2017).

Key findings: IP members participate in trainings to diagnose soil nutrient deficiencies and other production constraints, and field experiments to determine soil-type specific solutions. They host field trials of researcher recommended MPT. These include field preparation and measurement, seed selection, plant spacing, applying organic/inorganic fertilizers, weeding, post-harvest handling, and economics. Observations and comparisons during farmer field days promote social learning that stimulates widespread adoption of MPT. IPs significantly enhance awareness, availability, and access.

Farmer decisions are shaped by opportunities and incentives, and moderated by resource ownership and access, labor hiring practices, and social and economic networks. Households with more adult laborers more commonly purchase land and apply manure. Most households have few/no livestock, so fertilizer and manure tend to be purchased. Households hiring labor more commonly use manure, fertilizer, pesticides and herbicides to intensify efforts and achieve higher yields. Those who purchase inorganic fertilizers have income from non-agricultural sources, have savings, and access credit. Those who access credit apply manure, pesticides and herbicides. Households with savings more commonly apply manure and pesticides.

Significance: Identifying program and project strategies to address social, cultural and economic constraints is essential for widespread utilization of improved management practices and technologies to sustainably improve bean productivity.

CS4B-2 Market participation of smallholder common bean producers in Malawi

Yanjanani Lifeyo, Lawrence D. Mapemba, Kara Ross, and Vincent Amanor-Boadu

Malawi's smallholder agriculture remains the main engine for livelihood improvement and rural growth. Therefore, any policies that can move the rural people from poverty must find its way in transforming the rural smallholder farmers livelihood strategies (thus from subsistence to commercialized production).

The study used the Integrated Household Survey (IHS3) collected by National Statistical Office in 2010. The study's main objective was to analyze factors affecting smallholder common bean production and market participation. This objective was addressed using a triple hurdle model, which separated producing households and non-producing households using a probit model in the first

stage. The second stage, conditional of being a producer, an ordered probit was used to model factors affecting an agricultural household to be a net buyer, net seller or autarkic. Lastly, log-Normal regressions were used to analyze factors affecting net quantity sold and net quantity bought.

Results from the first stage suggested that access to credit, ownership of radio and availability of extension services positively influenced agricultural households to produce common beans. On the other hand, distance to main road and distance to market negatively affected the decision to produce common beans. Results from the ordered probit in the second stage showed that region and location significantly affected producers' role in the market as a net buyer, net seller or autarkic. In addition, market extension was found to reduce the probability of agricultural household to be autarkic. Factors affecting net quantity sold and bought (last hurdle) included market extension, price, household head education level, access to credit, ownership of bicycle and location.

Based on these findings, the study recommend strong extension intervention, reliable market information through radios, creating good roads and market networks, enhancement of credit supply and good common beans price mechanisms as possible interventions to aid in the bean value chain effectiveness.

CS4B-3 **Role of food choice determinants and nutrition interventions in sub-Saharan Africa: consumer insights based on peanut consumption in Malawi**

Aggrey P. Gama, K. Adhikari, D. Hoisington

Prevalence of malnutrition, especially under-nutrition, is high in Sub-Saharan Africa. To overcome this problem, governments in the region are implementing initiatives aimed at increasing production and access to nutritious foods. Unfortunately, the motivating factors that would make people consume more nutritious foods are often overlooked. As preliminary to the goal of developing a nutritious peanut-based beverage for Malawi, a survey of 489 Malawian consumers was conducted to determine the factors that influence food choices and consumption of peanuts.

The survey revealed that the factors influencing food choices of Malawian consumers are mood, health, price, preparation convenience, sensory appeal, familiarity, survival, safety assurance, patriotism, conformity, universality, and versatility. However, only mood, health, price, preparation convenience, sensory appeal, familiarity, universality, and versatility were found significant in affecting peanut consumption in Malawi. The dominant factors influencing food choices varied with socio-demographic profiles and type of product.

Based on peanut consumption patterns found in this study, socioeconomic restrictions are overriding consumer preferences resulting in food being eaten mostly for survival. Contrary to popular opinion, the survey also found that women could be a good target for nutrition interventions that involve household food preparation, while men could be good targets for nutrition interventions that promote consumption of new commercial food products.

This study reaffirms the need for nutrition interventions in Malawi not to just focus on increasing production of and access to nutritious food, but also to consider the food choice motives and preferences of the target consumer segments. Although the results are based on data from Malawi, trends and implications for policy formulation and research may apply to other countries in Sub-Saharan Africa, especially to countries in southern Africa.

CS4B-4

Crossing the threshold: An analysis of factors affecting household consumption of recommended weekly common bean servings in urban Lilongwe, Malawi

Edwin Kenamu, Lawrence D. Mapemba, Kara Ross, Vincent Amano-Boadu

One of the key arguments for promoting consumption of common beans is the assertion that beans are a cheap source of proteins and other micronutrients in human diets. Numerous programs aimed at improving human nutrition have used common beans as a means to achieving their goal with the understanding that the beans contribute the needed nutrients to human diets. The extent to which the beans effectively contribute towards this goal, however, depends largely on whether individuals take the recommended amount of bean servings to enable the body acquire the said nutrients in adequate amounts.

Surprisingly, literature on bean consumption is silent on factors affecting whether or not a household meets the recommended common bean servings. This lack of such important information adversely affects design of programs aimed at abating some forms of malnutrition through the use of common beans. This study, therefore, uses survey data collected by a Feed the Future Legume Innovation Lab supported project in Lilongwe urban to understand factors affecting household achievement of consuming at least the minimum recommended weekly common bean servings.

Results of a logistic regression analysis indicate that household size, residential area and amount of food budget allocated to legumes significantly affect whether a household crosses the threshold of recommended weekly common bean servings. The results show that a one-member increase in household size increases the probability of crossing the threshold by about 6 percent whereas a one percent increase in food budget allocated to legumes reduces the probability by 88 percent. Residence in low density areas of Lilongwe reduces the probability of meeting the threshold by 12 percent when compared to residence in high density areas of the city.

The paper closes with policy recommendations on how to help households achieve at least the minimum recommended weekly common bean consumption requirements.

CS4B-5

Utilizing Imperfect and Inconsistent Data: Economic Feasibility Analysis of Common Bean Production in Uganda and Mozambique

Ebby Luvaga, Robert Mazur, Richard Miiro, Stewart Kyebogola, Fred Kabango, Jafali Matage, Eric Abbott, Onesmus Semalulu, Moses Tenywa

Statement of the problem: Smallholder farmers make investment decisions based on imperfect information. Economic assessment offers farmers guidance on how to respond to innovative management practices. In Uganda and Mozambique, maintenance and access to data for economic feasibility of bean production is tenuous. Reliable price and cost data can stimulate investments in bean production and improved soil fertility management practices.

Research method or approach: The 2014-2017 study includes economic data from household surveys in Uganda (n=302) and Mozambique (n=305), graduate students (field scientists), project PIs, and weekly bean market prices. Reliance on any one of these sources for cost and price data for economic feasibility analysis has proved insufficient. Realized streams of revenue (profits) based on the different sources of data vary, calling for the utilization of mixed methods of analysis.

Key findings: Based on one acre of land, bean production cost and price data for land, labor, and inputs and output depends on the data source. There was a 54% difference in the

average cost of land, average labor costs by field scientists varied by 24%, and variable costs (seed and fertilizer) differed too, because seed was subsidized for some field trial participants. Cost data from multiple sources is appropriate for addressing imperfect and inconsistent data in benefit-cost analysis.

Significance of the results to grain legume sector development: Beans, often intercropped, require special attention in Benefit-Cost Analysis. Costs associated with mixed cropping systems can be elusive, impacting economic assessment. Reliance on cost or price data from a single source or onetime household survey, market price, and field data can be misleading or further contribute to inaccurate/unreliable results, hence affecting successful adoption. Broad utilization of cost data, especially land and labor, major source for imperfect data, is vital.

Index of Abstracts for Poster Presentations

(**Odd-numbered posters** [Poster Session A] will be presented **from 10:30 am to 12:30 pm, Tuesday, 15 August,** in **Waongo 2.** Presenters of **odd-numbered posters** should be at their poster during this session for discussion.)

(**Even numbered posters** [Poster Session B] will be presented **from 2:00 to 4:00 pm, Wednesday, 16 August,** in **Waongo 2.** Presenters of **even-numbered posters** should be at their poster during this session for discussion.)

Poster	Presenter	YS[1]	Title

Theme 1: Farmer Decision Making, Technical Dissemination, Impact Assessment

P-1	**Ibrahim Baoua**		The Farmer Field School, A Participatory Process for The Cowpea Yield Improvement: Results of the Pilot Experiments Conducted in the Regions of Maradi and Zinder
P-2	**David DeYoung**	✓	An Assessment of The Local Bean Seed Production and Marketing Model: The Case of Community Seed Banks in Nicaragua
P-3	**David DeYoung**	✓	Gender Differences in Varietal Preferences and Willingness to Pay for Quality Bean Seeds: Evidence from the Guatemalan Highlands
P-4	**Atsuko Kanazawa**		HyperspeQ: A PhotosynQ-Capable, Hand-held Hyperspectral Spectrometer for Assessing Grain and Soil Properties
P-5	**Edward Opoku**	✓	Willingness to Pay for Quality Cowpea Seeds: Experimental Evidence from Northern Ghana
P-6	**Mywish Maredia**		Role of Legume Technologies in a Nutrition-Focused Agricultural Strategy: Evidence from Uganda
P-7	**B. Reyes**	✓	Quantifying Farmers' Willingness to Pay for Biofortified Characteristics in Three Qualities of Planting Materials: The Case of Bean Producers in Nicaragua
P-8	**Antonio Rocha**	✓	Crop Management Strategies in the Mepuagiua Community, Gùrué District
P-9	**Celina Wille**		Impacts on MASFRIJOL Beneficiaries' Knowledge, Attitudes and Practices Identified through the Most Significant Change Technique

[1] YS = Young Scholar

Poster	Presenter	YS[1]	Title
Theme 2: Genetic Improvement for Abiotic Factors			
P-10	**Karen Cichy**		Cooking Time Prediction in Dry Beans (*Phaseolus vulgaris* L.) Using Vis/SNIR Spectroscopy and Hyperspectral Imaging Techniques
P-11	**Kelvin Kamfwa**	✓	Understanding the Genetic Basis of Symbiotic Nitrogen Fixation in Common Bean (*Phaseolus vulgaris* L.) Using Genomic and Transcriptomic Analyses
P-12	**Isaac Osei-Bonsu**	✓	Assessing Tolerance of Photosynthesis to High Night Temperature Stress in Cowpea Genotypes and Mapping of QTLs Associated With Photosynthetic Traits
P-13	**J.C. Rosas**		A Differential Nursery for Testing Nodulation and Effectiveness of Rhizobium Strains in Common Beans
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P-17	**Patrick Attamah**	✓	Inheritance of Resistance of IT97K 556-6 to Cowpea Aphids in Ghana
P-18	**Emmanuel Prophete**		Development, Release and Dissemination of 'Sankara' Black Bean in Haiti
P-19	**Consuelo Estevez/Tim Porch**		Selection of Bean Lines That Combine Resistance to Web Blight and Common Bacterial Blight
P-20	**Coulibaly Soumabere**	✓	Mode of Inheritance and Identification of Markers Linked to Pod-Sucking Bug Clavigralla Tomentosicollis Stäl Resistance in Cowpea
P-21	**Sory Diallo**		Identification and Validation of SSR Markers Linked to Race 2 *Striga* Resistance Genes in Cowpea.
P-22	**Consuelo Estevez de Jensen**		Evaluation of the Response of Common Bean (*Phaseolus vulgaris*) to Charcoal Rot
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P-24	**Francis Kusi**		The Feed the Future Legume Innovation Lab S01.A5: The Progress Made So Far At SARI, Ghana
P-25	**Carlos Maldonado-Mota**	✓	Identification of New Sources of Resistance to Anthracnose in Climbing Bean Germplasm from Guatemala
P-26	**Jessica R. Moscoso**	✓	Agroeconomic Evaluation of Three Varieties of Climbing Bean (*Phaseolus vulgaris* L.), Grown in Three Spatial Arrangements.
P-27	**Leandre S. Poda**	✓	Phenotyping for Megalurothrips Sjostedti (Trybom) and *Striga Gesnerioides* (Willd.) Resistance in Cowpea (*Vigna unguiculata* L. Walp.) in Northern Ghana
P-28	**Mame Penda Sarr**	✓	Is the Recently Described *Macrophomina pseudophaseolina* Pathogenically Different from *Macrophomina phaseolina*?
P-29	**James Steadman**		Search for Resistance to Bean Rust in Zambia and Uganda: Field and Greenhouse Tools
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P-33	**Dennis N. Katuuramu**	✓	Agronomic and Sensory Attributes Evaluation of Nutritionally Superior Common Bean Genotypes With Farmers in Three Agro-Ecological Zones in Uganda
P-34	**Carolina Molina**	✓	Diets of Mayan Women in the Western Highlands of Guatemala Lack Diversity and Legumes
P-35	**Carolina Molina**	✓	Household Bean Consumption, A Visual Monitoring Tool to Assess Agricultural Efficacy
P-36	**Theresa Nakoma Ngoma**	✓	Effect of Traditional Processing Methods on the Retention of Zinc, Crude Fiber and Flavonoids in Cowpea Flour
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Theme 5: Integrated Pest Management

P-38	**Maimouna Abdourahmane**	✓	Life Cycle of *Clavigralla Tomentosicollis* (Stal.) and Its Impact on Crop Yields of Cowpea (*Vigna unguiculata* L. Walp.) in Niger

P-39	**Graciela Godoy-Lutz**		Species of *Fusarium* Are Root and Crown Rot Primary Pathogens in Zambia and Mozambique Based on Molecular and Culture Based Methods.
P-40	**Joelle Toffa Mehinto**	✓	Comparative Efficacy of Bio-Pesticides for Controlling The Legume Pod Borer, *Maruca vitrata* Fabricius (Lepidoptera: Crambidae) Under Field Conditions in Benin
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Theme 7: Policy, Economics, Value Chains (incl. Seeds)

P-47	**Dinah Banda**	✓	Effect of Interaction of Attributes That Influence Consumer Choice of Bean Varieties in Lilongwe City
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P-49	**Edwin Kenamu**	✓	Joint Consumption of Multiple Common Bean Varieties in Lilongwe City, Malawi
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P-51	**Marynia Mazunda**	✓	Consumer Choice of Dry Common Beans in Lilongwe City of Malawi
P-52	**Elizabeth Medard**	✓	Factors Underlying the Consumption of Common Beans in Dar es Salaam, Tanzania
P-53	**Nyumbani Moyo**	✓	Production and Marketing Constraints, Current Status and Future Outlook of Common Bean Sub-Sector in

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P-55	**Kennedy K Muimui**		Enhancing Bean Productivity Through Community Seed Multiplication in Mbala and Mporokoso Districts of Northern Zambia
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Poster Abstracts

Theme 1: Farmer Decision Making, Technology Dissemination, Impact Assessment

P-1

The Farmer Field School, a Participatory Process for the Cowpea Yield Improvement: Results of the Pilot Experiments Conducted in the Regions of Maradi and Zinder

M. M. Rabé, I. Baoua, L. Sitou, L. Amadou, S. Mahamane, B.R. Pittendrigh

From 2013 to 2014, 30 Farmer Field Schools were established and introduced improved agricultural technologies for 600 producers in the Guidan Roumdji, Madarounfa, Mirriah, Tanout departments and Droum district in south central Niger.

Twelve (12) improved technologies, including seven improved cowpea varieties, application of organic manure and the mineral fertilizer NPK (15-15-15) alone and in combination to facilitate recovery of soil fertility, and the use of both neem seeds aqueous extracts and chemicals for crop protection, were introduced and tested for efficacy. For improved cowpea, a highest average yield of 1074 kg/ha was obtained from one varietal and from 649 to 812 kg/ha for five more, compared to an average 300 kg/ha in Niger with traditional varieties. Similarly, the combined organic and mineral fertilizer method resulted a 323% yield increase compared to the control. and the use of neem seed aqueous extracts reduced infestations of *Clavigralla tomentosicollis*, *Anoplocnemis curvipes, Aphis craccivora* Koch, *Amsacta moloneyi*, *Mylabris sp*. and increased cowpea yield by 258%. Overall, the improved cropping system combined with improved varieties, normal plant density, neem seed pest control, and the organic and mineral fertilizer combination can increase total cowpea yield by 113%.

P-2

An Assessment of the Local Bean Seed Production and Marketing Model: The Case of Community Seed Banks in Nicaragua

David DeYoung, Byron Reyes, Mywish K. Maredia

Many models of legume seed production and distribution have been tried in developing countries that are based on a combination of private, NGO and public sector partners playing niche roles in filling the gap between seed supply and demand.

In recent years, the Government of Nicaragua has implemented a locally managed and operated model called “Community Seed Banks” (CSBs) to produce and market seeds of various crops including beans. The CSBs follow a model of self-governance with technical assistance from the Nicaraguan Institute of Agricultural and Livestock Technology (INTA). Local extension agents were responsible for assisting farmers in the development of CSBs, training the members in quality seed production, and providing the registered seed and other inputs for seed production. The CSBs sought to grow into formal businesses by generating working capital through the sale of seed.

Between 2011 and 2014, CSBs in Nicaragua successfully multiplied and disseminated seed of improved varieties to 16,065 farmers (representing 23% of all Nicaraguan smallholder farmers). The seed was produced from Registered Seed but called Apta seed because it was not certified. It was not Quality Declared Seed because no such category of seed exists in the Nicaraguan seed law. The CSB leadership

determined various pricing mechanisms, often depending on their relationships with the clients.

The results of an initial baseline study of 154 CSBs indicate that the level of organizational formality and members' leadership experience had an impact on sustainability (measured in years operated). Client repayment compliance, seed marketing training and access to productive assets were also predictors of sustainability. Here we will combine the baseline data with a follow up assessment conducted in 2017 and present the results that track the survival or failure of a subset of CSBs and identify factors that are important in explaining their sustainability.

P-3 **Gender Differences in Varietal Preferences and Willingness to Pay for Quality Bean Seeds: Evidence from the Guatemalan Highlands**

David DeYoung, Mywish Maredia, Juan Osorno,

Climbing beans, intercropped with maize, are commonly produced in the highlands of western Guatemala, mostly for home consumption. They play an important role in the diets of indigenous people living in this region. However, few studies have examined farmer preferences for bean varietal traits, and whether these preferences differ by gender. Using data collected through a farmer survey in five departments, we analyze men and women farmers' preferences for bean varietal traits, and their willingness to pay (WTP) for improved quality bean seeds.

Overall, the top five traits most preferred were yield, grain size, grain color, flavor and resistance to insects. Our analysis shows that women farmers preferred flavor, cooking time and resistance to insects and disease on average more than men. On average men preferred the following traits more than women—higher yield, bean color and size, and varieties that do not affect maize by lodging. Analyzed together, farmers' WTP for improved quality bean seed of preferred variety increased if they expressed preference for insect resistance and early maturity. For men, an additional trait that significantly increased their WTP was resistance to storage pests; and for women it was grain size.

The results of this study have important implications for the bean breeding and seed dissemination efforts. This study confirms that men and women farmers have slightly different preferences for varietal traits. However, the effect of varietal trait preferences on WTP for bean seed is similar between men and women. All things equal, farmers who preferred insect resistant and early maturing beans were willing to pay significantly more for bean seeds than those that did not. Men with preference for storage pest resistant bean and women with preference for grain size were also willing to pay more than those that did not indicate these varietal trait preferences.

P-4 **HyperspeQ: A PhotosynQ-Capable, Hand-held Hyperspectral Spectrometer for Assessing Grain and Soil Properties**

Atsuko Kanazawa, Christopher Zatzke, Veronica Greve, *Danilo Moreta, Robert Zegarac, Rebecca Nelson, and David M. Kramer*

Hyperspectral measurements can often detect subtle differences in the optical properties of samples that can be used as indicators of plant health, grain quality, soil properties and other important properties. The broadscale application of these techniques has been hindered by the lack of affordable instrumentation, critical data sets and analytical approaches.

To overcome these obstacles, we are developing an inexpensive, easy to use device, HyperspeQ that connects to the PhotosynQ open science platform (www.photosynq.org). The device can measure spectral reflectance (from 380 to 800 nm), transmission through

samples (or absorption, from 380 to 800 nm) and fluorescence emission spectra (excitation wavelengths from 405, 435, 450, 525 and 605 nm, and emission wavelengths up to 800 nm). It can also make a wide range of pulse amplitude (PAM) fluorescence measurements to detect and characterize photosynthetic processes.

Data collected with HyperspeQ are transmitted to the PhotosynQ platform, which already has a range of available analytical, statistical and visualization tools. Although the device can be used for many applications, we are focusing first on assessing grain quality, including the presence of certain pigments, molds and aflatoxins in grains, critical factors for improvement of agricultural production and economic support for the smallholder farmers. Preliminary results show that, training machine learning algorithms with baseline data collected on the PhotosynQ cloud can produce a highly accurate (R2>0.9) indicators for aflatoxins. We aim to establish further collaborations with the Legume community to co-develop HyperspeQ for the improvement of food production and safety.

P-5 **Willingness to Pay for Quality Cowpea Seeds: Experimental Evidence from Northern Ghana**

Edward Opoku, Mywish K.Maredia, Robert Shupp, Francis Kusi

There is an alarming gap between improved variety release rate and the demand for seeds of these released varieties by farmers in developing countries. A host of factors affect the low demand for improved variety seeds. Economic factors like affordability and availability of improved seeds contributes to the low seed demand. Also, most farmers do not perceive any quality differences between seed and grain which reduces the demand for improved variety seeds.

We conducted a Field Experiment in ten cowpea growing communities in the Upper East Region of Ghana to address the following questions: 1) Are farmers able to perceive the 'seed' product as a quality planting material? 2) Given the perceived quality difference, what is farmers' willingness to pay for 'quality' seed? We also collected cost of production data from producers of certified seeds, QDS and grain to assess how the price farmers are willing to pay for seed compare with the cost of producing different quality seed.

Results indicate that on average certified seeds performed better than QDS, which in turn performed better than the recycled seeds. On average farmers were willing to pay 73% and 20% more for certified and QDS over recycled seed, respectively. This was consistent with farmers observed seed quality difference obtain through their subjective plot rankings. Consistent with the downward sloping demand curve, the number of farmers willing-to-pay a premium price for quality seed declines as the price of seed increases. On the supply side, the average cost of production for a kilogram of certified seeds was higher than the average cost per kilo of QDS, which in turn was higher than that of recycled seeds. Implications of these results on designing effective strategies to meet the seed needs of smallholder cowpea farmers is Ghana and elsewhere will be discussed.

P-6 **Role of Legume Technologies in a Nutrition-Focused Agricultural Strategy: Evidence from Uganda**

Mywish K. Maredia, Mukesh Ray

In response to the persistence of malnutrition as a public health concern, legumes feature prominently as a strategic food group in the pathways linking agriculture to better nutritional outcomes. These agriculture-nutrition linkage pathways are conceptualized to include increased production of more and nutritious foods for self-consumption (production pathway), increased agricultural

income through increased production that can be used to purchase nutritious food and better health care (income pathway), and women's empowerment that gives them control on resources and enhances their decision making roles in agriculture, dietary choices and healthcare to influence the nutritional outcomes for both child and mother. Increased use of technologies and systems that strengthen these pathways can have positive impacts on nutritional outcomes for smallholder farmers' families.

For a nutrition-focused agricultural strategy, legumes play an important role across all three of these pathways. A production system that includes a greater variety of foods grants provides the household a greater diversity of food for own consumption. Thus, under the food production pathway, we hypothesize that households that integrate legumes into their cropping activities, be it by intercropping with cereals, rotating with cereals, or by other means, would have more and diverse availability of food.

This paper uses three rounds of nationally representative Living Standard Measurement Survey from Uganda to estimate the effect on cereal growing households of incorporating legume into their farms via cereal-legume crop rotation and intercropping. Specifically, we use endogenous switching regressions, instrumental variables and panel data techniques including fixed effects and correlated random effects approaches to measure the impacts of these legume technologies on net crop income, per capita calorie and protein production and months of adequate household food provisions. These indicators influence household food security. We thus explore the role of legume technologies in this broader agriculture-nutrition-food security nexus.

Quantifying Farmers' Willingness to Pay for Biofortified Characteristics in Three Qualities of Planting Materials: The Case of Bean Producers in Nicaragua **P-7**

B. Reyes, M. Maredia, R. Shupp, C. González, C. Rodríguez, R. Urbina, S. Posey

One of the recommendations often given to farmers to improve their yields is to use certified seeds as planting materials. This assumes that certified seeds are better in quality (i.e., more productive) than alternative planting materials, are available to farmers, and that farmers are willing to pay a premium for this better-quality seeds (since its price is usually higher than grain, the most common alternative used for planting).

This study implements a double-blind farmer-run demonstrative plot in 12 villages in Nicaragua, using three different qualities of bean (*Phaseolus vulgaris*) seed of an iron-rich biofortified variety – Certified, Apta, and recycled to address three objectives: first, to analyze the agronomic performance of the three planting materials – testing the hypothesis that certified seeds are better than the other alternatives, second to quantify the premium farmers are willing to pay (WTP) for these seed alternatives, and third to test the impact of information about the high iron content (and its nutritional benefits) of the variety on farmers' WTP.

To respond to the first objective, detailed agronomic information will be collected during field visits and analyzed. For the second two objectives, we will elicit WTP from 40-60 farmers (both male and female heads) in each village through participation in an auction (Becker-DeGroot-Marschak mechanism) during the second field day. To test the differences in WTP due to nutritional information (third objective), one half of the villages will be given the information that the variety is biofortified

while the other half will not receive this information. The results could help us understand: 1) whether certified seed performs better than alternatives, 2) if there is sufficient demand for high quality seeds, 3) if WTP changes when nutritional information is provided, and 4) if there is an interaction between information on nutrition (genetic trait) and WTP for quality seed.

P-8

Crop Management Strategies in the Mepuagiua Community, Gùrué District

António Rocha, M'Randa Sandlin, Russell Yost and Ricardo Maria

Crop management strategies as revealed by focus group discussion and surveys of farmers from Mepuagiua, Ruace, Lioma and Tetete communities, Gùrué district did not explicitly recognize the low soil pH and low levels of soil nutrients revealed by soil analyses.

Experiments were installed to increase grain legume yields in the Mepuagiua community. Two strategies to increase yields were proposed and tested. The first was to choose a crop adapted to the acid soil (pigeonpea) and the second was to changing the acid, infertile soil (common bean). Twelve farmers in Mepuagiua were interviewed using the local languages, Mácua and Lòmwé. Farmers identified and named their soils based on soil color and soil compaction, in relation to the soil catena and with regard to crop performance and soil moisture. Farmers did not seem to be aware that the soil could be managed to grow a desired crop (e.g., liming for common bean).

Farmers recognized crop pests such as the "kapatchuchu" insect as a pest that damages both pigeonpea and common bean. To reduce the damage, the local practice is to pass a stick through the insect's abdomen or cook the insect with salts and spread the mixture throughout the field. One field experiment on an acid, infertile soil revealed that local Evate rock phosphate was 25% as effective as imported triple super phosphate. Other experiments explore the alternative of changing the soil to meet crop requirements using limestone so that common bean might be produced on acid, infertile soils. Soil analyses are needed to understand and predict where lime applications can increase yields.

Impacts on MASFRIJOL Beneficiaries' Knowledge, Attitudes and Practices Identified through the Most Significant Change Technique

P-9

Celina Wille, Salvador Castellanos, Luis Flores, Carolina Molina, Sharon Hoerr

MASFRIJOL, a Feed the Future Legume Innovation Lab-affiliated project in its fourth year in Guatemala's western highlands, collected monitoring and evaluation data using a mixed methods approach combining traditional quantitative survey tools tied to project-specific indicators, along with qualitative data gathering through the Most Significant Change Technique (MSCT), a form of participatory monitoring and evaluation. In 2017, a professional team implemented the MSCT across the project's geographical area with participants, who used personal stories to identify changes in their knowledge, attitudes, and practices directly attributable to MASFRIJOL activities.

Eighteen beneficiaries participated in recorded interviews consisting of open-ended and follow-up questions asking them to consider the details and reasons behind the life changes they considered most significant. Interviewers then compiled a ranked list of the most significant changes they heard and had the audio files transcribed for secondary analysis to identify the new areas of knowledge, attitudes, and practices more systematically. Under knowledge, farmers cited learning first-hand that improved bean varieties are higher

yielding, grow faster, have good flavor, cook faster, and have thick broth; the benefits of using personal protection equipment; the value of improved bean storage, including how to close GrainPro bags; and signs of child malnutrition. Under attitudes, they now listen to expert technical advice on bean crop management, have developed greater interest in growing beans, and appreciate the nutritional value of beans. Under practice, they plant improved varieties and take better care of their bean crop, eat more beans and combine them with other foods for better nutrition, feed children more beans, implement new crop management practices and use organic products for soil fertility, select seed for the next planting, and use beans mostly for family consumption. Other impacts include no longer needing to buy beans in the market and improved household income through selling bean surplus.

Theme 2: Genetic Improvement for Abiotic Factors

P-10

Cooking Time Prediction in Dry Beans (*Phaseolus vulgaris* L.) Using Vis/SNIR Spectroscopy and Hyperspectral Imaging Techniques

Fernando A. Mendoza, Karen A. Cichy, Jason Wiesinger, Renfu Lu, and James D. Kelly

Automatized nondestructive sensing techniques are needed by dry bean breeders and processors to predict cooking time rapidly, accurately and economically. The successful application of these breakthrough technologies for cooking time estimations would substantially help in the objective characterization and screening of bean germplasm.

The main goal of this study was to implement and optimize an experimental procedure and data analysis for evaluating cooking time in dry beans with large genetic diversity using two optical sensing techniques: visible and short near-infrared spectroscopy (Vis/SNIR) over the wavelength range of 400–2,480 nm, and an hyperspectral imaging system (HYPERS) over the range of 450–1,000 nm. A diversity panel of Andean beans (*Phaseolus vulgaris*) grown in Michigan (USA) in different years (2013, 2014 and 2015) that exhibited wide variability in cooking time (soaked beans ranging from 17.1–120.3 min) was tested in this study. Spectral preprocessing methods, image preprocessing and analysis, feature selection and multivariate statistical methods were critically evaluated and optimized for improving cooking time predictions on soaked and unsoaked dry seeds.

Overall results showed that applying the two-band ratios preprocessing method and a single feature selection method, Vis/SNIR and HYPERS models have great potential for predicting cooking time of dry beans over a wide range of measurements. Based on partial least squares regression models, correlation coefficients for prediction (R_pred) and standard error of prediction (SEP) for soaked beans were significantly better for HYPERS (ranging from R_pred = 0.856–0.889, SEP = 8.1–7.7 min, respectively) than those for Vis/SNIR (ranging from R_pred = 0.681–0.761, SEP = 11.5–9.0 min, respectively). Also, as expected cooking times were longer for unsoaked beans (from 80.1–147.0 min), and their predictions using HYPERS models were less robust and accurate (ranging from R_pred = 0.667–0.708, SEP = 11.1–10.6 min, respectively) than for soaked beans.

P-11

Understanding the Genetic Basis of Symbiotic Nitrogen Fixation in Common Bean (*Phaseolus vulgaris* L.) Using Genomic and Transcriptomic Analyses

Kelvin Kamfwa, Karen Cichy, and James Kelly

Three studies were conducted to understand the molecular architecture of symbiotic nitrogen fixation (SNF) in common bean: (i) genome-wide association study (GWAS), (ii) Quantitative Trait Loci (QTL) mapping study, and (iii) transcriptome profiling study. GWAS was conducted using an Andean Diversity Panel (ADP) comprised of 259 genotypes. The ADP was evaluated for SNF in both greenhouse and field experiments, and genotyped with 5398 single nucleotide polymorphism (SNP) markers. The QTL mapping study was conducted using 188 recombinant inbred lines (RILs) derived from cross of Solwezi and AO-1012-29-3-3A. These 188 RILs were evaluated for SNF in greenhouse experiments, and genotyped with 5398 SNPs. Transcriptome profiling was conducted on leaves, nodules and roots of RILs SA36 and SA118 contrasting for SNF that were selected from the Solwezi x AO-1012-29-3-3A population used in QTL mapping study.

Using GWAS, significant associations for SNF were identified on chromosomes Pv03, Pv07 and Pv09. In QTL mapping, QTL for SNF were identified on Pv02, Pv04, Pv06, Pv07, Pv09, Pv10, and Pv11. The GWAS peak identified on Pv09 overlapped with the QTL on Pv09 for Ndfa identified in QTL mapping study. Out of the 51 genes that were in 400 kb region surrounding the GWAS peak on Pv07, only four including Phvul.007G048000 encoding a MADS BOX transcription factor (TF) were identified as expression candidates for SNF in the transcriptome profiling study. In the 400 kb region surrounding the GWAS peak on Pv09 there were 44 genes, but only Phvul.009G137500 encoding a WRKY TF was identified as an expression candidate gene in the RNA-seq study. Once validated, QTL and genes identified in the current three studies can be used to accelerate genetic improvement of common bean for SNF.

P-12

Assessing Tolerance of Photosynthesis to High Night Temperature Stress in Cowpea Genotypes and Mapping of QTLs Associated with Photosynthetic Traits

Isaac Osei-Bonsu, Donghee Hoh, Dan TerAvest, Jeffrey Cruz, Linda Savage, Bao-Lam Huyhn, Philip Roberts, and, David M. Kramer

High night temperature (HNT) is an important constraint to reproductive success in crops. Cowpea is considered tolerant to heat stress, although its reproductive stage is sensitive to HNT, characterized by floral abortion and pod dropping which culminate into reduced yield. Declines in photosynthesis and chlorophyll content have been reported under HNT stress and have been tagged as a contributing factor to the overall drop in crop yield under these conditions.

We tested the hypothesis that the mechanisms that contribute to reproductive success during elevated night temperature in cowpea genotypes that are tolerant to HNT stress may also contribute to tolerance of photosynthesis under such conditions. With the ultimate aim of mapping quantitative trait loci (QTLs) for photosynthetic parameters under HNT stress, 16 cowpea genotypes comprising of parental pairs for which recombinant in-bred (RIL) lines had been developed were screened for high photosynthetic capacity and chlorophyll content under HNT stress (33/30°C) at the seedling to juvenile stage using two high throughput chlorophyll fluorescence-based platforms (MultispeQ and the Dynamic Environment Photosynthesis Imager – DEPI chamber).

Four parental pairs showed contrasting photosynthetic phenotypes under HNT out of

which three were selected for more detailed studies. Declines in photosynthetic parameters were usually observed 7 – 10 d after treatment. Similar results were observed between gas exchange and chlorophyll fluorescence-based parameters. Significant and positive correlations (R2 = 0.62 and 0.88 respectively) between seed yield and photosynthetic efficiency (?II) and SPAD chlorophyll content measured at the juvenile stage were observed. One of the parental pairs (Yacine x 58-77) which consistently showed statistically significant contrasting photosynthetic phenotype will be used for mapping QTLs related to these traits. QTLs identified could be incorporated in breeding programs through Marker-assisted selection for improving tolerance of cowpea to HNT stress.

P-13 **A Differential Nursery for Testing Nodulation and Effectiveness of Rhizobium Strains in Common Beans**

J.C. Rosas, C. Estevez de Jensen, J.S. Beaver, T.J. Porch

Most common beans (*Phaseolus vulgaris* L.) in Central America are produced on soils having low nitrogen (N) and phosphorous content. The small-scale farmers do not have resources to use fertilizers or implement soil management practices. Strategies to improve the adaptation of beans to low N soils include the enhancement of nodulation and biological nitrogen fixation (BNF) and the use of effective Rhizobium inoculants.

The objective of this research was to develop and validate the BNF efficiency of Andean and Mesoamerican bean lines and develop a differential nursery to evaluate the performance of Rhizobium isolates as strains for nodulation and BNF studies and for use as commercial inoculant production. In 2013-14 a group of 32 Andean and Mesoamerican bean accessions were evaluated in a screen-house. The set of six Andean and six Mesoamerican differential lines were identified from those having the best response to inoculation with the strains CIAT 632 (*R. etli*) y CIAT 899 (*R. tropici*).

In 2015-16 the differential nursery was used to characterize Rhizobium isolates from nodules collected in farmer fields under screen-house conditions. In addition, sets of differential nurseries were also evaluated in farmer fields and at Zamorano University. Nodulation and plant biomass was determined at flowering and seed yield was measured at maturity. The results suggested that the differential nursery would be useful to evaluate the effectiveness of Rhizobium isolates and their identification as strains, and to estimate the nodulation effectiveness and BNF contributions of *Rhizobium* resident populations present in small farms.

P-14 **Progress in the Selection of Common Bean Lines with Adaptation to High Temperatures in Honduras**

J.C. Rosas, J.S. Beaver, T.J. Porch, S. Beebe, J. Burridge, J. Lynch

Common bean (*Phaseolus vulgaris* L.) production in Central America and the Caribbean (CA/C) is affected by periods of drought and increased temperatures due to climatic changes.

The objective of this study was to identify bean lines having greater adaptation to high temperature and good agronomic adaptation. The most promising lines will be considered for release as cultivars or for use as breeding parents for genetic improvement. During the summer (February), first (June) and second (October) planting seasons of 2015-16, the BASE 2014 y 2015 trials including 120 lines and several trials of the CA/C- Bean Research Network were evaluated in Nacaome, Honduras (44 masl). Maximum and minimum average temperatures during the trials registered with

iButtons sensors, were >36°C y >22°C, respectively. Plant samples were taken at pod filling (R8) to determine biomass and pod dry weight (DW), and pod partition index; and at harvest maturity, to determine pod and seed DW, harvest index, seed yield and seed size.

The effects of high temperatures in sensitive bean lines were flower and small pod abortion, smaller pod size with less seed, smaller seed size, poor seed yield and plants with excessive vegetative growth. Flowering of heat tolerant lines began from 30 to 45 days after planting. Many heat sensitive lines continued flowering and produced few or no seeds. Seed yields varied from <100 kg/ha to >2,000 kg/ha. A small number of common bean and tepary (*P. acutifolius*) lines were identified as tolerant to high temperatures. These lines also yielded well in more favorable conditions. One small red heat tolerant line was released in El Salvador and will be released in Honduras during 2017; other small red and blacks lines are being validated on farmer fields.

Theme 3: Genetic Improvement for Biotic Factors

P-15

Phenotypic Evaluation of Native Accessions of Climbing Beans Recollected in the Guatemala Highlands

Julio C. Villatoro, Angela N. Miranda, Jessica R. Moscoso, Karen A. Agreda, Juan M. Osorno, Phil McClean

Common bean (*Phaseolus vulgaris* L.) is one of the few alternatives for food and income earning in the rural area of the Guatemala highlands. The food base of the region is maize (Zea mays L.) as the principal crop and beans as a secondary crop, with an annual consumption of beans per capita for Guatemala of 9.4 kg.

An agroeconomic survey was carried out during 2015 in the departments of Quetzaltenango, Chimaltenango, Huehuetenango, San Marcos, and Quiché, where 460 native accessions of the genus *Phaseolus* (*P. vulgaris, P. coccineus,* and *P. Polyanthus*) were collected. Approximately 62.6% of the accessions are *P. vulgaris* (54.34% climbing and 8.26% bush), 31.1% is *P. polyanthus*, and the remaining 6.3% is *P. coccineus*.

To identify accessions with better agronomic characteristics, the 460 accessions were evaluated at the ICTA experimental stations of Quetzaltenango and Chimaltenango, planted in monoculture in a trellis system. A total of 24 accessions of *P. vulgaris* were selected, which showed superior agronomic characteristics in terms of reaction to diseases (2-3 in the CIAT scale for rust, angular spot, anthracnose, and ascochyta), agronomic value (pod load distribution), and seed yield potential at both locations. These selections are going to be evaluated again in 2017 and included in the crossing plan.

P-16

Training in Molecular Technology and Molecular Breeding of Cowpea at University of California, Riverside

R.Y. Agyare, F. Kusi, J.R.P.Santos, N. Arsenio, L. Sassoum, G. Yi-Ning, M. Munoz-Amatriain, B.L.Huynh, T. J. Close, and A.R.Philip

This training in molecular breeding was sponsored by the LIL project SO1.A5 under the Host Country Institutional Capacity Strengthening Award.

The objective was to strengthen the capacity of host country institutions partnering with US Universities under the LIL Projects. The nominee from SARI, was trained in modern breeding techniques to improve research output and contribute directly towards achieving the goals of the LIL project.

The training took place at UC Riverside from 29th March to 26th September, 2016. This hands-on training involved activities carried out in green-houses, molecular laboratory, on-station and on-farm trials and molecular data processing. Other included introgressing the aphid resistance locus in SARC 1-57-2 from Ghana into the susceptible US variety CB46. Cowpea genotypes with differential response to the cowpea aphid were screened to identify resistant genotypes for hybridization. An SSR marker, CP171F/172R, associated with cowpea aphid resistance in Ghana was used to screen 24 cowpea parental lines to detect polymorphism.

The genotyping indicated that the SSR marker was polymorphic among the parents. 89 RILs derived from a cross between CB27 x IT97K-556-6 were assayed with the SSR marker to determine the location of the marker in the cowpea genome. A genetic map with the location of the SSR marker in the cowpea genome was made from the results. Based on the genetic map, a PCR based CAPs marker closer to the resistance locus than CP171F/172R was designed. Phenotyping of foliar thrips in cowpea for QTL analysis was carried out to identify SNP markers associated with foliar thrips resistance in cowpea. Two QTLs were found to be responsible for foliar thrips resistance in cowpea. The knowledge and skills acquired has improved cowpea research at SARI and has also positioned SARI to train graduate and undergraduate students in molecular breeding techniques.

P-17 **Inheritance of Resistance of IT97K 556-6 to Cowpea Aphids in Ghana**

D.G. Agyeman, F. Kusi, N Opoku, P Attamah, B-L. Huynh, J. R. P. Santos, M. Munoz-Amatriain, T.J. Close and P.A. Roberts

The cowpea aphid (*Aphis craccivora*) is a major pest of cowpea that causes serious damage from the seedling stage to pod bearing stage of the plant. Under heavy aphid infestation, young seedlings often die, whereas the older plants show symptoms such as stunting, crinkling, curling of leaves, delayed flowering and shrivelling of pods, resulting in overall yield reduction.

The use of resistant varieties appears to be one of the best options for farmers in the tropics owing to its low cost. This study was aimed at determining the inheritance and the allelism of cowpea aphid resistance in an introduced resistant cowpea line, IT97K556-6. The introduced resistant line IT97K-556-6 was crossed with a known aphid resistant line SARC 1-57-2 and a susceptible, Apagbaala. The F2's developed from the resistant-resistant IT97K556-6 x SARC 1-57-2 and resistant-susceptible IT97K556-6 x Apagbaala crosses were phenotyped in aphid screens to determine their segregation ratios for response to infestation. The resistant-susceptible cross segregated 39 resistant to 9 susceptible which fits a 3:1 ratio (?2 =3.2667, P = 0.0707) for a single dominant gene control. The resistant-resistant cross segregated 64 resistant to 7 susceptible which fit a 15:1 ratio (?2 =1.57, P = 0.2090) indicating that the major aphid resistance gene in IT97K 556-6 is non-allelic to and different from the SARC 1-57-2 resistance gene. These different genes can be stacked to develop more robust aphid resistant cowpea cultivars.

Development, Release and Dissemination of "Sankara" Black Bean in Haiti **P-18**

E.Prophete, G.Démosthène, J.C. Rosas, P.N. Miklas, T.G. Porch, J.S. Beaver

Common bean (*Phaseolus vulgaris* L.) production in the Caribbean is threatened by Bean Golden Yellow Mosaic Virus (BGYMV), Bean Common Mosaic Virus (BCMV) and Bean Common Mosaic Necrosis Virus (BCMNV).

The University of Puerto Rico, the University of Nebraska, the USDA-ARS, Zamorano and the National Seed Service of the Republic of Haiti collaborated in the development and release of 'Sankara' black bean (Beaver et al., 2014. *J. of Agric. of the Univ. of Puerto Rico* 98:83-87). Sankara is a black bean with an upright indeterminate growth habit. It reaches maturity approximately 65 days after planting. Sankara had earlier maturity than the cultivar 'DPC-40' when evaluated in Haiti during the summer months. Sankara produced a mean yield of 2,014 kg/ha when tested in 12 field trials in Haiti, the Dominican Republic and Puerto Rico. It has the bgm-1 gene and SW12 QTL for resistance to BGYMV and the I and bc-3 genes for resistance to BCMV and BCMNV. Dr. Phil Miklas observed that Sankara was well adapted when planted in Prosser, WA. During 2016, Sankara produced a mean seed yield of 2,722 kg/ha in trials planted in the U.S. and Canada. During 2015, Dr. Phil Miklas produced at Prosser, WA, approximately 450 kg of breeder seed of Sankara.

With support from the USAID/USDA Participating Agency Services Agreement (PASA) for Haiti and the Feed the Future–ARS Grain Legume Project, seed of Sankara was multiplied during the summer of 2016 by Basin Seed Company in Nampa, Idaho. A container with 11,364 kg of high quality, disease-free seed of Sankara arrived in Port-au-Prince in November 2016. This seed was planted on approximately 190 ha and is expected to produce 200 MT of seed for farmers who plant beans on the hillsides during the summer months. Sankara was also released in Honduras as 'Azabache 40'.

P-19

Selection of Bean Lines that Combine Resistance to Web Blight and Common Bacterial Blight

H.C. Martínez Figueroa, J.C. Rosas, C. G. Estévez de Jensen, T.G. Porch, J.S. Beaver

Web blight caused by *Thanatephorus cucumeris* Frank (Donk) causes significant reductions in the yield and quality of beans produced in the humid, lowland tropics. A total of 644 lines from different breeding programs were evaluated for reaction to web blight and other diseases using conventional plant breeding techniques and marker-assisted selection (MAS).

Field trials were conducted over two years at Isabela, Puerto Rico to evaluate the reaction of the bean lines to web blight. The field trials were planted using RCB designs. Web blight resistance was identified in 37 lines that had mean scores ? 4.5 on the CIAT disease rating scale during both growing seasons.

Some lines (TARS MST1, PR1147-1 and Amadeus 77) produced mean seed yields > 1,800 kg/ha. Some lines with high seed yield potential had a low percentage of damaged seed despite having presented a high degree of damage in the foliage. It is advisable to conduct evaluations for both leaf reaction and seed damage to identify lines with resistance to web blight.

Evaluations for reaction to common bacterial blight with two strains of Xap, 484A and UPR 3353, were conducted in a greenhouse. Lines with high levels of CBB resistance were identified. Greenhouse inoculations with the BCMNV strain NL3 were conducted. MAS was used to detect genes conferring resistance to BCMV, BCMNV and BGYMV. Twelve lines were identified with multiple disease resistance. These lines also had mean seed yields > 1,400 kg/ha during the second growing season and produced high quality seed. A few of the most promising white, black and small red lines of bean from this study will be considered for release as commercial varieties or improved breeding lines.

P-20 **Mode of Inheritance and Identification of Markers Linked to Pod-Sucking Bug *Clavigralla Tomentosicollis* Stäl Resistance in Cowpea**

Soumabere Coulibaly, Benoit Joseph Batieno, Hamadou Sidibe, Hamadou Zongo, Serge Zida, Leandre Poda, Timothy J. Close, Jean-Baptiste Tignegre, Philip A.Roberts, and Jeremy Ouedraogo

Pod-sucking bug *Clavigralla tomentosicollis* Stäl is one of the most harmful insect pests attacking cowpea in Burkina Faso and Sub-Saharan Africa, causing considerable yield losses. *C. tomentosicollis* attack leads to pod spinning, pod malformation, reduction in seed set and germination potential, and grain size and yield reduction.

In order to contribute to the development of resistant, high yielding cowpea varieties, the genetic inheritance of resistance to *C. tomentosicollis Stäl* was studied at Kamboinsé research station. This study was conducted by screening in a greenhouse a resistant parent (IT86D-716) and a susceptible parent (KVx771-10G) and their F1, F2, BC1F1 progenies.

The phenotypic data did not conform to expected Mendelian ratios for segregation in a simple gene model and indicated that several genes are involved in the expression of this resistance. Two polymorphic SSR markers were identified discriminating between resistant and susceptible individuals. Moreover phenotypic significant and positive correlations, 0.66 and 0.62 were found between the survival rate of the bugs and the pods damage and seeds damage respectively.

P-21 **Identification and Validation of SSR markers Linked to Race 2 *Striga* Resistance Genes in Cowpea.**

Sory Diallo, Nerbéwendé Sawadogo, Mahammadi Hamed Ouedraogo, Sidy B Coulibaly, Joseph T Benoit Batieno and Mahamadou Sawadogo

Cowpea (*Vigna unguiculata* L. Walp.) Is one of the most important grain legumes grown in Mali. But its production is strongly limited by the SG2 strain of *Striga gesnerioides* (Willd.) Vatke which constitutes one of the major biotic constraints. Five of the 159 SSR markers screened (CP 333/334, CP 115/116, CP 743/744, MA62, and SSR1) were found to be informative between the susceptible and the resistant parents.

Of these, three (CP 33/334, CP115/116, CP743/744) were codominant and two (MA62, SSR1) were dominant. In the IT89KD-499-35 x M'Barawa population, 25 progeny carried the IT89KD-499-35 CP333/334 allele, 17 the M'Barawa allele and 57 were heterozygous. of the five informative SSRs, the one mapping closest to the *Striga* resistance gene was SSR1 (five recombinants out of 100).

Thus we intend to use SSR1 as resistance marker, in the same way that our colleagues in INERA, Burkina Faso are doing. The identification of the SSR-1 marker related to *Striga* resistance Race 2 in Mali is an excellent opportunity for the national breeding programs to develop a marker-assisted breeding (MAS) strategy for *Striga gesnerioides* resistance to the SG2.

Keywords: Cowpea, Marker-assisted selection, Striga, SSR markers

P-22 **Evaluation of the Response of Common Bean (*Phaseolus vulgaris*) to Charcoal Rot**

Consuelo Estevez de Jensen, Julian Colley, Timothy Porch, James S. Beaver

Charcoal rot in common beans (*Phaseolus vulgaris* L.), caused by *Macrophomina phaseolina* (Tassi) Gold. (Mph), is an endemic disease in the prevailing hot and dry conditions in southern Puerto Rico.

This study evaluated the 120 bean genotypes that compose the BASE 120 panel under screenhouse conditions, grown in a PROMIX substrate. After the panel was artificially inoculated with a colonized rice inoculum using the virulent Mph-JD2 isolate collected in common bean tissue grown in Juana Diaz, PR, disease severity (DS) was assessed using the CIAT scale 1 – 9, 1 = no visible disease symptoms and 9 = approximately 50% or more of the hypocotyl and stem tissues were covered with lesions and with pycnidia. The experiment was repeated twice, and the evaluations were conducted two and three weeks after inoculation. The stem tissue was then isolated on potato dextrose agar media to assess pathogen colonization. There were contrasting reactions between the different genotypes of the BASE 120 panel.

In the first and second experiments, the genotypes that exhibited intermediate reactions (DS <5) to Mph-JD2 were: BAT 477, MER 2212-28, PR 1147-3, TARS-LFR1 and TARS-MST1. Based on disease severity and on the colonization of the pathogen in the stem tissue, no resistant genotypes were identified for the isolate Mph-JD2 used in the study.

P-23 **Nodulation Ability of Different Common Bean Genotypes from the BASE 120 Trial after Inoculation with Rhizobium**

Consuelo Estevez de Jensen, Timothy Porch, James S. Beaver

This study examined the nodulation characteristics of the BASE 120 genotypes in a trial of 118 common bean (*Phaseolus vulgaris* L.) and two tepary bean (*Phaseolus acutifolius*) lines.

Inoculation with *Rhizobium tropici* strain CIAT 899 and *Rhizobium etli* strain CIAT 632 was carried out in a screenhouse at the Juana Diaz Substation using sterilized sand in benches. Ten seeds per cultivar/line were sown in a completely randomized design with two replications. At five days after planting, seedlings were inoculated with combination of both strains using 1 ml of inoculum at a concentration of 1 x 109 rhizobia cells/ml. Nodulation parameters were evaluated 12 days after inoculation by counting the nodules in the upper 3 cm of the roots. The distance to the crown of the nodule closest to the primary root was recorded. Genotypes that produced more than 50 nodules in the upper three centimeters of the root were Zorro, Amadeus 77, ICA Pijao, PR9920-171, ICB 301-204, BFS 139, SEQ 342-39, FNB 1203-47, SEF 16, Paraisito, Zenith and PR1217-1. In the second trial, FNB 1203-43, PR 1217-1, BIOF 4-70 and INTA Precoz formed more than 50 nodules at 12 days after inoculation. In the third trial, significant differences ($P > 0.05$) were also found among the different genotypes and 64 genotypes outperformed the local check Verano. Genotypes FNB 1210-48, BFS-29, BFS-139, ICA Pijao, BAT-477, and DOR 390 had over 60 nodules within the first 3 cm of the root.

The trials identified genotypes with the capacity to produce a large numbers of nodules located near the plant crown which are ideal for response to inoculation.

P-24 **The Feed the Future Legume Innovation Lab S01.A5: The Progress Made So Far at SARI, Ghana**

F. Kusi, P. Attamah, R.Y. Agyare, I. Sugri, I.D.K.Atokple, B-L Huynh, J.R.P. Santos, M. Munoz-Amatriain, T.J. Close, and P.A. Roberts

SARI's collaboration with UCR and other NARS under the LIL: S01.A5 has resulted in massive improvement in cowpea breeding at SARI. The primary project focus is to discover insect tolerance and resistance QTL for cowpea breeding; increase African and US cowpea productivity, drought tolerance or disease resistance; expand farmer marketing

opportunities with improved cowpea varieties and provide training and capacity building in modern cowpea breeding.

The major achievements in Ghana include development of protocol for seedling-stage screening for aphid resistance, identification of another source of aphid resistance from the panel of aphid resistance different from SARI's source and the deployment of these different genes in pyramiding aphid resistance genes in farmer preferred varieties.

Other achievements include the on-going efforts to develop a more rigorous screening method for Thrips resistance. This effort was made possible as a result of funds received from the host country institutional capacity strengthening awards to rehabilitate an old lab for Thrips culturing. SARI's capacity has been strengthened through training a young scientist at UCR for 6 months in modern molecular breeding and construction of a screen-house to support the cowpea breeding program at SARI. SARI sent samples of aphids, Thrips and PSB for use in molecular characterization under the collaboration between S01.A5 and SO1.B1 projects thereby allowing a robust comparative profiling of these insect populations.

Most of the major cowpea growing belts in northern Ghana are *Striga gesnerioides* endemic. The effort being made is to either introgress *Striga* resistance into the insect pest resistant varieties or to improve the *Striga* resistant varieties with insect resistance traits. The cowpea research team at SARI benefited from the annual training at UCR in modern molecular breeding and application of software and tools such as the Breeding Management System (BMS).

Identification of New Sources of Resistance to Anthracnose in Climbing Bean Germplasm from Guatemala **P-25**

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Common bean (*Phaseolus vulgaris* L.) is the most important food legume consumed in the world. Anthracnose *Colletotrichum lindemuthianum* (Sacc. and Magn.) Scrib is a fungal disease that affects dry bean worldwide.

Seed yield loses can reach up to 100% when the seed is infected and conditions favor disease development.

The breeding program of ICTA (Institute of Agricultural Science and Technology) in Guatemala has a germplasm collection of climbing beans from the highland regions. Climbing beans in Guatemala are relevant because they represent the main source of protein in the diet of the habitants of this region. This crop also has socioeconomic importance and is considered a basic grain with an annual per capita consumption of 8.3kg.

There are some field data related to anthracnose resistance based on natural pressure, but there has not been a systematic effort to identify the predominant races and the potential genes conferring anthracnose resistance within this germplasm. Therefore, new sources of resistance need to be identified for use by bean breeding programs not only in Guatemala but elsewhere.

In this research, resistance to anthracnose for race 73 from North Dakota was evaluated,

which is also the most predominant race in the rest of the U.S. Approximately 10% of 369 climbing bean accessions showed no symptoms (score of 1) to this race, while 56% were resistant (score of 2-3). In addition, an effort to map genomic regions associated with anthracnose resistance have been done using a Genome-wide Association Study (GWAS) approach. The results indicate that genomic regions for resistance to *C. lindemuthianum* exist in Pv04 and Pv11, however, none of these genomic regions map to previously known resistance genes. Race characterization of samples collected in Guatemala is underway and most frequent races will be used to screen the germplasm collection as well.

P-26

Agroeconomic Evaluation of Three Varieties of Climbing Bean (*Phaseolus vulgaris* L.), Grown in Three Spatial Arrangements.

Julio C. Villatoro, Angela N. Miranda, Jessica R. Moscoso, Karen A. Agreda, Juan M. Osorno, Phil McClean

Climbing bean (*Phaseolus vulgaris* L), is an important component of the Guatemalan's basic diet in the highlands. Bean plants are intercropped with maize (*Zea mays* L.), in a system locally known as Milpa. This intercropping system has differences regarding the sequence of planting dates but no differences are found regarding maize-bean field spacial arrangements.

With the objective to identify which space combination would produce higher seed yield and profitability for the farmer, different methods of intercropping were evaluated. Three topological arrangements were tested: bean monoculture in trellis system, double groove (maize with climbing bean and bush), and traditional planting (cornfield-climbing bean). Within each arrangement, the varieties cultivated were ICTA Texel, ICTA Labor Ovalle, and ICTA Utatlán.

We used a split plot design, in a totally randomized block design with some replications, main plots were as topological designs and the subplots were the varieties. The results showed that the best arrangements were by precocity and yield: was the trellis system and ICTA Utatlán variety with a seed yield of 1502 kg ha-1 compared with the other two systems, the difference is of 1340 kg ha-1. Contrastingly, an economic analysis done through partial budgets of CIMMYT showed that in terms of profitability, the arrangement with best results was the double groove and ICTA Texel because it showed net profit for the sale of maize, climbing beans, and bush beans.

Phenotyping for *Megalurothrips sjostedti (Trybom)* and *Striga gesnerioides* (Willd.) Resistance in Cowpea (*Vigna unguiculata* L. Walp.) in Northern Ghana

P-27

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Flower Thrips (*Megalurothrips sjostedti Trybom*) and Parasitic weed *Striga gesnerioides* (Willd.) are among the major constraints of cowpea (*Vigna unguiculata* L. Walp.) production in northern Ghana.

The single approaches used for their control appears to be highly insufficient. Host-plant resistance seems to have merit in effectively and economically controlling these pests. The objective of this study was to evaluate Recombinant Inbred Lines (RILs) developed between *Striga* and Thrips resistant parents, IT97K 499-35 and Sanzi respectively by Single Seed Descent (SSD), for *Striga* and Thrips resistance in Northern Ghana.

The study evaluated the promising *Striga gesnerioides* resistant lines for yield loss assessment. Both field and pot screening under artificial inoculation were used for the

identification of the *Striga* resistant lines. Twenty-seven (27) RILs out of the 251 RILs screened were completely resistant to *Striga gesnerioides*. The level of Thrips infestation was relatively low (0 to 11 flower Thrips per plant) and inconsistent in most of the lines making it difficult to rank these individuals genotypes into the resistant and susceptible categories. However, few lines recorded a consistent no incidence of Thrips in all the replications. The percentage reduction in grain and dry biomass yields due to *Stiga* infestation among selected lines of the RILs was lower in the resistant lines (0.55% to 7.7%) than the susceptible ones (28.45% to 61.71%). Some of the lines were found to combine Thrips and *Striga* resistance and were therefore identified as important genotypes to be evaluated in multilocation in a participatory variety selection.

P-28 **Is the Recently Described *Macrophomina pseudophaseolina* Pathogenically Different from *Macrophomina phaseolina*?**

P. M. Sarr Ndiaye, N. D. Cisse, Ibrahima Ndoye

In recent years, charcoal rot is one of the most important diseases on cowpea (*Vigna unguiculata*) in the drier northern production areas of Senegal. The causal agent of the disease was a longtime considered being *Macrophomina phaseolina*. However, a new *Macrophomina* species, *Macrophomina pseudophaseolina* was reported recently by Sarr et al. (2014) to also cause charcoal rot disease alone or in association with *M. phaseolina* on several hosts in Senegal, increasing therefore yields losses to cowpea.

This study aimed to investigate the pathogenicity of *M. phaseolina* and *M. pseudophaseolina* on three cowpea varieties Apagbala, IT93k-503-1 and Mouride under two temperature regimes (24/34° and 26/36°C). Plants were grown in soil infested with ten *M. pseudophaseolina* and nine *M. phaseolina* isolates at two growth temperatures in a climatic chamber. Disease incidence, level of tissue infection and potential primary inoculum produced in cowpea plants were determined 45 days after planting. The two *Macrophomina* species showed the same results, except that at 36°C, *M. pseudophaseolina* induced more disease development than *M. phaseolina* in the susceptible cowpea variety Mouride. Also at this temperature, the average incidences of the two species were not different, indicating that *M. pseudophaseolina* can be as destructive on cowpea at 36° C as *M. phaseolina*.

By and large, a diversity of pathogenicity was observed in isolates of *Macrophomina spp.* For better management of charcoal rot on cowpea, work should be conducted to identify the spatial distribution of *M. pseudophaseolina* in the Sahel, the effects of water stress and host origin on its pathogenicity

Keywords: pathogenicity, *Macrophomina phaseolina, Macrophomina pseudophaseolina*, cowpea, growth temperatures.

P-29 **Search for Resistance to Bean Rust in Zambia and Uganda: Field and Greenhouse Tools**

James Steadman, Blessing Odogwu, Stanley Nkalubo, Chikoti Mukuma, Kennedy Muimui, Janelle Millhouse, Carlos Urrea

Bean rust is a common disease in Africa and the Americas. The pathogen, *Uromyces appendiculatus*, has both distance urediniospores for dissemination and survival teliospores that contribute to its ability to cause significant yield losses in dry beans. Fungicides can help manage bean rust, but timing is critical and costs reduce profits. Thus disease resistance is the most cost effective management option.

The bean rust pathogen has many races that need to be identified to facilitate breeding for resistance. To identify the races in greenhouse

environments bean lines with specific rust resistance genes are inoculated with urediniospores from fields and responses are recorded. Another method uses bean plants with specific resistance genes placed in fields with bean rust. This mobile nursery is a set of differential bean lines at the primary leaf stage in a plastic tray. When placed in a field with rust, the plants will be naturally inoculated. Placing the nursery in a mist chamber with high humidity for 12-16 hours then transferred to a screen house or greenhouse for 14 days, this allows rust to develop. Bean lines identified with resistance to local races can be crossed with locally adapted bean varieties. We have found that rust resistance genes of Mesoamerican origin are typically resistant to Andean rust races and Andean origin genes are resistant to Mesoamerican rust races. This low cost technology available for African breeders will facilitate development of new bean germplasm with rust resistance and new bean varieties for local small farm and large farm growers that yield well and beans that cook in a shorter time, have more nutrients and taste good.

The outcome of this research addresses the preparation of healthy meals and a good price for the men to improve household income.

Advances in Cowpea Genome Resources **P-30**

Timothy J Close, *M Munoz-Amatriain, Stefano Lonardi, Philip A Roberts, Bao Lam Huynh, Ousmane Boukar, Christian Fatokun, Sassoum Lo, Ira Herniter, Yi-Ning Guo, Joseph Batieno, Francis Kusi, Ndiaga Cisse, Shizhong Xu, Arsenio Ndeve, Jansen Santos, Jerome Verdier*

The Feed the Future Innovation Lab for Climate Resilient Cowpea and the NSF BREAD project "Advancing the Cowpea Genome for Food Security" are providing new genetic information and tools that help to accelerate progress in the cowpea component of the Feed the Future Legume Innovation Lab. This has included the Illumina Cowpea iSelect Consortium Array, which assays 50,000 single nucleotide polymorphisms (SNPs), a consensus genetic linkage map containing 37, 372 SNP markers and an increasing list of marker-trait associations.

The new information also includes DNA sequences from over 30 diverse cowpea accessions, a state-of-the art reference genome sequence from IT97K-499-35 with associated genome browsers, and high density SNP data from several thousand diverse cowpea samples representing broad diversity within domesticated cowpea as well as key breeding lines in West Africa and California programs.

Theme 4: Grain Legumes in Human Health and Nutrition

Intestinal Permeability in Young Malawian Children Consuming Legumes **P-31**

Oscar Divala, Isabel Ordiz, Mark Manary, Ken Maleta, Chrissie Thakwalakwa, Yanko Kaimila and Teresa Ngoma

Background: Human intestinal permeability, a measure of gut health, is measured by the lactulose (L) absorption test, where a non-metabolized, disaccharide is given orally and its presence is measured in urine. Greater intestinal permeability is associated with stunting.

Methods: In a randomized legume supplementation intervention with either cowpea or common bean 291 children aged 6-12 mo had intestinal permeability measured at 6, 9 and 12 mo of age. L absorption was measured in a complete 4 hour urine collection using a standardized method. High pressure liquid chromatography was used to determine

the L concentration. %L < 0.20 was considered normal and %L > 0.5 remarkably abnormal. Household characteristics were associated with intestinal permeability, as well as type of legume consumed.

Results: of the children that completed the 6 month trial, 99, 99 and 93 completed the study were assigned to the cowpea, common bean and control group respectively. The median %L values at the measured time points are shown below.

Gut Health Measure (*Table not included*)

%L measured at 9 months of age was correlated with %L measured at 6 months of age (Pearson's r = 0.12, P=0.04; Spearman's r = 0.24, P< 0.0001). Environmental and sanitation factors such as water source, stool disposal practices and animal husbandry associated with intestinal permeability were also explored.

Conclusion: About half of children had abnormal intestinal permeability. Consumption of cowpea or common bean did not improve intestinal permeability.

P-32

The Effect of Legume Based Complementary Food on Energy and Nutrient in Rural Malawian Children: A Randomized, Investigator-Blinded, Controlled, Noninferiority Trial Sub-Study.

Yankho Kaimila, Oscar Divala, Sophia Agapova, Kevin Stephenson, Tereza Nakoma Ngoma, Isabel Ordiz, Chrissie Thakwalakwa,Indi Trehan, Mark Manary, Kenneth Maleta.

Background: Legume based complementary foods are widely used in low-income nations to supplement the monotonous protein and micronutrient poor diets. While Corn-soy blend is the recommended Malawian complementary food, it is not widely available. Common beans and cowpeas are more locally available and have the potential to improve the dietary intake of rural children.

Objective: The study tested the hypothesis that complementary food made from common beans and cowpeas flour would improve the energy and nutrient intake in rural Malawian children in similar direction like the nationally recommended corn-soy blend (CSB).

Design: The main study was a randomized, investigator blinded controlled noninferiority trial conducted in 860 healthy Malawian children aged 6-24 months who were randomly assigned to receive daily supplements of either common beans, cowpeas or CSB flour providing 15-40% of their daily energy requirements depending on the child's age. For this sub-study, a subset of children were randomly selected to participate in two interactive 24-hour dietary recalls to estimate their usual energy and nutrient consumption.

Results: The baseline characteristics were similar across the intervention groups (n=305). No significant differences in energy were observed. Analysis of nutritional value showed common beans and cowpeas superior in protein and fiber content, an effect that remained only for fiber after supplementation (24.31, 20.19 and 15.57g/day respectively, p <0.0001). Only common beans had a significantly higher intake of protein then CSB (29.67 and 21.88g/day respectively, p=0.0150). Common beans and cowpeas had higher intakes of folate and thiamin (p<0.0001), but CSB group had higher intakes of vitamin C and riboflavin (p=0.0001 and 0.0024 respectively).

Conclusion: In this rural Malawian population, supplementation of children with Common beans and cowpeas increases protein and fiber but not energy intake. Vitamin C, folate, Riboflavin, thiamin, and iron consumption is improved with legume supplementation.

P-33

Agronomic and Sensory Attributes Evaluation of Nutritionally Superior Common Bean Genotypes with Farmers in Three Agro-ecological Zones in Uganda

Dennis N. Katuuramu, James D. Kelly, Gabriel B. Luyima, Stanley Nkalubo, Raymond P. Glahn, and Karen A. Cichy

Iron and zinc deficiency are the most prevalent micronutrient deficiencies in the world. Biofortification has potential to address micronutrient malnutrition especially in developing countries where plant based staples are widely grown and consumed.

Common bean is an important source of protein and micronutrients. The efficacy of biofortified crops to address human malnutrition can further be improved if genotypes with highly bioavailable minerals are developed. Genotypes with fast cooking, high iron and zinc concentrations, and high iron bioavailability phenotypes were identified from a set of a diverse Andean bean germplasm.

A subset of 15 genotypes that are nutritionally superior were identified and have been evaluated in the growers' fields along with local check genotypes in a participatory variety selection approach using a mother-baby trial design for two field seasons (2015 and 2016). Nine farmer groups each comprised of about 40 farmers participated in the field research. The growers were from districts representing three agro-ecological zones in Uganda that are important for dry bean production and consumption. Angular leaf spot and rust were the most prevalent foliar diseases observed in the field. Majority of the farmers preferred genotypes with upright architecture, many and longer pods, had red mottled or yellow grain color, and were high yielding especially under hostile growth conditions of too little or too much water. Seed yield across locations over the two growing seasons ranged from 400 to 1,030 kg ha-1. ADP0445 from Puerto Rico was the most productive across locations and seasons. For the post-harvest preference scores 80% of the farmers selected genotypes ADP0001 and ADP0445 (red mottled), and ADP0468 and ADP0512 (yellows) to be included in the community-based sensory evaluations.

Based on the data from 2015 and 2016 field trials, nutritionally superior genotypes exhibiting good adaptation to the Ugandan bean production conditions and are preferable to the farmers and consumers based on yield and acceptable sensory characteristics will be highlighted and recommended for use in the common bean nutrition breeding and improvement programs.

P-34

Diets of Mayan women in the Western Highlands of Guatemala Lack Diversity and Legumes

Carolina D Molina, Sharon L Hoerr, Celina Wille, Salvador Castellanos, Luis Flores

Indigenous Mayan families are among the shortest in world, wherein women average only 145cm in height. This has been attributed to lack of clean water as well as diets deficient in good quality protein. MASFRIJOL is a four-year USAID project to marry agriculture to nutrition education via distribution of bean varieties improved to grow at high altitudes with nutrition education extension lessons delivered in remote rural communities.

To evaluate the dietary diversity of women prior to program implementation, the FAO Women's Dietary Diversity form (2011) was used to determine the number of different types of foods consumed the previous day. The 12 types of foods were cereals, roots and tubers, vegetables, fruits, meat/poultry/offal, eggs, fish and seafood, pulses/legumes/seeds, dairy foods, oil and fats, sugar and sweets, and miscellaneous—here coffee/tea/condiments. Each food was scored as 1, if consumed.

A representative sample of 767 women with children under 5 years of age were recruited and a trained interviewer administered the form. These women averaged 4.8+1.5 food groups using a scale that averaged only the first nine food groups. The three most consumed, however, were cereals (here corn), sugar/honey, and coffee/tea/condiments. The three least consumed food groups (<25%) were foods with high quality protein—dairy, fish, and meat/poultry, but 78% reported eating beans the previous day. About half the women consumed eggs or fruits and 70% ate vegetables other than potatoes.

These data depict a lack of dietary diversity and room for improvement via distribution of superior bean and nutrition education about why and how they are good for growth and good health.

P-35 **Household Bean Consumption, A Visual Monitoring Tool to Assess Agricultural Efficacy**

Carolina D Molina, Sharon L Hoerr, Celina Wille, Salvador Castellanos, Luis Flores

Small, indigenous, rural Mayan communities exist at high altitudes, where their children are handicapped by chronic malnutrition and child stunting. Beans, domesticated in the Americas, can provide many missing nutrients but are not consumed daily. MASFRIJOL is a 4-yr USAID project that marries agriculture to nutrition education via distribution of bean varieties improved to grow at high altitudes with nutrition education extension lessons delivered in remote rural communities.

Agronomists and nutritionists both needed to know whether the bean seeds distributed and grain grown were used in rural Households (HH). To assess the HH beans cooked/HH over 1 week, MASFRIJOL developed a visual and reusable instrument on which HH could record the amounts of beans cooked each week in amounts and frequency. This instrument is a large laminated poster (40x140cm) with drawings of 3 empty 2-cup measures per day. Each HH was given a plastic 2-cup measure and a marking pen to mark the amount of dry black beans cooked each day. MASFRIJOL staff members distributed the posters to HH and recorded the number and ages of men, women—pregnant/lactating, and children/HH.

The average frequency of cooking beans was 1-2x/wk. The dry beans cooked/HH/wk is determined by adapting the FAO techniques for Adult Male Equivalents (AME) (Weisell et al., 2012). The amount is pro-rated based on energy needs of adults vs children by age, gender and reproductive status. Then the amounts of beans cooked/wk in each HH is converted to the energy in those beans, wherein 1 cup (225gm) dried black beans equals 480gm of cooked beans. The amounts of beans/HH/wk is reported as the energy from beans cooked where 100gm cooked black beans have 88Kcal divided by the Adult Male Equivalent Units/HH. MASFRIJOL has used this HH bean consumption successfully with 822 families with minimal problems.

P-36 **Effect of Traditional Processing Methods on the Retention of Zinc, Crude Fiber and Flavonoids in Cowpea Flour**

Ngoma Nakoma Theresa, Agnes Mwangwela, Ken Maleta, Mark Manary, Indi Trehan, Chrissie Thakwalakwa, Oscar Divala, Yankho Kaimila

Background: Cowpea is widely grown in Malawi and contains substantial amounts of zinc, crude fiber, and flavonoids, in addition to protein and other minerals. However, it remains under-utilized in childhood feeding despite the challenge of malnutrition due to poor feeding practices and environmental enteric dysfunction (EED), among others. Effective utilization of cowpea in complementary feeding requires processing, which may affect the chemical composition. The present study

evaluated the effect of processing on zinc, crude fiber, and flavonoid retention in roasted, boiled, and dehulled cowpea flours.

Methods: Roasted cowpea flour was processed by roasting (120°C for 50 minutes); boiled cowpea flour by boiling (100°C for 40 minutes); and dehulled cowpea flour by soaking cowpea for 11 hours, manually dehulling then boiling (100°C for 20 minutes) before milling. Crude fiber was analysed using the enzymatic-gravimetric method; zinc and flavonoid contents were analysed spectrophotometrically.

Results: Roasting, dehulling, and boiling had no effect on zinc content, which ranged from 4.9-6.0 mg per 100 g. Crude fiber content ranged from 3.1-4.4 g per 100g; all food processing methods increased this amount. Processing had no effect on measurable flavonoids which ranged between 3.5-4.6 mg per 100 g.

Conclusion: Traditional processing of cowpea retained the nutritional content for zinc, flavonoids and fiber, which may confer health benefits.

P-37 **Nutrition-sensitive Agriculture Needs an Integrated Approach: An Example in the Western Highlands of Guatemala**

Celina G Wille, Sharon L Hoerr, Salvador Castellanos, Luis Flores, Carolina Molina

Traditionally, agronomists and health professionals have addressed under-nutrition independent of each other, working from in different ministries or departments, pursuing similar, but separate distinctly different goals. At one end, agronomists support rural households in increasing food production through improved farming practices while at the opposite end, health professionals address chronic and acute under-nutrition.

Recent international development goals call for nutrition-sensitive agriculture which, according to FAO/WHO, “seeks to maximize agriculture’s contribution to nutrition” by targeting households with limited resources and “promoting gender equity and providing nutrition education so that household resources are used to improve household nutrition, especially that of women and young children.”

Implementing nutrition-sensitive agriculture requires that the traditional separation of agronomy and health professionals’ roles be integrated through coordinated efforts. Such coordination is needed because producing more food alone is not sufficient to end undernutrition among people making poor food choices due to lack of knowledge. Without nutrition education, the food produced through improved agriculture does not necessarily increase household consumption; instead, the additional crops are sold for cash and the money spent on other necessities or even less nutritious foods, like sweets and fried snacks. Additionally, children rescued from acute undernutrition by health officials return to households where more food is produced, but the food consumed doesn’t enhance protein quality, micronutrients, or dietary diversity—ensuring that these children will become undernourished again and again in an endless cycle.

Nutrition-sensitive agriculture, however, provides both agricultural and nutrition education delivered through extension workers cross-trained in agriculture, public health, and nutrition, leading to households that consume more of their nutrient-dense and nutritionally balanced crops. This paper illustrates how this coordination can be accomplished, with examples from the MASFRIJOL project in Guatemala’s Western Highlands, where partnering agricultural, public health, and nutrition professionals were were cross-trained both on improving maternal and child nutrition and increasing bean production.

Theme 5: Integrated Pest Management

P-38 Life Cycle of *Clavigralla tomentosicollis* (Stal.) and its Impact on Crop Yields of Cowpea (*Vigna unguiculata* L. Walp.) in Niger

M. Abdourahmane, I Baoua, L Amadou., M. Tamò, B.R. Pittendrigh, *S. Mahamane*

While cowpea (*Vigna unguiculata* L. Walp.) is an important food crop in West Africa, its yield is often less than 300 kg/ha due to several factors including insect pest damage.

On station experiments were conducted to assess the developmental cycle of the cowpea pod bug *Clavigralla tomentosicollis* (Stal.) on cowpea crops. Periodic observations on eight experimental plots established that the pest infects the legume plants during their fruiting phase and has a least two generations in a cropping cycle. Moreover, densities of larvae and adults were more important at the time of crop maturity. Maximum proportion of damaged pods reached 75.5% and a seed yield loss of 35.3%.

While application of biopesticide during the flowering and pod formation phases may contribute to a reduction of the first pest population generation, and further research is still needed, the current findings already may be used to raise crop producer's awareness about the life cycle and threat-periods of this pest.

P-39 Species of *Fusarium* Are Root and Crown Rot Primary Pathogens in Zambia and Mozambique Based on Molecular and Culture Based Methods

Graciela Godoy-Lutz, Chickoti Mukuma, Suzana V. Fernandes and James R. Steadman

Dry bean is an important crop in Zambia and Mozambique as a source of protein and micronutrients as well as income. Root/crown root (RCR) has emerged as an important production constraint due to various factors such as climate change effects, lack of certified seed and proper soil management and no genetic resistance to target pathogen(s).

Molecular and culture based methods were compared to identify the RCR fungal pathogen(s). RCR bean samples were collected from 2013-2015 at the breeder nursery sites and farmer fields in bean producing zones in both countries. Diseased and healthy interface tissue was either cut for direct plating on agar media or ground for DNA extraction and homogenates used for blotting onto FTA® cards. DNA extracted from FTA® cards and root tissue were used for metagenomics analysis by the Illumina System and 454 pyrosequencing of small subunits of the rRNA gene and PCR amplification with specific primers. Isolates from cultures were identified by morphology and sequences of the ITS rRNA region and the elongation factor gene and also were tested for pathogenicity. Analysis of variance and Multivariate analysis were used to compare results of three methods.

Analysis of DNA from plant tissue and ground tissue extracts spotted on FTA cards identified *F. oxysporum*, *F. solani* and other species of the *Fusarium* complex as the most abundant reads and Operational Taxonomic Units (OTU). *Fusarium* spp. were also detected in over 70% of the samples analyzed by conventional PCR using specific primers and also had the highest frequency of recovery (>0.8) from culture. Over 90% of the *Fusarium* species recovered were pathogenic. Identification of a different primary pathogen associated with RCR in Zambia and Mozambique provides evidence and isolates to use in screening for RCR resistance and incorporating in bean breeding.

P-40

Comparative efficacy of Biopesticides for Controlling the Legume Pod Borer, *Maruca Vitrata* Fabricius (Lepidoptera: *Crambidae*) Under Field Conditions in Benin

Toffa Mehinto, Joelle, Elie A Dannon, Ouorou Kobi Douro Kpindou, Manuele Tamò

Cowpea is an important food security crop in most rural areas of West Africa. However, its production is limited by several constraints among which biotic pressure from insect pests remain the major one. Several control methods have been developed to control cowpea insect pests, among which the use of biopesticides has been the object of recent studies.

The present study was designed to compare the efficacy of biopesticides consisting of *Beauveria bassiana* (isolate Bb 115), the combination of an emulsifiable neem product (Topbio) with the baculovirus MaviMNPV and the chemical insecticide Decis (deltamethrin) for the control of the legume pod borer (LPB), *Maruca vitrata* Fabricius (Lepidoptera: *Crambidae*) under field conditions.

The trial was conducted in six villages in central (Glazoue municipality) and southern Benin (Djakotomey municipality). Four treatments consisting of 1) unsprayed control, 2) Topbio combined with MaviNPV, 3), B. bassiana and 4) Decis were arranged in a complete randomized block design with three replicates.

Reproductive organs (flowers buds, flowers and pods) were sampled for estimating population densities of *M. vitrata*. In spite of the between-field variation, biopesticides significantly reduced the population density of M. vitrata and its damage level as well. The overall grain yield was improved in treated cowpea compared to the untreated control, regardless of the experimental zone. Thus, in Glazoue, yields ranged from 858.1 ± 5.04 kg/ha (Decis) and 1012.03 ± 8.7 kg/ha (*B. bassiana*). In Djakotomey, grain yields of 649.1±4.7 kg/ha, 618.07±5.1 kg/ha, 602.19±4.04 kg/ha and 217.11±3.9 kg/ha were recorded for Decis, B. bassiana, Neem+Virus and untreated control, respectively. The possibilities of the using biopesticides as efficient IPM components in cowpea are discussed.

P-41

Effect of Neem Oil Application Period on Insect Pests in the Cowpea Field

Edouard Drabo, Fousséni Traore, A. Waongo, N. Malick Ba, Clémentine Dabire, Antoine Sanon, and Barry R. Pittendrigh

Effective control of insect pests of cowpeas (*Vigna unguiculata*) in cultivation has been long based on the chemical pesticides use with its adverse effects on human health and the environment. Today, for ecological and economic reasons, the need of the biopesticides use as an alternative to synthetic insecticides has emerged.

The objective of this study is to determine the period of neem oil application in the cowpea crop which reduces the population of insect pests. The trial using the improved variety named KVX 775-33-2G was planted in a farmer's field, in which six treatments replicates four times were used. A control (unsprayed plot), a reference control using the Lambda-cyhalothrin and Acetamiprid and four dates of neem oil application at 40, 45, 50 and 55 days after planting (DAP). Fructiferous organs were randomized taken twice a week to count thrips and *Maruca* as well as yields.

The results obtained show that when these two oils are applied at 40 DAP which corresponds to the floral button stage of the plant, the number of thrips per flower is not significantly different from those obtained with the reference insecticide. The oils used did not control the populations of *Maruca* at the dates of applications assessed. The yields obtained are the same as those obtained with the reference control but greater than those obtained at the

other application dates. Neem oils can significantly reduce the populations of thrips in cowpea field when early applied.

P-42 **Precision Pest Management Technology Delivers Financial and Health Benefits for Farmers in West Africa**

Michael Agyekum, Cynthia Donovan, Manuele Tamò, Barry Pittendrigh, and Eustache Biaou

Grain legumes, particularly cowpeas, are strategic crops in Africa as they provide food and income for millions. However, cowpea production faces formidable pest attacks leading to high yield loss (50-100%) with serious risks for food security. In Benin, 88% of farmers apply broad-spectrum chemicals to control pests often without following recommended practices. Also, over 75% of farmers do not wear protective equipment.

Existing chemical methods therefore raise serious sustainability concerns for agriculture and public health. In Benin, most farmers (57-73%) have reported acute health problems (eye and skin irritations) after spraying. In efforts to find sustainable options, a novel precision integrated pest management (IPM) technology is being explored for West Africa. The precision IPM technology is based on exotic biocontrol agents, locally produced biopesticides, and a smartphone app that aids farmer decision-making by identifying pest problems and delivering customized solutions to farmers in their own languages.

This study evaluates potential impact of the precision IPM technology on cowpea farm income if producers decide to shift from existing chemical methods. To achieve this, we employ farm enterprise and partial-budgeting analysis using data from: (1) experimental farm trials on biopesticides, (2) biocontrol experts' opinion on the effectiveness of identified parasitoids, and (3) survey data on 505 cowpea farmers across Benin. Results indicate that if farmers switch from current chemical methods and adopt the precision IPM technology, they would benefit from additional net income of FCFA 51,832 (US$83) per hectare.

Implication is that precision IPM has high potential to increase farm incomes substantially (>100%) for farmers in Africa. With 10 million hectares of cowpeas cultivated in West Africa, farmers would gain additional US$ 830 million annually. The full impact of precision IPM would likely exceed the financial benefit shown in this study if potential health and environmental benefits are duly accounted for.

Theme 6: Integrated Soil Fertility Management

P-43 **Influence of Bradyrhizobium Inoculation and Fungicide Seed Treatment on Development and Yield of Cowpea, Lablab, and Soybean**

Bulyaba Rosemary and Andrew W. Lenssen

Seed treatment with fungicide and rhizobia inoculation are common practices prior to planting of many grain legumes. We conducted a two-year field study to determine the influence of *Bradyrhizobium spp.* inoculation and fungicide seed treatment on development, nodulation and yield of cowpea [*Vigna unguiculata* L. Walp.], lablab (*Lablab purpureus* L.), and soybean [*Glycine max* L. Merr.]. The soybean was included because it is a widely researched grain legume in the U.S. Midwest.

The experimental design was a randomized complete block in a factorial of four grain legumes with and without *Bradyrhizobium spp.* inoculation and fungicide seed treatments. The cultivars in the study were cowpeas were 'CA46' and 'Top Crop', lablab 'Rongai' and soybean 'P92Y82'. The seeds were treated with

or without fungicide, mefenoxam + fludioxonil (ApronMaxx), and with or without Bradyrhizobium spp. or both before planting. We found cowpea plants to have numerous functional nodules (pinkish/reddish inside) even without *Bradyrhizobium spp.* inoculation while lablab crops had no nodules without inoculation. However, with *Bradyrhizobium spp.* inoculation, lablab had fewer but bigger nodules than cowpea or soybean. We found no significant effects of *Bradyrhizobium spp.* inoculation and fungicide seed treatment on cowpea, lablab or soybean grain yield.

Based on our results, Iowa farmers may be able to conserve scarce resources by not using Bradyrhizobium inoculant or fungicide seed treatments on soybean and cowpea, but when planting lablab, inoculant is necessary to obtain nodulation for N fixation.

P-44 **Improving Pigeonpea and Common Bean Yields in Gùrué District, Mozambique**

António Rocha, Ricardo Maria, Unasse S. Waite, Uatema A. Cassimo, and Russell Yost

Low soil fertility and high soil acidity limit crop productivity and mitigation of food insecurity in the Mepuagiua community. Pigeonpea (*Cajanus cajan* L.) and common bean (*Phaseolus vulgaris* L.,), are staple food crops grown in 17.4% and 7.6% of Mozambique households, respectively.

Field experiments with inputs of triple super phosphate (TSP) and Evate rock phosphate (ERP) were conducted to increase yields of pigeonpea and common bean in infertile, reddish-brown soils of Mepuagiua community. Pigeonpea grain yields of 1 Mg ha-1 were possible with an application of 80 kg ha-1 of total P added as ERP. By comparison, 20 kg P ha-1 as TSP was needed to reach a maximum yield of 1.2 Mg ha-1 of pigeonpea grain.

This research suggests that ERP can be an effective amendment for food grain production on the acid, infertile upland soils of Mozambique. For common bean, soil pH was adjusted upward using lime from nearby Nampula Province. Germination and early growth were extremely limited with no lime application; however maximum growth occurred with the modest application of 1 Mg ha-1 of lime. Soil analyses are needed to better understand and predict when such a small lime application can provide yield increases. Further studies are needed to determine how long the 1 Mg ha-1 of lime will continue to support improved common bean growth.

P-45 **Fine-Tuning Research Findings to Farmer Decision Making in Soil Fertility Management: from Bean Fertilizer Recommendations to Farm Level Action**

O.Semalulu, S. Kyebogola, M.M.Tenywa, R. Miiro, A. Lenssen, R. Yost, E. Abbot, and R. Mazur

Soil fertility is a major factor limiting bean productivity in Sub-Saharan Africa. However, farmers in Uganda rarely apply fertilizer on beans; the few that do report varying response among soil types. Existing recommendations address only inorganic fertilizers and are not soil-specific.

This study explored how revising fertilizer recommendations could influence farm-level decision making. Three soils commonly cropped to beans in Masaka, are locally classified as Liddugavu (black soil, Phaeozem), Limyufumufu (red soil, Cambisol) and Luyinjayinja (gravelley soil, Umbrisol).

Research-based (2015A and B seasons) revised recommendations established that combined application of organic and inorganic fertilizer was superior to either material applied separately. For black soil, 7.5 kg N ha-1 + 7.5 kg P ha-1 + 2.5 t ha-1 chicken manure (CM); for gravelley soil, 7.5 kg N ha-1 + 15 kg P ha-1 + 2.5

t ha-1 CM, and for red soil, 15 kg N ha-1 + 15 kg P ha-1 + 2.5 t ha-1 CM gave highest yields.

These recommendations were validated through participatory farmer-controlled trials using a no-fertilizer control, organic (CM), inorganic (DAP plus urea) and combination of organic and inorganic. During 2016A season fertilizer application significantly ($P<0.05$) increased bean yield (909, 1454, 1345 and 1386 kg ha-1 for control, organic, inorganic and combination, respectively, $P<0.05$, LSD=296). During 2016B season, bean yields were: 983, 1594, 1540 and 1540 kg ha-1 for control, organic, inorganic, and combination, respectively ($P<0.05$, LSD=322).

These results show that during normal rain seasons (e.g. 2015A and B), combined organic with inorganic fertilizer application gives higher yields; however under moisture stressed 2016A and B seasons, application of manure or inorganic fertilizer was as good as the combination. Thus, during a forecasted normal season, farmers can apply a combination of organic with inorganic fertilizer, but for a predicted low rainfall season, farmers should apply either organic or inorganic fertilizer, but not combination.

P-46 **Evate Rock Phosphate: A Potential Regional Source of a Nutrient Input for Acid, Impoverished Soils of Gurúè District, Mozambique.**

António Rocha, Ricardo Maria, Uatema Cassimo, Christine T. Glazer, Susan Crow, Sounder Rajan, and Russell Yost

The nutrient phosphorus often limits yields of food crops in Sub-Saharan Africa. Recent summaries of local sources of phosphate in Africa did not include the Evate rock phosphate (ERP) deposit of Mozambique. This important deposit is estimated at 155 million metric tons, which is about 30 times larger than the well-known Minjinggu rock phosphate in neighboring Tanzania. The International Fertilizer Development Center (IFDC) reports that prior to 2015 they had no chemical analysis of this deposit (Singh, 2015, personal communication). A detailed analysis was conducted by the IFDC mineralogical and chemical laboratory indicating a very high concentration of total P (40.7% total P_2O_5) but with low citrate solubility (3.5%) that typically indicates low plant availability.

This large deposit of rock phosphate may be a potential source of the critical nutrient P for not only Mozambique but for other parts of Africa. A field study was carried out to assess the value of this potential local source of P for grain legumes such as pigeon pea and, in rotation, common bean.

The field study indicated that with the choice of a suitable crop such as pigeon pea (acid-tolerant, long growth cycle) 80 kg total P as Evate rock phosphate provided yields similar to 20 kg total P of the soluble, imported, and expensive triple super phosphate. A laboratory study indicated that solubility could be increased with the addition of sulfur and Thiobacillus bacteria. ERP appears to be a very attractive option to supply P on the many P deficient soils.

Theme 7: Policy, Economics, Value Chains (incl. Seeds)

P-47 **Effect of Interaction of Attributes that Influence Consumer Choice of Bean Varieties in Lilongwe city**

Dinah Tuwanje Banda, Kara Ross, Vincent Amanor-Boadu and Lawrence Mapemba

Common bean (*Phaseolus vulgaris* L.) is the most important legume to both producers and consumers in Malawi. It has great economic value as it is a source of income particularly to smallholder farmers and it has high nutritive value to human healthy. Common beans are known to provide essential elements that are significant in controlling human conditions such as diabetes, obesity, and coronary disorders. In another aspect, common beans as a crop has been attributed to enhance climate change adaptation because of its high resilience to climate change. Despite the importance of beans to human nutrition little has been done to understand the observed low levels of consumption of beans. Hence, this study aimed at identifying the combination of bean attributes that influence consumer choice of bean varieties.

The study used secondary data from bean value chain project that was collected from households in Lilongwe district with sample size of 685. A multinomial logit regression was used to determine the combination of attributes that influence consumer choice of bean varieties. Furthermore, interaction of large grain size with good gravy quality increased the likelihood of consumer choice of purple bean, khakhi bean, mottled bean and red bean, all other factors held constant. However, interaction of large grain size and thick gravy quality with cooking time had no great effect in probability choice of all varieties.

The study recommended that breeding programs and strategies should produce beans with large grain size and good gravy quality to further increase consumption. Furthermore, the study recommended that agricultural and nutrition policies should aim at improving the consumer demand for the beans through the supply of preferred varieties (i.e., red kidney beans) by making sure that markets are available and accessible to both traders and consumers.

P-48 **Cowpea Pest Management Patterns in the Department of Couffo (South-West of Benin)**

A. Eustache Biaou, C. Hervé SOSSOU, 3O.C. Aurelle Sedegnan

The objective of this study is to identify the potential chemical pesticide use patterns in the control of pests of cowpea in order to promote the acceptability of biopesticides in the cowpea value chain and to help resolving public health problems in the environment.

The methodology used, consist to collect qualitative data (stakeholder discourse, determinants and justifications of different control practices) and quantitative data (representations, pest management practices at the level of producers and traders, use of chemical and botanical pesticides and risks related to human, animal and environmental health). The Kendall test was used to rank the reasons for the choice of the methods used by the actors and the content analysis for the speeches.

As a result, the diagnosis of the different methods of pest control showed that chemical control is the one used by the majority (98.3%) of cowpea producers and traders. The reasons for its use are: good yield, product availability, grain quality, efficiency and affordability. The harmful effects of the use of chemicals on human and animal health are known to the actors involved but these actors know little

about the environment. Biological control through botanical extracts is known to many (72%) of these actors but the lack ofreadily availableproductson the marketlike forchemical pesticides, the duration of theireffectiveness, the fear of yield loss are key factors that limit its use on a large scale.

Résumé en Francais

L'objectif de l'étude, est d'identifier les potentielles chaînes d'utilisation des produits chimiques dans la lutte contre les nuisibles du niébé afin de promouvoir l'acceptabilité des biopesticides au niveau des acteurs de la chaîne de valeur niébé et aider à la résolution des problèmes de santé publiques etenvironnementaux. La méthodologie utilisée aconsisté à recueillir des données (discours des acteurs, aux déterminants et justifications des différentes pratiques de lutte et l'univers de représentations) et des données quantitatives (représentations, pratiques de gestion des nuisibles au niveau des producteurs et des commerçants, utilisation des pesticides chimique et botanique et les risques liés à la santé humaine, animale et environnemental). Le test de Kendall a été utilisé pour hiérarchiserles raisons qui justifient le choix des méthodes utilisées par les acteurs et l'analyse de contenu pour les discours. Comme résultats, le diagnostic des différentes méthodes de lutte et de contrôle des nuisibles a montré que la lutte chimique est celle qui est la plus utilisée par la majorité (98,3%) des producteurs et commerçants du niébé. Les raisons qui justifient son usage sont: un bon rendement, la disponibilité du produit, la qualité des grains, l'efficacité et le prix abordable. Les effets négatifs de l'utilisation des produits chimiques sur la santé humaine et animale sont connus des acteurs en présence mais ces acteurs connaissent peu de l'environnement. La lutte biologique à travers les extraits botaniques est connue de beaucoup (72%) de ces acteurs mais son absence en produit fini à l'instar des pesticides chimiques sur le marché, la durée de son efficacité, la peur de pertes de rendement sont des facteurs qui limitent son usage à grande échelle.

Mots clés: Niébé, bio pesticide, pesticides chimiques, acteurs, chaîne de valeur

Joint Consumption of Multiple Common Bean Varieties in Lilongwe City, Malawi

P-49

Edwin Kenamu, Lawrence D. Mapemba, Vincent Amanor-Boadu, Kara Ross

Consumption of common beans and other legumes has become an important aspect of nutrition policy in most of the developing world due to the legumes' position as cheap source of plant proteins and other micronutrients to human diets. Common beans, specifically, have been known to contain high values of proteins, iron, zinc and folates. Consumption of various varieties of the beans, however, tends to be varied and generally low in the country. There is a multiplicy of factors that aid or impede consumption of common beans.

Developing workable policies that facilitate improved consumption of the various bean varieties therefore hinges on understanding the effects of various household socioeconomic and demographic variables on decision to consume the various bean varieties.

This study uses household data collected in Lilongwe City by the Feed the Future Legume Innovation Lab supported project to assess factors affecting consumption and frequency of consumption of red beans, white beans, red-mottled beans as well as cream-mottled beans in the city. Multivariate and ordered probit models are used to model common bean consumption decisions when households are faced with various varieties, which they can consume in various combinations.

Results show that there is significant correlation amongst consumption of the four common bean varieties, signaling that consumption decisions are highly interrelated. The results further indicate that household incomes, sex of the household head, education level of the household head, total household food budget, perceived importance of common beans to household food security and age of the household head affect the probability of consuming as well as the frequency with which the households consume the four beans varieties. The paper ends by recommending policy actions that can improve consumption and frequency of consumption of the bean varieties under consideration.

P-50 **Expenditure and Price Elasticities of Demand for Cowpea in Northern Ghana**

Pacem Kotchofa, Kara Ross, Vincent Amanor-Boadu, Yacob Zereyesus

Grain legumes are ranked second most important produced crop after cereals such as maize in Sub-Saharan Africa (SSA). Monyo (2015) and IITA (2016) indicated that globally, about 5.4 million tons of dried cowpeas are produced yearly with more than 70% from SSA. Smallholder farmers in SSA are increasing their production due to their agricultural and nutritional benefits such as soil fertility, drought resistance, and as an inexpensive source of protein and micronutrients (Pele, 2015).

Despite their nutritional and economic benefits, the consumption of cowpeas, is still quite low. The per capita consumption is as low as under 10 Kg (Mishili, 2009; Coulibaly et al., 2010). Multiple factors could explain this consumption gap. The literature provides a wide range of information on the production and post-yield management of cowpeas in the SSA, but very little is known specifically about the demand for cowpeas in the northern Ghana.

In order to fill in this literature gap, this study aims to analyze household price and expenditure elasticities of cowpeas in the northern Ghana. Specifically, a descriptive statistics analysis and a Quadratic Almost Ideal Demand System (QUAIDS) model of Banks, Blundell, and Green (1990) were estimated using consumers' data collected from approximately 4.600 randomly selected households in the northern Ghana. The QUAIDS was preferred because of its ability to fit better household data and also due to its flexibility in fitting some household demographic variables like the household size which is important in evaluating food expenditures. It is expected that household size, cowpea price and the income level will influence the decision and intensity of the consumption of cowpea. Results of this study could help to investigate how household allocate their budget share across different foods categories and provide deep understanding on how to strengthen health and nutritional public policies in the northern Ghana.

P-51 **Consumer Choice of Dry Common Beans in Lilongwe City of Malawi**

Mazunda Marynia, Mapemba Lawrence, Amanor-Boadu Vincent, Ross Kara

Grain legumes play a critical role in smallholder's social and economic growth in Malawi and several other countries worldwide. Grain legumes are an important source of dietary protein, calories and, micro nutrients (Shewry and Halford, 2002). Improving nutrition and food security outcomes are important goals for the Feed the Future initiative as well as other policy initiatives including the Malawi Growth and Development Strategy (MGDS) and the Agriculture Sector Wide Approach (ASWAp).

To this end, dry common beans are among grain legumes in Malawi that have potential to contribute to food security, improved nutrition,

as well as household incomes (USAID, 2011). While empirical research has concentrated on yield and agronomic aspects, there is a dearth of knowledge from a consumer's perspective about the factors shaping demand for and consumption of dry common bean (Mishili et al., 2009).

The objective of the study was to analyze consumer choice and extent of consumption of dry common beans. The study employed a Craggit double hurdle model to analyze factors influencing consumer choice for common beans and the extent of household dry common bean consumption from primary data (n=684) collected in Lilongwe City. Results from the study suggests that socioeconomic factors such as gender, household size, education, and income play an important role in a household's decision to consume different varieties of dry common beans and the actual quantities consumed. Various product attributes such as grain size, gravy quality, and cooking time were also found influence a household's decision to consume common beans.

Policy approaches that address awareness of common bean attributes preferred by consumers have potential to increase common bean consumption by enabling breeders and farmers to be knowledgeable of consumers' needs.

P-52 **Factors Underlying the Consumption of Common Beans in Dar es Salaam, Tanzania**

Elizabeth Medard, Fredy T. M. Kilima, Gilead Mlay

Common beans are widely grown and consumed in Tanzania. The beans are major source of protein especially among low income consumers. While there is consensus that the consumption level of these beans has been decreasing over time major reasons to justify the decrease are not well established. The gap in knowledge undermines the ability of chain actors to respond to consumers' desire for common beans.

This study was conducted to assess key factors shaping consumers' preferences for, ultimate choices and consumption of beans. Specifically, the study determined factors influencing the decision to consume common beans at household level, examined consumption frequency of different beans and bean products and assessed factors influencing consumers' choices of these products. Primary data collected under Feed the Future Legume Innovation Lab Project SO2.2 in 2015 from random sample of 600 households in Dar es Salaam city were analysed to address these objectives. Binary probit, descriptive statistics and Cragg's double hurdle models were used in the analysis.

Results revealed that the decision to consume beans was significantly influenced by household size, income status of the residents, age and education of the main decision maker. Dry red beans were the most frequently consumed followed by dry brown and dry mottled beans. Processed bean products were the least frequently consumed bean products. Choices of beans were significantly influenced by gravy quality, cooking time, grain size, size of household, income status of the residents, age, education and sex of the main decision maker.

These results are important to breeders as they contemplate developing breeds that appeal to consumers. The benefits of new breeds of common beans will be felt directly by producers as they will be able to get better markets for their products. The findings are also useful to other chain actors wanting to seize new market opportunities for common beans.

P-53

Production and Marketing Constraints, Current Status and Future Outlook of Common Bean Sub-Sector in Malawi

Nyumbani Moyo, Lawrence Mapemba, Vincent Amanor-Boadu, Kara Ross

The common bean sub-sector offers multiple benefits to the Malawi population. As a source of food, income and restoration of declining soil fertility. However, the current low production affects the availability of quantities to be supplied on the market. Therefore, there is need to identify production and marketing constraints, examine current status and future outlook of the common bean subsector in Malawi.

The study employed trend analysis and SWOT techniques. The study revealed that production will increase from 164,182 to 350,176 t in 2010/2011 to 2024/2025 cropping seasons, respectively. Area is projected to increase from 299,966 to 510,146 hectares in 2010/2011 to 2024/2025 cropping seasons, respectively while yield is projected to decrease from 602 to 506 kg/ha in 2010/2011 to 2024/2025 cropping seasons, respectively. The SWOT analysis revealed that there is unpredicted weather condition affecting productivity, lack of clear polices and strategies that promote production and marketing of the crop, there is low bargaining power as each farmer negotiates his own prices to traders, the use of recycled seeds is hindering the development of common bean sub-sector.

The study recommended that to increase common bean production there is need to increase productivity through increasing farmer's access to high yielding varieties. Promote collective marketing and value addition at marketing level as there is little value additional activities taking place and institute advocacy for policies that promote production and marketing of common beans. The study will contribute towards attainment of Malawi national food security and national export goals, as common beans are expected to remain in the food security equation.

P-54

Household Demand for Common Beans in Lilongwe District of Malawi: A Censored Regression Approach

Wupe Msukwa, Lawrence Mapemba, Vincent Amanor-Boadu, Kara Ross

An in-depth understanding of the economics and common bean value chain is essential for the development of the common bean sector in Malawi. To bridge the gap in the aforesaid, the study analysed household demand for common beans. Consumer demand information is key for a market system that can signal the relative scarcity of goods and services, guide the decisions of economic agents, and ensure mobility of commodities over time and across space.

Duly, the main objective of the study was to analyse the responsiveness of quantity demanded of different varieties of common beans to price and income changes among households in Lilongwe urban of Malawi. The study employed the QuAIDS and its competitor LA/AIDS and assessed the performance of each model. Both models were censored and the demand analysis featured six varieties namely brown, yellow, red, khaki, mottled and mixed beans. Primary data collected by LIL-supported project was used in the study.

Based on performance, this study chose the QuAIDS as the best representation of demand for common beans among households of different locations in Lilongwe urban of Malawi.

The computed demand elasticities showed that all common bean varieties are necessity goods with price-elastic demand, but not all are normal goods and substitutes. Furthermore, red-mottled beans have the highest revenue

generation capacity intermediate value chain actors could take advantage of. In addition, demand for common beans is more sensitive to price than income effects.

Henceforth, the study recommends that: (1) interventions that would lower prices would maximize revenue maximisation from common beans traded by retailers, (2) revenue maximising retailers could focus on red-mottled variety, (3) government should consider providing incentives for increasing production of common beans, and (4) if meaningful changes are to occur in common bean consumption, policy makers should pay more attention to price rather than income-related policy instruments.

P-55 **Enhancing Bean Productivity through Community Seed Multiplication in Mbala and Mporokoso Districts of Northern Zambia**

Kennedy K. Muimui, Atoo L. Okello, Prospery Chikuma, Robert Lungu, and Martin Mathotho

Agricultural productivity in the developing world will remain low as long as farmers continue using recycled seed. In most cases these seeds have low germination and probably harbouring seed borne diseases.

The Bean programme has realised that to improve bean productivity, use of disease free seeds and certified seed is key. With this background, the programme embarked on a community seed multiplication coupled with integrated crop management. Farmers in Mbala and Mporokoso districts of northern Zambia were trained to be community seed producers to be able to supply disease free and certified seed within their communities. Farmers were supplied with seed, fertilizer and chemicals from the bean programme as starter packs. The crop was inspected by seed inspectors to ensure that seed regulations were followed. The productivity from the groups increased by almost 40% which was attributed to integrated crop management option employed by the farmer groups.

Consumers' Preferences for Common Beans' Attributes in Dar es Salaam, Tanzania P-56

Ezekiel Swema, Gilead Mlay, Fredy Kilima, Vincent Amanor-Boadu, Kara Ross

Consumers' preferences for food products are always based on observable and non-observable attributes. Common beans which are globally important for income generation as well as food and nutrition security, appeal to consumers in different ways. One important distinction of this nature is with respect to color, size, cooking time and gravy quality. However, these attributes have been studied in the context of demographic and socioeconomic characteristics of consumers. Studies that have explicitly associated these attributes with specific societal and cultural factors have generally been rare. Ignoring these factors can distort the measured effects and contribute to the failure of interventions aimed at altering food preferences.

This study incorporated the factors ignored in the previous studies along with demographic and socioeconomic factors to understand better consumers' preferences for the common bean in Dar es Salaam, Tanzania. The rationale was to identify means to support actors in the bean value chain to improve their businesses and wellbeing. Discrete Choice Experiment (DCE) was employed in order to elicit individual preference and uncover how individuals selected common beans' attributes combinations using a random sample of 732 respondents. Four different common beans' attributes including color (four levels), grain size (three levels), cooking time (two levels) and gravy quality (two levels) were studied. Data analysis involved the use of Poisson Regression Model (PRM).

Results showed that common beans with yellow color, large grain size, good gravy and that cooked fast were the most preferred attributes' combination. Common bean with pure grey color, small grain size, poor gravy and that cooked slowly were the least preferred attributes' combination. Furthermore, the results showed that societal and cultural factors were important in influencing consumers' choice of the attributes' combinations. The study recommends production of common beans with specific attributes' combinations that are preferred.

P-57 **Factors Affecting Bean Profitability among Bean Traders in Zambia**

Elizabeth Chishimba, Gelson Tembo, Vincent Amanor-Boadu, Mukwiti Mwiinga

There is a general lack of empirical evidence on value chains for pulse crops such as beans in most low-income developing countries.

This study contributes to the small but growing literature on the subject by identifying the factors that affect the profitability of bean trade. The results, based on a sample of 219 bean traders from three separate Markets in Lusaka, confirm a positive effect of education and ownership of information assets such as radio on profitability of wholesale and retail bean traders.

The results also suggest that the profitability of the bean trading enterprise is inversely and significantly correlated with the size of the operation. Soweto market, the largest market in Zambia, is significantly more profitable for beans than the smaller and more retail oriented markets.

In this field, Issa (*rt.*) looks out at the cowpea field trial with hope, having helped established INERA's next generation of bean breeders in Joseph Batieno, (*l.*) who worked side-by-side with Issa, ensuring that the good work of LIL and INERA will continue for decades to come.

In Memoriam

Dr. Issa Drabo

Dr. Issa Drabo: researcher, cowpea breeder, collaborator, mentor, colleague, and friend.

This past December, after a short illness, longtime cowpea breeder at the Institut de l'Environnement et de Recherches Agricoles (INERA) and research collaborator at the Feed the Future Legume Innovation Lab (LIL), Dr. Issa Drabo passed on, leaving behind a celebrated legacy of commitment to advancing cowpea research and breeding to improve the lives of resource-poor farmers in Burkina Faso.

Issa's life work centered on increasing cowpea productivity in West Africa through genetic improvement for economically important traits, such as grain quality, early maturity, and resistances to major biotic (e.g., Striga and thrips) and abiotic stresses. Issa utilized traditional breeding approaches but readily embraced modern molecular methods to guide his breeding strategy.

Never one to work in a vacuum, Issa's desire to alleviate hunger and poverty in West Africa led to his active involvement in ensuring that an adequate seed supply of improved INERA cowpea varieties were regularly available to the resource-poor farmers who needed them the most. To help ensure that supply, Issa and his INERA and LIL colleagues mentored numerous farmer organizations, many comprised solely of women, on methods for multiplying and conserving quality, disease-free seed to ensure seed security for the next planting season. These women's farmer organizations have developed into successful businesses that provide a reliable source of income for the members. These seed producers and cowpea producers across Burkina Faso will miss this researcher who knew their challenges and improved their lives.

Identified by Jeff Ehlers, program officer at the Bill & Melinda Gates Foundation, as the man who "has helped move cowpea from a subsistence crop to a real commercial opportunity (especially for women) in Burkina Faso," Issa will be greatly missed by the international grain legume research community. More than just a colleague, however, Issa will be missed for his kind nature, open hospitality, and genuine long-term friendship to those with whom he worked.

When Issa passed last winter in mid-December, we were terribly saddened, but his well-lived life will be remembered by all. Dr. Issa Drabo's exemplary career, his friendship, and his daily actions are a constant inspiration to those fortunate to have known him.